Computer Histories™

A History of Computing in 100 People, Places and Things

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All images by the author unless otherwise attributed

Updated at the start of each year, look for the latest version at:

www.computerhistories.org

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Dedication

- To my parents - who encouraged my interests as a child and bought me my first computer…
- To my wife - who encourages these interests as an adult…
- To my sons - I hope this record of the past guides you towards your future…
- To Harvey Richardson - who taught me how to program
- and to James Tomayko, the first computer archeologist I ever met…

Inspirations

- Alan Kay
- Theodor Holm Nelson
- Steve Jobs

User's Manual

- Stop! Before reading any further make sure you have the latest version of this course, which can be downloaded at http://www.computerhistories.org
- The initial version of this course was published in 2013
- An updated version of this course is published each January
- If you wish to print this course for viewing on paper, print it as "Handouts" with 6 slides per page to save on paper

"Excellence is never an accident. It is always the result of high intention, sincere effort, and intelligent execution; it represents the wise choice of many alternatives - choice, not chance, determines your destiny."

- Aristotle

Topic 1

Introduction

Song

Slide text

Thematic Quote

Our Philosophy

"Life can be much broader once you discover one simple fact: Everything around you that you call life was made up by people that were no smarter than you and you can change it, you can influence it, you can build your own things that other people can use.

Once you learn that, you'll never be the same again."

- Steve Jobs

(That is what all the people we will study did, that is what <u>you</u> can do)

The Painting

Painting Name

- Artist's Name

(Location of painting)

Artifact

- Name
  - Computer Histories To Learn More
    - www.computerhistories.org/ToLearnMore.html
- Year
  - 2013
- Story

The Question

Our three primary questions

- What is the history of computing?
- What is the future of computing?
- What lessons can we learn from computing's past that will help guide us in determining computing's future?

- or -

Clearly, computing has changed the world

- But where has it come from?
- And where might it be taking us?

What Is Computer History?

- **The study of the story of the people, places, and things related to the past of computation and communication**

- **[N.B. - For our purposes, computing = computing <u>and</u> communications]**

Why Study Computer History?

"Those who cannot remember the past are condemned to repeat it"

- George Santayana, historian

"History does not repeat itself, but it often rhymes"

- Mark Twain, author

[So if you learn the history of computers + communication you can avoid repeating the mistakes of the past and you will be better able to invent the future…]

Why Study Computer History?

"The farther backward you can look, the farther forward you are likely to see."

- Winston Churchill

Why Steve Jobs Studied Computer History

"You can't really understand what is going on now without understanding what came before...It's like that Scopenhauer quote about the conjurer."

- Steve Jobs

"He who lives to see two or three generations is like a man who sits some time in the conjurer's booth at a fair, and witnesses the performance twice or thrice in succession. The tricks were meant to be seen only once, and when they are no longer a novelty and cease to deceive, their effect is gone."

- Arthur Schopenhauer

- Leslie Berlin, To Invent the Future, You Must Understand the Past, Medium Backchannel, May 1, 2015

"History is a pack of lies about events that never happened told by people who weren't there"

- George Santayana, historian

Why Study History?

"What experience and history teach is this - that nations and governments have never learned anything from history, or acted upon any lessons they might have drawn from it."

- Georg Wilhelm Friedrich Hagel, philosopher

What is the Historian's Mind-set?

"How do I know the historian's mind-set when I see it? I know it because it's somebody interested in how things change over time, but not just that. They're also interested in the problem of how things change over time. And how to account for change over time."

- Peter Bol, historian

"I would say the historian's mind-set is the person who sees what's going on, today, and assumes that whatever's happening is not happening for the first time. And that whatever we're seeing must have happened in some iteration, at some point, sometime in the past somewhere. And that those versions of the kinds of change that we see around us in various scales are just the latest installment of a very long series of similar such changes"

- Mark Elliot, historian

Applied History

"'Applied history' - an attempt to illuminate current challenges and choices by analyzing precedents and historical analogues"

"Applied historians would take a current predicament and try to identify analogues in the past. Their ultimate goal would be to find clues about what is likely to happen, then suggest possible policy interventions and assess probable consequences."

- Graham Allison + Niall Ferguson, Why the US President Needs a Council of Historical Advisors, The Atlantic, Sep. 2016

Applied History

"The present, while never repeating the past exactly, must inevitably resemble it. Hence, so must the future."

- Thucydides, historian

"The events of future history…will be of the same nature - or nearly so - as the history of the past, so long as men are men."

- Thucydides, historian

Applied History

"The longer you can look back, the farther you can look forward."

- Winston Churchill

"More than ever one should study history in order to see why nations and men succeeded and why they failed."

- Henry Kissinger, US Secretary of State

Why Is Computer History Important?

- We are at a crucial time in the history of computing - will its future be open or closed?
  - What we learn from the past can teach us of the future we should have - and that you should demand from technologists and politicians

Why Is Computer History Important?

"…it behooves wired people to know a few things about wires…"

- Neil Stephenson, author

Why You Should Listen To Me

"The great thing about the computer industry is that history keeps repeating itself at 10 year intervals. The funny thing is that I'm the only one old enough in the Valley to have experienced several of these intervals, which is why I'm usually right in my predictions."

- Robert X. Cringely, journalist

Who Studies Computer History?

- Multidisciplinary field
  - Historians, social scientists, technologists, scientists, engineers, lawyers, politicians
- Therefore it is appealing to learners at all levels
  - From K-12 to Ph.D.

Goal of This Course

- Equip you with an intellectual toolkit for the multi-disciplinary study of computing that will allow you to:
  - Understand the history of computing from the micro to the macro levels - from the chip to the Internet
  - Undertake meaningful discussion and debate as computing plays an ever more crucial role in society and our lives
  - Embark upon a course of lifelong learning regarding computing and its role in society
- - or - Provide an introduction to computer history, interest you in the further study of computer history, point you to tools to aid your further study of computer history
- As a survey course, it is designed to encourage broad horizontal thinking across the discipline of computer history rather than vertical (silo) thinking

Themes

What we are going to discuss / What we have discussed
Everything is deeply intertwingled / We keep going in loops

- **Topic 2 - Bigger isn't better**
  - Smaller companies + teams out-innovate larger companies + teams
- **Topic 2 - Innovator's Dilemma**
  - Innovation rarely comes from the companies on the top of a field - they get taken out by the innovators (with the exception of Apple)
  - The producer of a higher priced product never thinks how they can make a cheaper version of it while the producer of the lower priced product is always thinking how they can make a cheaper version of more expensive product (HP turned down the Apple I)
- **Topic 3 - Arc of technology advances but the apps remain the same**
  - For computers - brass gears, electromagnetic relays, vacuum tubes, transistors, integrated circuits
  - For communications - copper wire, fiber optic strands, wireless
- **Topics 3, 10, 13, 23, 26 - Sufficient quantitative change can be qualitative change**
  - Moore's Law and increasing transistor density allows computing cycles to be wasted on frivolous tasks, Motorola StarTac mobile phone is always turned on + in your pocket due to long battery life and small size, AltaVista as first search engine to index whole Web…same is true in evolution of mammalian brain
- **Topics 4 + 13 - Computer location**
  - From being with you (Antikythera Mechanism) to being with you (mobile phone)

Themes

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- **Topics 4 + 13 - From Apps on Antikythera Mechanism to Apps on mobile phones**
  - From handheld Antikythera Mechanism to mobile phones, we want to take computing with us + use it in our daily lives
- **Topic 5 - Computing and cryptography have always served one another**
  - From Bombes + Enigma to Harvest Stretch to CRAY-1 to NSA PRISM
- **Topics 6 + 26 - Computer size**
  - Computer size goes from filling a room (ENIAC) to in your hand but connected to a computer filling a warehouse (Google)
- **Topics 6, 7, 9, 11, 13 - The primacy of open hardware systems**
  - Computing from closed (early computers) to open (IAS computer design in 1950's) to closed (mainframes) to open (minis with Unix) to closed (early PCs) to semiopen (Wintel) to closed (iOS) to open (Android)
  - An open standards computer (IBM-PC) produced by starched shirts at IBM trumped closed computer produced by hippies at Apple (Macintosh)
  - An open communication system (World Wide Web) trumped a closed system (Gopher)
- **Topics 7, 9, 11, 12 - From centralization to decentralization to centralization**
  - Computing - from centralized systems (mainframes) to decentralized systems (minis) to centralized systems (time sharing) to decentralized systems (PCs) to centralized systems (cloud) …

Themes

What we are going to discuss / What we have discussed
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- Topics 8, 12, 16 - From centralization to decentralization to centralization
  - Communication - mainframes / minis had timesharing with communication and collaboration tools (centralized) -> the advent of PCs as unconnected islands broke all this (decentralized) -> it took the Ethernet and Internet to connect them back together so they could communicate and collaborate on interoperable Web but much time was lost (centralized) -> mobile phones running apps that don't interoperate (decentralized)
- Topics 5 + 11 + 12 + 23 - Perfect is the enemy of good enough - people will embrace an available good enough solution that can be incrementally improved over time rather than wait for perfection - lowest common denominator solutions are often acceptable
  - Hollerinth instead of Babbage
  - The PC instead of the Dynabook
  - The Internet instead of interactive television
  - The Web instead of Xanadu
- Topics 11 + 12 - Killer App is never what you think it will be
  - For Apple II it was supposed to be computer programming, ended up being VisiCalc
  - For Mac it was supposed to be MacWrite / MacPaint, ended up being PageMaker
  - For ARPANet was supposed to be remote login + sharing resources, ended up being Email

Themes

What we are going to discuss / What we have discussed
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- **Topics 12 + 19 - The primacy of open software systems**
  - Open source software LAMP (Linux / Apache / MySQL / PHP) powers the Internet
  - Open source software (Android - derived from Linux) powers the mobile world
- **Topic 16 - The primacy of open communication systems**
  - Communications from open systems (BBSs / FidoNet / Usenet) to closed systems / walled garden (AOL / Prodigy) to open systems (Web) to closed systems (Facebook) to …
- **Topic 17 - Programming**
  - From mainframe machine language to assembler to high level languages as computer gets more powerful to PC's machine language / assembler to high level languages to mobiles...
- **Topic 25 - Monopolies arise and are then swept away, often for legal reasons**
  - ATT in communications, IBM in hardware, Microsoft in software
- **Topic 27 - Nothing new under the sun / Been there done that**
  - In contrast to what the media would have you think each day about the latest / greatest thing in computing
- **Topic 27 - The field of computing is full of smart people, but true visionaries are rare**
- **Topic 27 - The best products are the result of one company providing both the hardware and the software integrated together, controlling the whole solution**

Themes

What we are going to discuss / What we have discussed
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- Topic 15 Artificial Intelligence
  - Artificial Intelligence is a field that has been trying to live up to its promise for the last 50 years…until now?
- Topics 12 + 16 + 19 The best things in life are free
  - Open source software
  - Open standards-based communication systems (Web)
- Topic 16 There ain't no such thing as a free lunch (TANSTAAFL)
  - You are the product of Google, Facebook, etc.
- Topics 8 + 22 + 23 - Expansive visions of computing intended for intellectuals are dumbed down for the masses
  - Engelbart's NLS vision -> we got the mouse
  - Kay's Dynabook vision -> we got the consumption tablet
  - Nelson's Xanadu vision -> We got the Web
- Topic 3 - History of computing is that of increasing intimacy

Learning Objectives of This Course / Computer History Frequently Asked Questions (FAQs)

- What is the history of computing?
- What is the future of computing?
- What lessons can we learn from computing's past that will help guide us in determining computing's future?

Personal Case Study - Gwen Bell

- Role - Co-founder + First President of The Computer Museum
- Story
  - Served with her on The Computer Museum's Workshop on Virtual Museums in April 1995
  - She remarked that it could be disappointing to deal with the founders of the field of computing for as they got older their stories changed in that they took credit for more and more of the key breakthroughs and gave less and less credit to their partners

As a Baseline - Human Brain as a Computer

- Number of neurons ~ 86-100 billion neurons, each makes 1,000 connections to other neurons so there are 100 trillion connections
- Switching speed / computing speed = x
- Memory capacity = 1-100 terrabytes (Seth Shostak, Big Picture Science, Forget to Remember)

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- Who invented the computer(*)?
  - A. Charles Babbage - 1837 - designed mechanical computer that was general purpose, digital, programmable - but he didn't build it
  - B. Alan Turing - 1936 - Turing Machine - theoretical computer as powerful as any computer that can be built
  - C. Atanasoff-Berry
  - D. Konrad Zuse
  - E. Tommy Flowers
  - F. George Stibitz
  - G. Williams-Kilburn
  - H. Howard Aiken
  - I. Maurice Wilkes
  - J. Eckert and Mauchly
  - K. John von Neumann

- (*)What does computer mean? Electronic, Programmable, General Purpose, Digital, Stored Program

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
- Simulations

Conclusion

"An educated citizenry learns to exploit new technology. An ignorant one becomes its victim."

- Tom Stonier in The Making of the Micro

Topic 2

Computers as an Innovation Engine

Makers and Enterpreneurship

Song

Do you know the way to San Jose

I've been away so long

I may go wrong and lose my way

Do you know the way to San Jose

I'm going back to find some peace of mind in San Jose

- Burt Bacharach, Do You Know the Way to San Jose?

Thematic Quote

"Over time I've learned that the people involved in tremendous breakthroughs which have changed things forever mostly share certain basic qualities. I have three qualities in mind. First, put very simply, they all really just had a vision about how to solve a problem. Second, most of them had been told the problem was extremely difficult, if not impossible, to solve. And third, most of them described their work and their breakthroughs in the most humble terms. They say things like "We stumbled onto it" or "We had to do it on the side because we had day jobs" or my favorite "You know once we got into it we found out it would be a lot harder than we thought it was going to be." It's a wonderful and inspirational thing. "

- John Hollar, CEO Computer History Museum

Thematic Quote
Think Different

"Here's to the crazy ones. The misfits. The rebels. The troublemakers. The round pegs in the square holes. The ones who see things differently. They're not fond of rules. And they have no respect for the status quo. You can quote them, disagree with them, glorify or vilify them. About the only thing you can't do is ignore them. Because they change things. They push the human race forward. While some may see them as the crazy ones, we see genius. Because the people who are crazy enough to think they can change the world, are the ones who do."

- Apple Inc.

The Painting

Painting Name

- Artist's Name

(Location of painting)

Artifact

- Name
- Year
- Story

The Question

"I hear you say "Why?" Always "Why?" You see things; and you say "Why?" But I dream things that never were; and I say "Why not?""

- George Bernard Shaw, playwright

Sources of Inspiration

"I read the Tom Swift Jr. series when I was 8, 9 and 10. That impressed upon me the idea that you can find ideas and inventions to overcome any problem."

- Ray Kurzweil, inventor

"Another hero was Tom Swift, in the books. What he stood for, the freedom, the scientific knowledge and being an engineer gave him the ability to invent solutions to problems. He's always been a hero to me. I buy old Tom Swift books now and read them to my own children."

- Steve Wozniak, founder Apple Computer

Why Innovate

Who And What Is A Maker?

"…it's someone who is a builder, a creator, a producer, a developer, someone who has an active sense of taking an idea and developing it into something that's real and tangible and can be shared with other people."

- Dale Dougherty, editor + publisher Make magazine

Why It Is A Good Thing To Be A Maker

"Technological innovation is the source of all progress, so you should be in the technological innovation business, at the core of which is science and engineering. The highest calling is to be in technological innovation. Democracy, freedom, prosperity - they all stem from technological innovation, and the world needs more of us."

- Bob Metcalfe

"To do something, say something, see something,
before anybody else -
these are the things that confer a pleasure
compared with which other pleasures are tame and commonplace,
other ecstasies cheap and trivial."
- Mark Twain, author

"Life is full of golden opportunities carefully disguised as irresolvable problems"

- John Gardener, US Secretary of Health, Education, and Welfare

"What we have here is an insurmountable opportunity"

- Yogi Berra, baseball manager

"You know we're constantly taking. We don't make most of the food we eat, we don't grow it, anyway. We wear clothes other people make, we speak a language other people developed, we use a mathematics other people evolved and spent their lives building. I mean we're constantly taking things. It's a wonderful ecstatic feeling to create something and put it into the pool of human experience and knowledge."

- Steve Jobs

"In doing the Macintosh, for example, there was a core group of less than a hundred people, and yet Apple shipped over ten million of them. Of course everybody's copied it and it's hundreds of millions now. That's pretty large amplification, a million to one. It's not often in your life that you get that opportunity to amplify your values a hundred to one, let alone a million to one. That's really what we were doing."

- Steve Jobs, Smithsonian Institution Oral History Interview, Apr. 20, 1995

Who Innovates

"Big things have always been done by little people"

- Benjamin Disraeli, English Prime Minister

"If not me, then Who? If not now, then When?"

- Don Quixote to Sancho Panza in Man of La Mancha as to why he chases after windmills

"The reasonable man adapts himself to the world; the unreasonable man persists in trying to adapt the world to himself. Therefore, all progress depends on the unreasonable man"

- George Bernard Shaw, playwright

"Scientists are men who dream about doing things. Engineers do them"

- Harry Crampton at Langley in Space by James Michener p. 222

Who is the Innovator?

"Genesis stories tend to take on an outsize significance in Silicon Valley…In the Valley, these tales are called "the Creation Myth" because, while based on a true story, they exclude all the turmoil and occasional back stabbing that comes with founding a tech company."

"In Walter Isaacson's biography of Steve Jobs, Jonathan Ive, Apple's head of design, recalls how Jobs occasionally hit upon his ideas. "He will go through a process of looking at my ideas and say: 'That's no good. That's not very good. I like that one,'" Ive told Isaacson. "And later I will be sitting in the audience" - during a a product presentation - "and he will be talking about it as if it was his idea." Jobs certainly created a number of life-altering innovations, but Ive's point suggest a larger truth about Silicon Valley that Jobs understood well. Ideas rarely, if ever, come from the mind of a single person, but those who go down in lore as visionaries take credit for them as if they do."

"In Silicon Valley, most companies have their own Twitter story: a co-founder, always a friend, and often the person with the big idea behind the company, who is pushed out by another, hungrier co-founder."

"Twitter really was a collaboration; an idea that came out of a failed podcasting company that happened to come about at the right time...Such is the case with every company in Silicon Valley, though you never hear it in their creation myth."

- Nick Bilton, All is Fair in Love and Twitter, New York Times Magazine, Oct. 13, 2013

How To Innovate

"To ask permission is to seek denial"

- Scott McNealy, Sun Microsystems

"Luck is what happens when opportunity and preparation meet"

- James Martin, NASA Viking project manager

"Genius is 99% perspiration and 1% inspiration"

- Thomas Alva Edison, inventor

"Never tell people how to do things. Tell them what to do and they will surprise you with their ingenuity."

- George S. Patton, Jr., general

"In racing you make your own luck"

- Phil Hill, Formula 1 World Champion

"If you are in control you are not going fast enough"

- Mario Andretti, Formula 1 World Champion

"If you don't know where you are going you will wind up someplace else"

- Yogi Berra, baseball manager

"Basic research is what I am doing when I don't know what I am doing"

- Wernher von Braun, rocket scientist

"Imagination is more important than knowledge"

- Albert Einstein, physicist

"Do not go where the path may lead, go instead where there is no path and leave a trail"

- Ralph Waldo Emerson, essayist

The Engineering Mind-set

"Good engineers create structure so they can understand-pre-emptively-the context and value of any given problem and solution; after that, they acknowledge constraints, whether of money or politics or available materials, that they must work within or somehow supersede. Finally, they deftly evaluate trade-offs so that they can formulate the most effective application for a given situation."

> "Structure, constraints and trade-offs are the one-two-three punch of the engineering mind-set. They are to an engineer as time, tempo and rhythm are to a musician." - Guru Madhavan

- Jon Gertner, Anonymously Saving the World, Wall Street Journal, Aug. 3, 2015

"Use the lowest tech that will work"

- Burt Rutan, engineer, Scaled Composites

When Do You Ship?

"Better is the enemy of good enough"

\- Russian proverb

"Real artists ship"

- Steve Jobs

What Does it Take to Succeed as an Entrepreneur?

"I'm convinced that about half of what separates the successful entrepreneurs from the non-successful ones is pure perseverance. It is so hard. You put so much of your life into this thing. There are such rough moments in time that I think most people give up. I don't blame them. Its really tough and it consumes your life. If you've got a family and you're in the early days of a company, I can't imagine how one could do it. I'm sure its been done but its rough. Its pretty much an eighteen hour day job, seven days a week for awhile. Unless you have a lot of passion about this, you're not going to survive. You're going to give it up. So you've got to have an idea, or a problem or a wrong that you want to right that you're passionate about otherwise you're not going to have the perseverance to stick it through. I think that's half the battle right there."

- Steve Jobs, Smithsonian Institution Oral History Interview, Apr. 20, 1995

When Innovation Fails

"A Silicon Valley tenet is to fail fast, and often"

- Anonymous

"If you don't fail at least 90 percent of the time, you're not aiming high enough"

- Alan Kay, computer scientist

"Can learn more from failure than you can from success"

- Richard Saul Wurman, information architect

"Take risks"

"For of all sad words of tongue or pen,
The saddest are these: it might have been!"

- John Greenleaf Whittier

"I didn't see it then, but getting fired from Apple was the best thing that could have ever happened to me. The heaviness of being successful was replaced by the lightness of being a beginner again. It freed me to enter one of the most creative periods of my life."

- Steve Jobs

The Serial Entrepreneur

"When I asked Steve Jobs about Mac 25th anniversary, he brushed it off: "If you look backwards, you'll be crushed.""

- Steven Levy

Why Innovation Doesn't Occur

Innovator's Dilemma

- The innovator's dilemma is that doing the right thing is the wrong thing
- Definition
  - Successful companies put too much emphasis on customers' current needs, and fail to adopt new technology or business models that will meet customers' unstated or future needs; such companies will eventually fall behind
- Disruptive innovation
  - Selling of cheaper, poorer-quality product that initially reaches less profitable customers but eventually takes over + devours an entire industry

- Clayton Christensen, The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail

Innovator's Dilemma Examples

- HP was big in calculators and minicomputers, but turned down the Apple I
- Microsoft was the king of personal computing operating systems and application software, pretty much missed the Web, totally missed mobile
  - But did see IBM would be big in personal computing so they bought an operating system to be part of that
  - Saw network computing would be big so they borrowed some technology from 3COM
  - Saw the WIMP interface would be big so they licensed Windows 1 from Apple
  - Recognized almost too late the Internet would be big so they gave away Internet Explorer

Kodak's Moment

- First digital camera invented by Steve Sasson, engineer at Kodak, in 1975
  - Used lens from Super-8 movie camera, cassette recorder, 16 NiCAD batteries, analog to digital convertor
  - Captured image in 50 milliseconds, took 23 seconds to record image to tape, tape would be transferred to playback unit + 30 seconds later a 100 x 100 pixel black + white image appeared on TV screen
- Kodak had monopoly on US photography market
  - Photographic prints had worked well for 100 years, there were no complaints about them, they were very inexpensive - why would anyone want to look at image on TV set?
  - Estimated he would need 2 million pixels to compete against Kodak 110 color film, which would take 15 - 20 years
- Kodak patented digital camera in 1978
  - 1980 created first digital SLR camera with 1.2 megapixels, image compression, memory cards - but Kodak would not sell it because it would eat away at film sales
  - 1993 - Kodak sells its first consumer digital camera
  - 2012 - Kodak goes bankrupt

- James Estrin, In 1975 This Kodak Employee Invented the Digital Camera. His Bosses Made Him Hide It. Business Review Weekly, Aug. 14, 2015

Xerox

- Xerography - making dry, good-quality, permanent copies on ordinary paper with minimum of trouble
- 1959 Haloid Xerox introduces Xerox 914, first automatic xerographic office copier, size of a desk, makes copies up to 9 x 14 inches in size, has tendency to break
  - 1959 Xerox sales = $33 million
  - 1961 Xerox sales = $66 million
  - 1963 Xerox sales = $176 million
  - 1966 Xerox sales = > $500 million
- Revolutionized the transmission of information in business, academia, political movements
- Created the "paperfull office"

- John Brooks, Xerox Xerox Xerox Xerox, New Yorker, Apr. 1, 1967

Xerox

- Founded Palo Alto Research Center (PARC) to invent the "paperless office"
- PARC developed the personal computer, graphical user interface, local area network…and the laser printer
- Xerox failed to commercialize PARC's inventions
  - Apple, Microsoft and 3Com did

"It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change."

- Charles Darwin, biologist

Company's Successes and Failures

- Xerox
  - Fumbled the future at PARC
- IBM
  - Accidentally got into personal computers and then blew it
- Microsoft
  - Almost missed the Web, missed mobile
- DEC
  - Missed the personal computer because of Ken Olsen; they then went on to miss the Web even though they had AltaVista search engine
- Intel
  - Switched from memory to microprocessors in the nick of time, missed out on mobile
- Corning Glass
  - Switched from cookware to fiber

What Does It Require For Innovation To Be Adopted?

- The new way of doing something must be at least 10 times better than the old way of doing something

Consequences Of Innovation

"There is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in success, than to take the lead in the introduction of a new order of things…Innovation makes enemies of all those who prospered under the old regime, and only lukewarm support is forthcoming from those who would prosper under the new"

- Niccolo Machiavelli, historian

"A pioneer is a guy with an arrow in his back and his face in the mud."

- Anonymous

"Great Spirits have always received strong opposition from mediocre minds."

- Albert Einstein, physicist

"It is not the critic who counts nor the man who points out how the strong men stumbled, or where the doer of deeds could have done them better. The credit belongs to the man who is actually in the arena, whose face is marred by dust and sweat and blood, who strives valiantly, who errs and comes short again and again, who knows the great enthusiasm, the great devotions and spends himself in a worthy cause; who, at the best, knows in the end the triumph of high achievement; and who, at the worst, if fails, at least fails while daring greatly so that his place shall never be with those cold and timid souls who know neither victory or defeat."

- President Theodore Roosevelt

"Far better it is to dare mighty things, to win glorious triumphs, even though checkered by failure, than to rank with those poor spirits who neither enjoy nor suffer much, because they live in the gray twilight that knows not victory nor defeat."

- President Theodore Roosevelt

"First they ignore you. Then they laugh at you. Then they fight you. Then you win"

- Mahatma Gandhi, political leader

"Every truth passes through three stages before it is recognized. In the first it is ridiculed, in the second it is opposed, in the third is recognized as self evident"

- Arthur Schopenhauer, philosopher

"I know of no finer joy than that of designing and building some great work. An engineer then becomes a creator, and cannot be denied a humble place among the ranks of artists. He has the privilege and the delight, if he is a man of understanding, of creating something which is not only beautiful but useful and since he is usually a plain rugged sort of fellow, his works should be informed with a natural simplicity and candour. He passes through the same alternations of hope and fear, of anxiety and confidence, of despair and exaltation, as the creative artist, and on the completion of his work he has the added agonizing experience of the test of his bridge or dam by the use to which it is put."

- Victor Bayley, Engineer, the Khyber Railway

"The purpose of life is not to be happy, it is to be useful, to be honorable, to be compassionate, to have it make some difference that you have lived and lived well"

- Ralph Waldo Emerson, essayist

"She was one of those people who had the misfortune to recognize an idea about a century before its appointed arrival in the history of mankind and spent her life throwing herself against the obstinancy of her times"

- Thornton Wilder in The Bridge of San Louis Rey

"Christopher Columbus was a failure. His business model did not pan out: no western route to Asia, hardly any gold, abandonment by his investors, not much of an enduring first-mover advantage for Spain . . . but he f*king discovered America."

- Kurt Andersen, Inside Magazine, on dot.com pioneers/failure

Place - Bell Labs

- Significance

  "In a time before Google, the Labs sufficed as the country's intellectual utopia. It was where the future, which is what we now happen to call the present, was conceived and designed." - Jon Gertner

  - Powerhouse of basic science research in communications + computing
- Location
  - New Jersey
- Definition
  - Alexander Graham Bell obtains patent on phone + defends it
    - Leads to wealthy regulated monopoly in US to provide telephone service
    - Leads to generous funding of Bell Telephone Laboratories
- People who worked there
  - At peak of reputation in 1960's employed 15,000 people including 1,200 PhDs
  - Claude Shannon, William Shockley, Ken Thompson, Dennis Ritchie
- Things created there
  - Conducted fundamental research in transmission of information
    - Developed much of the theory of information coding / transmission / storage
  - Information theory - Claude Shannon
  - Transistor
  - Unix operating system + C programming language
  - CCD chip
  - Solar cell -> solar panels
  - Big Bang
  - Communications satellites (Echo + Telstar)
  - Theory of laser
  - Picturephone
  - (Telesophy - from Bellcore)

- Jon Gertner, The Idea Factory - Bell Labs and the Great Age of American Innovation, Talk at the Computer History Museum on March 28, 2012

Bell Labs

- Since 1925 Bell Labs generated seven Nobel prizes + changed course of humanity
- Bell Labs inventions that led to Internet
  - Transistor
  - Information theory
  - Lasers
  - Solar energy
  - Radio astronomy
  - Microchips
  - UNIX
  - Mobile phones
  - Mobile networks

- Douglas Coupland, Kitten Clone, p. 29

Frederick Terman

From Wikipedia

Person - Frederick Terman

- Significance
  - Father of Silicon Valley
- Profession
  - Professor and Dean of School of Engineering and Provost
- Places worked
  - Stanford University
- Years of work
  - 1925 - 1965
- Things worked on
  - Silicon Valley - urged his best students to form companies there

Place - Stanford University

- Significance
  - Intellectual and academic hub of Silicon Valley
- Location
  - Palo Alto, California
- Definition
  - Private university founded in 1891 by Leland Stanford, Governor of and US Senator from California and railroad tycoon
- People who worked there
  - Fred Terman, Stanford professor, was Dean of School of Engineering and Provost who urged his best students to form companies there - father of Silicon Valley
- Things created there
  - Silicon Valley

What Makes Stanford Tick?

"Stanford has established itself as the intellectual nexus of the information economy."

"If the Ivy League was the breeding ground for the elites of the American Century, Stanford is the farm system for Silicon Valley."

"Frederick Terman, an engineer who joined the faculty in 1925, became the dean of the School of Engineering after the Second World War and the provost in 1955. He is often called "the father of Silicon Valley." In the thirties, he encouraged two of his students, William Hewlett and David Packard, to construct in a garage a new line of audio oscillators that became the first product of the Hewlett-Packard Company. Terman nurtured start-ups by creating the Stanford Industrial Park, which leased land to tech firms like Hewlett-Packard; today, the park is home to about a hundred and fifty companies. He encouraged his faculty to serve as paid consultants to corporations, as he did, to welcome tech companies on campus, and to persuade them to subsidize research and fellowships for Stanford's brightest students."

"…'secret sauce' a phrase that university officials use almost mystically to describe whatever it is that makes the school succeed as an entrepreneurial incubator…"

"Stanford's public-relations arm proclaims that five thousand companies "trace their origins to Stanford ideas or to Stanford faculty and students." They include Hewlett-Packard, Yahoo, Cisco Systems, Sun Microsystems, eBay, Netflix, Electronic Arts, Intuit, Fairchild Semiconductor, Agilent Technologies, Silicon Graphics, LinkedIn, and E*Trade." [and Google, Instagram, Snapchat]

- Ken Auletta, Get Rich U, New Yorker, April 30, 2012

Hewlett Packard Garage

From Wikimedia Commons

Place - Hewlett Packard

- Significance
  - The original startup in 1939
  - The HP Way

    "'the HP Way.' The essence of the idea, radical at the time, was that employees' brainpower was the company's most important resource. ...one of the first all-company profit-sharing plans... gave shares to all employees... among the first to offer tuition assistance, flex time, and job sharing..." - Peter Burrows, BusinessWeek

    - Model for many who subsequently followed - Steve Jobs
  - Management by Walking Around
- Location
  - Silicon Valley, California
- Definition
  - Symbolic founding company of Silicon Valley
  - Founded in a garage
- People who worked there
  - William Hewlett, David Packard
- Things created there
  - First product - HP200A precision audio oscillator sold to Walt Disney for use in film Fantasia
  - Scientific instruments, calculators, computers

John Bardeen, William Shockley and Walter Brattain

From Wikimedia Commons

Fairchild FC-2

Built by and for Sherman Fairchild's Aerial Surveys company as a camera platform

Place - Silicon Valley

- Significance
  - Shockley Semiconductor -> Traitorous 8 leave to form Fairchild Semiconductor -> Robert Noyce (IC coinventor) / Gordon Moore (Moore's Law) / Andrew Grove form Intel in 1968
- Location
  - Santa Clara Valley south of San Francisco
- Definition
  - Home of Fairchild Semiconductor
    - Journalist Dan Hoefler called it "Silicon Valley" in 1971
- People who worked there
  - Fred Terman, Stanford professor, was Dean of School of Engineering and Provost who urged his best students to form companies there - father of Silicon Valley
- Things created there
  - Integrated circuits made of silicon, hence its name

Silicon Valley's Culture

The unique business culture with which the place would come to be associated:

Openness over hierarchy

Risk over stability

Innovation over the tried and true

- PBS The American Experience - Silicon Valley

Silicon Valley Culture

"Google pioneered what has become the archetype of the modern Silicon Valley company - an engineering-driven culture in which internal hierarchies are suppressed, empirical evidence is prized and people are given wide leeway to work on problems that excite them, even if they seem far removed from a central corporate mission."

- Farhad Manjoo, With Google as Alphabet, A Bid to Dream Big Beyond Search, New York Times, Aug. 10, 2015

The Forces That Created Silicon Valley

- Technology
  - William Shockley moved back to Palo Alto
    - Brilliant physicist, outstanding teacher, terrible entrepreneur + boss
    - Recruited best researchers who began innovating in field of semiconductors
    - Many of them could not wait to get away from him - most notably 8 of his employees launched Fairchild Semiconductor in 1957 = first modern startup in Valley
    - In 1960's Fairchild Semiconductor blew apart into dozens of companies (Fairchildren)
  - The transistor - everything Silicon Valley creates is related to what Shockley taught his people to build
- Culture
  - Stanford professor Frederick Terman created "a community of technical scholars" where links between industry + academia were fluid
  - Created business environment around needs of new companies on the way up
  - Silicon Valley saw themselves as cowboys + pioneers who dared greatly + learned from failure, in direct opposition to East Coast counterparts
- Money
  - US government, in form of Department of Defense, served as Silicon Valley's first venture capitalist by funding advanced electronics work
  - First wave of venture capital firms started in 1970's by Fairchild alumni - Sequoia Capital + Kleiner Perkins Caufield + Byers
  - One generation succeeds + turns around to offer next generation financial support + managerial expertise

    "Re-stocking the stream I fished from" - Robert Noyce

- Leslie Berlin, To Invent the Future, You Must Understand the Past, Medium Backchannel, May 1, 2015

Why Has Silicon Valley Endured?

- Technology
  - Silicon Valley still glides in long wake of transistor, in terms of technology + infrastructure that supports companies reliant on transistors
- Culture
  - Silicon Valley is built + sustained by immigrants
    - 37% of people Silicon Valley today born outside of US
    - 66% of people in Silicon Valley who have completed college are foreign born
  - Stanford remains at center of action
- Money
  - Venture capital remains dominant source of funding for young companies in Silicon Valley
  - Rise of software - little is required to create software, programmers like to live near Silicon Valley (San Francisco)

- Leslie Berlin, To Invent the Future, You Must Understand the Past, Medium Backchannel, May 1, 2015

Why it Happened in Silicon Valley

"I do think when people look back on this in a hundred years, they're going to see this as a remarkable time in history. And especially this area believe it or not. When you think of the innovation that's come out of this area, Silicon Valley and the whole San Francisco Berkeley Bay area, you've got the invention of the integrated circuit, the invention of the microprocessor, the invention of semi-conductor memory, the invention of the modern hard disk drive, the invention of the modern floppy disk drive, the invention of the personal computer, invention of genetic engineering, the invention of object oriented technology, the invention of graphical user interfaces at PARC, followed by Apple, the invention of networking. All that happened in this bay area. Its incredible.

Two or three reasons. You have to go back a little history. I mean this is where the beatnik happened in San Francisco. Its a pretty interesting thing. This is where the hippy movement happened. This is the only place in America where Rock 'n Roll really happened. Right? Most of the bands in this country, Bob Dylan in the 60's, I mean they all came out of here. I think of Joan Baez to Jefferson Airplane to the Grateful Dead. Everything came out of here, Janis Joplin, Jimmy Hendrix, everybody. Why is that? You've also had Stanford and Berkeley, two awesome universities drawing smart people from all over the world and depositing them in this clean, sunny, nice place where there's a whole bunch of other smart people and pretty good food. And at times a lot of drugs and all of that. So they stayed. There's a lot of human capital pouring in. Really smart people. People seem pretty bright here relative to the rest of the country. People seem pretty open-minded here relative to the rest of the country. I think its just a very unique place and its got a track record to prove it and that tends to attract more people. I give a lot of credit to the universities, probably the most credit of anything to Stanford and Berkeley, UC California."

- Steve Jobs, Smithsonian Institution Oral History Interview, Apr. 20, 1995

Dark Side of Silicon Valley

"Silicon Valley is not a place where one is invited to show frailty or despondence. It is, as Nick puts it, "the place where everybody is killing it all the time." This might seem peculiar, given that the lot of the small-business founder has always been a fragile one. But in recent years the Valley has successfully elaborated the fantasy that entrepreneurship-and, more broadly, creativity-can be systematized. This is the basic promise of accelerators (Y Combinator et al.), that success in the startup game can be not only taught but rationalized, made predictable. Starting a company was once an urge felt only by the blindly ambitious and slightly unsound, but in the Valley it's been ostensibly transformed into a scheduled path one can simply elect and apply for, rather as one might choose law school or Wall Street. And the promise of professionalized entrepreneurship has had a particular allure in recent years, since finance has been tarnished and a career in law made increasingly uncertain. Starting a company has become the way for ambitious young people to do something that seems simultaneously careerist and heroic."

"But in practice, business in the Valley continued to run in a familiarly exploitative way. The Valley might not actually make much in the way of tangible goods, but like industrial centers before it, it's the place where the astounding success of the very few has been held out to the youth in exchange for their time, their energy, and-well, their youth."

- Gideon Lewis-Krauss, One Startup's Struggle to Survive the Silicon Valley Gold Rush, Wired, April 2014

Dark Side of Silicon Valley

"All these kids, who didn't yet know what it was like to have a company of their own, or wind down a company of their own, or work for a giant company and ride the bus, seemed certain of one thing: that the longing for total revolution that had for so long been the hallmark of youth was, at last, about to be fulfilled. The only thing they could count on was that they were going to be the generation that partook of the process by which all would be rendered irrevocably different. It didn't seem to matter what the difference was, or whom it helped or hurt. It just mattered that things in the future would be unlike anything we'd seen before. And that, in the process, they were sure, many of them would get very rich."

"Let me tell you what the worst thing would be. The worst thing is that these guys get their funding tomorrow and are stuck doing this for another year. So far, they only lost one."

"All the while, Martino's ultimate warning-that they might someday regret actually getting the money they wanted-would still hang over these two young men, inherent to a system designed to turn strivers into subcontractors. Instead of what you want to build-the consumer-facing, world-remaking thing-almost invariably you are pushed to build a small piece of technology that somebody with a lot of money wants built cheaply. As the engineer and writer Alex Payne put it, these startups represent "the field offices of a large distributed workforce assembled by venture capitalists and their associate institutions," doing low-overhead, low-risk R&D for five corporate giants. In such a system, the real disillusionment isn't the discovery that you're unlikely to become a billionaire; it's the realization that your feeling of autonomy is a fantasy, and that the vast majority of you have been set up to fail by design."

- Gideon Lewis-Krauss, One Startup's Struggle to Survive the Silicon Valley Gold Rush, Wired, April 2014

Dark Side of Silicon Valley

"Entrepreneurs are the new labour" - Venkatesh Rao

"The lean startup methodology, the accelerators and the standardized term sheets for investments are all signs that the knowledge required to run a startup is becoming codified and commoditized. This has tilted the balance of power between investors and entrepreneurs."

"Investors have won, and their dealings with the entrepreneur class now look far more like the dealings between management and labour" - Venkatesh Rao

- Founders will end up being acqui-hired where large tech company buys startup not for its tech but for its team
  - Startups become less about providing the next new thing but instead provide a new system to train workers

- Founder's Blues, The Economist, Jan. 18, 2014

The Dark Side of Silicon Valley
Job Destruction

- Eastman Kodak
  - Founded 1880
  - Employed 145,000 people in its heyday to provide photography to the world
  - Bankrupt in 2012
- Instagram
  - Founded in 2010
  - Employed 16 people when it was acquired by Facebook in 2012 for $1 billion
  - Provides photosharing to 130 million customers world-wide in 2012
- Facebook
  - Employs 5,800 people
  - Has 1.2 billion users today it provides photosharing to

- Founder's Blues, The Economist, Jan. 18, 2014

Californian Ideology

- Promises salvation through technology-induced decentralization while ignoring + obfuscating the reality of power while concentrating wealth in hands of the elite

"Silicon Valley tends to ignore even its own version of conflict: beneath its much popularized stories of aspiration and success is a netherworld of ruthless struggle that punishes more people than it rewards. "This is one of the things nobody talks about in the Valley, (Marc) Andreessen told me. Trying to get a start-up off the ground is "absolutely terrifying. Everything is against you." Many young people wilt under the pressure. As a venture capitalist, he hears pitches from three thousand people a year and funds just twenty of them. "Our day job is saying no to entrepreneurs and crushing their dreams," he said. Meanwhile, "every entrepreneur has to pretend in every interaction that everything is going great. Every party you go to, every recruiter, every press interview-'Oh, everything's fantastic!'- and, inside, your soul is just being chewed apart, right? It's sort of like everybody's fake happy all the time."

- George Packer, Change the World, New Yorker, May 27, 2013

Conflicting Pressures of Silicon Valley

"It's work ethic, status consciousness, idealism, and greed"

- George Packer, Change the World, New Yorker, May 27, 2013

"Between "Halt and Catch Fire" and "Silicon Valley," people can finally see what tech startups are actually like on the inside."

"What I like best about both "Halt" and "SV": Both fully capture the emotional rollercoaster of euphoria and terror, dead on."

- Marc Andreessen @pmarca on Twitter

Threats to Silicon Valley's Dominance of Tech Landscape

- Current anti-immigrant attitude in US

  "One of the key aspects of Silicon Valley is it was a magnet for the best and brightest from the entire world. If you basically block that, if people go to China or they go to Europe, the chemistry falls apart." - John Markoff, computer journalist + historian

- Moore's Law may be coming to an end / slowing down

  "We're at a stage now, 50 years in, where it's a real question of whether we're still on that pace. You can argue that we're at least stalled for awhile. If the exponential's over, is it going to continue to spin out new industries?" - John Markoff

- Digital culture may be veering away from the original view that computers are "instruments of liberation" from centralized control of technology

  "I come from a generation where we really hated taking direction from anybody, but I see younger people who take direction from the palm of their hand. " - John Markoff

- John Hof, In conversation with John Markoff: Can Silicon Valley keep the innovation flywheel spinning?, Silicon Angle, Jan. 28, 2017

Venture Capitalist's Role in Innovation

- Venture capital is perfect embodiment of Joseph Schumpeter's capitalist dynamic of "creative destruction"

- Venture capital became profession when Arthur Rock funded Intel in 1968
  - Gordon Moore, Intel's co-founder, coined the term "vulture capital" because VCs can pick you clean

- Venture capitalists (VCs) gets money for a 10 year fund by recruiting investors like university endowments + pension funds + making them limited partners (LPs)
  - VCs invests money over 3-4 years + then harvests return for remainder of fund's 10 year term
  - VC standard fee is 2% of fund each year + 20% of ultimate profits
  - The dream is a 5X to 10X return on investment

- Tad Friend, Tomorrow's Advance Man, New Yorker, May 18, 2015

Venture Capitalist's Role in Innovation

- Rounds of funding
  - Seed-round funding - when startup is just an idea + few employees
  - A round - when it has product early adopters like
  - B round - once the product catches on

- There are 803 venture capital (VC) firms in US, in 2014 they invested $48 billion
- Each year, 3,000 startups approach the VC firm A16z with a "warm intro" from a friend of the firm
  - A16z invests in 15 startups / year
  - 10 will fold, 3 or 4 will prosper, 1 might become worth $1 billion (a unicorn)
  - Once every 10 years that unicorn will become Google or Facebook and provide 1,000 times return on the VC's investment

- Tad Friend, Tomorrow's Advance Man, New Yorker, May 18, 2015

The Pitch

- Stand Up Straight - strong stance + confident authoritative demeanor, also look appreciative
- Get to the Point - emphasize existing revenue + most importantly opportunity for growth
- Keep it Simple - stick to basic concepts of revenue, growth, potential market
- Why You? - prove you can run a successful business
- Show Your Toughness - fine to acknowledge failures
- Don't be Greedy - don't ask for valuation that is stratospheric
- Show Somebody Cares - have some evidence of market interest
- Where's the Pot of Gold? - show potential for scalability
- Please, Please Know Your Numbers - so you can answer tough questions about your business
- Don't Beg - not interested in tales of woe

- Kevin Brass, Secrets of Surviving the 'Shark Tank', Wall Street Journal, Aug. 25, 2014

How To Evaluate A Startup

- 1. A strong management team
  - VC's invest primarily in people + secondarily in ideas
- 2. An attractive market
  - Successful startups focus on markets capable of becoming large, fast growing + profitable for new entrants
  - Market must be structurally sound - high barriers to entry to new competitors, rivalry should not lead to vicious price wars, neither buyer power nor supplier power should be strong enough to negotiate prices easily downward, should not be good substitute for basic product
- 3. A compelling new product or service
  - Appears as must-have to specific type of customer
- 4. Strong evidence of consumer interest
  - Actual customers are willing to buy new product or service

- Michael Cusmano, Evaluating a Startup Venture, Communications of the ACM, Oct. 2013

How To Evaluate A Startup

- 5. Overcoming the "Credibility Gap"
  - Fear among customers that the venture will fail leaving them without tech support + upgrades
  - May be most common cause of failure for startups
- 6. Demonstrating early growth + profit potential
  - How the startup will grow business + generate enough cash to reach breakeven + profitability
- 7. Flexibility in strategy + technology
  - Startups need focus but also need flexibility in strategy, business models, technology
  - Need to focus resources on particular approach, but be prepared to pivot quickly if initial strategy not working
- 8. Potential for large investor payoff
  - VC's want significant payoff within time frame of not more than 7 years - looking for > 20% annual returns on portfolios
  - Market opportunity has be be large enough for startup to become worth > $100 million

- Michael Cusmano, Evaluating a Startup Venture, Communications of the ACM, Oct. 2013

Entrepreneur Ecosystem

- Startup colony (ecosystem)
  - Startup schools (accelerators)
  - Co-working spaces
  - "Anyone who writes code can become an entrepreneur - anywhere in the world" - Simon Levene, venture capitalist
- Basic building blocks for digital services + products (technologies of startup production) are so evolved, cheap, ubiquitous they can be easily combined
  - Startups can be thought of as experiments on top of such platforms
  - "Combinatorial innovation" - Hal Varian, Google's chief economist
  - Bricolage (tinkering) - Claude Levi-Strauss, anthropologist
- Run on hype but dark side is having no private life, little sleep, living on noodles
- More than 90% of startups crash + burn
- World of startups today may be preview of economy tomorrow - platforms with small innovative firms operating on top of them

"Give me a place to stand on, and I will move the Earth" - Archimedes

- A Cambrian Moment, The Economist, Jan. 18, 2014

Andy Grove, Robert Noyce, Gordon Moore

From Wikimedia Commons

Person - Robert Noyce

- Significance
  - Management techniques come from Dissenting Protestantism and form basis of management techniques for Silicon Valley companies
    - Reject ideas of social hierarchy
    - Company as community
    - Delegate responsibility to lowest level
    - Distribute stock options instead of profit sharing
- Profession
  - Computer engineer, VP + GM of Fairchild Semiconductor, CEO of Intel
- Places worked
  - Shockley Semiconductor, Fairchild Semiconductor, Intel
- Years of work
  - 1953 - 1980's
- Things worked on
  - Coinventor of integrated circuit

- Tom Wolfe, The Tinkerings of Robert Noyce, Esquire, Dec. 1983

Iowa's Influence on Silicon Valley

"The appeal of the start-up has always been that it's a small operation, usually led by the smartest guy in the room but with the assistance of all players. The goals of the company are those of its people, who are all very technically oriented. The character of the company matches that of its founders, who were inevitably engineers-regular guys. Noyce was just a preacher's kid from Iowa, and his social sensibilities reflected that background.

There was no social hierarchy at Fairchild-no reserved parking spaces or executive dining rooms-and that remained true even later when the company employed thousands of workers and Noyce was long gone. There was no dress code. There were hardly any doors; Noyce had an office cubicle, built from shoulder-high partitions, just like everybody else. Thirty years later, he still had only a cubicle, along with limitless wealth."

- Robert X. Cringely, Accidental Empires

The Contrarian View

"Silicon Valley is still a place of big minds chasing small ideas."

- Kara Swisher, journalist

Evolution of the Entrepreneur

From

"Publish or perish"

- Academia

To

"Demo or Die!"

- Nicholas Negroponte, Founder MIT Media Lab

To

"Deploy or Die!"

- Joi Ito, Director MIT Media Lab

Something In The Air

"In the late 19th century Alfred Marshall, a founding father of modern economics, asked why firms in the same industry were often geographically near each other. Proximity, he said, created something "in the air": "…if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas."

Marshall was thinking about Victorian manufacturing, but the same is true of the information-technology companies of the 2010s. Silicon Valley is home to many of the industry's giants, and hopeful founders of young start-ups still head for northern California. A certain Mark Zuckerberg left Harvard for Palo Alto as soon as he got the chance. Others beat a path to newer hubs, such as Berlin, London, Moscow, New York or Tel Aviv.

Economic theory suggests four main reasons why firms in the same industry end up in the same place. First, some may depend on natural resources, such as a coalfield or a harbour. Second, a concentration of firms creates a pool of specialised labour that benefits both workers and employers: the former are likely to find jobs and the latter are likely to find staff. Third, subsidiary trades spring up to supply specialised inputs. Fourth, ideas spill over from one firm to the next, as Marshall observed."

- The Geography of Start-Ups. Something In The Air. Why Birds Of A Tech Feather Flock Together. The Economist. Oct 25, 2012

Focused Case Study - Arsenal of Democracy - Open Source Development + Wars Won

- Hypothesis
  - Geographic proximity / focus of manufacturers in key industries led to US victories in wars of 20th century due to shared R+D through employees switching from one to another
- Examples
  - WW I - Detroit - Mass production of vehicles
    - Manufacturers: Ford, GM, Chrysler, Packard, etc
      - …and continues with WW II
  - WW II - Los Angeles - Aviation
    - Manufacturers: North American, Douglas, Lockheed, Vega, Vultee, Northrop
  - Cold War - Silicon Valley - Computers
    - Manufacturers: HP, Apple, etc.

Personal Case Study - MIT $10K Entrepreneurship Competition

- Role
  - Attendee of course in 1995 - learned incredible amount
- Story
  - Business plan competition started in 1990 by MIT School of Engineering + MIT Sloan School of Management
  - Must have at least 1 MIT student on each team
  - Preceded by entrepreneurship course taught by local entrepreneurs
  - Winner gets $10K (now $100K) to start business + mentorship
  - In 1998 a participant (but not winner) was Akamai who now provides most of the plumbing for Internet content caching

Personal Case Study - Innovation Ecosystem

- Role
  - Created HyperLung eBook and Virtual Hospital digital library in 1991-1992
- Story
  - How do you enable innovation? You need an innovation ecosystem
    - It's about serendipity
    - Having a critical mass of talented people in close proximity
    - No barriers to accessing these people
    - Free + unfiltered access to Internet
    - Occurred behind the scenes / off the radar of the University

Personal Case Study - Vulture Capitalists

- Role
  - Asked by University to give demo of Web and Virtual Hospital to investors and professors in 1993
- Story
  - They took our idea, founded Patient Education Institute
  - Persist today as successful company
  - Never asked for further insight or help from us - they sucked our brains dry and left without so much as a thanks
  - This is no way to build an entrepreneurial ecosystem in a University

Personal Case Study - Apple's World Wide Developer Conference 1994

- Role
  - Yearly meeting of all Apple developers to learn about upcoming Apple hardware + software technologies
- Story
  - Selected to give a lecture highlighting work on Virtual Hospital digital library
  - Needed to feature a 3rd-party video display board which was delivered to us the night before the talk by an exhausted engineer who said he had been debugging it to get it working for 72 hours non-stop.
    - I was comatose, being post call and having not slept for 48 hours so when the engineer walked into our hotel room I thought he was a patient and tried to perform a medical procedure on him
    - "That's life in a start-up" our Apple rep told him
    - The video board worked flawlessly in our talk

Personal Case Study - .Nuts Height of Dot Com Insanity

- Role
  - Eating lunch at Ikea on Saturday afternoon in fall 1999 during height of .com bubble chatting about our research
- Story
  - Approached by two women sitting near us who complimented us on our cute baby and then out of the blue asked us if we wanted to invest in and help them start an Internet company focused on travel
  - You know the bubble is about to burst when your average Ikea shopper is trying to cash in on it…

Personal Case Study - A Pain in the Butt

- Role
  - Mentor to a group of biomedical engineering students who are participants in a design of medical devices competition at University
- Story
  - Project involves design of efficient + easy to use method to alleviate intussusception (telescoping of the bowel) in children under 3 years
  - Won 2nd prize at Student Design Showcase at Annual Design of Medical Devices Conference
  - Resulted in a provisional patent application for the device

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- Innovators - Who, What, Where, When, Why, How?
- What does it take to make the grade as a successful entrepreneur?
- What impedes innovation in a company?
- What is the effect of monopolies on innovation?
- What lessons from the past can we apply to the present and future?
- Are the Silicon Valley idealists 'good guys' who are challenging the old order or are they tax-minimizing corporations that threaten humanity's future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
  - Bronson, Po - The First $20 Million Is Always The Hardest
  - Dillon, Pat - The Last Best Thing
- Documentaries
  - Startup.com
- Movies
  - Halt and Catch Fire (Television series)
  - Silicon Valley (Television series)
  - The Social Network
- Simulations

To Learn More at U of Iowa About a Career in the Computer or Communications Industry

- Pomerantz Career Center
  - careers.uiowa.edu

Conclusion

"By his death the greatest of England's engineers was lost, the man with the greatest originality of thought and power of execution, bold in his plans but right. The commercial world thought him extravagant; but although he was so, things are not done by those who sit down to count the cost of every thought and act."

- Daniel Gooch's epitaph on Isambard Kingdom Brunel

Conclusion

"Humans are tool builders. We build tools that can dramatically amplify our innate human abilities. We ran an ad like this once at Apple that the personal computer is the bicycle of the mind. I believe that with every bone in my body.

Of all the inventions of humans, the computer is going to rank near if not at the top as history unfolds and we look back. It is the most awesome tool that we have ever invented. I feel incredibly lucky to be at exactly the right place in Silicon Valley, at exactly the right time, historically, where this invention has taken form.

When you set a vector off in space, if you can change its direction a little bit at the beginning it's dramatic when it gets a few miles out in space. I feel we are still really at the beginning of that vector. If we can nudge it in the right directions, it will be a much better thing as it progresses on. I think we have had a chance to do that a few times. It brings all of us associated with it tremendous satisfaction."

- Steve Jobs in The Lost Interview

Conclusion

"No matter who you are, most of the smartest people work for someone else"

- Bill Joy, computer scientist

Topic 3

What Computers Are Made Of

How Computers Work

Song

Slide text

Thematic Quote

"Technology is a gift of God. After the gift of life it is perhaps the greatest of God's gifts. It is the mother of civilizations, of arts and of sciences."

- Freeman Dyson, physicist

The Painting

Chip Building

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - PC Motherboard + hard disk
- Year
  - 2000's
- Story
  - Look inside the computer

The Question

Is technological determinism true or false?

Do technological advances drive history?

Or do social and political forces drive inventions, which in turn shape society?

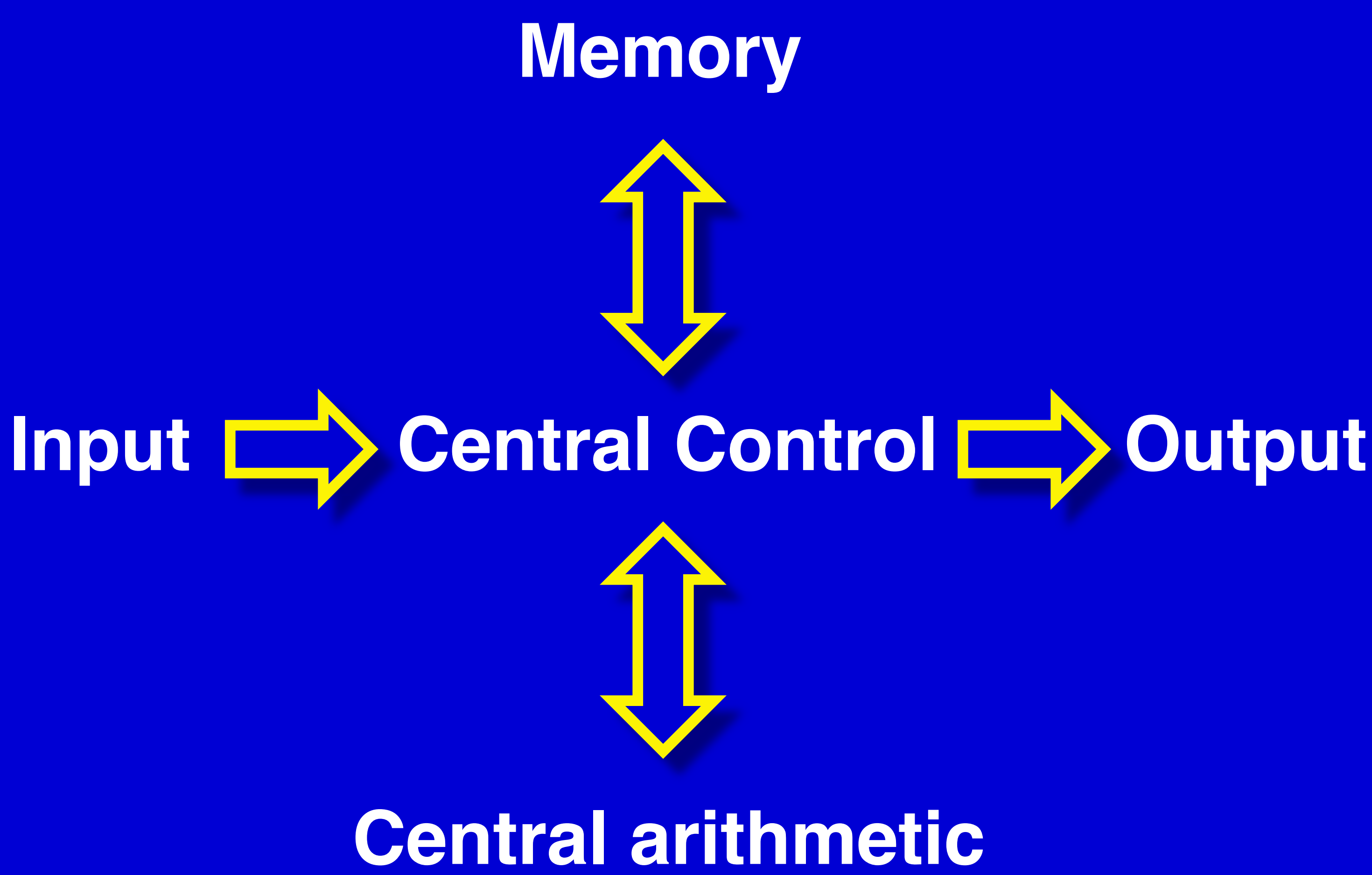
Anatomy of a Computer

- The 5 elements of a computer
  - Control
  - Storage
  - Calculation
  - Programmability / use of circuits
  - Communication

    - Paul Ceruzzi, Computing A Concise History

Von Neumann Architecture

5 elements of stored program computer



Elements + Substrates of Computing

- A computer works the same way whether it is in or on a warehouse / room / desk / lap / hand / body
  - Needs a location
    - Air-conditioned warehouse, air conditioned room, regular room, desktop, laptop, hand, body
  - Needs power to run
    - Direct current, battery, solar, hand crank
  - Needs central processing unit for thinking
    - Logic composed of pebbles, gears, electromagnetic relays, vacuum tubes, transistors, integrated circuits
  - Needs memory for short term storage
    - Pebbles, gears, mercury delay lines, cathode ray tubes, magnetic core, integrated circuits
  - Needs memory for long term storage - Local or Remote (Cloud)
    - Gears, magnetic tape, magnetic drum, magnetic disk, optical disk, integrated circuits (flash)
  - Needs input / interactivity to start processing
    - Punch cards, magnetic tape, paper tape, keyboard, pen, finger, voice
  - Needs output to communicate results
    - Paper printer, screen, 3D printer, voice
  - Needs operating system for organization + control
  - Needs apps to do things
  - Needs languages to write apps and operating system in
    - Machine, assembler, high level languages, interpreted vs. compiled
  - Needs network to communicate
    - Copper wire, fiber optics, wireless

Anatomy of a Personal Computer Circa 1993

- Power Plug - A personal computer runs off of standard household current which it obtains by inserting its power plug into a wall outlet
- Power Supply - The power supply takes the strong but uneven current that is delivered via a household wall outlet and transforms it into the low steady stream of current the personal computer needs to power its delicate circuits
- Keyboard - The keyboard is the most common way of entering information into the computer
- Mouse - The mouse is a tool for communicating with the computer - rolling the mouse on a flat surface moves the pointer on the screen while clicking the mouse button tells the computer you have made a choice that you want it to act on.
- Keyboard/Mouse Interface - When you type on the keyboard or move the cursor by moving the mouse, a message is received by the keyboard-trackball interface and held by it until the Central Processing Unit asks for it

Anatomy of a Personal Computer Circa 1993

- Motherboard - The motherboard is a printed circuit board that holds the computer's chips, provides the wires they need to communicate with each other, and supplies them with power
- Video Board - The video board controls the image you see on the computer screen. The Central Processing Unit tells the video board what should be shown on the screen, and the video board tells the computer screen which dots to turn off and on, thereby creating the image
- Clock - The system clock within the computer functions like an orchestra conductor, beating out a steady tempo that all the different parts of the computer can use to synchronize their work to
- Monitor (screen) - The monitor is your window into the operations of the computer. It displays information you put in, questions for you to answer, and the results of whatever task you asked the computer to perform
- Central Processing Unit (CPU) - The CPU is the heart of the computer and consists of more than one million tiny switches packed together in a space the size of a postage stamp

Anatomy of a Personal Computer Circa 1993

- Where Software Meets Hardware - The software program consists of instructions that are fed to the CPU. The CPU therefore is where the software meets the hardware as the CPU controls the flow of information throughout the computer, and directs the work of all the other parts of the computer in order to insure the software program's instructions are carried out

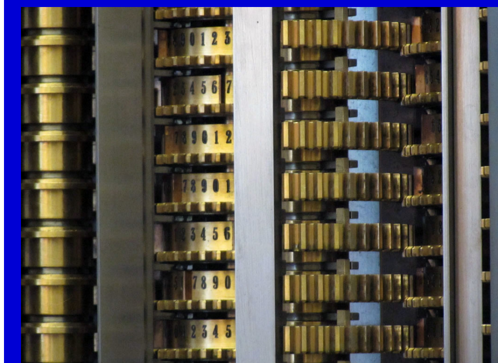
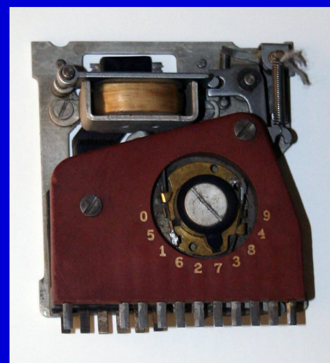
- Random Access Memory (RAM) - RAM is where information is stored in the computer so that it may be retrieved quickly. RAM usually contains a copy of the computer program that is currently running and all the data the program is currently working on. RAM forgets everything when it is turned off

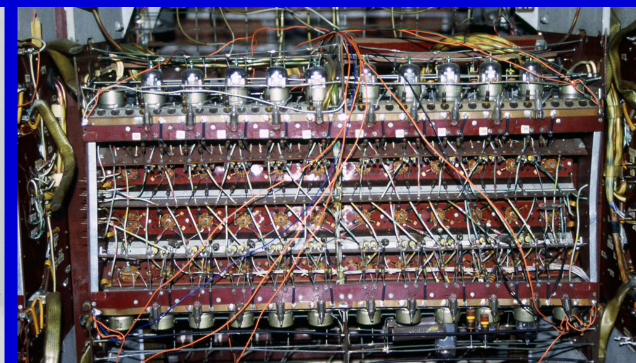
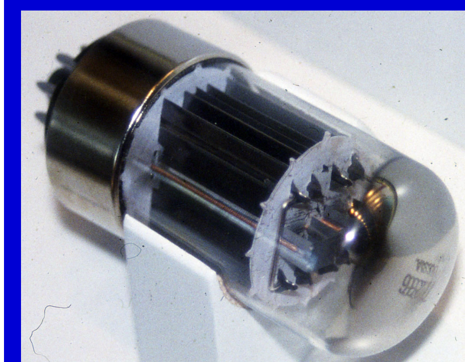
- Read Only Memory (ROM) - ROM is a permanent memory that is not forgotten when the computer is turned off. In fact, when a computer is first turned on or "booted" the information in the ROM reminds the computer what it needs to do to get started running

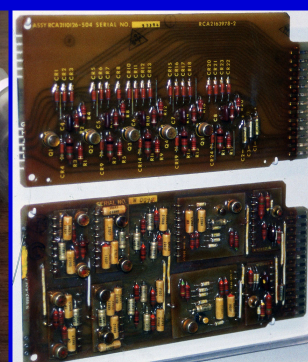
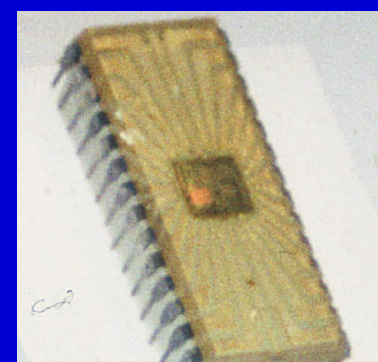
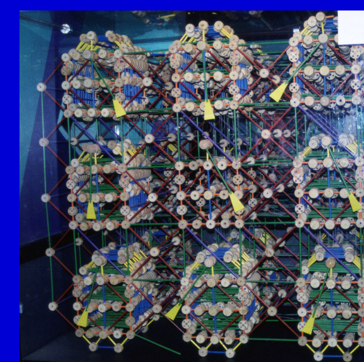
- Floppy Disk - A floppy disk is used to transfer information between computers. A single floppy disk can store all the words of a very long novel

- Hard Disk - The computer uses a hard disk to store large amounts of information. It can store the contents of several hundred floppy disks and can read and write data many times faster than a floppy disk

Computing Logic Substrates

Top - Difference Engine cog / Harvard Mark I relay / IBM 701 vacuum tubes / JOHNNIAC vacuum tubes

Bottom - SAGE vacuum tube / Vacuum tubes / RCA 1108 Saturn Launch Computer transistors / TI calculator integrated circuit / Tinkertoys

Computer Logic Technology

- Pebbles
- Brass gears
- Vacuum tube computer module
- Transistorized computer module
  - The advent of transistorized circuit modules allowed an increase in circuit density over vacuum tubes, but on a scale that could still be hand-wired
- Integrated circuit board
  - Here, the circuitry is encased exclusively in chips. A single chip was equivalent to a circuit board / module of the transitorized era
- Microprocessor
  - The computer on a chip was becoming common by 1976

History of Integrated Circuits

- The first transistor was assembled at Bell Labs
- The first integrated circuits were assembled at Texas Instruments
- The Intel 4004 was the first microprocessor and started a new era by introducing the microprocessor on a single chip

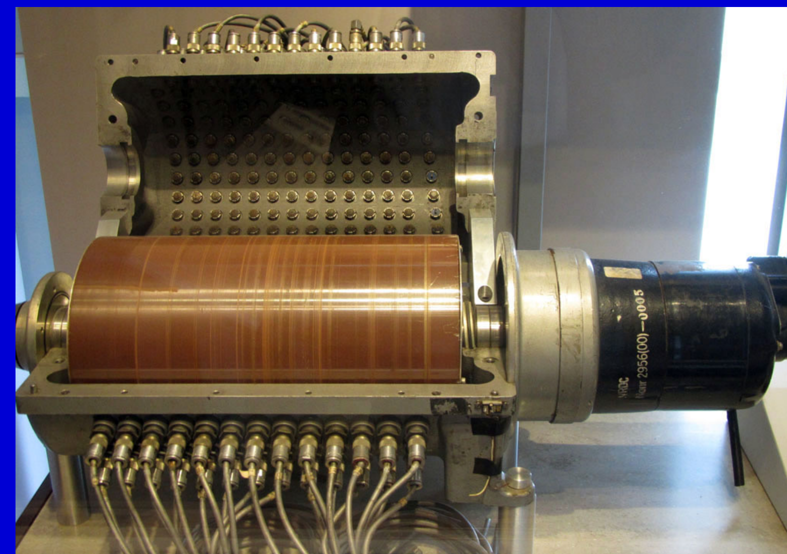
Computer Memory Substrates

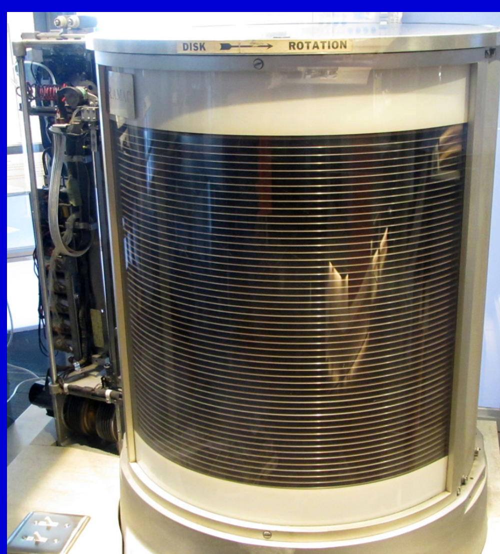
Top - EDSAC Mercury Delay Line / UNIVAC-1 Mercury Pool Acoustic Memory / IBM 701 Williams-Kilburn Tube
Middle - Ferranti Mk I Williams-Kilburn Tube / Manchester Mark I Williams-Kilburn Tube / SWAC Williams-Kilburn Tube
Bottom - JOHNNIAC Selectron Tube / Whirlwind vacuum tube / Whirlwind core memory / Integrated circuit

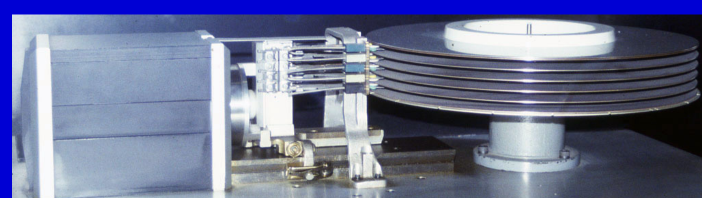
Computer Memory Technology

- Pebbles
- Brass gears
- Relays
- Mercury delay line memory - really a serial access memory
  - Stores info as sound waves traveling through metal tubes filled with liquid mercury
  - Electrical pulses, when passing through a quartz crystal, are converted into mechanical vibrations. In a mercury delay line memory, the vibrations travel through the mercury at a far slower speed than would the original electrical impulses. They are reconverted by a second crystal at the far end and amplified and fed back to the beginning again and in this way hundreds of pulses can be stored, by being kept continuously circulating in a relatively small space, at a circulation rate of about 1000 times per second
- Williams-Kilburn tube memory - 1948 - first true random access memory - Frederick Williams at University of Manchester
  - Used a cathode ray tube as a random access memory for computers in the 1950's to store programs and data such as the early Manchester computers and the IBM 701
  - Dots of two different sizes when on the screen of a cathode ray tube represented binary 1 and 0. Inside the door, which was closed when in use, is the collector plate that read the data by detecting the state of the dots on the tube.
  - Single Williams-Kilburn tube could store 1024 binary digits
- Drum memory
- Electrostatic storage
- Vacuum tubes
  - Conducted a current or not
  - Was complexly engineered + difficult to manufacture, but very reliable once burned in
  - Replaced by magnetic core memory
- Magnet core memory - 1951 - Jay Forrester at MIT
  - Became the most reliable and widely used primary storage device in computers until the advent of semiconductor memories
  - Is ferrite donut that could be magnetized clockwise (zero) or counter clockwise (one)
  - Use 2 wires at right angles to read + write individual cores ~ Each core = 1 bit, was non-volatile
- Semiconductor

Computer Storage Substrates







Top - Papyrus plant / Analytical Engine punched cards / ERA magnetic drum /
Bottom - UNISERVO magnetic tape drive / IBM RAMAC magnetic disk drive / Magnetic disk drive / Flash memory

Computer Storage Technology

- **Fixed Head Drum Memory - 1957**
  - Prior to the development of the RAMAC disk storage, magnetic drums along with magnetic tapes provided the major form of secondary memory. The drums spun around and information was read off them by fixed heads
- **Hard Disk - 1956**
  - The IBM RAMAC for IBM 7030 Stretch was introduced in 1956 with layers of hard disks, increasing its storage capacity, and decreasing the access time to this secondary storage
  - Had 50 24" disks that hold 5 million characters of information

Trends For Computing 1930's - 1970's

- **Trends for computing in the 1930's**
  - During the Great Depression, a number of new federal agencies were created to aid the United States' economic recovery. Though varying in function, they had in common the need to process large amounts of information. This was impossible to do by hand and therefore was done by electromechanical calculating machines which were the ancestors of computers. These machines used gears, switches, and paper cards to perform their calculations. Information was entered on keypunch machines, sorter machines sorted cards, adding machines added cards, and some machines printed out information
- **Trends for computing in the 1940's**
  - Before World War II it took dozens of people using mechanical calculators to solve a single problem. The advent of electronic computers in the 1940's allow the use of a single electronic computer to solve a single problem.
- **Trends for computing in the 1950's**
  - Business show an initial interest in computers as tools to keep track of inventory and payroll.
- **Trends for computing in the 1960's**
  - Widespread adoption of computers by businesses as tools to keep track of inventory and payroll. By the late 1960's the creation of smaller and cheaper computer parts, first through the use of transistors and then through the use of small integrated circuits, led to the creation of smaller and cheaper computers which did not need air conditioned special rooms for their operation. This brought computing to new and smaller users. As computers decreased in size they often were built into other pieces of equipment.
- **Trends for computing in the 1970's**
  - The invention of the microprocessor in 1971 set the stage for the invention of the personal computer.

4 Generations of Computing

- In your room (mainframe)
- On your desk (personal)
- In your hand (mobile)
- On your clothes (wearable)

…as size decreases, network connectivity increases…

4 Generations of Communication

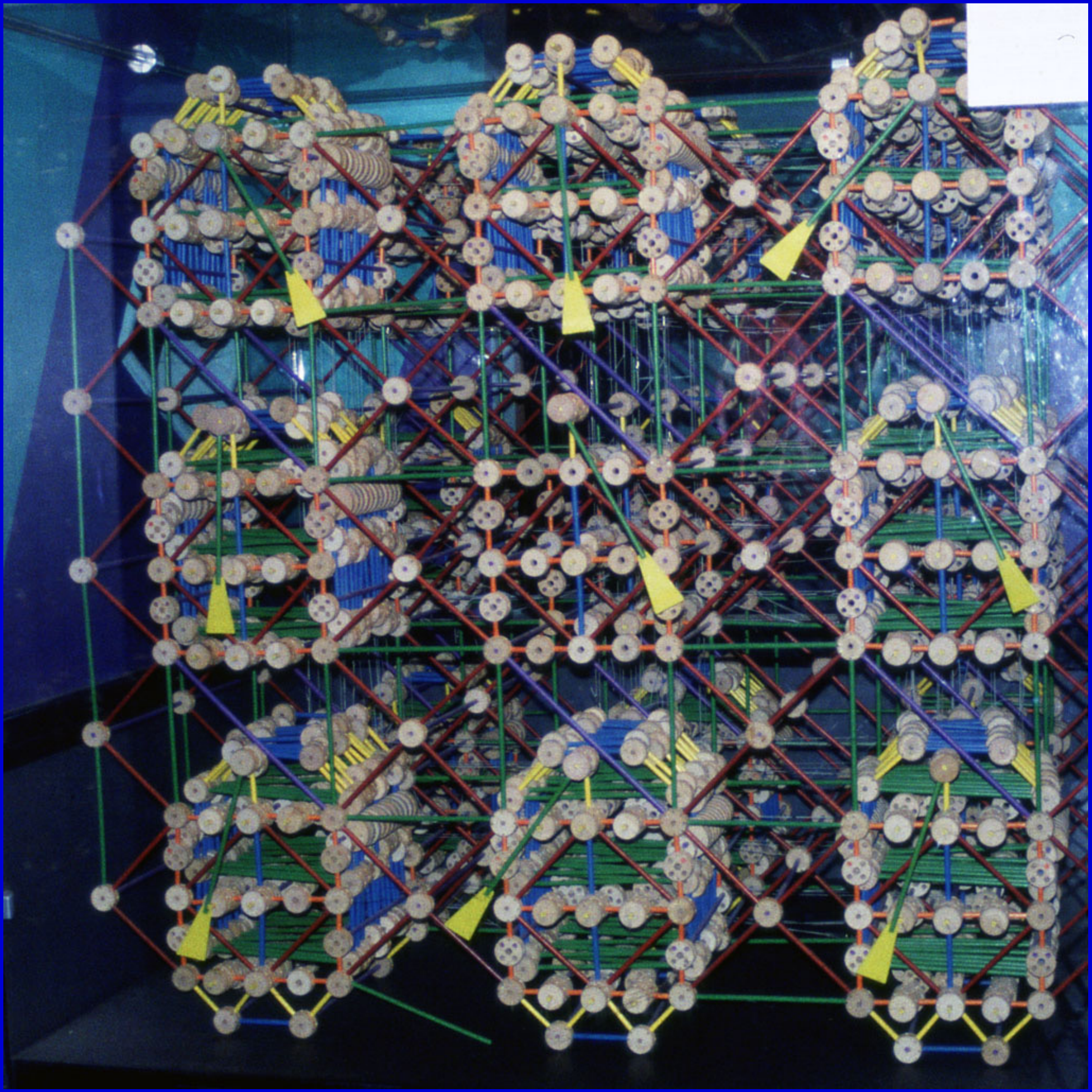
- By analog voice (spoken word)
- By analog paper (written word)
- By analog wire (telegraph) + radio + TV
- By digital network (Internet)

- …as communications become digital, the amount of information communicated increases exponentially

The Intimate Computer

- History of computers is that of increasing intimacy
  - Computer in a room (mainframe)
  - Computer on a desk (personal computer / desktop)
  - Computer on your lap (portable computer / laptop)
  - Computer in your pocket (smartphone)
  - Computer on your body (augmented reality)

Tinkertoy Computer



Thing / Hardware - Tinkertoy Computer

- **Firsts / Achievements / Uniqueness / Significance**
  - Built to demonstrate that computer logic could be built with simple components - Tinkertoy pieces
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - N/A ~ 1980's ~ USA
- **People involved (Designer)**
  - Danny Hillis + Brian Silverman
- **Type**
  - Calculator
- **Price / Cost**
  - Text
- **Size**
  - 6' x 6' x 6'

Thing / Hardware - Tinkertoy Computer

- Computing technology
  - Composed of 10,000 wooden parts, fishing line, fishing sinkers, and brass pins
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Wooden wheels
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Designed to play tic-tac-toe in the following manner. The nine green flags on the front show the position of each tic-tac-toe square. If the flag is horizontal, the square is empty. If the flag is down, it is filled with X, if the flag is up it is filled with O. When a player moved one of the knobs under the flag to indicate their move, the Tinkertoy logic immediately responded with another move.
  - Tinkertoy computer never lost a game, but because the fishing line would lose tension and slip, it played unreliably
- Predecessors - N/A ~ Successors - N/A

Future Substrates - Quantum Computing

- Bit = basic element of conventional computer = 1 or 0
- Qubit = basic element of quantum computer = can exist in state of superposition where it is 1 and 0 simultaneously
- Entanglement = linking quantum properties of two subatomic particles so changing one changes the other in the same way
  - If qubits are placed in entangled state where they are physically separate but act with other qubits as if connected, they can represent vast number of values simultaneously
- Qubits don't like to stay in state of superposition = coherence, so they have to be shielded
  - Problem is that looking at the results collapses it out of quantum state
- Initial applications = find prime factors of massive numbers (cracking cryptography) + searching databases

- Clive Thompson, The Revolutionary Quantum Computer That May Not be Quantum At All, Wired, May 2014

Future Substrates - Quantum Computing

- In classical computer, at any moment, each bit is 1 or 0, it is in one state, can perform only one calculation next, and to increase its power you must increase its speed
- In quantum computer, using quantum phenomena of superposition + entanglement, you create qubits + link them together, thus it is in many states simultaneously, thus to increase its power you do not need to increase its speed
- Superposition = value of qubit described in terms of probability of being 1 or 0
- Entanglement is caused because qubits can mix their probabilities with one another if set up carefully so energy flows between them unimpeded
  - If entanglement can be achieved, results in a device that at any instant is in all of the possible states permitted by its qubits' probability mixtures
  - Entanglement also means to operate on any one of entangled qubits is to operate on all of them
- Quantum computer requires quantum algorithms that break problems into parts and then sum up the various probabilities of each qubit's value to arrive at most likely answer
- Applications
  - Shor's algorithm for factorizing non-prime numbers to break cryptography
  - Simulating physics at atomic level

- A Little Bit Better, The Economist, Jun 20, 2015

Future Substrates - Quantum Computing

- Quantum bits (qubits) behavior depends upon two quantum phenomena
  - Superposition - state of inherent uncertainty that allows particles to exist in a mixture of states at same time, so qubit is not a certain 1 or a certain 0 but instead is mixture of both
  - Entanglement - binds together destiny of quantity of different particles so what happens to one of them immediately affects the others, so quantum computer can manipulate all its qubits at same time
  - So quantum computer can represent + process vast amounts of data simultaneously
- 300 qubit machine can represent 2^{300} different strings of 1s + 0s at same time + because those qubits are entangled all those numbers can be manipulated simultaneously
- But superpositions are delicate things to maintain although we are getting better
- Killer apps - codebreaking, AI deep learning, simulating quantum mechanics in chemistry

- Harnessing Weirdness, The Economist, Mar. 12, 2016

Future Substrates - Quantum Computing

- Superimposition turns bit into qubit which is mixture of 1 and 0
  - 4 bit classical computer can represent 16 different states, 1 at a time
  - 4 qubit quantum computer can exist in superposition of all 16 states at once
- Entanglement binds the qubits together + makes it possible to manipulate groups of qubits all at once
  - As number of qubits grows, number of states a quantum machine can occupy rises exponentially…300 qubit quantum computer would have more possible states than there are atoms in universe
- Applications include cracking cryptographic codes + simulating chemical reactions at molecular level
- Challenge is quantum computers answer questions probabilistically rather than definitely
  - To get answer you must measure the machine + this causes quantum superposition to vanish thus leaving it in a single state
  - To ensure the single state is the one with the correct answer needs careful management so quantum computers need to be coddled

- Now Try This, the Economist, May 7, 2016

Future Substrates - Optical Computing

Future Substrates - DNA + Proteins

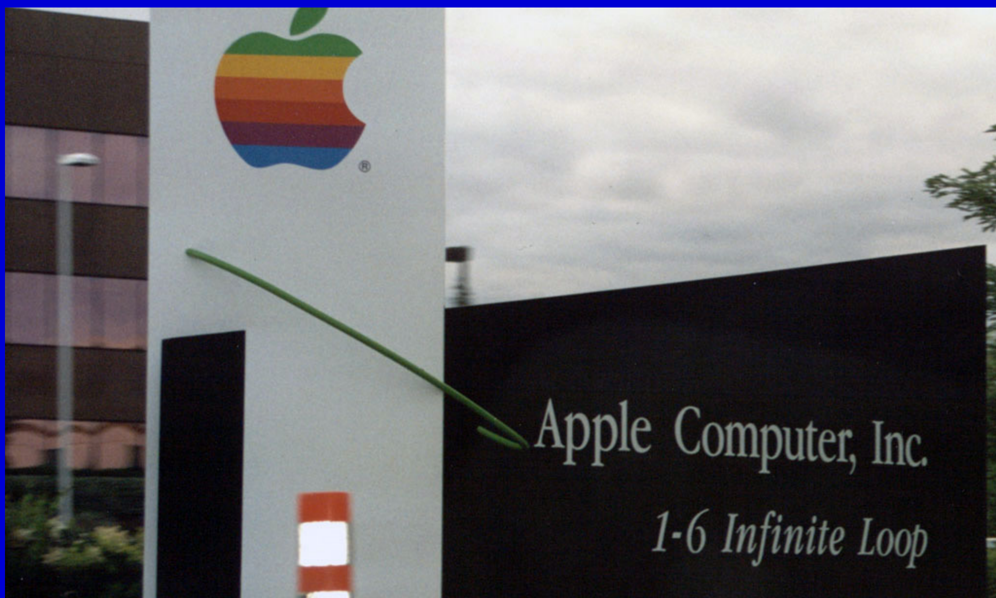
- Theoretically possible to store exabyte of information (200 million DVDs), in volume of a grain of sand, if it were encoded into DNA

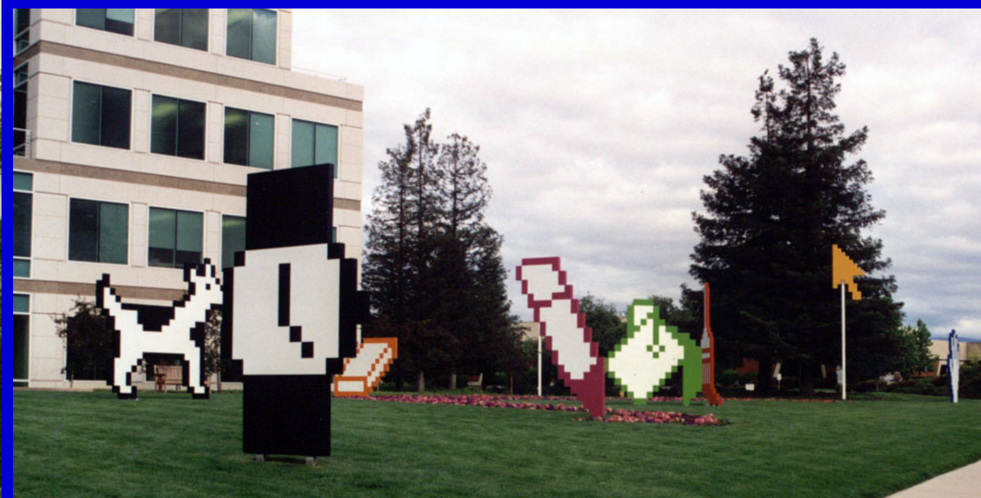
- John Markoff, Data Storage on DNA Can Keep it Safe For Centuries, New York Times, Dec. 3, 2015

- Michael Conrad, On Design Principles for a Molecular Computer, Communications of ACM, May 1985

Future Substrates - Carbon Nanotubes

1 Infinite Loop - Apple





Personal Case Study - Signing the NDA

- Role
  - First consumer handheld computer
- Story
  - Soon after purchase of Newton in August 1993 began developing a medical eBook for it using the Newton Book Maker
  - Became connected to the Apple Newton Group and in spring 1994 signed a non-disclosure agreement with them and saw their future hardware + software plans and physical prototypes and tried to work with them to link Newton to our Virtual Hospital digital library project
  - Saw how computers went from ideas to sketches to mockups to prototypes and how advances in technology lead to innovations in computer functionality and sizes

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- What substrates will come after semiconductors - Quantum mechanics Optics? DNA?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History - Introduction and Glossary
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
- Simulations

Conclusion

"Any sufficiently advanced technology is indistinguishable from magic"

- Arthur C. Clarke, author

Topic 4

Computers in the Ancient World

Song

Slide text

Thematic Quote

"Old technologies don't die, they just fade away"

- Michael P. D'Alessandro

The Painting

Painting Name

- Artist's Name

(Location of painting)

Artifact

- Name
  - Abacus, pebbles
- Year
  - 450 BC
- Story

- Name
  - Antikythera Mechanism model in Etoys
- Year
  - ~ 50 AD
- Story

The Question

What was the first computer?

Thing / Hardware - Abacus

- Firsts / Achievements / Uniqueness / Significance
  - First universal calculating device
- Place Produced (Company / Institution) ~ Year ~ Country
  - 450 BC Greeks ~ 50 BC Romans ~ 1300 China
- People involved (Designer)
  - N/A
- Type
  - Calculator
- Price / Cost
  - Tens to hundreds of dollars
- Size
  - 14.5" x 6.5" x 1"

Thing / Hardware - Abacus

- **Computing technology**
  - Pebbles
- **Computing speed (in MIPS)**
  - 1 calculation / 60 seconds
- **Primary memory type / technology ~ Size ~ Word length**
  - Paper ~ ∞ ~ N/A
- **Secondary memory type / technology ~ Size**
  - Paper ~ ∞
- **Uses / Applications / Software**
  - Abacus is computing device on which calculations are performed by sliding counters (beads or pebbles) along rods, wires, lines
  - Stones know as calculi (Greek khalix = pebble) -> calculate
  - Abacus = Greek for board or slab
  - Counter = object used in calculation as well as place in store where counting carried out
  - Used in Medieval + Renaissance Europe, North America, China, Japan, Russia
- **Predecessors - N/A ~ Successors - Mechanical calculator**

Antikythera Mechanism

From Wikimedia Commons

Thing / Hardware - Antikythera Mechanism

- Firsts / Achievements / Uniqueness / Significance
  - World's first computer (analog computer)
- Place Produced (Company / Institution) ~ Year ~ Country
  - School of Archimedes? ~ 150-100 BC ~ Greece
- People involved (Designer)
  - Archimedes?
- Type
  - Calculator
- Price / Cost
  - Expensive
- Size
  - Shoebox sized

- Diomidis Spinellis, The Antikythera Mechanism: A Computer Science Perspective, IEEE Computer, May 2008

Thing / Hardware - Antikythera Mechanism

- Computing technology
  - Mechanical (cams, gears, levers, pins, rods)
  - 30 - 35 bronze wheels / gears
  - Made with hammer + chisel + file, gearing was Hellenistic, astronomy was Babylonian
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Bronze gears
- Secondary memory type / technology ~ Size
  - Bronze gears
- Uses / Applications / Software
  - Apps - Predict dates of lunar + solar eclipses, Track Moon's motion through sky, Calculate dates of significant events like Olympics
  - Prediction of eclipses, Moon's position + phase, Lunisolar calendar, solar / lunar / planetary positions
- Predecessors - N/A ~ Successors - Not until 700 - 900 in Middle East and 1200 or 1300 in Western Europe were there astronomical clocks like this
  - Most likely not a unique device
  - Technology may have been transferred from Greeks to Byzantines to Arabs and back to Europe

\- Diomidis Spinellis, The Antikythera Mechanism: A Computer Science Perspective, IEEE Computer, May 2008

Thing / Software - Antikythera Apps

- **Firsts / Achievements / Uniqueness / Significance**
  - **First apps**
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - **School of Archimedes? ~ 150-100 BC ~ Greece**
- **People involved (Programmer)**
  - **Archimedes?**
- **Type**
  - **Predict dates of lunar + solar eclipses, Track Moon's motion through sky, Calculate dates of significant events like Olympics**
- **Price / Cost**
  - **Unknown**
- **Computer and operating system it runs on**
  - **Antikythera Mechanism**
- **Computer language written in**
  - **Gears**
- **Memory required**
  - **N/A**
- **Predecessors - N/A ~ Successors - N/A**

Person - Archimedes of Syracuse

- Significance
  - May have provided the math behind the Antikythera Mechanism
- Profession
  - Mathematician, engineer, inventor
- Places worked
  - School of Archimedes
- Years of work
  - 287 BC - 212 BC
- Things worked on
  - Many unique inventions

"Give me a place to stand and with a lever I will move the whole world." - Archimedes

Place - Ancient Greece

- Significance
  - The first creative place
    - Place with lots of creative people that produces for short period of time a disproportionate number of brilliant minds and good ideas = a genius cluster
    - Do so via symposia - drinking together - discussions fueled by diluted wine
    - Open to experience of outsiders + borrowed from them
  - Definition of genius is a person who has an effect on future generations
    - Genius is creative genius - not a know it all but a see it all - someone who sees the connections that others don't - changes the way we see the world + leave an impact
  - All genius clusters need to have
    - Diversity - of ideas
    - Discernment - ability to separate good ideas from bad ones
    - Disorder - need to have chaos + tension / upheaval
  - Genius clusters are fragile and don't last very long - peak in a few decades
    - Creeping vanity is what brings a genius cluster down - you feel like you can do nothing wrong
- Location
  - Athens in particular
- Definition
  - The first genius cluster
- People who worked there
  - In Athens - Socrates, Aristotle, Plato, Aristophanes
- Things created there
  - Philosophy, mathematics, literature

- Eric Weiner, The Geography of Genius: A Search for the World's Most Creative Places From Ancient Athens to Silicon Valley

"What is honored in a country is cultivated there"

- Plato

Forgotten Revolution

- Hellenistic period of late fourth to late second century BC sees explosion of scientific + technological objective knowledge about world - center is in Alexandria
  - Mathematics, optics, geography, astronomy, ballistics, mechanics, medicine
- For first time science + scientific method as we understand it appears - not accumulation of facts or philosophically based speculations, but organized effort to model nature + apply such models / scientific theories towards solutions of practical problems + understanding of nature
- Leads to rise of sophisticated technology that falls due to Roman conquests + persecutions of Alexandrian scientists + reduction of Egypt to Roman province
  - Romans absorb Hellenistic practical achievements but not their method + worldview
- Knowledge is preserved in Middle Ages via Byzantine + Arabian sources and not seen again until scientific revolution in 18th century which drew heavily from these Hellenistic writings

- Lucio Russon, The Forgotten Revolution: How Science Was Born in 300 BC and Why it Had to be Reborn

Personal Case Study - Antikythera Mechanism

- Role
  - Thwarted viewing attempt
- Story
  - Wished to see it in National Archeological Museum, Athens
  - Knew that it had been in a special exhibition which had closed ~ month before
  - Went to its case in the Bronze Collection, found it empty
  - Asked at front desk, learned it was to be featured in another temporary exhibition that was under construction, they tried to get me into the temporary exhibition but they had not yet pulled electricity to the room so it could not be done…I was heartbroken

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- Was the Antikythera Mechanism a computer?
- What is the best way to preserve a computer? - By keeping the physical hardware in working condition or via simulation / emulation?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
- Simulations

Conclusion

"It's a rather rare phenomenon for an established medium to die. If media make it past their Golden Vaporware stage, they usually expand wildly in their early days and then shrink back to some protective niche as they are challenged by later and more highly evolved competitors. Radio didn't kill newspapers, TV didn't kill radio or movies, video and cable didn't kill broadcast network TV; they just all jostled around seeking a more perfect app.

But some media do, in fact, perish. Such as: the phenakistoscope. The teleharmonium. The Edison wax cylinder. The stereopticon. The Panorama. Early 20th century electric searchlight spectacles. Morton Heilig's early virtual reality. Telefon Hirmondo. The various species of magic lantern. The pneumatic transfer tubes that once riddled the underground of Chicago. Was the Antikythera Device a medium?"

- Bruce Sterling, author, in The Dead Media Manifesto

Topic 5

Computers in the Steam Era

Not Hackers But Clackers

Song

Slide text

Thematic Quote

"The problem of explaining the nature of a digital computer to students, to users, to the public was of quite a different order of magnitude at that time than now. There was no appreciation whatever of the nature of such a machine and one had to draw on such analogies as he could and the analogy that was familiar to people at that time was this kind of computer. [Picture of a female computer from a booklet written in 1951 to illustrate the nature of computation.] And so we would point out that the control element is the person. The arithmetic element is the mechanical adding machine. The notebook represents the storage. And the digital computer simply did all of this very much faster and with fewer drops of perspiration flying about."

- Jay Forrester, computer engineer

The Painting

Human Dimension

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - Gears + Punch card
- Year
  - 1950's
- Story

The Question

Why was there such a long gap between the Antikythera Mechanism and Babbage?

Human Computers

From Wikimedia Commons

Thing / Hardware - Computer As Person

- Firsts / Achievements / Uniqueness / Significance
  - Scientific calculations performed on mechanical or electromechanical desktop calculators by people, usually women
  - Labor intensive ~ Slow - took hours + weeks to do ~ Fraught with error
  - Inspiration for Babbage to create Difference Engine + Analytical Engine and for computer creators in 1930's + 1940's
- Place Produced (Company / Institution) ~ Year ~ Country
  - Worldwide ~ Throughout time but especially in 1930's + 1940's ~ Worldwide
- People involved (Designer)
  - Parents
- Type
  - Person computer
- Price / Cost
  - Variable but usually quite cheap
- Size
  - 5 - 6 feet tall

Thing / Hardware - Computer As Person

- Computing technology
  - Mechanical or electromechanical calculator
- Computing speed (in MIPS)
  - 1 calculation / 60 seconds
- Primary memory type / technology ~ Size ~ Word length
  - Paper ~ ∞ ~ N/A
- Secondary memory type / technology ~ Size
  - Paper ~ ∞
- Uses / Applications / Software
  - Navigation tables, ballistic tables
- Predecessors - N/A ~ Successors - Difference Engine / Analytical Engine / Harvard Mark I / ENIAC

Place - Victorian London

- Significance
  - Center of wealth, power, science (Royal Society) and Industrial Revolution in the 19th Century
- Location
  - London, England
- Definition
  - Capital of British Empire
- People who worked there
  - Charles Babbage, Ada Lovelace
- Things created there
  - Difference Engine, Analytical Engine

Charles Babbage

Person - Charles Babbage

- Significance
  - Father of computing
  - English inventor whose most successful invention was the cowcatcher for trains
  - Designed but never successfully built the first four function mechanical calculator - The Difference Engine, and the first computer - The Analytical Engine
- Profession
  - Mathematician, inventor
- Places worked
  - England
- Years of work
  - 1822 - 1871
- Things worked on
  - Difference Engine, Analytical Engine

Computing Case Study Summary - Charles Babbage 1823

- Goal
  - Build mechanical computer powered by steam that would calculate + print mathematical tables automatically (starting with navigational tables)
- Center of Gravity (Strategy)
  - Math tables have military uses ~ Get funding from British government
- Technology / Equipment
  - Difference Engine - started 1823, abandoned 1842
    - Automatic calculator that calculated using repeated addition via Method of Differences
  - Analytical Engine - started 1834, abandoned at death 1871
    - Real computer with store (memory) + mill (CPU)
    - Controlled by punch cards for input / output, had program loops, conditional branching, microprogramming

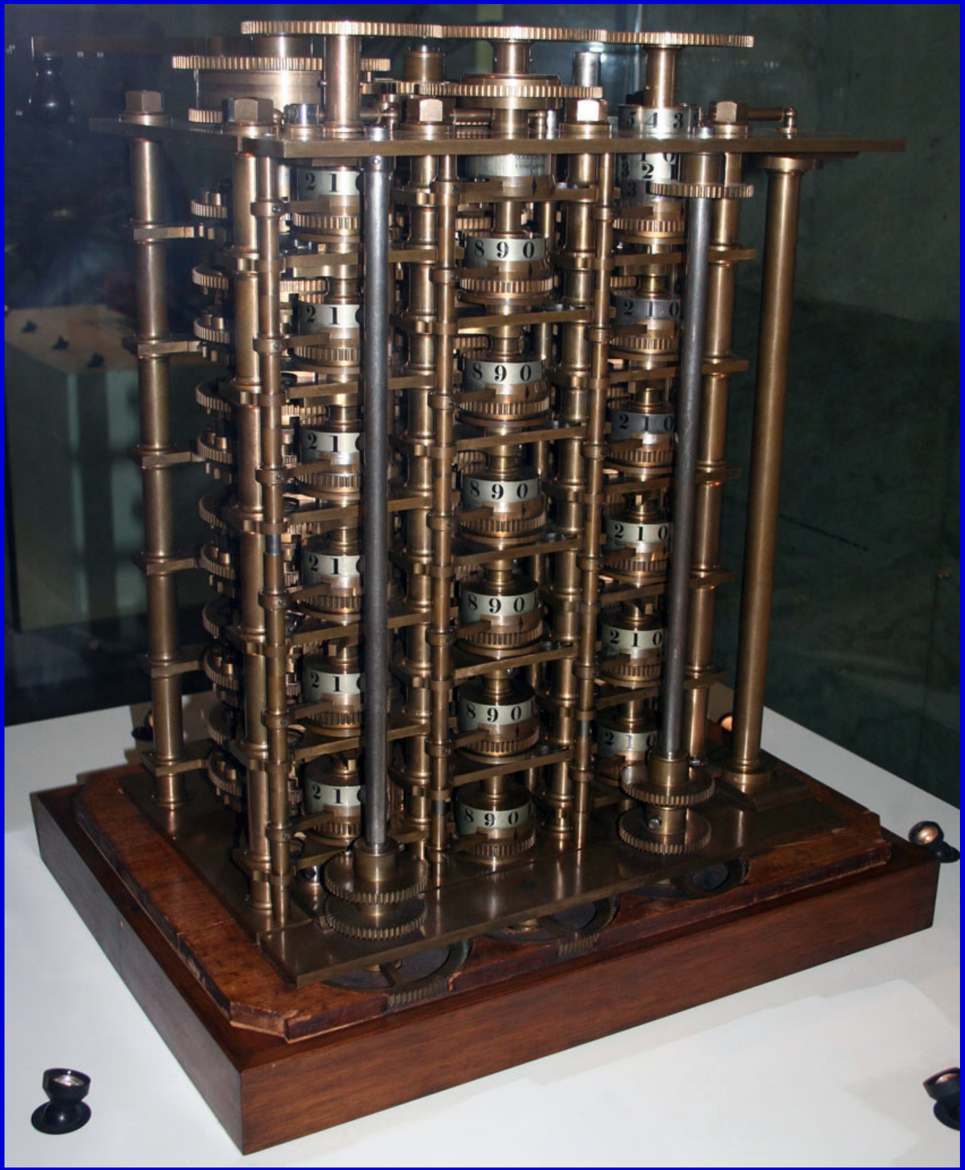
- Doron Swade, Building Babbage's Dream Machine, New Scientist, June 21, 1991
- Glyn Jones, The Life and Times of a Computing Pioneer, New Scientist, June 21, 1991
- Tom Standage, The Little Engine that Couldn't, Feed Magazine, Jan. 15, 1999

Computing Case Study Summary - Charles Babbage 1823

- Training ~ Leadership ~ Morale ~ Tactics
  - Babbage was diffuse - also invented cowcatcher for trains, speedometer, operational research for improving railway safety, flashing lighthouse
  - Babbage had many enemies
  - Ada Lovelace - an ally - the first computer programmer
- Intangibles
  - Victorian engineering was equal to task of implementing the designs, in terms of precision manufacturing of parts
- Mistakes
  - They were too expensive to make - there was no mechanical Moore's Law
- Outcome
  - Babbage dies in obscurity, derided by contemporaries
  - Difference Engine built in 1990's by Science Museum
  - Analytical Engine never built (…yet…see Plan28…)
  - Directly influenced Howard Aiken, creator of IBM / Harvard Mark I Computing Engine
  - Babbage today regarded as father of computing

- Doron Swade, Building Babbage's Dream Machine, New Scientist, June 21, 1991
- Glyn Jones, The Life and Times of a Computing Pioneer, New Scientist, June 21, 1991
- Tom Standage, The Little Engine that Couldn't, Feed Magazine, Jan. 15, 1999

Difference Engine Number 1



What is seen here is a finished portion of the unfinished difference engine

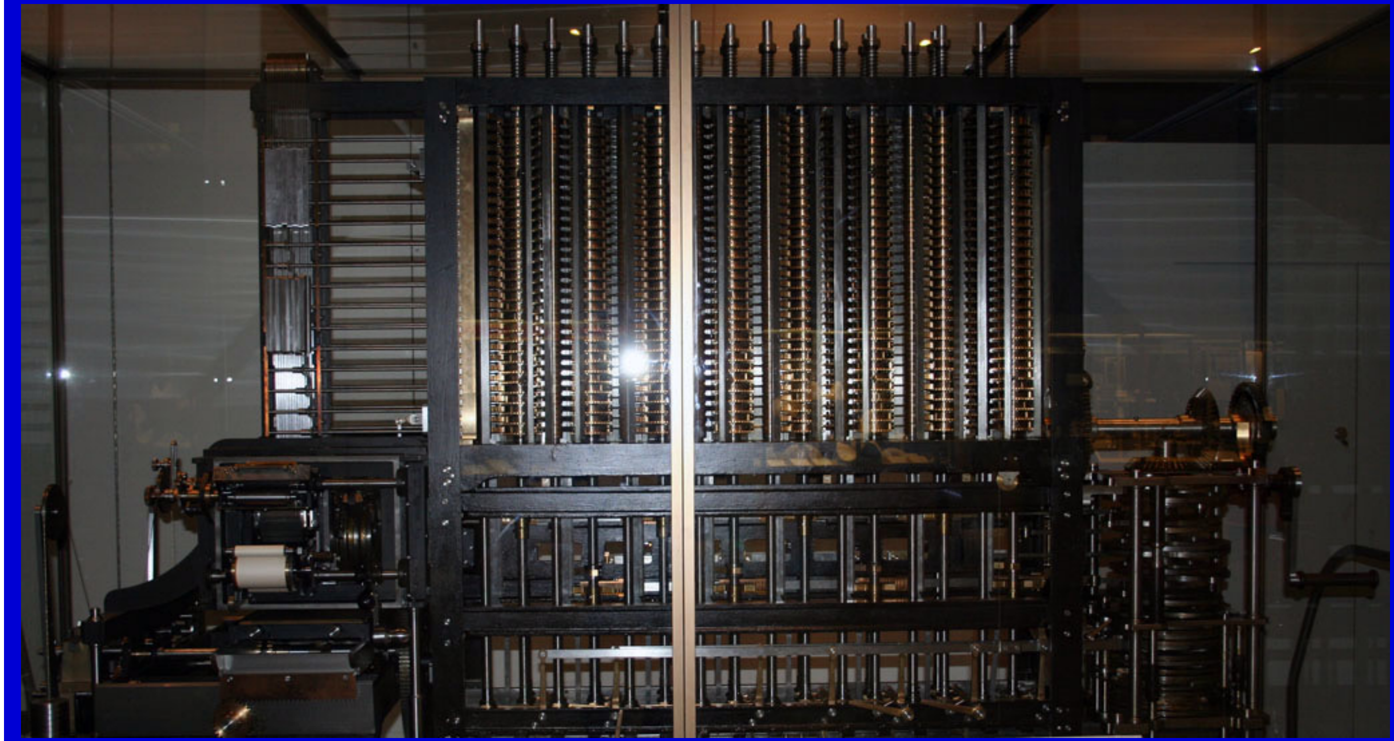
Thing / Hardware - Difference Engine Number 1

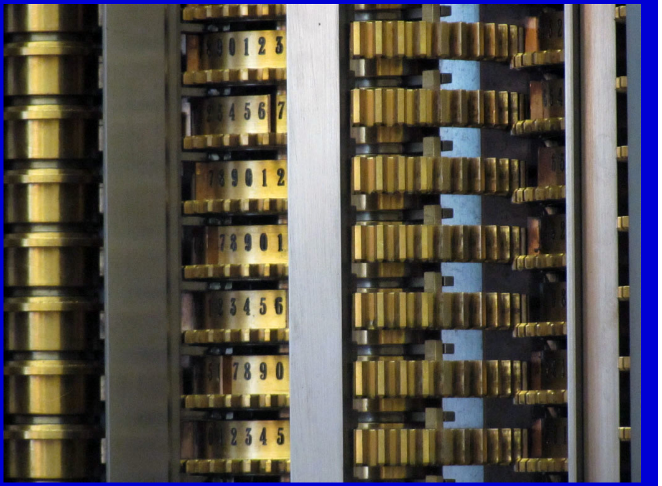
- **Firsts / Achievements / Uniqueness / Significance**
  - Difference Engine Number 1 was the first automatic calculator
  - Babbage's ideas were to have a mechanical calculator to calculate mathematical tables coupled with a mechanical printer that would automatically print out results to eliminate errors arising from transcription during copying and typesetting
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Babbage's workshop in London ~ 1820's - 1833 designed + worked on ~ England
- **People involved (Designer)**
  - Charles Babbage, Joseph Clement was the engineer who created the mechanical parts used in the Difference Engine
- **Type**
  - Calculator
- **Price / Cost**
  - £17,000 - the equivalent of two warships at that time
- **Size**
  - Completed, it would have taken up a space 2.4 meters high x 2.1 meters long x 0.9 meters deep
  - Completed, it would have weighed several tons

Thing / Hardware - Difference Engine Number 1

- **Computing technology**
  - Mechanical (cams, gears, levers, pins, rods) ~ Complete design called for 25,000 parts
  - Design work started in early 1820s ~ In 1832, demonstration piece assembled ~ Is 1/7th of calculating part of Difference Engine + has 2000 parts + is operated by cranking handle at top ~ Worked faultlessly but work abandoned on it in 1833 due to dispute between Babbage and Clement after 12,000 parts had been made but not been assembled
  - Calculated using "the method of finite differences" that involves only addition + subtraction, avoiding multiplication + division which are more difficult to mechanize
  - Worked by linking adding and subtracting mechanisms to each other to calculate values of more complex mathematical functions
  - Reason for failure was not that Victorian engineering lacked precision + accuracy to create machine ~ Reasons for failure were issues of economics, politics, Babbage's fiery temperament + his management style
- **Computing speed (in MIPS)**
  - Text
- **Primary memory type / technology ~ Size ~ Word length**
  - Brass gears
- **Secondary memory type / technology ~ Size**
  - N/A
- **Uses / Applications / Software**
  - Compute mathematical tables + navigation tables
- **Predecessors - N/A ~ Successors - Difference Engine Number 2 from Babbage, Difference Engines made by George + Edvard Scheutz**

Difference Engine Number 2





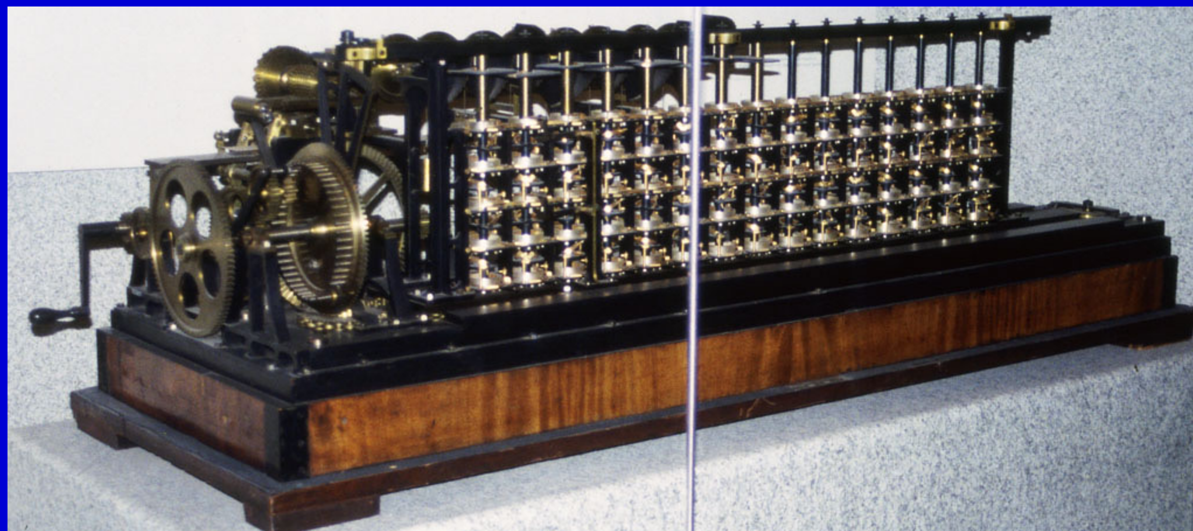
Thing / Hardware - Difference Engine Number 2

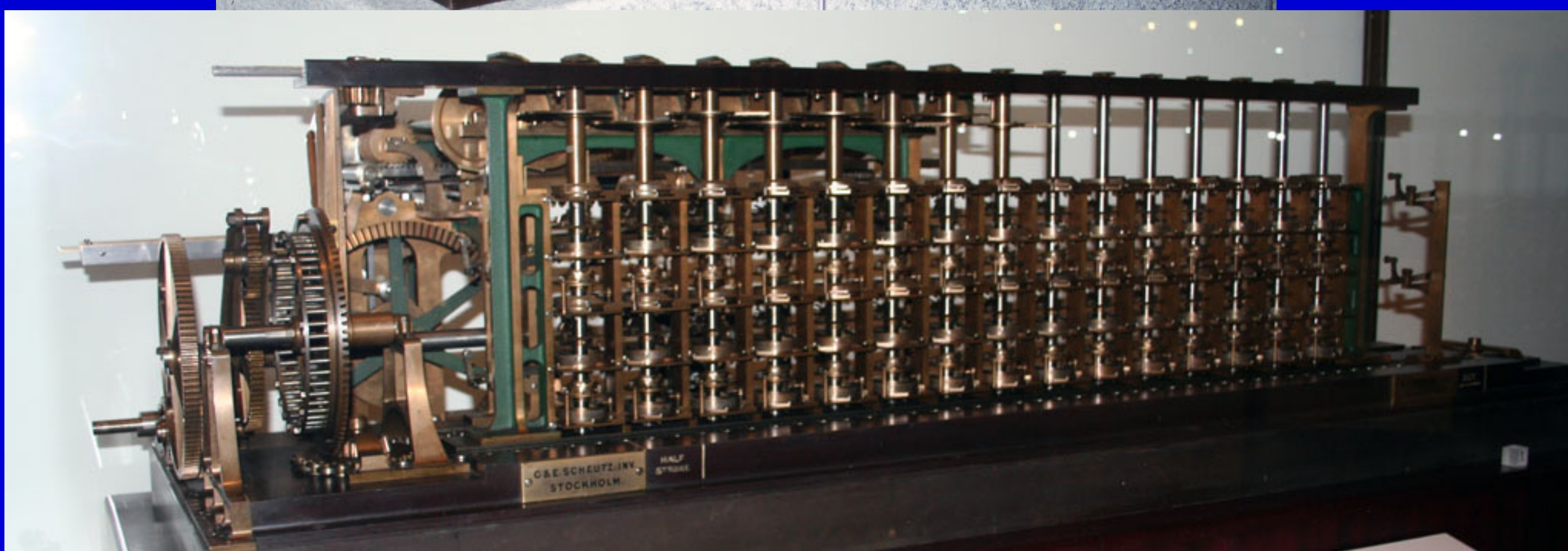
- **Firsts / Achievements / Uniqueness / Significance**
  - Simpler + more elegant version of difference engine than Difference Engine Number 1 + benefited from design being done on Analytical Engine
  - Three times fewer parts than Difference Engine Number 1 for same computing power
  - Designed to calculate + print class of mathematical functions known as polynomials
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Babbage's workshop (design) / Science Museum (construction) ~ Designed in 1847-1849 / Built in 1985 ~ England
- **People involved (Designer)**
  - Charles Babbage, Science Museum constructed it
- **Type**
  - Calculator
- **Price / Cost**
  - Text
- **Size**
  - 11' long x 7' high x 1.5' deep
  - Weighs 5 tons

Thing / Hardware - Difference Engine Number 2

- Computing technology
  - Mechanical (cams, gears, levers, pins, rods) ~ 8000 parts in this engine
  - Has 7 orders of difference + calculates to 31 digits of precision ~ Starting values are set by hand on the column of figure wheels ~ Operated by turning crank handle ~ 30 figure result is produced at end of each calculating cycle ~ Carry mechanism can be seen from rear of the machine + is repeated 210 times
  - Offered to English government in 1852 without success ~ In 1985 Science Museum built it, using materials that would have been used by Babbage: cast iron, steel, + "gunmetal" which is bronze ~ Although modern manufacturing techniques were used, care was taken to make parts no more precisely than Babbage could have
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Brass gears
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Compute mathematical tables + navigation tables+ automatically prints results + typesets them
- Predecessors - Difference Engine #1 ~ Successors - Analytical Engine

Schuetz Difference Engine





Second in 1853 (above) and Third in 1859 (below)

Thing / Hardware - Scheutz Difference Engine

- Firsts / Achievements / Uniqueness / Significance
  - Influenced + encouraged by Babbage
  - First successful difference engine that produced first tables calculated + printed by machinery
  - First printing calculator sold
  - First computing machine to carry out computations under US government contract
  - Both inventors died bankrupt from pursuing their mission to build + market calculating engines
- Place Produced (Company / Institution) ~ Year ~ Country
  - Home of Georg and Edvard Scheutz ~ Prototype in 1843 ~ Sweden
- People involved (Designer)
  - Georg and Edvard Scheutz
- Type
  - Calculator
- Price / Cost
  - Second model sold to Dudley Observatory in Albany New York for £1000
- Size
  - 22" x 67" x 23"

Thing / Hardware - Scheutz Difference Engine

- Size
  - 22" x 67" x 23"
- Computing technology
  - Mechanical (cams, gears, levers, pins, rods)
  - Operated with 3 orders of difference (Babbage's Difference Engine Number 2 uses 7 orders of difference)
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Brass gears
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Second model, sold to Dudley Observatory, was largely unused
  - Third model, sold to General Register Office in London for use in production of 1864 English Life Table, but its contribution was slight as it was temperamental
- Predecessors - Babbage's Difference Engines ~ Successors - N/A

Jacquard Loom

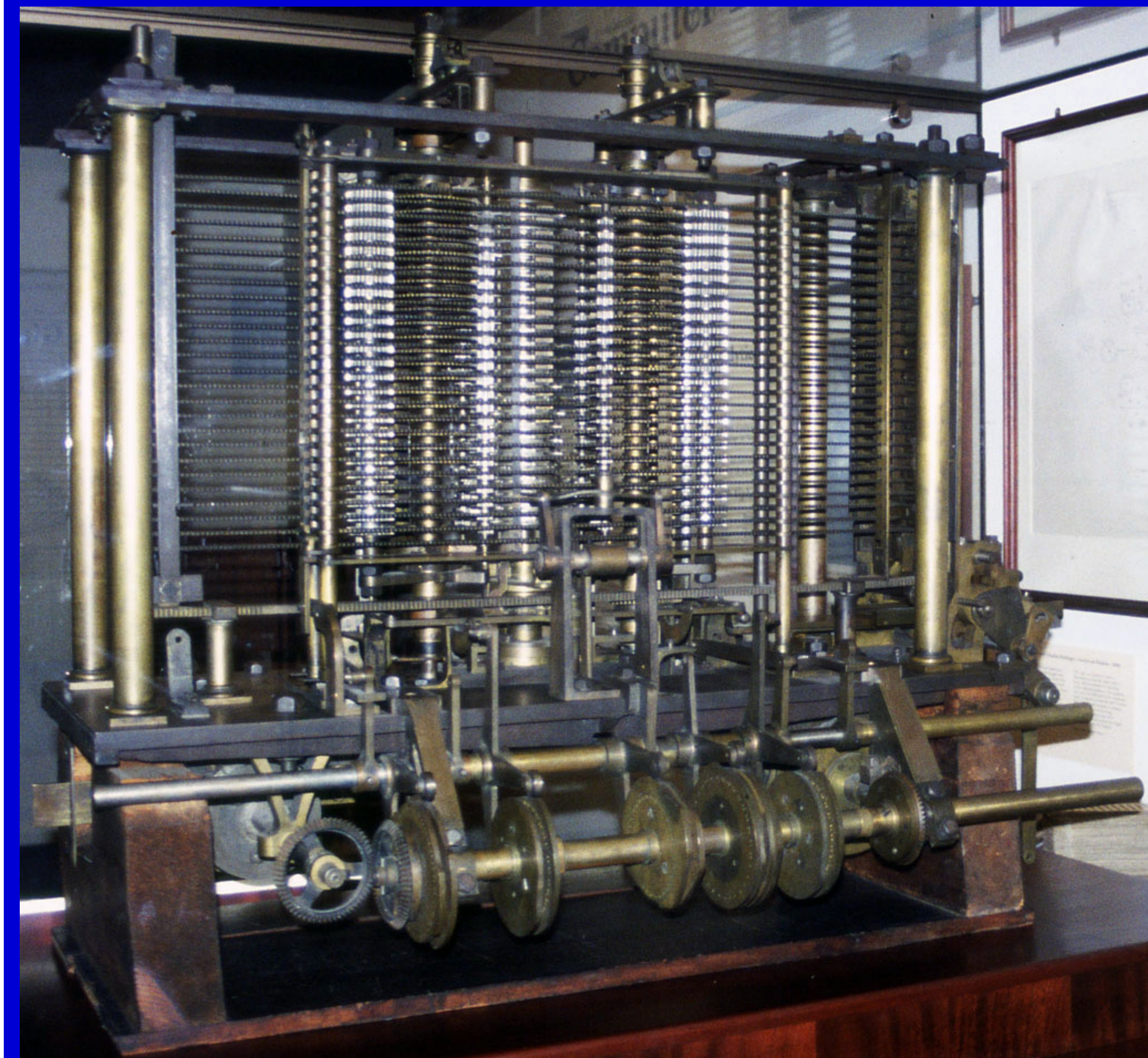
Thing / Hardware - Jacquard Loom

- Firsts / Achievements / Uniqueness / Significance
  - First device that featured automatic control
  - Really is inside-out version of device that had controlled machines for centuries - the cylinder - which had pegs mounted on it which tripped levers as it rotated - think medieval clocks and music boxes; today we call this Read Only Memory (ROM)
- Place Produced (Company / Institution) ~ Year ~ Country
  - Jacquard workshop in Lyon ~ 1803 ~ France
- People involved (Designer)
  - Joseph Marie Jacquard
- Type
  - Printer
- Price / Cost
  - Text
- Size
  - 6' x 6' x 6'

Thing / Hardware - Jacquard Loom

- Computing technology
  - Punched cards that were bound together in a program
  - Was separate unit that could be added to conventional loom
- Computing speed (in MIPS)
  - N/A
- Primary memory type / technology ~ Size ~ Word length
  - Punched card ~ ∞ ~ N/A
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Automated the weaving of complex graphical patterns in silk
- Predecessors - N/A ~ Successors - Analytical Engine, Hollerith Tabulating System

Analytical Engine



Siimplified Mill from 1871

Punched cards

Thing / Hardware - Analytical Engine

- **Firsts / Achievements / Uniqueness / Significance**
  - Design embodied most features of modern digital computers
  - Would have had the key components of computing - calculation, automatic storage + retrieval of information in coded form, automated execution of sequence of operations (automatic control = software)
  - Store (or memory) was separate from mill (or arithmetic logic unit)
  - Designed to be programmable + would have been able to do conditional branching (if-then), looping + would have had microprogrammable control which is process where several elementary instructions are executed to produce a single complex action
  - Failed due to problems with finance, management, politics
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Babbage's workshop in London ~ Design begun 1834 ~ England
- **People involved (Designer)**
  - Charles Babbage, Ada Lovelace (programmer), Joseph Clement (builder)
- **Type**
  - Mainframe computer
- **Price / Cost**
  - Text
- **Size**
  - Text

Thing / Hardware - Analytical Engine

- Computing technology
  - Mechanical (cams, gears, levers, pins, rods) ~ Steam powered
  - Complete mill designed to perform addition, subtraction, multiplication, and division. This simple mill has 2 vertical columns of number wheels and between them an anticipated carry mechanism
  - It was thought reason Difference Engine + Analytical Engine were never completed was that mechanical engineering was not advanced enough in Babbage's time to create parts with fine mechanical tolerances needed but this proven to be false as evidenced by The Science Museum's construction of Difference Engine Number 2 from Babbage's original plans using only technology that would have been available to him
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Brass gears
- Secondary memory type / technology ~ Size
  - Punched cards - information was coded as holes punched into cards ~ ∞
  - Cards are of two types - smaller cards are operation cards which specify type of mathematical operation to be performed while larger cards are variable cards which dictate where numbers to be operated on are located in the store (memory) and where results should be placed
- Uses / Applications / Software
  - Calculate mathematical tables and print results directly to typesetter
- Predecessors - Difference Engine Number 2 ~ Successors - Harvard Mark I

Analytical Engine

- Size of a train locomotive
- Consist of 50,000 moving parts
- Compute mathematical tables to 30- or 50-digit precision at rate of one result every 4 seconds

- Stephen Wolfram, Untangling the Tale of Ada Lovelace

Thing / Software - Analytical Engine

- Firsts / Achievements / Uniqueness / Significance
  - First computer software ever written
- Place Produced (Company / Institution) ~ Year ~ Country
  - Ada Lovelace's home ~ 1843 ~ England
- People involved (Programmer)
  - Ada Lovelace
- Type
  - Pseudocode algorithms to solve mathematical problems
- Price / Cost
  - N/A
- Computer and operating system it runs on
  - Analytical Engine
- Computer language written in
  - Pseudocode
- Memory required
  - N/A
- Predecessors - N/A ~ Successors - N/A

Real Artists Ship

"One of the sad memories of my life is a visit to the celebrated mathematician and inventor, Mr. Babbage. He was far advanced in age, but his mind was still as vigorous as ever. He took me through his work-rooms. In the first room I saw parts of the original Calculating Machine, which had been shown in an incomplete state many years before and had even been put to some use. I asked him about its present form.

"I have not finished it because in working at it I came on the idea of my Analytical Machine, which would do all that it was capable of doing and much more. Indeed, the idea was so much simpler that it would have taken more work to complete the Calculating Machine than to design and construct the other in its entirety, so I turned my attention to the Analytical Machine."

After a few minutes' talk, we went into the next work-room, where he showed and explained to me the working of the elements of the Analytical Machine. I asked if I could see it. "I have never completed it," he said, "because I hit upon an idea of doing the same thing by a different and far more effective method, and this rendered it useless to proceed on the old lines." Then we went into the third room. There lay scattered bits of mechanism, but I saw no trace of any working machine. Very cautiously I approached the subject, and received the dreaded answer, "It is not constructed yet, but I am working on it, and it will take less time to construct it altogether than it would have taken to complete the Analytical Machine from the stage in which I left it." I took leave of the old man with a heavy heart."

- John Fletcher, Lord Moulton, reflecting on a meeting with Charles Babbage

Ada Lovelace

From Wikimedia Commons

Person - Ada Lovelace

- Significance
  - First computer programmer
    - 1843 - published translation of description of Analytical Engine - "Sketch of the Analytical Engine Invented by Charles Babbage" along with her interpretation ("Notes")
      - Note G described many of concepts of modern computer programming
      - The Notes contain series of elemental instruction sets that could be used to direct calculations of Analytical Engine + can be considered to be first examples of published software
    - Recognized a general purpose programmable calculator is nothing like a special purpose calculator
- Profession
  - Mathematician, Aristocrat
- Places worked
  - England
- Years of work
  - 1842-1851
- Things worked on
  - Software for Analytical Engine

"We may say most aptly that the Analytical Engine weaves algebraical patterns just as the Jacquard-loom weaves flowers and leaves."

- Ada Lovelace

"Many persons imagine that because the business of the engine is to give its results in numerical notation, the nature of its processes must consequently be arithmetical and numerical, rather than algebraical and analytical. This is an error. The engine can arrange and combine its numerical quantities exactly as if they were letters or any other general symbols."

- Ada Lovelace

"[The Analytical Engine] might act upon other things besides number, were objects found whose mutual fundamental relations could be expressed by those of the abstract science of operations, and which should be also susceptible of adaptations to the action of the operating notation and mechanism of the engine… Supposing, for instance, that the fundamental relations of pitched sounds in the science of harmony and of musical composition were susceptible of such expression and adaptations, the engine might compose elaborate and scientific pieces of music of any degree of complexity or extent."

- Ada Lovelace

Lovelace's Influence

"Ada saw something that Babbage in some sense failed to see. In Babbage's world his engines were bound by number. He saw that the machines could do algebra in the narrow sense that they could manipulate plus and minus signs. But all his calculating engines, his Difference Engine and his Analytical Engine, which is the programmable general-purpose machine, were all bound by number. They manipulated number as a manifestation of quantity, as a measure of quantity. What Lovelace saw-what Ada Byron saw-was that number could represent entities other than quantity. So once you had a machine for manipulating numbers, if those numbers represented other things, letters, musical notes, then the machine could manipulate symbols of which number was one instance, according to rules. It is this fundamental transition from a machine which is a number cruncher to a machine for manipulating symbols according to rules that is the fundamental transition from calculation to computation-to general purpose computation-and looking back from the present high ground of modern computing, if we are looking and sifting history for that transition, then that transition was made explicitly by Ada in that 1843 paper." - Doron Swade

…it would take over 100 years for Ada to be proven right

- John Fuegi and Jo Francis, Lovelace & Babbage and the Creation of the 1843 'Notes', IEEE Annals of the History of Computing, Oct.-Dec. 2003

Lovelace's Influence

- In her essay on the Analytical Engine, Ada developed more abstract understanding of it than Babbage had by glimpsing idea of universal computation
  - Difference Engine was special purpose computer
  - Analytical Engine would have been first universal computer
- Alan Turing started articulating concept of universal computation again in 1936

"I think one can fairly say that Ada Lovelace was the first person ever to glimpse with any clarity what has become a defining phenomenon of our technology and even our civilization: the notion of universal computation"

- Stephen Wolfram

- Stephen Wolfram, Untangling the Tale of Ada Lovelace

Lovelace's Influence

"The Analytical Engine has no pretensions whatever to originate anything. It can do whatever we know how to order it to perform...Its province is to assist us in making available what we are already acquainted with."

- Ada Lovelace

- Alan Turing read her Notes, + coined the term "Lady Lovelace's Objection" ("an AI can't originate anything") in his 1950 Turing Test paper

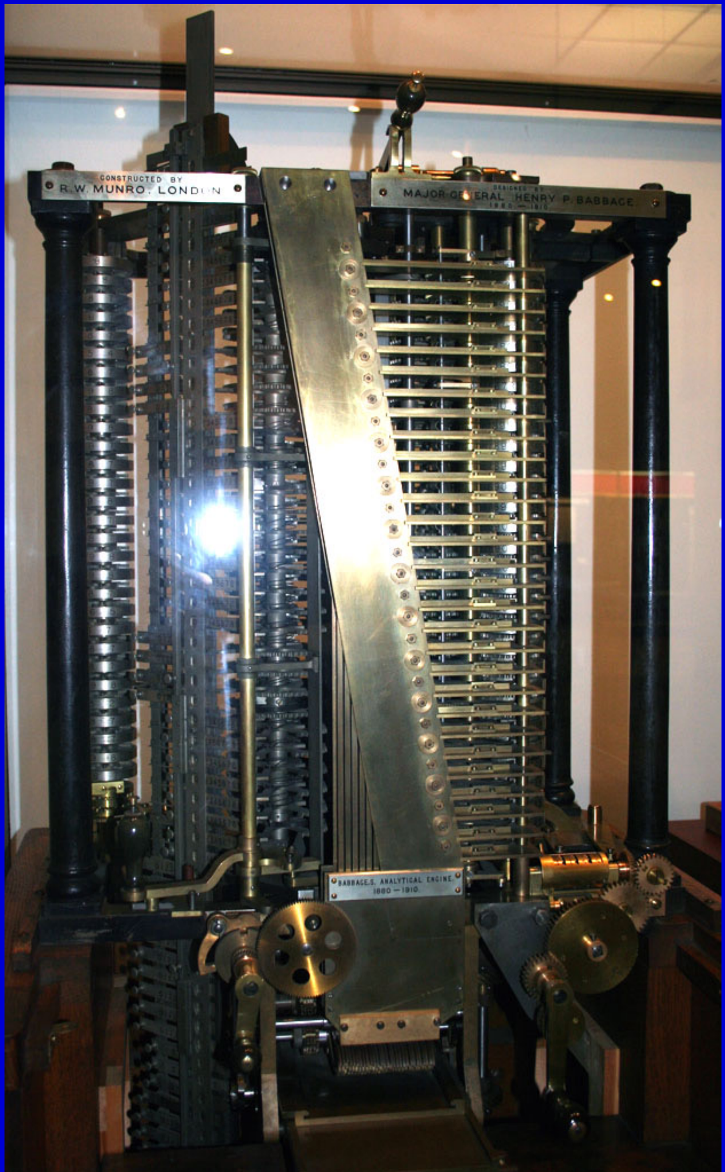
- **Luddites were 19th-century English textile artisans who protested against newly developed labor-replacing machinery from 1811 to 1817**
  - **Stocking frames, spinning frames and power looms introduced during Industrial Revolution threatened to replace the artisans with less-skilled, low-wage laborers, leaving them without work.**
- **Ada Lovelace's father, Lord Byron, was a Luddite**

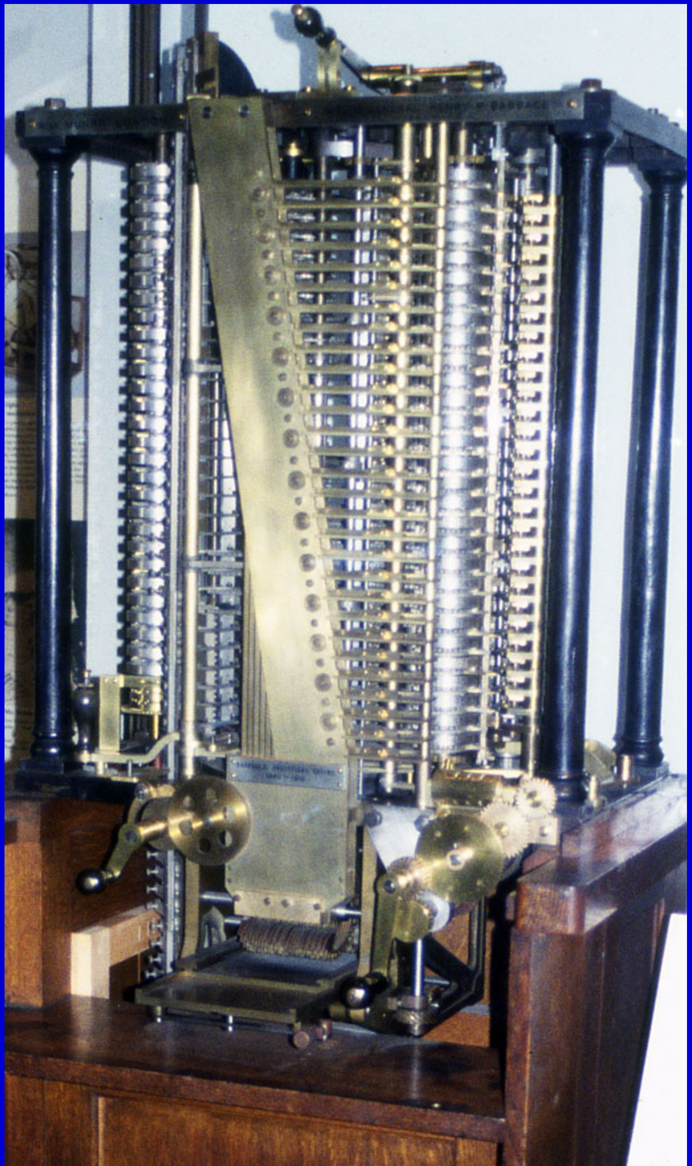
Babbage on Lovelace

"After he got up to go, by some chance of conversation the late Lady Lovelace's name (Lord Byron's daughter "Ada") was mentioned; he knew her intimately and spoke highly of her mathematical powers, and of her peculiar capability - higher he said than of any one he knew, to prepare (I believe it was) the descriptions connected with his calculating machine."

- Henry Hope Reed, letter to Alexander Bache, published in The Southern Review in 1867, describing an encounter with Charles Babbage

Analytical Engine by Henry Babbage





Thing / Hardware - Analytical Engine by Henry Babbage

- Firsts / Achievements / Uniqueness / Significance
  - In his will, Charles Babbage gave his life's work to his son Henry who had shown an interest in it + Henry continued his father's work
  - Analytical Engine Simplified Mill is a mechanically operated calculator built by Henry based on Charles' design for the mill and could perform addition, subtraction, multiplication, and division
- Place Produced (Company / Institution) ~ Year ~ Country
  - Babbage's workshop ~ 1880 - 1910 ~ England
- People involved (Designer)
  - Henry Babbage
- Type
  - Mainframe computer
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Analytical Engine by Henry Babbage

- **Computing technology**
  - Steam powered, Mechanical (cams, gears, levers, pins, rods)
- **Computing speed (in MIPS)**
  - Text
- **Primary memory type / technology ~ Size ~ Word length**
  - Brass gears
- **Secondary memory type / technology ~ Size**
  - Punched cards - information was coded as holes punched into cards ~ ∞
  - Would have printed results directly to typesetter
- **Uses / Applications / Software**
  - Calculate mathematical tables and print results
  - In 1910 it printed first 25 multiples of pi to 29 places, but with errors - probably never worked reliably
- **Predecessors - Charles Babbage's Analytical Engine ~ Successors - N/A**

Babbage's Influence

- Henry Babbage put together six demonstration models of Difference Engine Number 1 after his father's death in 187
- One of the demonstration models was donated to Harvard University by Henry in 1886 and later came to the attention of Howard Aiken during his design of the Harvard Mark I, the first large scale program controlled calculator in the United States
- Aiken said it was these calculating wheels that led him to Babbage's work and this is the link between Babbage's work and the modern electronic era

Babbage's Influence

"Aiken was generally ignorant of Babbage's machines" (when writing his 1937 proposal to construct what became the Harvard Mark I, having seen only brief accounts and including) "summary and somewhat erroneous statements about Babbage's machines."

"Aiken praised Babbage to enhance his own stature" (even though) "Babbage did not play a major role in the development of Aiken's ideas."

(Grace Hopper was unaware of Lovelace's work) "until 10 or 15 years later"

- I.B. Cohen, Howard Aiken: Portrait of a Computer Pioneer, 1999

Burroughs Calculator

Thing / Hardware - Burrough's Adding Machine

- Firsts / Achievements / Uniqueness / Significance
  - Grew up across the street from his descendants
- Place Produced (Company / Institution) ~ Year ~ Country
  - American Arithmometer Company -> Burroughs Adding Machine Company ~ 1890 ~ USA
- People involved (Designer)
  - William S. Burroughs
- Type
  - Calculator
- Price / Cost
  - By 1909 was $175-$575
- Size
  - 11" x 15" x 12"

Thing / Hardware - Burrough's Adding Machine

- Computing technology
  - Mechanical (cams, gears, levers, pins, rods)
- Computing speed (in MIPS)
  - 1 calculation / 60 seconds
- Primary memory type / technology ~ Size ~ Word length
  - Paper ~ ∞ ~ N/A
- Secondary memory type / technology ~ Size
  - Paper ~ ∞
- Uses / Applications / Software
  - Added numbers
- Predecessors - Abacus ~ Successors - HP-35

Hollerith Tabulator and Sorter

Thing / Hardware - Hollerith Tabulating System

- Firsts / Achievements / Uniqueness / Significance
  - 1880 US census took 7 years to calculate, it was feared 1890 US Census would take > 10 years to calculate, thus triggering a Constitutional crisis because US needs the census numbers to allocates seats in House of Representatives
  - Designed to process the data gathered in the 1890 US Census, the Hollerith Tabulator and Sorter was the first successful commercial information processing machine
  - Calculated 1890 census in 2.5 years
  - Hollerith developed not just punched cards but suite of machines that used cards to sort, retrieve, count, perform calculations on data on cards
- Place Produced (Company / Institution) ~ Year ~ Country
  - Tabulating Machine Company -> Computing Tabulating Recording Company (CTR) -> 1924 International Business Machines (IBM) ~ 1890 ~ USA
- People involved (Designer)
  - Herman Hollerith
- Type
  - Tabulating machine, punch, sorting box
- Price / Cost
  - Text
- Size
  - 39.5" x 32" x 55"

Thing / Hardware - Hollerith Tabulating System

- **Computing technology**
  - Electromechanical relays
  - Had 3 parts - punch for entering data onto blank cards, tabulator for reading cards + summing up information, sorting box for sorting cards for further analysis
  - Pantograph used to record data onto punched card by punching it onto card while it was held in iron frame. Each card represented response of one citizen to each of 240 questions in 1890 census
  - Card reader worked by placing card to be read on plate which had 240 cups partially filled with mercury. Each hole corresponded to one of 240 holes on punched card. When lever was depressed, an electrical circuit was created where electrical conducting pins from lever above could make contact with mercury in cups if there was a hole punched in card. Electrical circuit caused information to be recorded on dials on the front on tabulating machine
  - Punched card sorter was a box with 24 compartments, same electrical current that activated counter dials could also be wired to sorter so that lid of a specific compartment could be opened automatically for a card to be placed into it manually
- **Computing speed (in MIPS)**
  - Average operator could process 7,000 cards / day which was 10 times faster than manual methods
- **Primary memory type / technology ~ Size ~ Word length**
  - N/A
- **Secondary memory type / technology ~ Size**
  - Punched cards - information was coded as holes punched into cards ~ ∞
- **Uses / Applications / Software**
  - Census tabulation
  - Descendants used to keep records - railroads tracking freight, insurance companies following policy holders, US government to run Social Security
  - This system became basis for punched card accounting machines for most of 20^{th} Century
- **Predecessors - N/A ~ Successors - UNIVAC-I**

Thomas J. Watson Sr.

From Wikimedia Commons

Person - Thomas J. Watson, Sr.

- Significance
  - Chairman + CEO of IBM who oversaw its growth into international force by developing its distinctive management style / corporate culture
  - Leader of IBM during its transition from electromechanical tabulating and sorting machines to electronic computers
  - His son, Thomas Watson Jr., was the leader of IBM at the time it achieved near complete dominance in mainframe computing
- Profession
  - Businessman
- Places worked
  - NCR, IBM
- Years of work
  - 1914-1956 - He and his son ran IBM for 60 years
- Things worked on
  - Renamed the Computing-Tabulating-Recording (CTR) Company to The International Business Machines (IBM) Corporation

IBM's Business Model

- Leased machines instead of selling them
- Made money from blades (punched cards) as well as razors (machines)
- In 1930 IBM sold 3 billion punched cards, accounting for 10% of their revenue + 35% of their profit

IBM Tabulating Equipment

IBM and the Final Solution

- **IBM's technology applied by its German subsidiary Dehomag facilitated Nazi genocide through generation and tabulation of punch cards based upon national census data.**

  "[The book] tells the story of IBM's conscious involvement - directly and through its subsidiaries - in the Holocaust, as well as its involvement in the Nazi war machine that murdered millions of others throughout Europe."

  "Mankind barely noticed when the concept of massively organized information quietly emerged to become a means of social control, a weapon of war, and a roadmap for group destruction.... Hitler and his hatred of the Jews was the ironic driving force behind this intellectual turning point. But his quest was greatly enhanced and energized by the ingenuity and craving for profit of a single American company and its legendary, autocratic chairman. That company was International Business Machines, and its chairman was Thomas J. Watson."

- **The 1933 German census, by IBM through its German subsidiary Dehomag, allowed the Nazis to identify, isolate, and ultimately destroy the country's Jewish population.**

  "Since the advent of the Third Reich, thousands of Jews nervously assumed they could hide from the Aryan clause."

  "But Jews could not hide from millions of punch cards thudding through Hollerith machines, comparing names across generations, address changes across regions, family trees and personal data across unending registries. It did not matter that the required forms or questionnaires were filled in by leaking pens and barely sharpened pencils, only that they were later tabulated and sorted by IBM's precision technology."

- **IBM through its German subsidiary Dehomag also played a role in running the concentration camps**

  "without IBM's machinery, continuing upkeep and service, as well as the supply of punch cards, whether located on-site or off-site, Hitler's camps could have never managed the numbers they did."

- Edwin Black, IBM and the Holocaust: The Strategic Alliance Between Nazi Germany and America's Most Powerful Corporation

Phone Phreaking

- In 1950's ATT was the largest company in the world and the ATT telephone network was the largest machine in the world
- The automated network of switching systems was largest distributed computer in the world
- These switching systems used in-band signaling - on the same analog lines that carried conversations, single frequency (SF) + multifrequency (MF) tones were used to communicate to switches the numbers that customers were dialing
- This elegant + economical solution to how to automate signaling and eventually allow direct distance dialing by users also allowed it to be easily hacked by them
  - Blue box - device that simulated an operator by generating the tones they employed to switch long-distance calls, allowing users to place free calls
  - Red box - device that generated tones to simulate inserting coins in pay phones
  - Black box - device that allowed incoming calls to be received without charge to the caller

\- Phi Lapsley, Exploding the Phone

Phone Phreaking

- Social engineering (calling someone on a pretext to get information or convince them to do something for you) was very helpful to phreaks
- Not dumpster diving - but library diving for Bell Labs Technical Journal
- Phone phreak code of conduct - don't seek publicity, don't call during peak hours, don't profit from phreaking
- Phreaking information spread initially by word of mouth and isolated media stories
- Later phreaking information was spread by mass-market media stories and counter-culture newsletters (Youth International Party Lines)
- Game changed from understanding / appreciating / playing with phone network to making free calls
- To catch blue box and black box usage by phreaks, ATT used Greenstar toll-fraud surveillance system which from 1964 - 1970 monitored 33 million long distance calls + taped 1.8 million of them...from this they projected that 350,000 fraudulent calls were being made each year

\- Phi Lapsley, Exploding the Phone

Phone Phreaking

- Blue box replaced by beige box (home computer) which could be used to hack phone network + computer networks + computers
- MF tones replaced by common channel interoffice signaling in the 1980s, putting an end to phone phreaking

"It was the magic of the fact that two teenagers could build this box for $100 worth of parts and control hundred of billions of dollars of infrastructure in the entire telephone network of the whole world from Los Altos and Cupertino, California. That was magical...If we hadn't made blue boxes, there would have been no Apple." - Steve Jobs

"In the end the phone phreaks taught us that there is a societal benefit to tolerating, perhaps even nurturing (in the words of Apple) the crazy ones - the misfits, the rebels, the troublemakers, the round pegs in the square holes. Say Wozniak and Jobs hadn't been so lucky when they would up in the back of the police car that evening back in 1972, when they convinced the cops that their blue box was actually a music synthesizer. Say they had been arrested, possibly gone to jail. We might never have had Apple computer or any of the other things that Apple went on to make. Would we be the better for it?" - Phi Lapsley

- Phi Lapsley, Exploding the Phone

Personal Case Study - Difference Engine

- Role
  - At a visit to the Computer History Museum in 2012 I saw it in action via hand cranking
- Story
  - What a sound and what a sight!
  - Not hackers but clackers

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- Why was there such a long gap between the Antikythera Mechanism and Babbage?
- What were the computational challenges facing Victorian England?
- Who were Babbage and Lovelace and what did they contribute to solving these challenges?
- What is the significance of the Difference Engine, the Analytical Engine, and the Hollerith Tabulator in addressing these challenges?
- Why did Babbage fail? What entrepreneurial skills was he lacking?
- If Great Britain had mastered mechanical computing ala Babbage in the late 19th century - how would that have altered the course of the British Empire and / or changed world history?
- How can computers be used for evil as well as good?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History - Chapter 1 The Digital Age
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
  - The Difference Engine by William Gibson and Bruce Sterling
- Movies
- Simulations

Conclusion

"I wish to God these calculations had been executed by steam"

- Charles Babbage, inventor

Topic 6

Computers in War

War as a Crucible

Song

Every breath you take and every move you make
Every bond you break, every step you take, I'll be watching you
Every single day and every word you say
Every game you play, every night you stay, I'll be watching you

Oh, can't you see you belong to me
How my poor heart aches with every step you take

Every move you make, every vow you break
Every smile you fake, every claim you stake, I'll be watching you
- Sting - Every Breath You Take

Thematic Quote

"No plan of operation extends with any certainty beyond first contact with the main hostile force"

("No plan survives first contact with the enemy").

- Count Helmuth von Moltke (the Elder), Prussian general

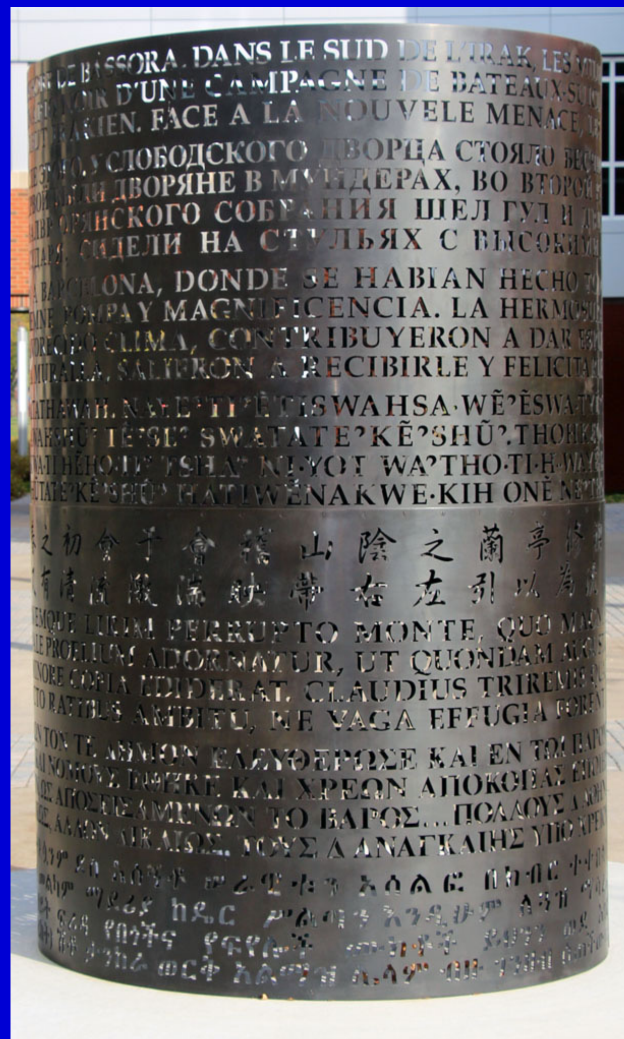
The Painting

The Moth

- Mac Adams

(Iowa State University, outside the Atanasoff Building)

The Painting



Iacto

- James Sanborn

(University of Iowa, outside the School of Journalism and Mass Communications)

Artifact

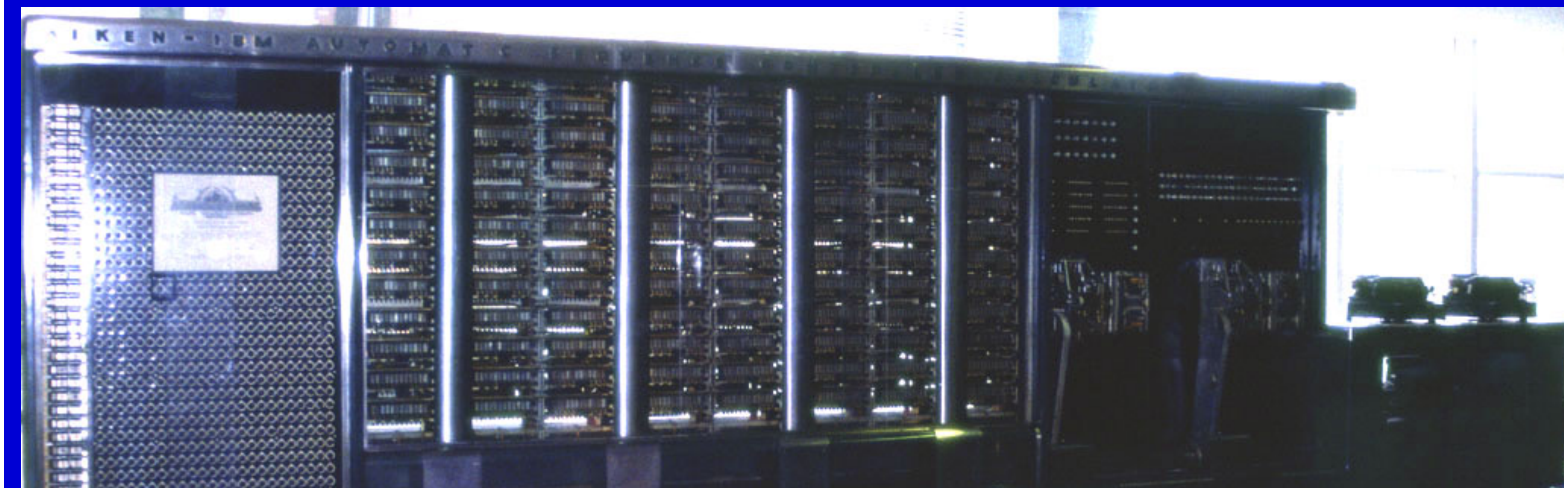
- Name
  - CPU 26 A/P Computer Air Navigation (Analog computer)
- Year
  - 1958
- Story
  - Descendant of E-6B analog computer from 1930's created by US Navy officers Philip Dalton + Philip Van Horn Weems
  - Is circular slide rule for pilot's in-flight calculations
  - Also used by Mr. Spock in Star Trek

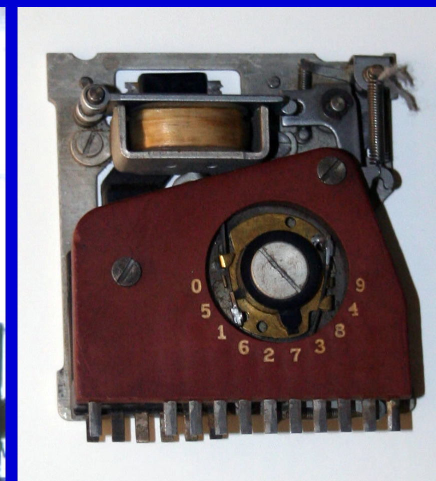
- Name
  - IBM 12 point relay
- Year
  - 1960's
- Story
  - Roughly similar to relays used in Harvard Mark I

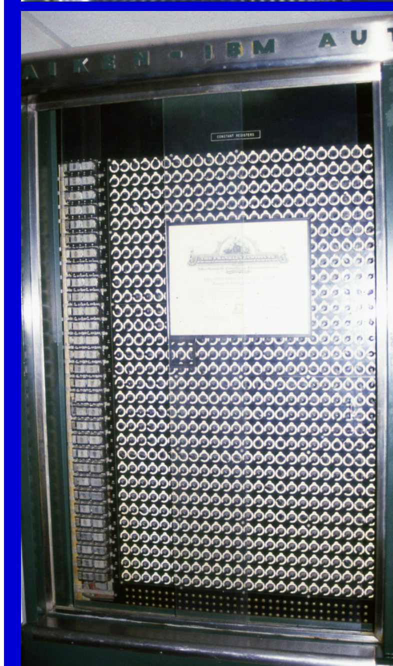
The Question

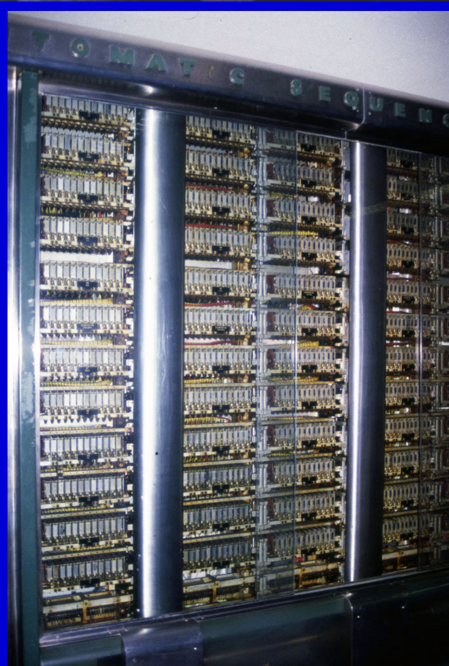
Why was there such a long gap between Babbage and the Harvard Mark I?

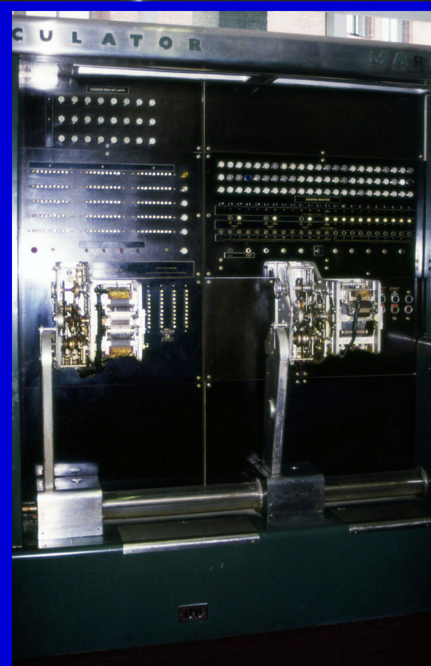
Harvard Mark I

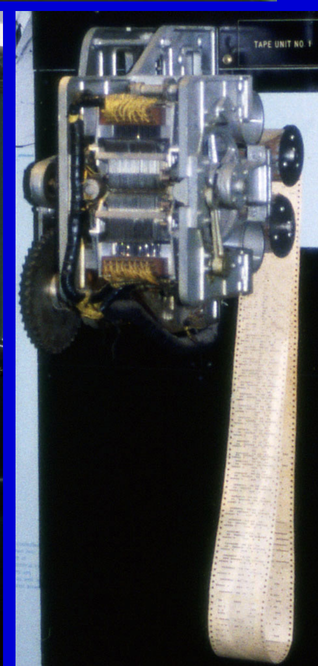












Thing / Hardware - Automated Sequence Controlled Calculator (ASCC) (Harvard Mark I)

- Firsts / Achievements / Uniqueness / Significance
  - Aiken was inspired by work of Babbage, Aiken called Mark I a "Computing Engine"
  - Was the first large scale program controlled calculator in the United States / First large scale digital computer in USA
  - It was sequentially programmed (ENIAC was first electronic computer but was not programmed when built)
  - Technically not a computer because programs could not be stored internally
  - Mark I's glass case designed by Norman Bel Geddes - first use of industrial design in computing
  - In 1945, it's successor - Harvard Mark II - another relay machine - failed on hot summer afternoon - inside a relay was found a moth - "First actual bug found"
- Place Produced (Company / Institution) ~ Year ~ Country
  - US Navy / IBM / Harvard ~ 1944 ~ USA
- People involved (Designer)
  - Howard Aiken (designer), Grace Murray Hopper (programmer)
- Type
  - Mainframe computer
- Price / Cost
  - $500,000
- Size
  - 51' long x 8' high x 8' wide

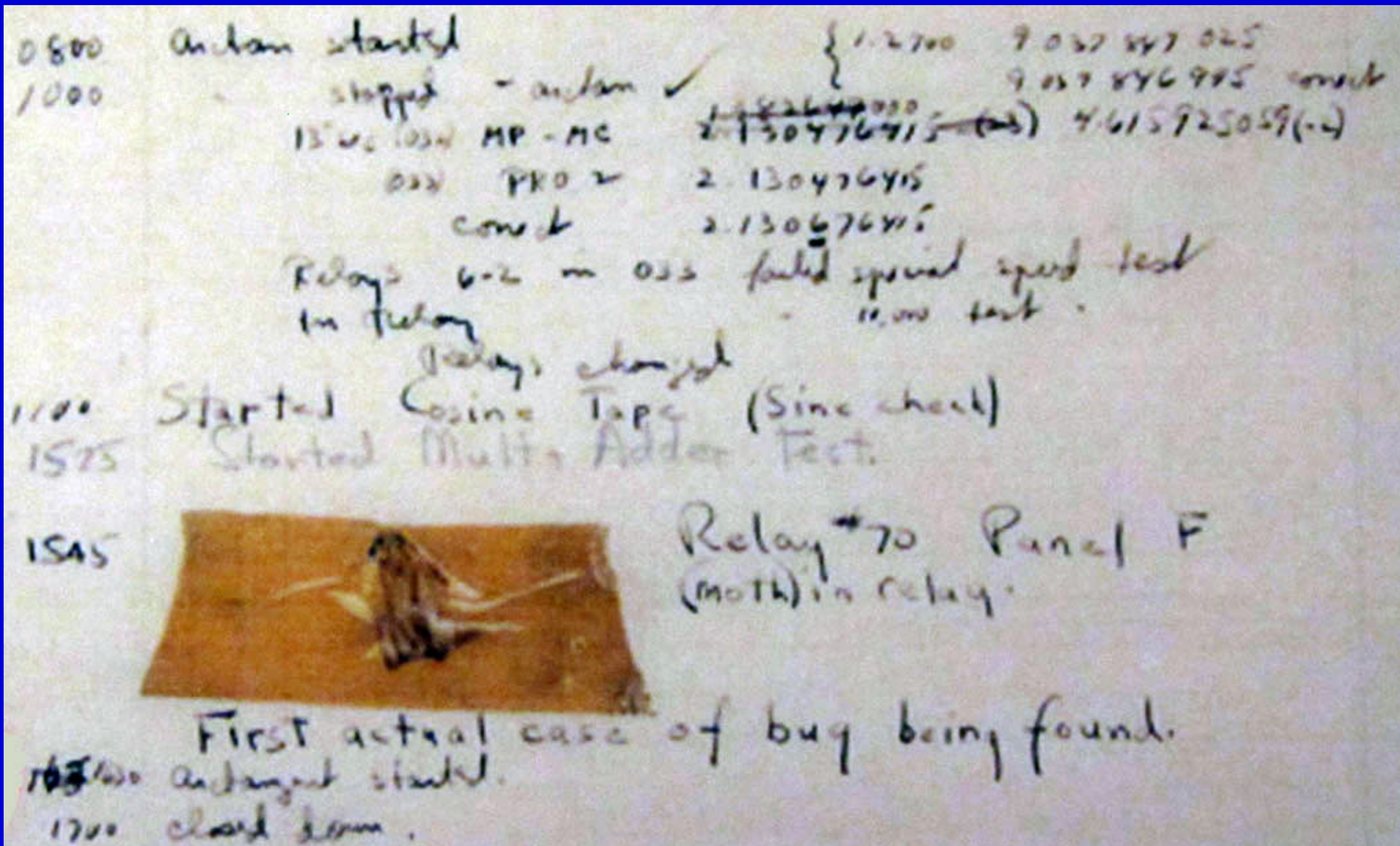
Thing / Hardware - Automated Sequence Controlled Calculator (ASCC) (Harvard Mark I)

- **Computing technology**
  - Electromechanical computer using counters to store decimal numbers and relays for control and switching ~ 750,000 parts, 500 miles of wire
  - The electromagnetic counters were arranged in horizontal banks and used for arithmetic operations with each horizontal bank containing 23 counters to make up one 23 digit number
  - Relay engaged the counter with the shaft rotating at a constant speed. The duration of an electric pulse represented the digit being added in, holding the relay on for a fraction of one revolution
  - Instructions were input via punched tape, punched cards, or manual switches. Output was delivered via typewriter or punched on cards
- **Computing speed (in MIPS)**
  - 3.3 operations / sec
  - Computational speed was 6 seconds per multiplication
- **Primary memory type / technology ~ Size ~ Word length**
  - Counters ~ 132 ~ 23 digit words
- **Secondary memory type / technology ~ Size**
  - Text
- **Uses / Applications / Software**
  - Designed during 1937-1939. Built between 1939-1943, it continued in operation until 1959
  - Ballistic calculations, wanted to evaluate integrals
  - It was used for scientific calculations on ballistics and ship design
- **Predecessors - Babbage's Difference + Analytical Engines ~ Successors - Harvard Mark II**

Thing / Software - Name

- Firsts / Achievements / Uniqueness / Significance
  - First production computer software
- Place Produced (Company / Institution) ~ Year ~ Country
  - Harvard ~ 1944 ~ USA
- People involved (Programmer)
  - Grace Murray Hopper
- Type
  - Ballistic calculations
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Harvard Mark I
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - N/A ~ Successors - N/A

First Actual Case of Bug Being Found



Grace Murray Hopper

From Wikimedia Commons

Person - Grace Murray Hopper

- Significance
  - Programmer on Harvard Mark I
  - First used term "bug" (debugging) to refer to flaws in operation of Harvard ASSC Mark II
    - Operators of Harvard Mark II found moth in electromechanical relay - "First actual case of bug being found"
  - Developed first commercial language compiler
  - Helped create COBOL language
- Profession
  - Math professor
- Places worked
  - US Navy, Eckert-Mauchly Computer Corporation / Remington Rand
- Years of work
  - 1944-1986
- Things worked on
  - Harvard ASSC Mark I and Mark II, UNIVAC I, COBOL language, subroutines

Place - Bletchley Park

- Significance
  - Cracked German Enigma + Fish codes, helped shorten World War II
- Location
  - Bletchley, Milton Keynes, England
- Definition
  - Site of Government Code and Cypher School (GC and CS) in Great Britain
- People who worked there
  - Alan Turing
- Things created there
  - Bombe, Colossus

Enigma

Kreigsmarine Enigma with 4 rotors

Computing Case Study Summary - Enigma

- Goal
  - Rapidly decode intercepted German Enigma encrypted messages so the results could be used against Germans
  - These message were at tactical level - most important were those regarding U-Boat movements
- Center of Gravity (Strategy)
  - Use electromechanical computers to do this
- Technology / Equipment
  - Broken by Poland in 1933 with electromechanical computer called bomba
  - Techniques given to British in 1939, who created bombes
  - Techniques given to Americans, who improved bombes

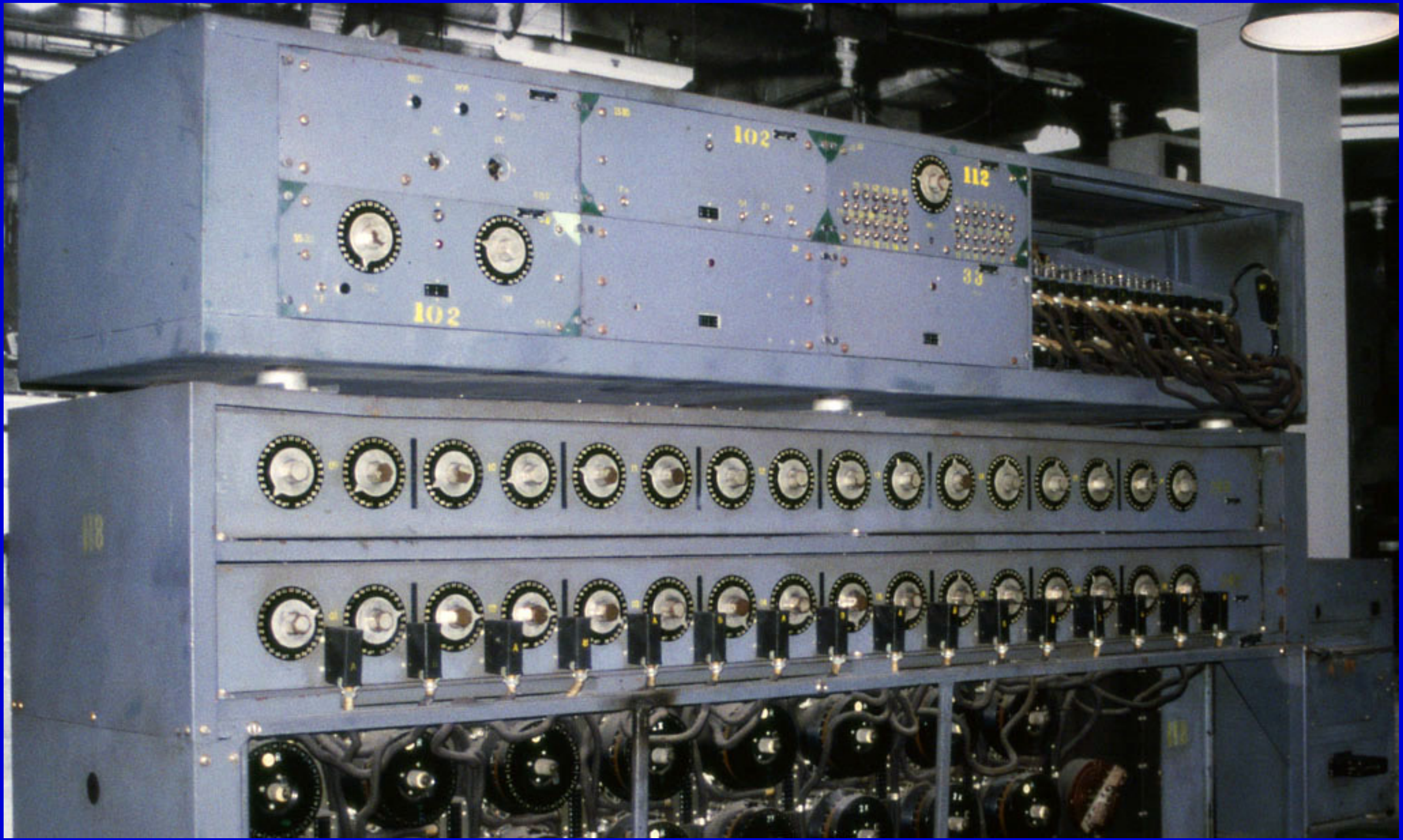
- Jim Holt, Code Breaker, New Yorker, Feb 6, 2006
- Glenn Zorpette, Breaking the Enemy's Code, IEEE Spectrum, Sept 1987
- Gordon Corera, Poland's Overlooked Enigma Codebreakers, BBC News, Jul. 4, 2014

Computing Case Study Summary - Enigma

- Training ~ Leadership ~ Morale
  - French agent in Germany prewar gave details of Enigma to Poland
  - Polish realized key to cracking it was to use mathematicians, rather than linguists, to look for codes
  - Involved cream of British academics during the war
- Tactics
  - By 1944 bombes are decrypting 90,000 Enigma messages / month
- Intangibles
  - Naval Enigma was most impenetrable - Alan Turing worked on developing an improved bombe for it
- Mistakes / Outcome
  - Played key role in turning the tide in Battle of the Atlantic
  - Germans never suspected a thing

- Jim Holt, Code Breaker, New Yorker, Feb 6, 2006
- Glenn Zorpette, Breaking the Enemy's Code, IEEE Spectrum, Sept 1987
- Gordon Corera, Poland's Overlooked Enigma Codebreakers, BBC News, Jul. 4, 2014

Bombe



Thing / Hardware - Bomba / Bombe

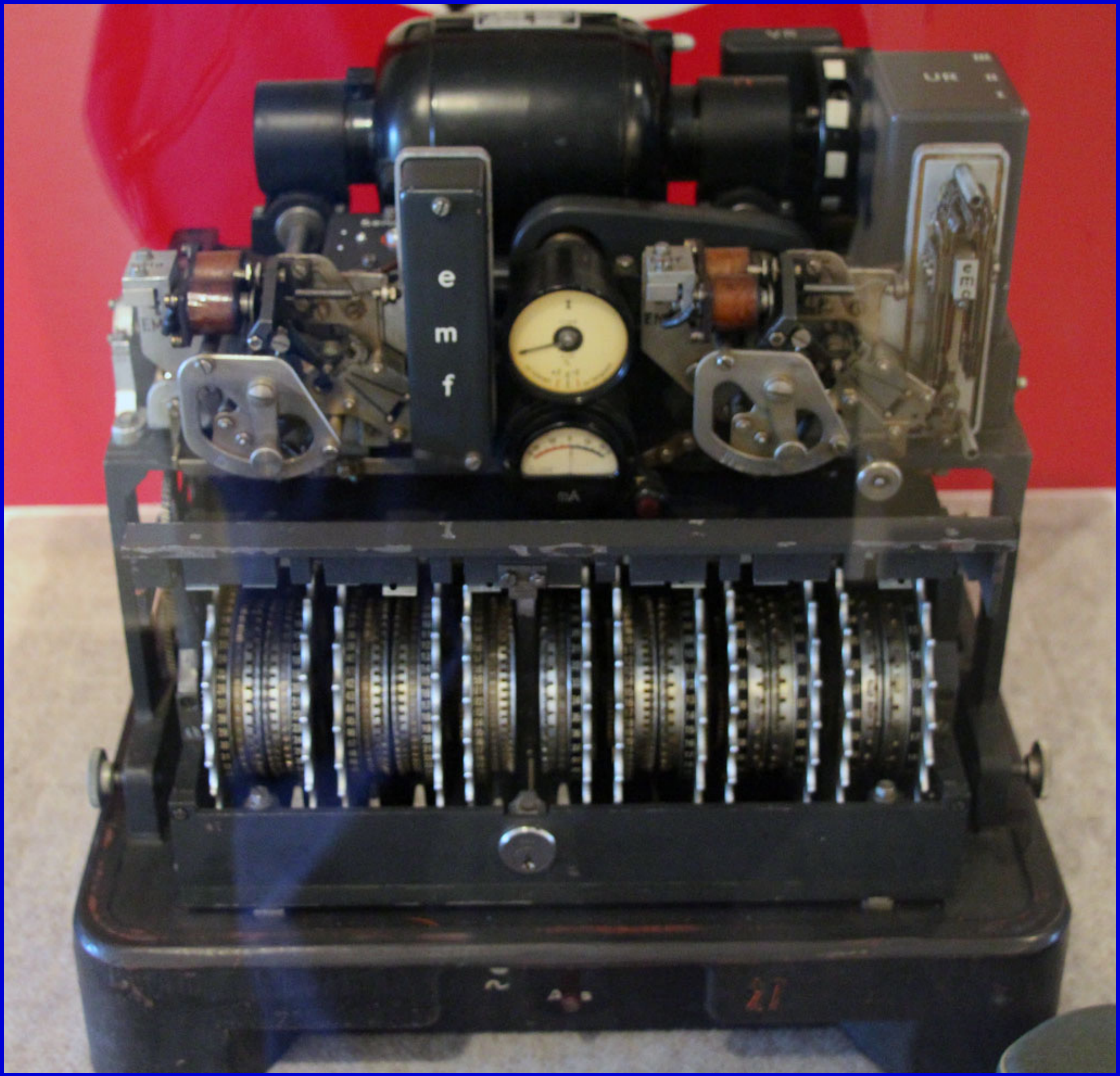
- Firsts / Achievements / Uniqueness / Significance
  - By breaking German tactical Enigma codes, could help locate and attack German U-Boats, helped win Battle of the Atlantic
- Place Produced (Company / Institution) ~ Year ~ Country
  - Bomba - Polish government ~ 1938
  - Bombe - British - Tabulating Machine Company ~ 1940
  - Bombe - US - National Cash Register ~ 1943
- People involved (Designer)
  - Marian Rejewski did Bomba ~ Alan Turing + Gordon Welchman did British Bombe ~ Joseph Desch did US Bombe
- Type
  - Special purpose mainframe computer
- Price / Cost
  - Text
- Size
  - 10' x 2' x 7'

Thing / Hardware - Bomba / Bombe

- **Computing technology**
  - **Electromechanical relays**
- **Computing speed (in MIPS)**
  - **US Navy Bombes could search through 456,976 Enigma rotor settings in 20 minutes + were faster than British Bombes**
- **Primary memory type / technology ~ Size ~ Word length**
  - **Text**
- **Secondary memory type / technology ~ Size**
  - **Text**
- **Uses / Applications / Software**
  - **Enigma was typewriter that scrambled text by sending typed characters through series of wheels before being transmitted**
  - **Bombe was reverse engineered Enigma - Were Enigma machines running in reverse with sets of wheels testing possible code combinations**
  - **Used to decipher messages sent by German Enigma cipher machines, those used by German Navy were most difficult to crack**
- **Predecessors - N/A ~ Successors - N/A**

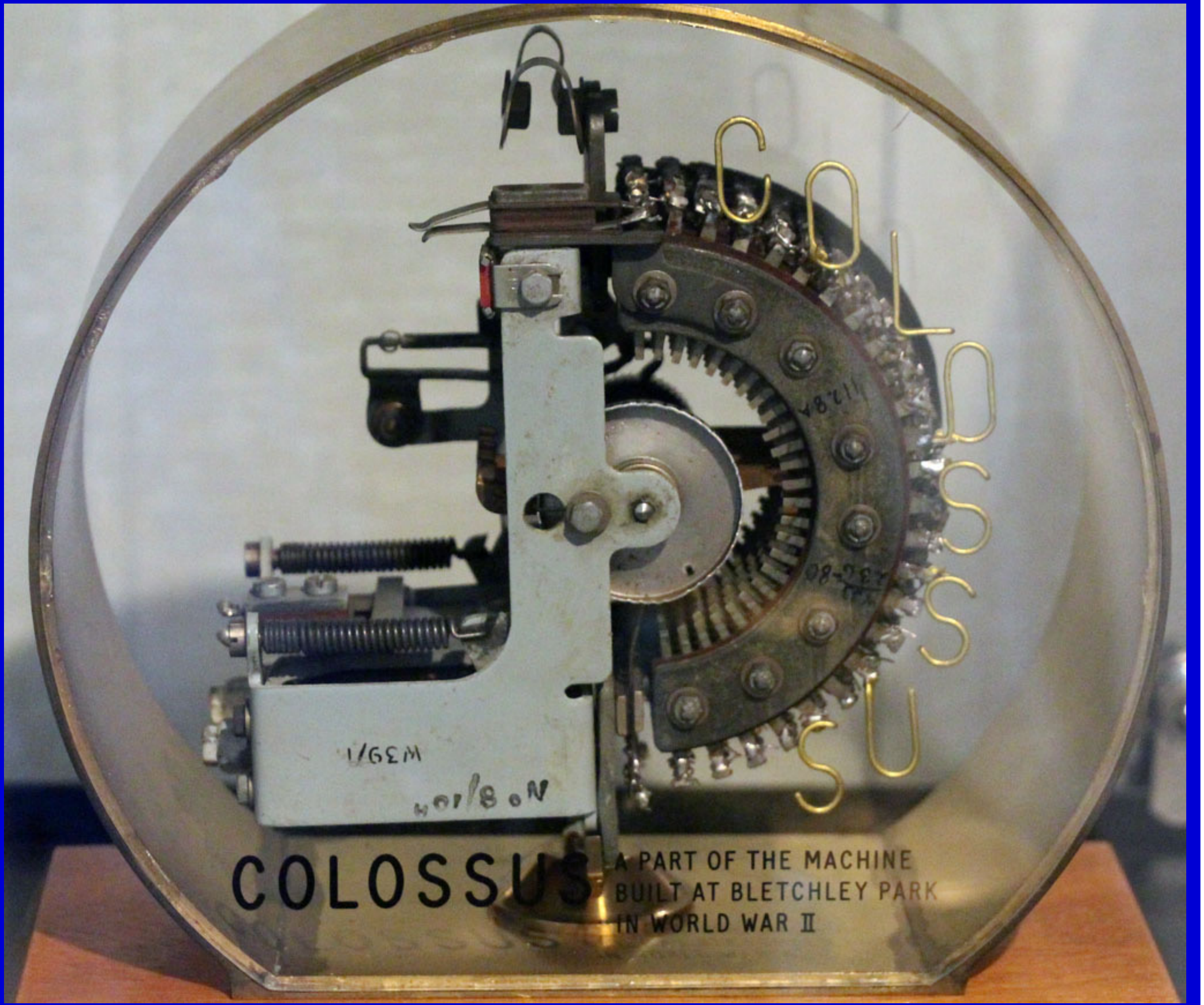
- Computers built with vacuum tubes were 1000 times faster than computers built with relays

Tunny



Colossus


MV45
FE40


COLOSSUS
COLOSSUS
A PART OF THE MACHINE
BUILT AT BLETCHLEY PARK
IN WORLD WAR II

Thing / Hardware - Colossus

- Firsts / Achievements / Uniqueness / Significance
  - Colossus was an electronic code breaking computer used during WWII by the British Foreign Office to decode German operational Lorenz (TUNNY) codes, and thus shortened the war
  - Colossus can now claim to be the first digital electronic computer, taking the title away from ENIAC. Colossus, however was a special purpose computer while ENIAC was a general purpose computer
  - Colossus had data storage + retrieval capability, parallel processing, ability to be programmed
  - Colossus was not a computer as calculator, it was a text-processing machine
  - Declassified in 1970's
- Place Produced (Company / Institution) ~ Year ~ Country
  - Post Office Research Station ~ 1943 ~ England
- People involved (Designer)
  - Designed by MHA Newman with the assistance of TH Flowers, AM Coombs and Alan Turing. The electromechanical prototype was built at Malvern by Wynn-Williams.
- Type
  - Special purpose mainframe computer
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Colossus

- Computing technology
  - Vacuum tubes were used for switching and for storing various patterns required during the code breaking process
  - Operated at electronic speed, used vacuum tubes for storing + processing data, circuits were binary, used symbolic logic
  - Patterns were set manually via plug in pins. Information from punched tape could be input at the fast speed of 5000 characters per second. Results were printed out by electric typewriter
- Computing speed (in MIPS)
  - Colossus could search intercepted radio messages for patterns at the rate of 25,000 characters per second
- Primary memory type / technology ~ Size ~ Word length
  - Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Operational at Bletchley Park from end of 1943, was a reverse engineered Lorenz
  - Was proto computer, programmed to decode electronically encrypted teletype traffic
  - Did no numerical calculation - it processed text
- Predecessors - N/A ~ Successors - Need for secrecy hindered transfer of knowledge to commercial sector

Computing Case Study Summary - Colossus

- Goal
  - Rapidly decode intercepted German Geheimschreiber (Fish) encrypted messages produced by Lorenz machines (TUNNY) so the results could be used against the Germans
  - Messages were at Army level or above (operational + strategic)
- Center of Gravity (Strategy)
  - Develop + use electronic computer to do this
- Technology / Equipment
  - Colossus - first digital modern electronic computer
    - 2,400 vacuum tubes
    - First completed in 1943 - 11 in service by end of war
    - Controlled by wired logic rather than stored program

- Colossus at Bletchly Park, Annals of the History of Computing, July 1983
- Glenn Zorpette, Breaking the Enemy's Code, IEEE Spectrum, Sept 1987

Computing Case Study Summary - Colossus

- Training ~ Leadership ~ Morale
  - Built by British Post Office Dollis Hills Research Station
- Tactics
  - By end of war decrypting 1,200 messages / month
- Intangibles ~ Mistakes
- Outcome
  - Never suspected by Germans ~ Kept secret until 1976

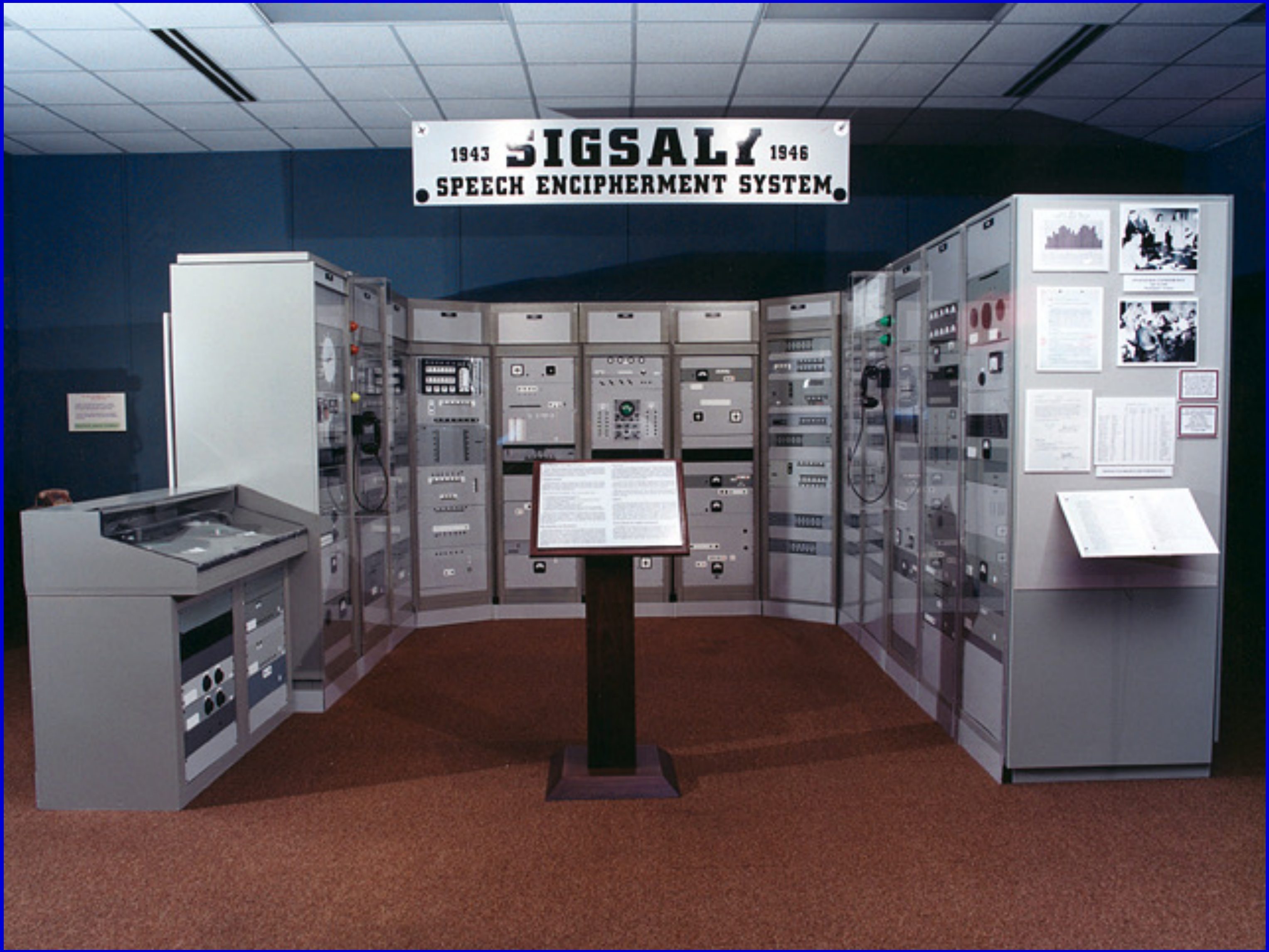
- Colossus at Bletchly Park, Annals of the History of Computing, July 1983
- Glenn Zorpette, Breaking the Enemy's Code, IEEE Spectrum, Sept 1987

The Influence of ULTRA in the Second World War

"Now the question remains how much did it shorten the war, leaving aside the contribution made to the campaigns in the Far East on which the necessary work hasn't been done yet. My own conclusion is that it shortened the war by not less that two years and probably by four years - that is the war in the Atlantic, the Mediterranean and Europe."

- Sir Harry Hinsley, historian who during the Second World War worked at Bletchley Park

SIGSALY



From Wikimedia Commons

SIGSALY Terminal
Cabinet War Rooms

Thing / Hardware - SIGSALY

- Firsts / Achievements / Uniqueness / Significance
  - Secure speech system used in World War II for high-level Allied communication
  - First transmission of speech using pulse-code modulation
  - Sounded like buzzing hornet to anyone eavesdropping
  - NSA claims this was start of digital revolution
- Place Produced (Company / Institution) ~ Year ~ Country
  - Bell Labs ~ 1943 ~ USA
- People involved (Designer)
  - A.B. Clark assisted by Alan Turing
- Type
  - Text
- Price / Cost
  - Text
- Size
  - 40 racks of equipment ~ Weighed 50 tons

- Paul Ceruzzi, Are Historians Failing to Tell the Real Story About the History of Computing?, IEEE Annals of the History of Computing, Jul-Sep 2014

Thing / Hardware - SIGSALY

- Computing technology
  - Used random noise mask provided on records to encrypt voice conversations that had been encrypted by vocodor
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Encrypted speech ~ 12 installations ~ First pair in Selfridges department store + Pentagon for Churchill + Roosevelt
- Predecessors - A-3 voice scrambler ~ Successors - N/A

- Paul Ceruzzi, Are Historians Failing to Tell the Real Story About the History of Computing?, IEEE Annals of the History of Computing, Jul-Sep 2014

Cypherpunks

- In 1976, computer scientist + cryptographer Whitfield Diffie, along with Martin Hellman, developed public key cryptography, which democratized the use of strong encryption
  - Every user has public + private key - public key is widely distributed, private key is closely held, and a message encoded with either key can be decoded with the other key
- In 1977, 3 MIT mathematicians - Ronald Rivest, Adi Shamir + Leonard Adleman developed algorithms which put Diffie's system into practice + called it RSA encryption + made it a product
  - RSA encryption keys can be any size (the prior encryption scheme - Data Encryption Standard (DES) developed by IBM had 56 bit keys, supposedly because the NSA could break it)
  - Cryptography genie was now out of bottle
- In 1991 Phillip Zimmerman, computer programmer + social activist, released Pretty Good Privacy (PGP) encryption as freeware worldwide using RSA's algorithms so now anyone could have strong encryption for free
  - "If privacy is outlawed, only outlaws will have privacy" - Phillip Zimmerman

- Steven Levy, Crypto Rebels, Wired, Feb. 1993

- Steven Levy, Battle of the Clipper Chip, New York Times, Jun. 12 1994

Cypherpunks

- Drawback is that cryptography shields law abiding + lawless equally
  - Law enforcement + intelligence agencies say if strong encryption is used widely they won't be able to protect public
- US Government's way to neutralize encryption = Clipper chip
  - Purpose of Clipper Chip was to make genie wear leash + collar
  - US Government wanted to create a cyberspace police state using Clipper chip
- Arrayed against US Government were Cypherpunks - computer hackers, hardware engineers, high-tech activists
  - Believe in "Crypto Anarchy" - where strong, easy-to-use encryption is accessible to all
  - Believe cryptography is silver bullet to help individuals reclaim privacy
  - Believe that cryptography is liberating tool that empowers individuals by protecting communications from government

- Steven Levy, Crypto Rebels, Wired, Feb. 1993

- Steven Levy, Battle of the Clipper Chip, New York Times, Jun. 12 1994

Cypherpunks

- Clipper chip used key escrow to neutralize encryption
  - Normally two parties communicate in total privacy using public key encryption using public + private keys
  - But Clipper chip used an additional key, created during telephone equipment manufacture, that is held by US Government in escrow. When US Government gets a court-approved wiretap, they withdraw the additional key from escrow and use it to defeat your encryption
  - With Clipper chip in phones, all telephone communication is private from everybody except the US Government
  - But key escrow reintroduced vulnerability that lead to development of public key cryptography - any system that relies on trusted third parties to hold keys is vulnerable to coercion and thus weak
- US Government's plan to make Clipper chip phone an industry standard was to require it on all government phones
  - Thus for companies + individuals who wanted to talk to the government they would need a Clipper chip phone, and rather than having two phones, everyone in the US would eventually end up with a Clipper chip phone
- Bottom line was a war between those who would liberate cryptography and those who would suppress it

- Steven Levy, Crypto Rebels, Wired, Feb. 1993

- Steven Levy, Battle of the Clipper Chip, New York Times, Jun. 12 1994

What Happened to the Clipper Chip?

"The Clipper proposal sought to have all strong encryption systems retain a copy of keys necessary to decrypt information with a trusted third party who would turn over keys to law enforcement upon proper legal authorization. We found at that time it was beyond the technical state of the art to build key escrow systems at scale. Governments kept pressing for key escrow, but Internet firms successfully resisted on the grounds of the enormous expense, the governance issues, and the risk. The Clipper Chip was eventually abandoned."

- Peter Neuman et.al., Keys Under Doormats, Communications of the ACM, Oct. 2015

On Encryption

"We recognize the importance our officials attach to being able to decrypt a coded communication under a warrant or similar legal authority. But the issue that has not been addressed is the competing priorities that support the companies' resistance to building in a back door or duplicated key for decryption. We believe that the greater public good is a secure communications infrastructure protected by ubiquitous encryption at the device, server and enterprise level without building in means for government monitoring."

...

"History teaches that the fear that ubiquitous encryption will cause our security to go dark is overblown. There was a great debate about encryption in the early '90s. When the mathematics of "public key" encryption were discovered as a way to provide encryption protection broadly and cheaply to all users, some national security officials were convinced that if the technology were not restricted, law enforcement and intelligence organizations would go dark or deaf.

As a result, the idea of "escrowed key," known as Clipper Chip, was introduced. The concept was that unbreakable encryption would be provided to individuals and businesses, but the keys could be obtained from escrow by the government under court authorization for legitimate law enforcement or intelligence purposes.

The Clinton administration and Congress rejected the Clipper Chip based on the reaction from business and the public. In addition, restrictions were relaxed on the export of encryption technology. But the sky did not fall, and we did not go dark and deaf. Law enforcement and intelligence officials simply had to face a new future. As witnesses to that new future, we can attest that our security agencies were able to protect national security interests to an even greater extent in the '90s and into the new century."

- Mike McConnell, Michael Chertoff, William Lynn, Why The Fear Over Ubiquitous Data Encryption is Overblown, Washington Post, Jul. 28, 2015

[Mike McConnell is the former director of the NSA. Michael Chertof is the former Secretary of Homeland Security]

[These views are also held by Michael Hayden, the former director of the NSA and the CIA]

Communications Case Study Summary - The Program

- Goal
  - No more 9/11's
- Center of Gravity (Strategy)
  - Create warrantless surveillance program that looks at everyone to find unknown conspirators
- Technology / Equipment
  - ThinThread - program that can capture + sort massive amounts of phone + email data but that would encrypt the privacy of individual Americans - but its privacy provisions were removed and it was up + running by summer 2002
- Training
  - Predecessor NSA programs included Shamrock (intercept overseas telegraph traffic) and Echelon (intercept Soviet Union + allies communications traffic)
- Leadership
  - President Bush authorizes the program ~ President Obama re-authorizes the program
- Morale
  - But it is legal? Many in the Justice Department including the Attorney General + Director of FBI think it is a violation of US Constitution
  - Director of National Intelligence lied to Congress about extent of program ~ Presidents Bush + Obama lied about extent of program to American people

- United States of Secrets, PBS Frontline, May 13 2014

Communications Case Study Summary - The Program

- Tactics
  - Look at everyone's phone, e-mail, text messages, Internet usage and financial transaction data
  - All US phone companies were turning phone metadata over to NSA + allowing NSA to tap their fiber optic Internet cables ~ Large Internet companies (Google / Yahoo / Microsoft / Facebook) were having their unencrypted data transfers over fiber optic cables surreptitiously tapped outside the US
  - Large Internet companies perform surveillance on their users for advertising purposes ~ NSA performs surveillance for law enforcement purposes
  - If courts allow surveillance for advertising, why not allow it for law enforcement?
  - By watching Google's tracking cookie, the NSA knows everything you look at on Internet
- Intangibles

  "You have this huge agency (the NSA) set up to prevent a surprise attack, and they learned about it (9/11) on a $300 television set tuned to CNN in the Director's office." - James Bamford
  - During the Nixon administration NSA had spied on Americans, Congress then made it illegal to do so, so it could not collect or connect the dots and that is why it missed 9/11
- Mistakes
  - There was so much work for the NSA to do it outsourced much work to private contractors and did not take proper security precautions, thus allowing Edward Snowden to make off with a large quantity of information about the program
- Outcome
  - Still currently in full operation

- United States of Secrets, PBS Frontline, May 13 2014

Two Sides of the Same Coin?

"In a sense, the tech companies are more like the NSA than they would like to think. Both have seized on the progress in computing, communications, and storage to advance their respective missions. (When you think of it, Google's original mission statement - "to collect and organize the world's information" - might also apply to the activity at Fort Meade.) Both have sought to fulfill those missions by amassing huge troves of personal information-and both offer trade-offs that seemingly justify the practice. Google, Facebook, and others argue that they can use that information to improve the lives of their customers far in excess of any discomfort that may come from sharing that data. The NSA believes that it's necessary to draw on that information to prevent a replay of 9/11 or worse. Both have established elaborate self-policing procedures to minimize abuse and claim to strictly follow the external constraints that limit their activities. When either makes a mistake, it invariably vows to do better-at least when its overreaches become public. Of course, the comparison goes only so far. If the NSA doesn't connect the dots, the door is open to catastrophe.

- Steven Levy, How the NSA Almost Killed the Internet, Wired, Jan. 2014

Why Did Snowden Do It?

"I am more willing to risk imprisonment or any other negative outcome personally, than I am willing to risk the curtailment of my intellectual freedom and that of those around me, who I care for equally as I do for myself."

- Edward Snowden

"I didn't want to change society. I wanted to give society a chance to determine if it should change itself…All I wanted was for the public to be able to have a say in how they are governed."

- Edward Snowden

Was Snowden Right to Do It?

"He has revealed evidence of what appears to be crimes against the Constitution of the United States."

- Al Gore, former US Vice President, November 6, 2013

NSA's surveillance is "significantly likely" to be unconstitutional

- Judge Richard Leon, Federal District Court of the District of Columbia, December 16, 2013

"He clearly violated the law so you can't say OK, what he did is all right. It's not. But what he revealed in the course of violating important laws included violations of the US constitution that were way more serious than the crimes he committed...In the course of violating important law, he also provided an important service. OK. Because we did need to know how far this has gone."

- Al Gore, former US Vice President, June 10 2014

The Final Word?

"Stop acting like the president takes an oath to keep us safe, when his job is to protect and defend the Constitution. Doing so keeps the American project safe. Past generations fought monarchies, slaveholders, and Nazis to win, expand, and protect that project. And we're so risk-averse -- not that we're actually minimizing risk -- that we're "balancing" the very rights in our Constitution against a threat with an infinitesimal chance of killing any one of us?"

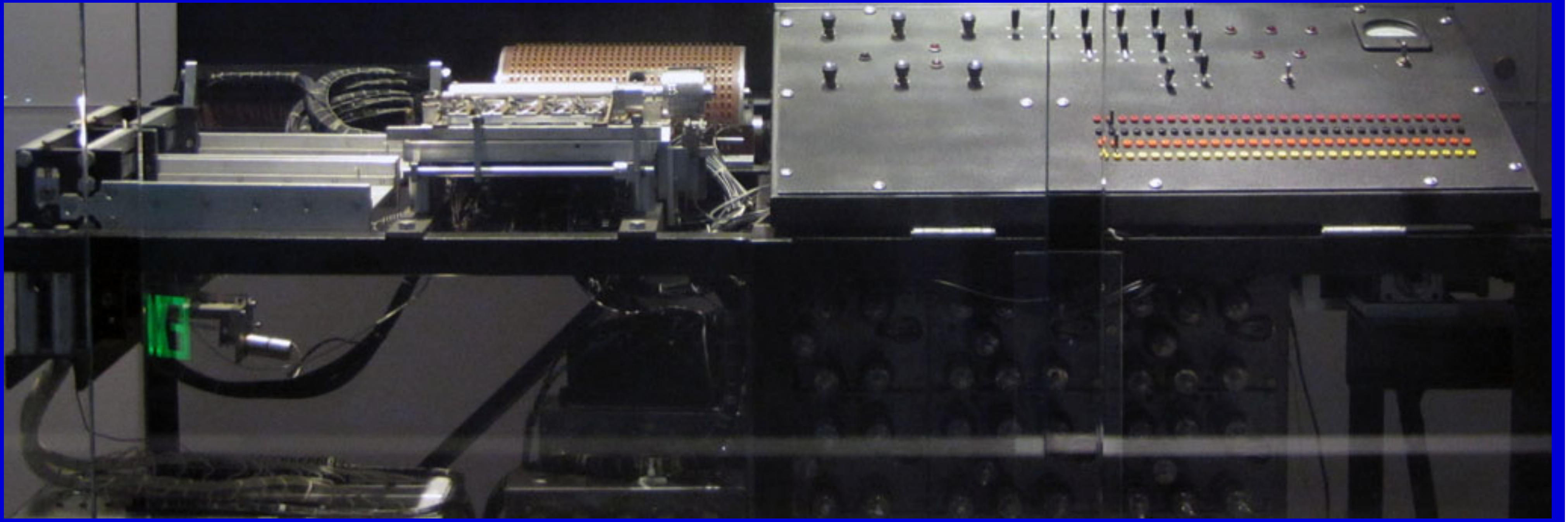
- Conor Friedersdorf, All the Infrastructure a Tyrant Would Need, Courtesy of Bush and Obama, The Atlantic, Jun. 7, 2013

Positive Control

- Negative control systems focus on detecting exceptions
  - Good behavior is expected, so system only takes action when failure occurs
- Positive control systems focus on continuous surveillance of potentially dangerous item (originally nuclear warheads, now people)
  - No information = danger
- Past attempts to apply positive control to complete societies failed (communism, fascism) due to lack of technology to allow for continuous surveillance
- But now, thanks to advances in technology, we are moving towards a society based on positive control, due to paranoia over terrorism
  - Problem - Everyone is a potential terrorist
  - Solution - Put everyone under positive control
- Positive control means continuous monitoring of your location, network usage, behavior with any lack of data flow being considered a dangerous act
  - Trying to hide means you have something to hide with any blocking of monitoring being made illegal
- There is no way to avoid this. It's already here and nobody cares

- John Robb, Positive Control, Global Guerillas, Jun. 21, 2013

Atanasoff Berry Computer



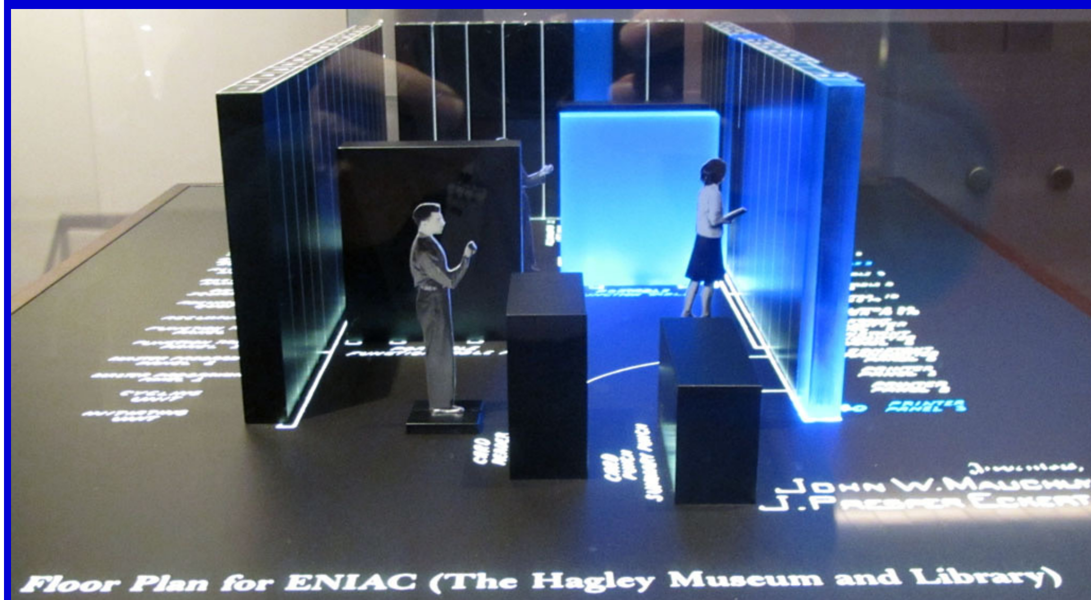
Thing / Hardware - Atanasoff Berry Computer (ABC)

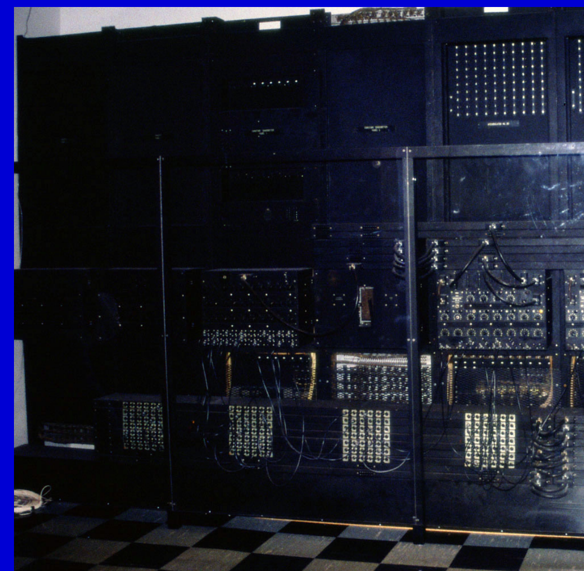
- Firsts / Achievements / Uniqueness / Significance
  - Amongst first to use electronic devices to do actual calculation
  - First American computer to use binary arithmetic and vacuum tubes for direct digital computation
  - Atanasoff's mind mined for ideas by John Mauchly for ENIAC in 1941
  - Broke broad ENIAC patents filed in 1964
  - Ultimately awarded patent for the computer rather than UNIVAC / Remington Rand [Mauchly /Eckert]
- Place Produced (Company / Institution) ~ Year ~ Country
  - Iowa State University ~ 1942 ~ USA
  - Drove hard from Ames Iowa to Quad Cities for a drink in Illinois road house, mind was cleared, worked for 3 hours in bar, made 4 decisions including use electricity + electrons and use base 2 instead of base 10 for economy
- People involved (Designer)
  - John Atanasoff, Clifford Berry
- Type
  - Mainframe computer
- Price / Cost
  - $7,000
- Size
  - 6' x 3' x 3'

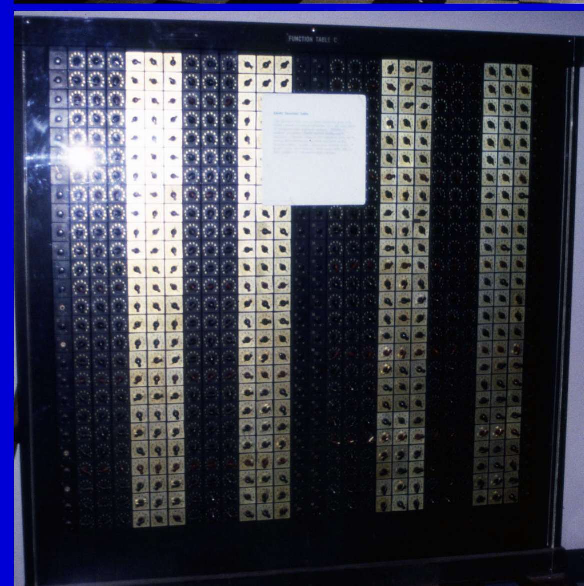
Thing / Hardware - Atanasoff Berry Computer (ABC)

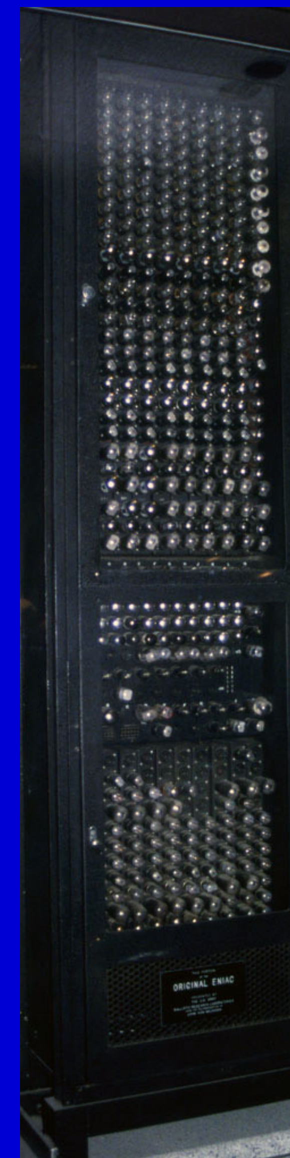
- Computing technology
  - Vacuum tubes, capacitors, cards
- Computing speed (in MIPS)
  - 32 add operations / second
- Primary memory type / technology ~ Size ~ Word length
  - Drums ~ 500 bytes of 64 50-bit words ~ 50 bits
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Solve linear algebra equations
- Predecessors - N/A ~ Successors - ENIAC

ENIAC









The Big Picture

CPU (above) + Function Table (below)

Rack

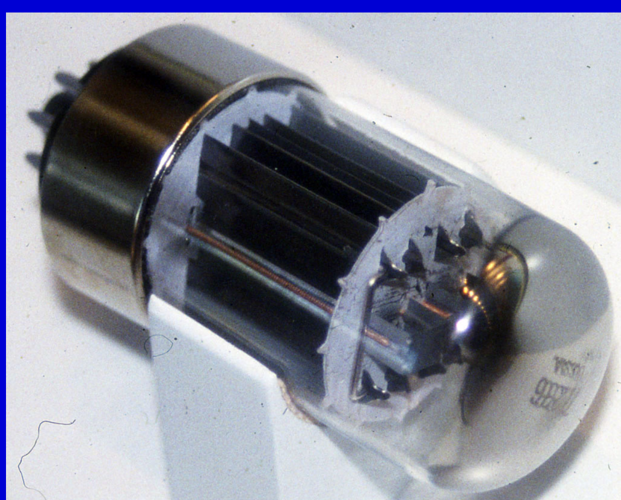
Thing / Hardware - Electronic Numerical Integrator and Computer (ENIAC)

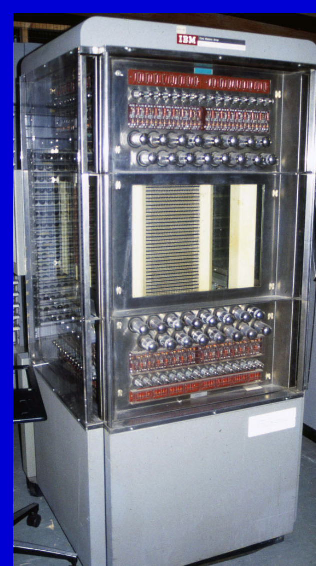
- **Firsts / Achievements / Uniqueness / Significance**
  - World's first regularly operated / successful general purpose and large scale digital electronic computer - but was not a stored program computer
  - Could be reprogrammed via function tables - you would rewire it for each new problem which took days to do but then it could calculate at electronic speed
  - Designers conceived stored program principle first because it was so difficult to program which leads to generalized version of ENIAC, the commercial UNIVAC-1
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - University of Pennsylvania Moore School of Engineering ~ 1946 ~ USA
- **People involved (designer)**
  - J Presper Eckert, John Mauchly, Herman Goldstine
- **Type**
  - Mainframe computer
- **Price / Cost**
  - $500,000
- **Size**
  - 1800 square feet, 30 tons, filled a 30' x 50' room
  - Used 160kw of energy when running

Thing / Hardware - Electronic Numerical Integrator and Computer (ENIAC)

- **Computing technology**
  - 18,000 vacuum tubes for storage + calculation
  - Programmed initially via plugboards
- **Computing speed (in MIPS)**
  - 1,000 instructions / second ~ 5,000 add operations / second ~ 360 multiplications per second
- **Primary memory type / technology ~ Size ~ Word length**
  - Flip flops, function table, plug board, cards ~ 20 words of 10 decimal digits (2,000 bytes) ~ 10 digits
- **Secondary memory type / technology ~ Size**
  - Text
- **Uses / Applications / Software**
  - Goal was to build electronic, digital version of analog differential analyzer
  - Used for design of nuclear weapons + ballistics tables + weather prediction
- **Predecessors - N/A ~ Successors - EDVAC, UNIVAC-1**

SAGE





Top - SAGE Direction Center / CPU
Bottom - Vacuum tube / Core Memory Stack / Display Console

Thing / Hardware - Semi Automatic Ground Environment (SAGE) AN/FSQ-7 (Whirlwind II)

- Firsts / Achievements / Uniqueness / Significance
  - Created belief there was a technical solution to nuclear war
  - Connected together by first large scale computer network
- Place Produced (Company / Institution) ~ Year ~ Country
  - IBM ~ Began in 1956, completed in 1963 ~ USA
- People involved (Designer)
  - Text
- Type
  - Mainframe computer
- Price / Cost
  - $8-12 billion
- Size
  - 15,000 square feet - largest computer ever built - 2 CPUs for redundancy
  - 40,000 square feet for each two-system installation
  - 3 Megawatts of power per system

Thing / Hardware - Semi Automatic Ground Environment (SAGE) AN/FSQ-7 (Whirlwind II)

- Computing technology
  - 55,000 vacuum tubes (30,000 tubes per system x 2 systems per installation), 175,000 diodes, 13,000 transistors, and 7,000 plug-in units all of which consumed 3 million watts of power
  - The operator queried the system and directed actions by pointing a light-gun at the screen
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Magnetic core ~ 4 kilobytes ~ 32 bits
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Air defense system linking radars, aircraft, anti-aircraft missiles + command centers designed to protect the United States against manned bomber attack
  - Collect + analyze radar data in real time, compute paths of incoming bombers, calculate course for US fighter jets to intercept them, communicate data to fighter jets and surface to air missiles
- Predecessors - Whirlwind ~ Successors - First air traffic control systems, SABRE airline reservation system, Safeguard Antiballistic Missile (ABM) system

Computing Case Study Summary - Semi Automatic Ground Environment System (SAGE)

- Goal
  - Make the sky transparent / automate control of air defense
- Center of Gravity (Strategy)
  - Radar based early warning system using centralized network computer control
- Technology / Equipment
  - AN/FSQ-7 computer (Whirlwind II)
    - Outgrowth of Whirlwind real time flight simulator designed to replace Link trainer
    - A computer you could walk inside of
    - 15,000 square feet in size, largest computer every built
    - 50,000 vacuum tubes consuming 3 million watts of power
    - 2 CPUs with warm standby
  - System
    - 3 SAGE Combat Centers + 23 SAGE Direction Centers, each approximately 100-150,000 square feet in size

- SAGE Special Issue, Annals of the History of Computing, October 1983
- Vigilance and Vacuum Tubes: The SAGE System, 1956-1963, The Computer History Museum, May 19, 1998
- Gordon Bell, The Computer Museum's First Field Trip: The Northbay AN/FSQ-7 SAGE Site, Communications of the ACM, Feb 1983
- Paul N. Edwards, The Closed World: Computers and the Politics of Discourse in Cold War America

Computing Case Study Summary - Semi Automatic Ground Environment System (SAGE)

- Technology / Equipment
  - Innovations
    - Magnetic core memory
    - Duplex standby system gave four 9's reliability (99.99%)
    - Digital communications network over phone lines with modems
    - Real-time computing
    - Time sharing
    - Marginal checking
    - CRT display + light gun
    - Long lasting vacuum tubes
- Training ~ Leadership ~ Morale ~ Tactics
  - Deployed 1958-1961 ~ Decommissioned 1982
  - Laid foundations for US computer industry by advancing state of the art + training a generation of hardware + software engineers
    - 20% of world's programmers worked on it

- SAGE Special Issue, Annals of the History of Computing, October 1983
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- Paul N. Edwards, The Closed World: Computers and the Politics of Discourse in Cold War America

Computing Case Study Summary - Semi Automatic Ground Environment System (SAGE)

- Intangibles
  - Very expensive
  - Vulnerable to jamming
  - It's got to work right the first time!
- Mistakes
  - Co-located at SAC bases to take advantage of SAC lifestyle
  - Had no performance specifications as air defense system
  - Made obsolete by ICBM
- Outcome
  - IBM built hardware - led to their dominance of computer industry
  - Led to air traffic control system + SABRE airline reservation system
  - Created belief there was a technical solution to nuclear war

- SAGE Special Issue, Annals of the History of Computing, October 1983
- Vigilance and Vacuum Tubes: The SAGE System, 1956-1963, The Computer History Museum, May 19, 1998
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Computing Case Study Summary - Safeguard Anti-Ballistic Missile (ABM) System

- **Goal**
  - **Provide defense against Soviet ballistic missile threat**
- **Center of Gravity (Strategy)**
  - **From Nike-Zeus (point defense) to Sentinel (US population defense) to Safeguard (US missile field defense) to defending single missile field near Grand Forks North Dakota**
- **Technology / Equipment**
  - **Radars - Perimeter Acquisition Radar for long range tracking / Missile Site Radar for guiding Spartan + Sprint interceptors to targets**
  - **Missiles - Spartan long range missile / Sprint short range missile**
  - **Computers - SAGE on steroids ~ Largest programming project up to that time ~ Run by Western Electric ~ Written in assembly language for speed ~ Shaving microseconds off the program would let them save more cities ~ Ran on UNIVAC fault tolerant computers ~ Would have worked against non-MIRVed enemy**

- Mark A. Berhow, US Strategic and Defensive Missile Systems 1950-2004 pp.30-36

Computing Case Study Summary - Safeguard Anti-Ballistic Missile (ABM) System

- Training ~ Leadership ~ Morale
  - This is a computer system with a number of computer programs that have to work perfectly the first time…or else - doubt over whether it can…
  - Is the video game Missile Command a good simulation of this?
- Tactics
  - First intercept incoming warheads in space with 5 MT nuclear warhead from Spartan, then intercept those that get through in atmosphere with low KT warhead on Sprint

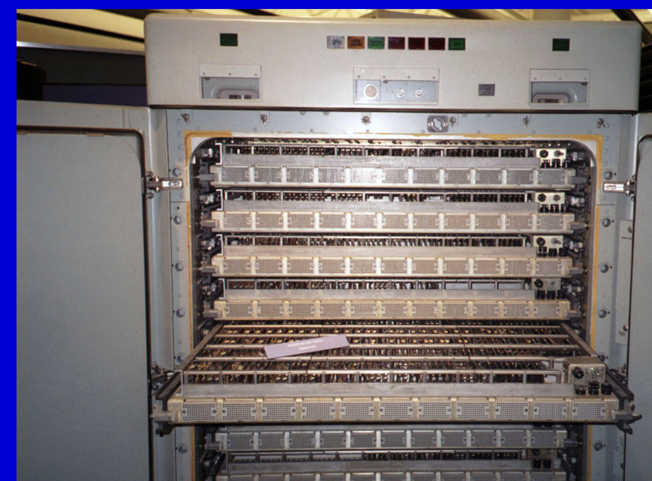
  - Mark A. Berhow, US Strategic and Defensive Missile Systems 1950-2004 pp.30-36

Computing Case Study Summary - Safeguard Anti-Ballistic Missile (ABM) System

- Intangibles / Mistakes
  - What is the effect of Electro magnetic pulse (EMP) from system's nuclear warhead explosions on the system's operation?
  - What is the effect of radiation from system's nuclear warhead explosion on population you are defending?
  - How can Spartan avoid being overwhelmed by decoys in space?
  - How can Sprint avoid being overwhelmed by multiple independent reentry vehicles (MIRVs)?
- Outcome
  - 99.5% uptime
  - Ultimately limited to 1 site with 100 missile launchers by SALT I ABM treaty
  - Shut down by vote of Congress 8 months after deployed in 1975 for stated fiscal reason of it being too expensive a system to defend only 1 missile field…and for unstated reason of belief in the doctrine of Mutually Assured Destruction (MAD) rather than defense
  - For the first time, offense (MIRVs) become cheaper than defense (ABM)

- Mark A. Berhow, US Strategic and Defensive Missile Systems 1950-2004 pp.30-36

Naval Tactical Data System (NTDS)



Combat Information Center (CIC)
NTDS

Thing / Hardware - Naval Tactical Data System (NTDS)

- Firsts / Achievements / Uniqueness / Significance
  - US Navy answer to US Air Force SAGE
- Place Produced (Company / Institution) ~ Year ~ Country
  - Remington-Rand UNIVAC ~ 1962 ~ USA
- People involved (Designer)
  - Seymour Cray
- Type
  - Mainframe computer
- Price / Cost
  - $500, 000
- Size
  - 50 cubic feet

Thing / Hardware - Naval Tactical Data System (NTDS)

- Computing technology
  - Transistors
- Computing speed (in MIPS)
  - 9.6 microseconds / add
- Primary memory type / technology ~ Size ~ Word length
  - Magnetic core ~ 32,000 words ~ 30 bits
- Secondary memory type / technology ~ Size
  - Magnetic drum + magnetic tape
- Uses / Applications / Software
  - Automate Combat Information Center on ships to help them manage subsurface, surface, air threats
  - Hard to get it to work correctly
- Predecessors - SAGE ~ Successors - N/A

Computing Case Study Summary - Virtual Naval Hospital

- **Goal**
  - Maximize readiness by creating + curating medical digital library that can be used as Medical reference / Health promotion / Knowledge management tool
- **Center of Gravity (Strategy)**
  - Function as unofficial depository library for Navy Medicine
- **Technology / Equipment**
  - Linux ~ Apache ~ Lowest common denominator Web technology ~ CD-ROMs
- **Training**
  - Used Web so none required
- **Leadership + Morale**
  - Key intermediaries ~ very high morale
- **Tactics**
  - Needs assessment ~ Problem based interface ~ Focus on nomadic user ~ Continuous quality improvement

Computing Case Study Summary - Virtual Naval Hospital

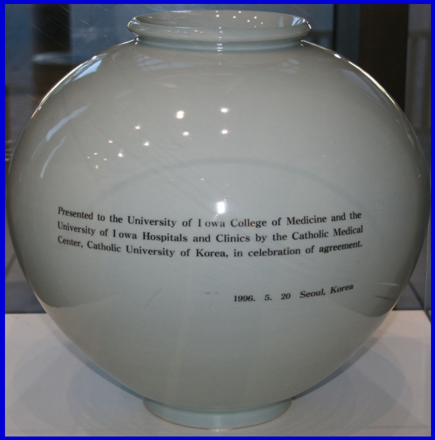
- Intangibles
  - Biggest advantage was being outsiders to Navy Medicine
- Mistakes
  - Biggest disadvantage was being outsiders to Navy Medicine
- Outcome
  - Maximized readiness
  - Heavily used, highly regarded, economically cost effective
  - To succeed…one must focus initially and then consistently on population served and what their mission is and tailor digital library to their needs
    - Result will be a tool that is heavily used + sincerely appreciated
  - Consistently over delivered + came in under budget -> defunded
  - Our focus was in operating with Sailors and Marines at the tip of the spear…not in operating within BUMED bureaucracy
  - Once our clinical champion in Navy retired, we were taken out politically
  - Like all good veterans, continued to serve

Personal Case Study: One Professor's Contracting Odyssey

- Virtual Naval Hospital (www.vnh.org)
  - Digital library to promote wellness in Sailors + Marines and aid disease correction by health care providers
  - Budget creep while doing the same job the whole time
    - FY1996 - $180,000 ~ 10 page contract ~ I understood 50% of it
    - FY 2005 - $360,000 ~ 20 page contract ~ I understood 5% of it
    - Funding agencies: SPAWAR->NMIMC->Navy Medical Logistics Command
  - Success
    - User-centric, well received, tri-service, international, military + civil usage, cost-effective
    - …so naturally it was canceled because it made the Navy look bad…

"You should get it funded through an earmark, it would be an earmark we would actually use for once" - SOCOM operator

Personal Case Study - How to Make (Military) Friends and Influence People



- **Top down**
  - "Presented to the University of Iowa College of Medicine and the University of Iowa Hospitals and Clinics by the Catholic Medical Center, Catholic University of Korea, in celebration of agreement. 1996.5.20 Seoul, Korea"
- **Bottom up**
  - "Please accept this book on the first Olympics as a small token of appreciation from the Hellenic Navy Medical Directorate for your supply of Virtual Naval Hospital CD-ROMs to us." - CDR K.N., M.D., Hellenic Navy

  - Another great example of bottom up
    - Russian FAO - Colonel Tom Wilhelm in Mongolia
      - "Colonel Wilhelm is a great man. He makes us like America so much." - Mongolian officer

- Robert D. Kaplan, The Man Who Would Be Khan, The Atlantic, March 2004

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- What were the computational challenges facing Great Britain and the US in World War II?
- Who were Hopper and Turing and what did they contribute to solving these challenges?
- What is the significance of the Harvard Mark I, Enigma/Bombe, Colossus, Atanasoff Berry Computer, ENIAC, and SAGE in addressing these challenges?
- Why was Bletchley Park an important place?
- Why are computing and codebreaking such close bedfellows?
- What is the fundamental problem with computers that use relays as their building blocks?
- What is the fundamental problem with computers that use vacuum tubes as their building blocks?
- Why does war lead to such rapid technological advances?
- How did war advance the development of computing?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History - Chapter 2 The First Computers
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
- Simulations

Conclusion

"It is the first and last machine to have a truely major psychological impact on the observer. You could hear it, you could see it and everything progressed at a speed compatible with human senses. Since then computers have become nothing but boxes that you have to assume something is going on inside of."

- Jay Forrester, computer engineer, on the Harvard Mark I

Topic 7

Computers in the Electronic Era

Song

There's a thrill in store for all,
For what we're about to toast.
The corporation known in every land.
We're here to cheer each pioneer
And also proudly boast,
Of that "man of men" our friend and guiding hand.
The name of T. J. Watson means a courage none can stem,
And we feel honored to be here to toast the I. B. M.

Ever Onward! Ever Onward!
That's the spirit that has brought us fame.
We're big but bigger we will be,
We can't fall for all can see,
That to serve humanity has been our aim.
Our products now are known in every zone,
Our reputation sparkles like a gem.
We've fought our way through
And new fields we're sure to conquer, too,
For the Ever Onward I.B.M!
- IBM Song Book, Ever Onward, 1931

Thematic Quote

"I think there is a world market for maybe five computers."

- Thomas Watson, chairman of IBM, 1943

Thematic Quote

"I am thinking about something much more important than bombs. I am thinking about computers."

- John von Neumann, mathematician, 1946

The Painting

Computer Architecture

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - Vacuum tube and Vacuum tube radio
- Year
  - Early 1950's
- Story

The Question

How did such a diversity of choices amongst mainframe vendors get effectively narrowed down to one dominant vendor - IBM?

["Snow White and the Seven Dwarfs" - IBM and Burroughs / UNIVAC / NCR / Control Data Corporation / Honeywell / General Electric / RCA]

John von Neumann

From Wikimedia Commons

Person - John Von Neumann

- Significance
  - Wrote first description of a stored program computer in 1945
    - "First Draft of a Report on the EDVAC (Electronic Discrete VAriable Computer) - Seminal description of first stored program computer, summarized discussion of ENIAC successor
    - 1946 series of lectures on "Theory and Techniques for Design of Electronic Digital Computers" at Moore School in Philadelphia leads to widespread adoption of EDVAC type design / Von Neumann architecture / stored program computer
    - Although credited with idea of stored program computer his conception was influenced by working with Eckert + Mauchly and familiarity with Turing's work
  - In 1946 described IAS computer and its parallelism in Arthur Burkes, Herman Goldstine, John Von Neumann "The Preliminary Discussion of the Logical Design of an Electronic Computing Instrument"
    - Described general principles of computer architecture - Von Neumann architecture
- Profession
  - Mathematician
- Places worked
  - Institute for Advanced Study
- Years of work
  - 1945-1957
- Things worked on
  - Carried out calculations on atomic bomb

First Draft of a Report on the EDVAC

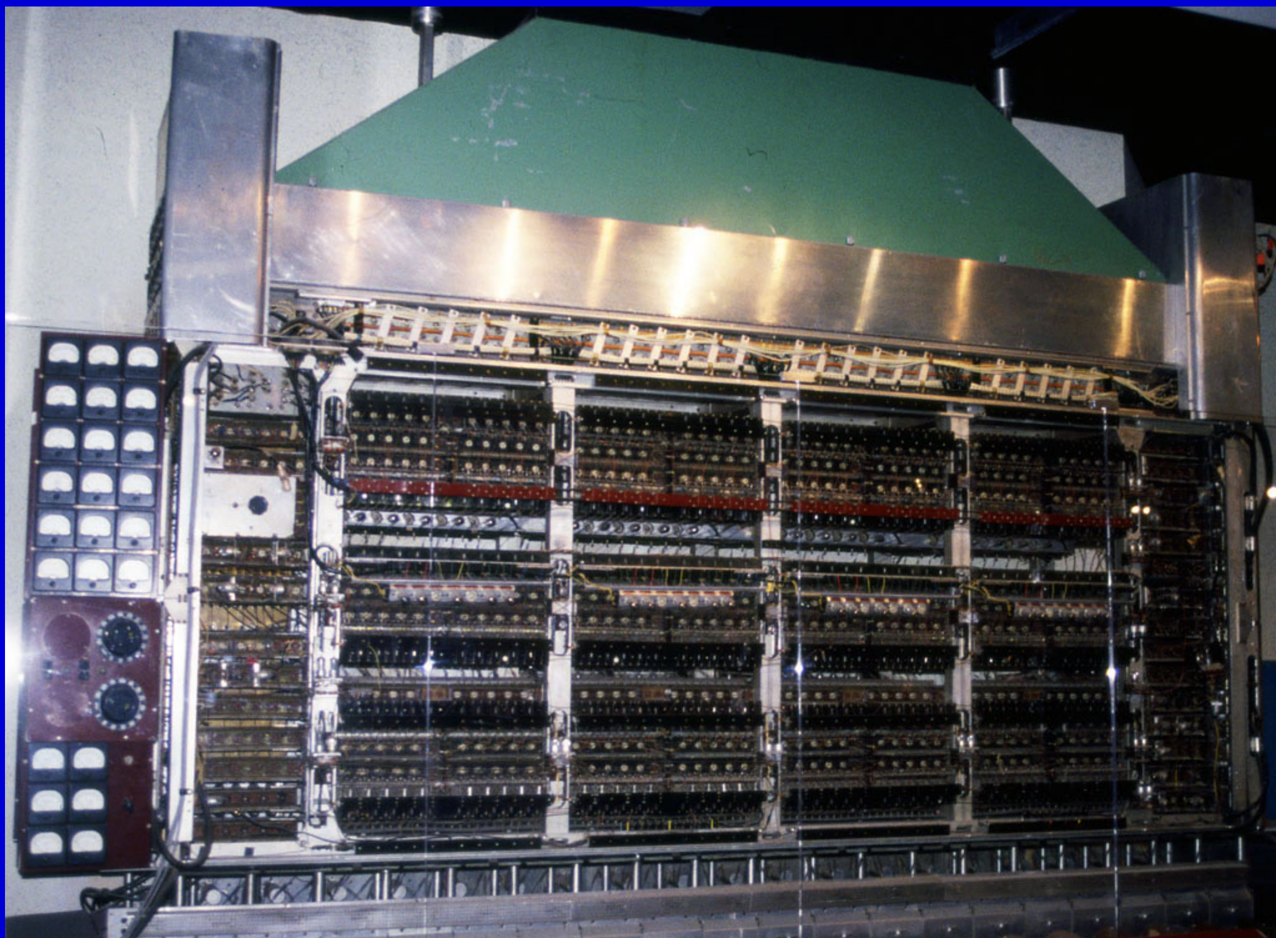
- Contains 3 ideas
  - EDVAC Hardware Paradigm - describes electronic binary computer with much larger memory than anything previously built
  - Von Neumann Architecture Paradigm - sets out basic structure of modern computer
  - Modern Code Paradigm - describes concept of stored program computer
- These ideas taken together allowed the construction of computers that were cheaper, smaller, more reliable + flexible than predecessors
  - ENIAC, first general purpose electronic digital computer had 18,000 vacuum tubes
  - Immediate successors had 1,000 - 2000 vacuum tubes

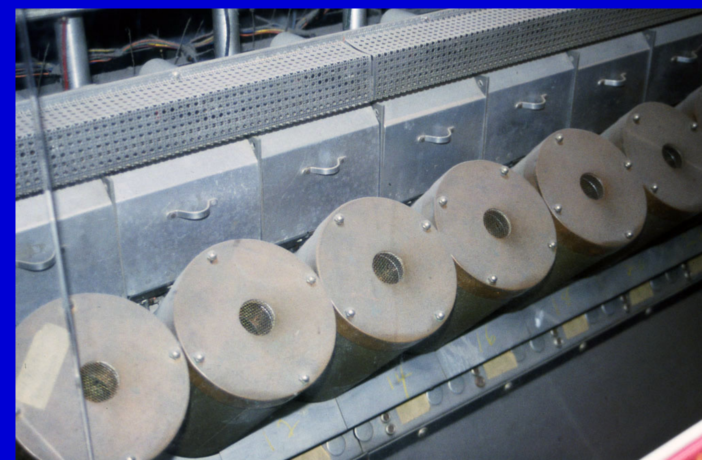
- Thomas Haigh, Actually Turing Did Not Invent the Computer, Communications of the ACM, Jan. 2014

Place - Institute for Advanced Study

- Significance
  - Open sourced the design + architecture of computers for all to use
- Location
  - Princeton University
- Definition
  - Research center for theoretical research + intellectual inquiry
- People who worked there
  - John Von Neumann
- Things created there
  - IAS computer design

Institute For Advanced Studies (IAS) Computer



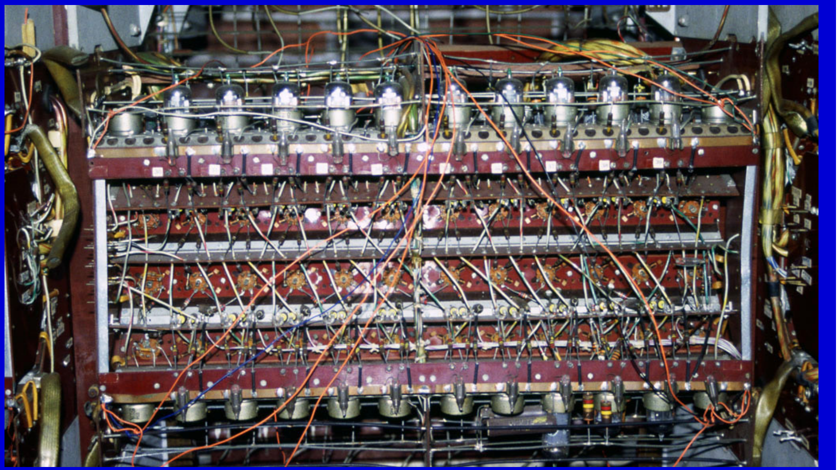


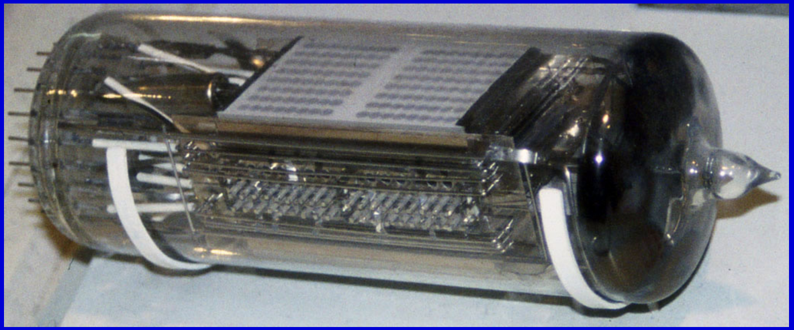
CPU

Williams-Kilburn Tube Memory

JOHNNIAC

Central Processing Unit





Vacuum tube registers (above)
Selectron tube memory (below)

Thing / Hardware - Institute for Advanced Study (IAS) Computer

- **Firsts / Achievements / Uniqueness / Significance**
  - Stored program, general purpose, high speed, electronic, digital computer
  - Among the first American computers to have stored programs
  - This is the first example of the von Neumann architecture
  - Spawned several similar machines due to open sourcing of design
  - IBM 701 based on it for engineering computing
  - Parallel computer - arithmetic operations carried out in parallel
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Institute For Advanced Study ~ 1952 ~ US
- **People involved (Designer)**
  - John Von Neumann, Arthur Burks, Herman Goldstine, Julian Bigelow (engineer), James Pomerene
- **Type**
  - Mainframe computer
- **Price / Cost**
  - $500,000
  - [JOHNNIAC = $487,000]
- **Size**
  - 100 square feet ~ 6' x 2.5' x 10' [22 square feet + 1,000 pounds]
  - [JOHNNIAC weighed 5,000 pounds]

Thing / Hardware - Institute for Advanced Study (IAS) Computer

- Computing technology
  - 4,600 vacuum tubes, electrostatic tubes ~ [JOHNNIAC had 5,000 vacuum tubes]
- Computing speed (in MIPS)
  - 1,000 instructions / second ~ 14,000 operations / second
- Primary memory type / technology ~ Size ~ Word length
  - Cathode ray tubes (Williams-Kilburn Tubes) - 40 of them ~ 1024 words [5 kilobytes] ~ 40 bits
  - [JOHNNIAC used Selectron tubes - 40 of them each containing 1,024 bits ~ 1,024 words ~ 40 bits]
- Secondary memory type / technology ~ Size
  - Drum memory ~ 16,384 words
- Uses / Applications / Software
  - Hydrogen bomb design, evolutionary biology (artificial life), weather forecasting
- Predecessors - N/A ~ Successors - IBM 701
  - Computers built to IAS blueprints include JOHNNIAC at RAND, ILLIAC at University of Illinois, WEIZAC in Israel, CILIAC in Australia, MANIAC at Lost Alamos

Privacy Has Always Been a Concern

"The computer will touch men everywhere and in every way, almost on a minute-to-minute basis. Every man will communicate through a computer, whatever he does. It will change and reshape his life, modify his career, and force him to accept a life of continuous change."

- Willis Ware in 1966, electrical engineer who helped build IAS Computer

"Willis Ware laid the foundation for modern privacy laws. His insight was that in the computer age, organizations that collected private information would have to take responsibility, and individuals who gave up personal information would need to get rights."

- Marc Rotenberg, executive director of Electronic Privacy Information Center

- John Markoff, Willis Ware, 93, Engineer at Dawn of Computer Age, Dies, New York Times, Dec. 1, 2013

"Do not fold, spindle, or mutilate"

- Warning printed on every IBM punched card

- Office workers would organize papers by folding them together, sticking them on a spindle, or stapling (mutilating) them
- Because any such damage to a punch card makes it unreadable, this warning was printed on every card
- Students adopted it as a battle cry against authority

Thing / Hardware - Manchester Baby

- Firsts / Achievements / Uniqueness / Significance
  - First stored program computer (first real computer)
  - Prototype of Manchester Mark I (1949)
- Place Produced (Company / Institution) ~ Year ~ Country
  - Manchester University ~ June 21, 1948 ~ England
- People involved (Designer)
  - Tom Kilburn + Geoff Tootill + Freddie Williams (CRT memory)
- Type
  - Mainframe computer
- Price / Cost
  - Text
- Size
  - 16 feet long ~ Weighed 0.5 tons

Thing / Hardware - Manchester Baby

- **Computing technology**
  - **Vacuum tubes**
- **Computing speed (in MIPS)**
  - **Text**
- **Primary memory type / technology ~ Size ~ Word length**
  - **Cathode ray tubes (Williams-Kilburn Tubes) ~ 32 words ~ 31 bits**
- **Secondary memory type / technology ~ Size**
  - **Text**
- **Uses / Applications / Software**
  - **Built to test cathode ray tube Williams-Kilburn tube memories**
- **Predecessors - N/A ~ Successors - Manchester Mark I**
  - **Manchester Mark I led to Ferranti Mark 1 which was world's first commercial computer in February 1951**

Thing / Hardware - Electronic Delay Storage Automatic Computer (EDSAC)

- Firsts / Achievements / Uniqueness / Significance
  - The first practical stored program computer used regularly in operation, the EDSAC first ran on May 6, 1949.
  - Commercialized as LEO the Automatic Computer, the first business computer in 1951, which computerized the Lyons Tea Shop company's inventory in 1953
- Place Produced (Company / Institution) ~ Year ~ Country
  - Cambridge University ~ 1949 ~ England
- People involved (Designer)
  - Maurice Wilkes
- Type
  - Mainframe computer
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Electronic Delay Storage Automatic Computer (EDSAC)

- **Computing technology**
  - Vacuum tubes
- **Computing speed (in MIPS)**
  - 714 operations / second
- **Primary memory type / technology ~ Size ~ Word length**
  - Mercury delay line ~ 1,000 words ~ 17 bits
  - Eventually, EDSAC had 32 long mercury delay lines and 2 short mercury delay lines.
- **Secondary memory type / technology ~ Size**
  - Text
- **Uses / Applications / Software**
  - The Cambridge group, lead by Maurice Wilkes, went on to specialize in programming techniques and in the creation of the EDSAC II and in modifications to Atlas
- **Predecessors - EDVAC ~ Successors - LEO I**

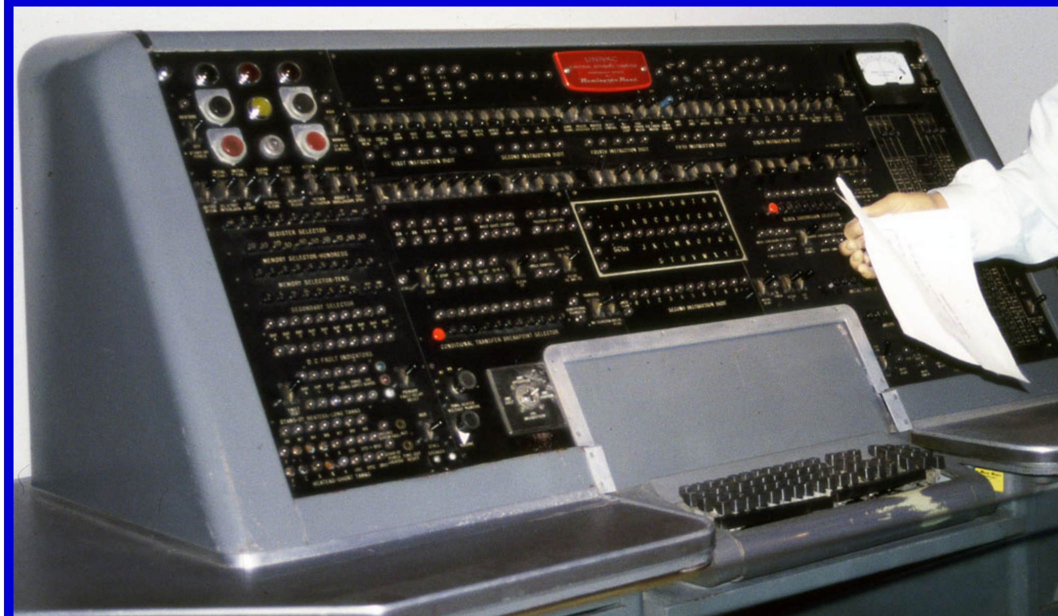
Thing / Hardware - EDVAC

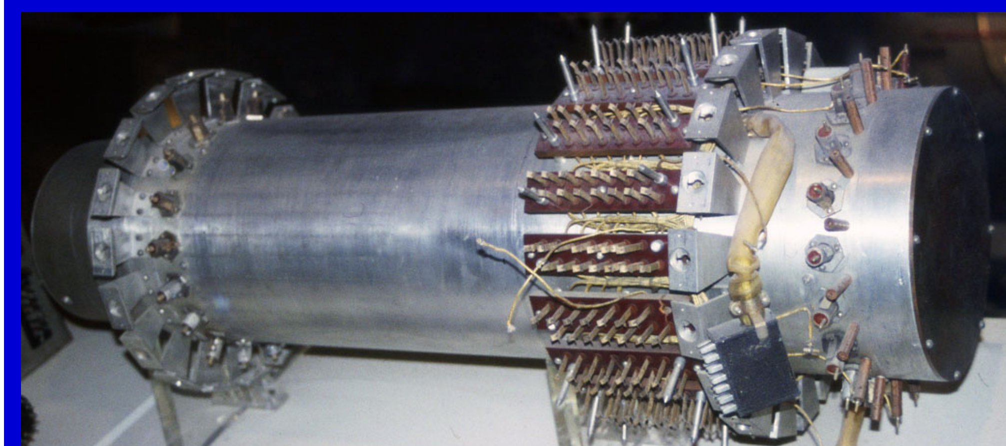
- **Firsts / Achievements / Uniqueness / Significance**
  - Stepping stone between ENIAC and UNIVAC-1
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Moore School University of Pennsylvania ~ 1951 ~ USA
- **People involved (Designer)**
  - J Presper Eckert, John Mauchly
- **Type**
  - Mainframe computer
- **Price / Cost**
  - $467,000
- **Size**
  - 480 square feet, 17,000 pounds

Thing / Hardware - EDVAC

- Computing technology
  - Vacuum tubes
- Computing speed (in MIPS)
  - 1,200 operations / second
- Primary memory type / technology ~ Size ~ Word length
  - Mercury delay lines ~ 1,024 words x 44 bits
- Secondary memory type / technology ~ Size
  - Memory drum ~ 4,608 words
- Uses / Applications / Software
  - Ballistic tables
- Predecessors - ENIAC ~ Successors - UNIVAC-I

UNIVAC-1





Top - Control Console / CPU + UNITYPER + Mercury Pool Acoustic Memory
Bottom - Mercury Pool Acoustic Memory Tank Holding 18 mercury delay lines (two views) + UNISERVO tape drive

Thing / Hardware - Universal Automatic Computer (UNIVAC-I)

- Firsts / Achievements / Uniqueness / Significance
  - First commercially sold computer in the US that was used for scientific and business data processing
  - Conceived as general purpose computer that could be programmed to do anything
  - First one to US Census Bureau
  - Made it clear electronic computers would replace mechanical + electromechanical tabulating machines of earlier era
  - COBOL developed on it
  - November election 1952 - first time many people saw a computer, became public's idea of what computer looked like, UNIVAC predicted landslide victory for Eisenhower over Stevenson after looking at just a small voter sample in key states but wasn't believed and not allowed to speak
  - Still in public mind as the Jetson's computer UNIBLAB
- Place Produced (Company / Institution) ~ Year ~ Country
  - Eckert Mauchly Computer Corporation -> Remington Rand ~ 1951 ~ USA
- People involved (Designer)
  - J Presper Eckert, John Mauchly, Grace Hopper (languages + programming)
- Type
  - Mainframe computer
- Price / Cost
  - $750,000 + $185,000 for high speed printer
- Size
  - 943 cubic feet, filled a room 25' x 50'
  - 1000 cubic feet for processing unit
  - Weight was 16700 lbs
  - Power consumed was 124.5 kilowatts with 4 Uniservo tape drives

Thing / Hardware - Universal Automatic Computer (UNIVAC-I)

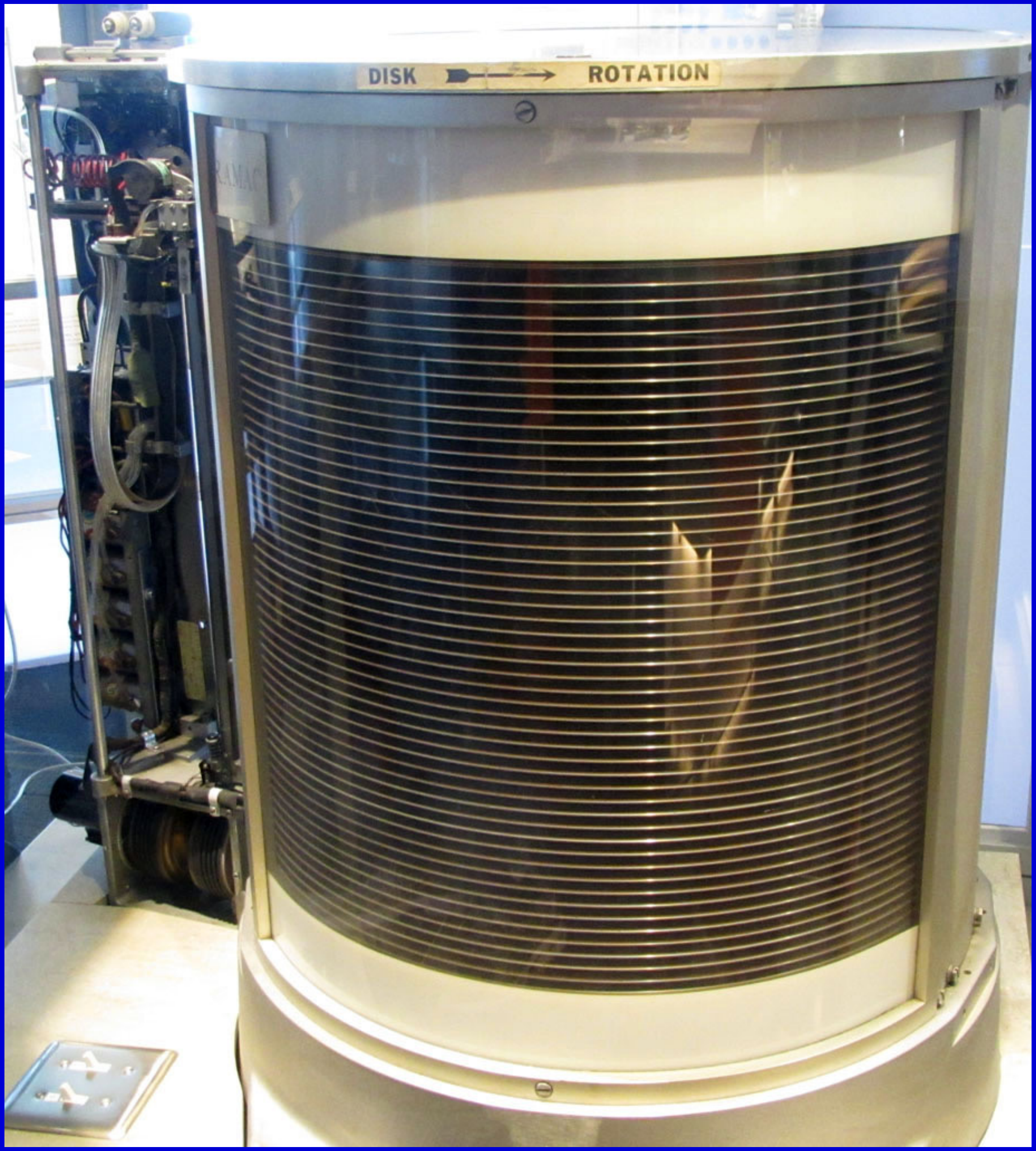
- **Computing technology**
  - 5,000 vacuum tubes, mercury delay lines, magnetic tape
  - Architecture consisted of serial processing of alphanumeric characters and binary coded decimal arithmetic with 63 single address instructions were available
  - Input / output devices were printers, magnetic tapes, punch cards
- **Computing speed (in MIPS)**
  - 1,905 operations / second
  - 525 microseconds / add
  - UNIVAC-1's calculation speed was 1/4011th of an average 1991 PC. It's calculation speed was 1900 additions per second and it had a clock rate of 2.25 million cycles per second
- **Primary memory type / technology ~ Size ~ Word length**
  - 7 acoustic delay line / mercury delay line memory tanks with 400 microsecond maximum access time ~ 1024 words ~ 12 decimal digits
  - Each tube weighed 800 pounds when filled with mercury
  - UNIVAC-1's word length was 11 decimal digits and a sign, and 2 instructions could be stored in a word ~ Memory width was 72 bit (decimal)
- **Secondary memory type / technology ~ Size**
  - Magnetic tape with 120,000 words on a 1500 foot reel ~ Customers could no longer hold their data (in the form of punch cards) in their hands
- **Uses / Applications / Software**
  - Total of 46 built
  - Early compilers, short code A-O
  - Data processing by businesses + governments, replace tabulating machines
- **Predecessors - ENIAC / EDVAC ~ Successors - IBM System 360**

Tape Uber Alles

- Tape is oldest computer storage medium still being used - first used in UNIVAC-I in 1951
- Tape sales had been falling up to 2012, but started rising again in 2013 - Why?
- Tape has 6 advantages over hard disks for long-term preservation of data
  - Speed
    - Extracting data from tape is 4 times faster than reading it from hard disk
  - Reliability
    - When tape snaps, it can be spliced back together, losing few hundred megabytes
    - When a terabyte hard drive fails, all of its data is lost
  - Do not need power to preserve data on tape
    - Stopping a disk rotating increases likelihood it will fail
  - Security
    - Hacker can rapidly delete data from hard disks in minutes
    - It could take years to delete same amount of data from tapes
  - Tapes are cheaper than disks
  - Tapes last longer (30 years) than disks (5 years)
- Storage hierarchy
  - Hot data - needs to be available for immediate access - use flash memory
  - Lukewarm data - looked at frequently but not instantaneously - use disks
  - Cold data - long term storage - use tape
    - 90% of organizations data becomes cold in a few months

- Tape Rescues Big Data, The Economist, Sep. 26, 2013

IBM RAMAC Disk Drive



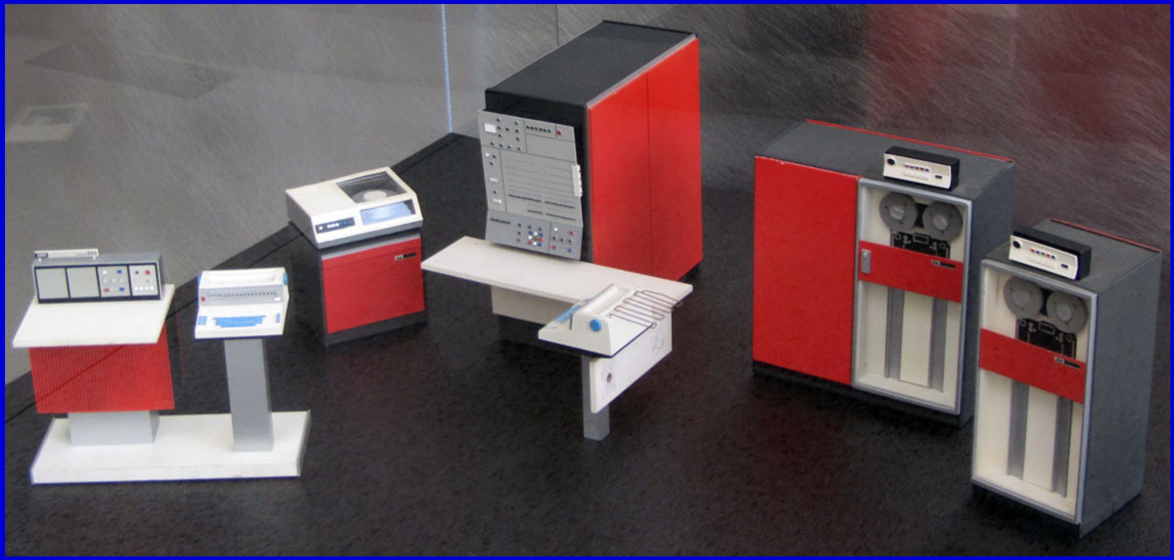
Thing / Hardware - IBM RAMAC Disk Drive

- Firsts / Achievements / Uniqueness / Significance
  - World's first disk drive
  - Has 50 24" disks that hold 5 million characters of information
  - Layers of hard disks increased its storage capacity and decreased access time
- Place Produced (Company / Institution) ~ Year ~ Country
  - IBM ~ 1956 ~ USA
- People involved (Designer)
  - Text
- Type
  - Text
- Price / Cost
  - Text
- Size
  - Bigger than refrigerator ~ Weighed > 1 ton

Thing / Hardware - IBM RAMAC Disk Drive

- Computing technology
  - Text
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Text
- Secondary memory type / technology ~ Size
  - Magnetic disk storage - store data by changing orientation of particular spot on disk + retrieve it by reading the orientation
- Uses / Applications / Software
  - Was part of IBM 305 RAMAC machine to keep business accounts immediately up to date
- Predecessors - N/A ~ Successors - N/A

IBM System 360 Model 30



Thing / Hardware - IBM System 360

- Firsts / Achievements / Uniqueness / Significance
  - IBM bet the company - Cost $5 billion to develop over 4 years
  - Unified IBM product line of business + scientific / engineering computers
  - Family of machines from low to high end, using same instruction set, peripherals, programs
  - There was a 400 ~ 600 : 1 performance range
  - Incorporated 8 bit byte which opened up lowercase alphabet and thus language processing
  - Most successful computer of 1960's due to modular construction + impressive sales force
  - Architecture continues today
- Place Produced (Company / Institution) ~ Year ~ Country
  - IBM ~ 1964 ~ USA
- People involved (Designer)
  - Gene Amdahl, Fred Brooks (software)
- Type
  - Mainframe computer
- Price / Cost
  - For IBM 360/Model 30 - the smallest 360, $133,000+
- Size
  - CPU was 2.5' x 4.5' x 6'
  - 60 cubic feet. Had to be kept in heavily air conditioned computer rooms to prevent overheating
  - Weighed 1000 pounds
  - Power consumed was 10,000 watts

Thing / Hardware - IBM System 360

- **Computing technology**
  - Discrete components printed on 0.5 inch square ceramic modules using primitive integrated circuits
  - Key to IBM 360 was microprogramming
  - Architecture consisted of 4 types of instructions including logical instructions and 3 types of arithmetic: fixed point binary, fixed point decimal for variable length numbers and floating point hexadecimal
  - Instruction set consisted of variable length instructions which were 2, 4, or 6 bytes long
  - Input / output devices were console typewriters, card punchers, card readers, disk storage units, magnetic tape drives
- **Computing speed (in MIPS)**
  - For IBM 360/Model 30 - the smallest 360, its speed was 34,500 adds / second
  - The IBM 360's calculation speed was 5.36 times the calculating speed of an average 1991 personal computer. Its calculating speed was 500,000 additions per second and its clock rate was 0.5 million cycles per second
- **Primary memory type / technology ~ Size ~ Word length**
  - For IBM 360/Model 30 - the smallest 360, it used core memory ~ 64 kilobytes ~ 4 bytes of 8 bits
- **Secondary memory type / technology ~ Size**
  - IBM 2314 magnetic disk drive with each disk pack having 11 platters holding 29.2 megabytes per disk pack. The IBM 2401 Tape Drive was also used
- **Uses / Applications / Software**
  - Addressed full circle (360 degrees) of business + scientific customers
  - Operating System 360 including FORTRAN, COBOL, PL/1, RPG
- **Predecessors - IBM 1401 for business + IBM 7090 for science ~ Successors - IBM System 370 in 1970**
  - [First IBM vacuum tube computers were IBM 650 for business + 701 for science / engineering, they were succeeded by transistorized computers IBM 1401 for business + IBM 7090 for science / engineering]
  - [IBM 701 used cathode-ray tube memory, IBM 704 used magnetic core memory]

Fear, Uncertain, Doubt (FUD)

- Marketing principle of spreading negative but unspecific information about a competitor's project
  - Begun by IBM against Amdahl
  - Described by Gene Amdahl
  - Perfected by Microsoft

Amdahl 470V/6

Thing / Hardware - Amdahl 470V/6

- Firsts / Achievements / Uniqueness / Significance
  - A plug compatible mainframe (PCM) = clone of IBM System 370, cost less and was smaller and faster and more reliable than System 370
  - Amdahl 470 V/6 was 25% the size and 4 times as fast as IBM System 360/165 at the same price
- Place Produced (Company / Institution) ~ Year ~ Country
  - Amdahl ~ 1975 ~ USA
- People involved (Designer)
  - Gene Amdahl who was chief architect of IBM System/360 mainframe
- Type
  - Mainframe computer
- Price / Cost
  - $3.75 million
- Size
  - Text

Thing / Hardware - Amdahl 470V/6

- **Computing technology**
  - Integrated circuits
- **Computing speed (in MIPS)**
  - 3.5 MIPS
- **Primary memory type / technology ~ Size ~ Word length**
  - Integrated circuits ~ Up to 8 megabytes ~ 32 bits
- **Secondary memory type / technology ~ Size**
  - Disk drives + tape drives
- **Uses / Applications / Software**
  - Ran all IBM System 360 / System 370 software
- **Predecessors - IBM System 360 / System 370 ~ Successors - IBM System 390 / System z**

Personal Case Study - Russell L

- Role
  - Systems analyst for mainframes
- Story
  - Worked at Burroughs -> Unisys -> downsized
  - Reinvented himself as industry changes -> GE -> IBM

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- What were the computational challenges facing Great Britain and the US after World War II?
- Who was von Neumann and what did he contribute to solving these challenges?
- What is the stored program principle and why is it important?
- What is the significance of the IAS Computer, UNIVAC-1 and IBM System 360 in addressing these challenges?
- What makes an individual computer, and / or a computer company a success? Why does one company usually dominate the market? What does it do better than the others?
  - Is it technology / applications / marketing / support / reliability / ecosystem of supporting software + hardware companies / user groups / fans / spreading of fear, uncertainty, doubt?
  - [Or why did the BUNCH lose to IBM?]
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History - Chapter 3 The Stored Program Principle
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
- Simulations

Conclusion

"We all worked so hard and selflessly because we believed - we knew - it was happening here and at a few other places right then, and we were lucky to be in on it. We were sure because von Neumann cleared the cobwebs from out minds as nobody else could have done. A tidal wave of computational power was about to break and inundate everything in science and much elsewhere, and things would never be the same…"

- Julian Bigelow, computer engineer

Conclusion

"No one ever got fired for buying IBM"

- Anonymous

(…as opposed to BUNCH [Burroughs, UNIVAC, NCR, Control Data, Honeywell])

Topic 8

Computers as Something to Interact With

Birth of the Hacker

Song

It's poetry in motion
She turned her tender eyes to me
As deep as any ocean
As sweet as any harmony
Mmm - but she blinded me with science
She blinded me with science
And failed me in biology

- Thomas Dolby + Jonathan Kerr, She Blinded Me With Science

Thematic Quote

"Demo or Die!"

- Nicholas Negroponte

Thematic Quote

"A hacker is admirable. A cracker is contemptible. On these two definitions hang all the Law and the Profits."

- Jerry Pournelle, journalist

The Painting

Painting Name

- Artist's Name

(Location of painting)

Artifact

- Name
  - Paper tape
- Year
  - 1960's
- Story

The Question

What is computer literacy?

What does it mean to be fluent in computing?

What does it mean to "know" about computing?

MIT Tech Model Railroad Club


Building 20 **Layout** **Computer**

Place - Tech Model Railroad Club

- Significance
  - Wellspring of hacker culture ~ Driven by Hands-On Imperative
- Location
  - MIT
- Definition
  - Student organization that operates an HO scale model railroad - The Tech Nickel Plate
- People who worked there
  - All the early MIT hackers in 1950's
- Things created there
  - Automatic Railroad Running Computer based on telephone relays donated by ATT ~ Overseen by Signals + Power Subcommittee

- Steven Levy, Hackers

The Hacker Ethic

- Access to computers - and anything which might teach you something about the way the world works - should be unlimited and total. Always yield to the Hands-On Imperative!
- All information should be free
- Mistrust Authority - Promote Decentralization
- Hackers should be judged by their hacking, not bogus criteria such as degrees, age, race, or position
- You can create art and beauty on a computer
- Computers can change your life for the better

- Steven Levy, Hackers

Hackers 30 Years Later

A hacker's "fascination with (the) computer becomes an addiction, and with most addictions, the substance that gets abused is human relationships"

- Philip Zimbardo, The Hacker Papers, Psychology Today, Aug. 1980 - article that first introduced hackers to general public

"The people I met from academia, at Stanford, and the growing PC world were not anti-social nerds. They were explorers, adventurers. They were flushed with joy, really thrilled about what they were doing on the computer. I found so many amazing things by looking at the way they view the world. And they were a real joy because they felt they were empowering themselves by programming" - Steven Levy

"My point is that nearly all the things that masses of people do with computers today were things invented by hackers"

"I think that hackers are the key thinkers of our age" - Steven Levy

"They [hackers] are telling us, all of us, that if you aren't making use of this technological bonanza and make something new, you're missing the great opportunity of our times" - Steven Levy

- George Hulme, Author Steven Levy: What We Owe to the Hackers, Qualsys Blog, Sep. 27, 2013

Hackers 30 Years Later

"I shot high...making the case that hackers - brilliant programmers who discovered worlds of possiblity within the coded confines of a computer - were the key players in a sweeping digital transformation"

"I found their playfulness, as well as their blithe disregard for what others said was impossible, led to the breakthroughs that would define the computing experience for millions of people...." (word processing, videogames, personal computers, etc.) ..."And most of them did it simply for the joy of pulling off an awesome trick."

"The Internet itself exists thanks to hacker ideals - its expansion was lubricated by a design that enabled free access."

- Steven Levy, Geek Power: Steven Levy Revisits Tech Titans, Hackers, Idealists, Wired, May 2010

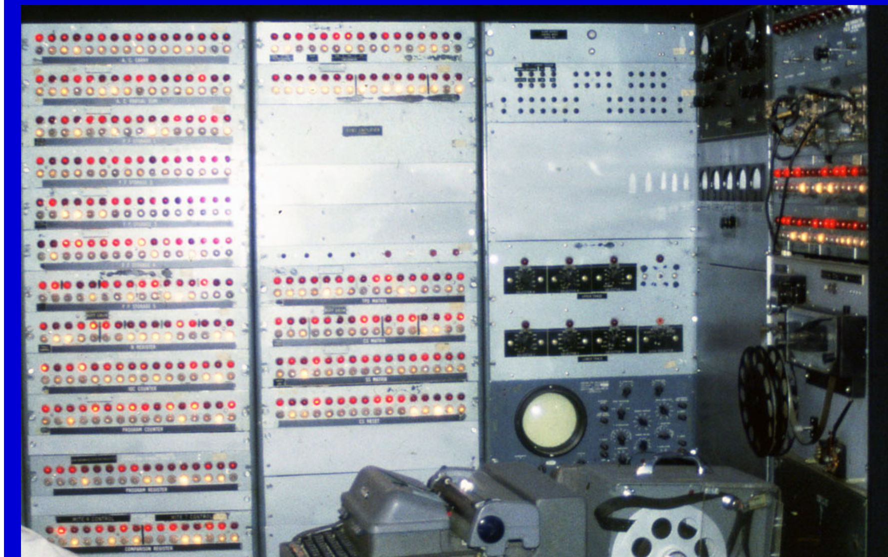
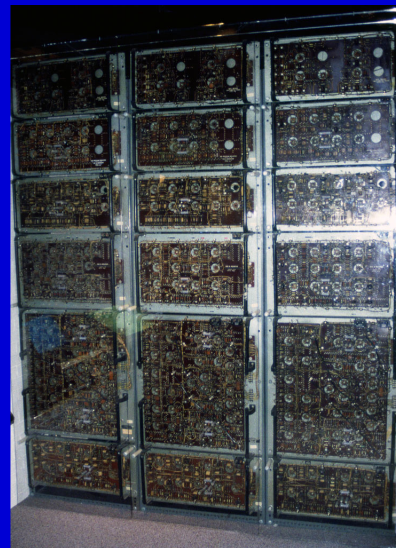
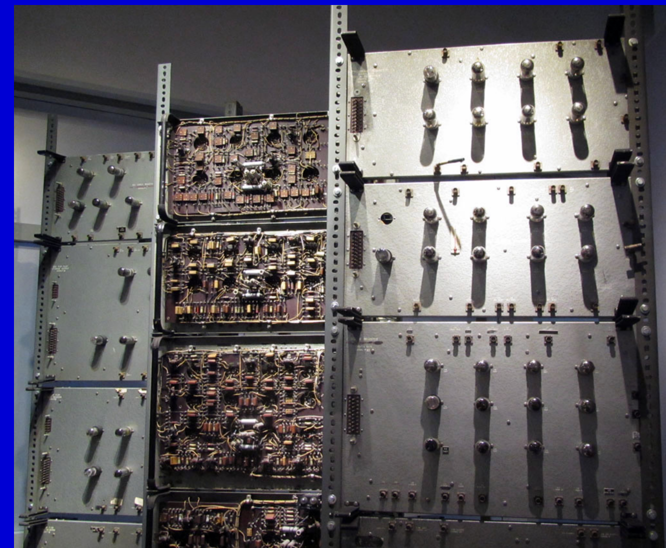
"Digital had a unique role in computer history. The industry was comprised of companies that took punched cards, sorted them, and did a little bit of arithmetic with them. From the very beginning we started with computers controlling things. So we build interactive computers, which was almost beyond the understanding of most people. We had this new concept - like with the SAGE system - that computers had the ability to do something, to interact with something. It was a paradigm shift."

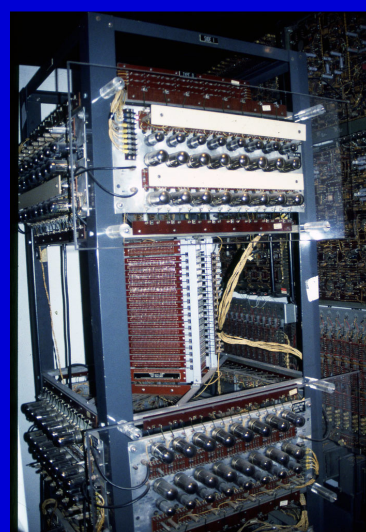
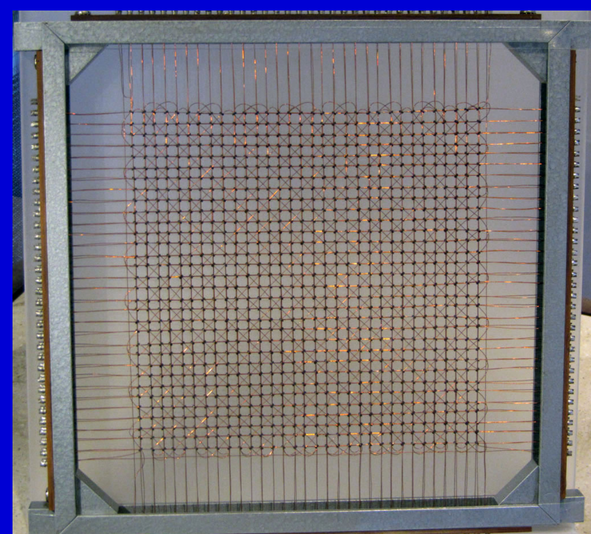
- Stan Olsen, engineer at Digital Equipment Corporation

Link Simulator

Blue Box

Whirlwind

Top - Control room / CPU / Rack

Bottom - Vacuum tube storage / Core memory stack / Core memory plane

Thing / Hardware - Whirlwind

- Firsts / Achievements / Uniqueness / Significance
  - First high speed, reliable, real time digital computer ~ Able to process data + display the results almost instantaneously on its computer screen
  - First use of magnetic core memory (which led to increased performance + reliability), first operating system, first graphic output on a CRT
  - ?First compiler - "Algebraic system" by JH Laning + N Zierler - was felt to be wasteful
  - Success in ability to control aircraft warning + control, leads to SAGE
  - Helps give birth to Route 128 minicomputer industry in New England
- Place Produced (Company / Institution) ~ Year ~ Country
  - MIT ~ 1945-1953, starts operation in 1951 ~ USA
- People involved (Designer)
  - Jay Forrester + Robert Everett
- Type
  - Mainframe computer
- Price / Cost
  - $4.5 million in 1951
- Size
  - Logic modules were 32 feet long ~ Total space occupied was 3,100 square feet, or 4400 cubic feet, the equivalent of a 10 room house ~ Weight was 20,000 lbs
  - Power consumed was 150-160 kilowatts, which is equal to 150,00 lightbulbs ~ Required tons of air conditioning to prevent overheating

Thing / Hardware - Whirlwind

- **Computing technology**
  - Vacuum tubes (5,000 of them initially) were primary technology ~ By 1954 Whirlwind comprised 12,500 vacuum tubes and 23,803 crystal diodes
  - Whirlwind was designed to allow easy testing and replacement of vacuum tubes with tubes tested + replaced before burnout so calculations were not damaged
  - Vacuum tube reliability was improved, partly through use of marginal checking to detect weakened components
  - Flexowriter punched holes into papertape + papertape was mounted onto a reel and fed into Whirlwind's memory using a Ferranti photoelectric tape reader.
  - Cathode ray tubes were also used for display
- **Computing speed (in MIPS)**
  - 125,000 additions / second ~ 42,000 additions or 25,000 multiplications / second
  - Whirlwind had 1/67th the calculation speed of an average personal computer in 1991. It's calculation speed was 40,000 additions per second. It's clock rate was 1 million cycles per second. It's architecture used fixed point arithmetic and its instruction set contained 29 single address instructions
- **Primary memory type / technology ~ Size ~ Word length**
  - Initially electrostatic / cathode ray tube storage
  - Magnetic core memory in 1953 in 4 x 4 x 8 foot memory stack ~ 16 kilobytes ~ 16 bit
- **Secondary memory type / technology ~ Size**
  - In 1953 magnetic drums + magnetic tapes installed - Two fixed head magnetic drums were used - one for auxiliary storage and one for overflow, called the buffer drum. Magnetic drums held 36,848 words + magnetic tapes held 125,000 words/tape
- **Uses / Applications / Software**
  - Began as flight simulator for US Navy but too expensive
  - Evolved into prototype air defense system for US Air Force
  - Whirlwind software development included pioneering work on a symbolic assembler, a mathematics package with floating point, a batch operating system, and an offline print out system
- **Predecessors - N/A ~ Successors - AN/FSQ7 SAGE air defense system, modern air traffic control systems, TX-0, TX-2**

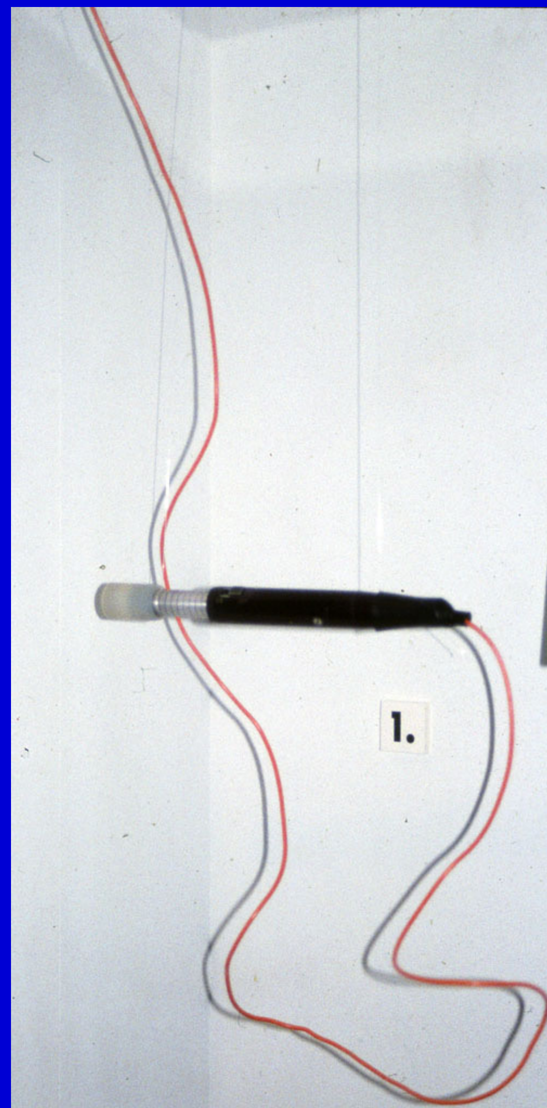
Thing / Hardware - TX-0

- Firsts / Achievements / Uniqueness / Significance
  - One of the first full-scale transistorized computers
- Place Produced (Company / Institution) ~ Year ~ Country
  - MIT's Lincoln Laboratory ~ 1956 ~ USA
- People involved (Designer)
  - Ken Olsen + Wesley Clark
- Type
  - Minicomputer
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - TX-0

- Computing technology
  - Transistorized with each transistor circuit being placed in a bottle similar to a vacuum tube to allow for easy replacement
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Ivan Sutherland, the father of interactive computer graphics, created his Sketchpad program on the TX-2, using a light pen, in 1962
- Predecessors - Whirlwind ~ Successors - TX-2, PDP-1

TX-2



Lightpen from Ivan Sutherland's Sketchpad program

Thing / Software - Sketchpad

- Firsts / Achievements / Uniqueness / Significance

  "This was not just the invention of interactive computer graphics, but of real-time end-user "authoring of ideas" which were embodied in Sketchpad as working simulations." - Alan Kay
- Place Produced (Company / Institution) ~ Year ~ Country
  - MIT ~ 1963 ~ USA
- People involved (Programmer)
  - Ivan Sutherland
- Type
  - CAD / CAM software
- Price / Cost
  - N/A
- Computer and operating system it runs on
  - TX-2
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - N/A ~ Successors - CAD/CAM systems

Thing / Hardware - Project MAC

- Firsts / Achievements / Uniqueness / Significance
  - Timesharing = Share a large mainframe computer amongst many users
  - Each user has illusion they have powerful computer at their personal beck and call
  - Contrast to batch processing
  - Metaphor was computer utility, ultimately beaten by personal computer
- Place Produced (Company / Institution) ~ Year ~ Country
  - MIT ~ 1963 ~ USA
- People involved (Designer)
  - Robert Fano, JCR Licklider (funder)
- Type
  - Mainframe computer - Modified IBM 7094 running Compatible Time Sharing System (CTSS)
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Project MAC

- Computing technology
  - Transistors
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - 2 banks of magnetic core memory ~ 32,768 bytes ~ 36 bit word
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Had 100 Teletype terminals hooked up to it, could service 30 users at a time
- Predecessors - N/A ~ Successors - Cloud computing today

Face of Interactivity

Above: ASR-33 Teletype, DECWriter
Below: DEC VT-100, Tektronix 4012

Thing / Hardware - ASR-33 Teletype

- Firsts / Achievements / Uniqueness / Significance
  - Popular input + output device for minicomputers and timesharing
  - Initially designed as low cost terminal for Western Union telegram communications network
- Place Produced (Company / Institution) ~ Year ~ Country
  - Teletype Corporation (ATT) ~ 1964 ~ US
- People involved (Designer)
  - Text
- Type
  - Computer terminal
- Price / Cost
  - $700
- Size
  - 2' x 2' x 1'

Thing / Hardware - ASR-33 Teletype

- Computing technology
  - N/A
- Computing speed (in MIPS)
  - N/A
- Primary memory type / technology ~ Size ~ Word length
  - None
- Secondary memory type / technology ~ Size
  - None
- Uses / Applications / Software
  - Input / output device for time sharing
- Predecessors - Flexowriter ~ Successors - DECWriter

DEC System-10 (PDP-10)

Thing / Hardware - DEC System

- Firsts / Achievements / Uniqueness / Significance
  - Designed from start to be time sharing computer
- Place Produced (Company / Institution) ~ Year ~ Country
  - Digital Equipment Corporation (DEC) ~ 1968 ~ USA
- People involved (Designer)
  - Text
- Type
  - Mainframe computer
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - DEC System

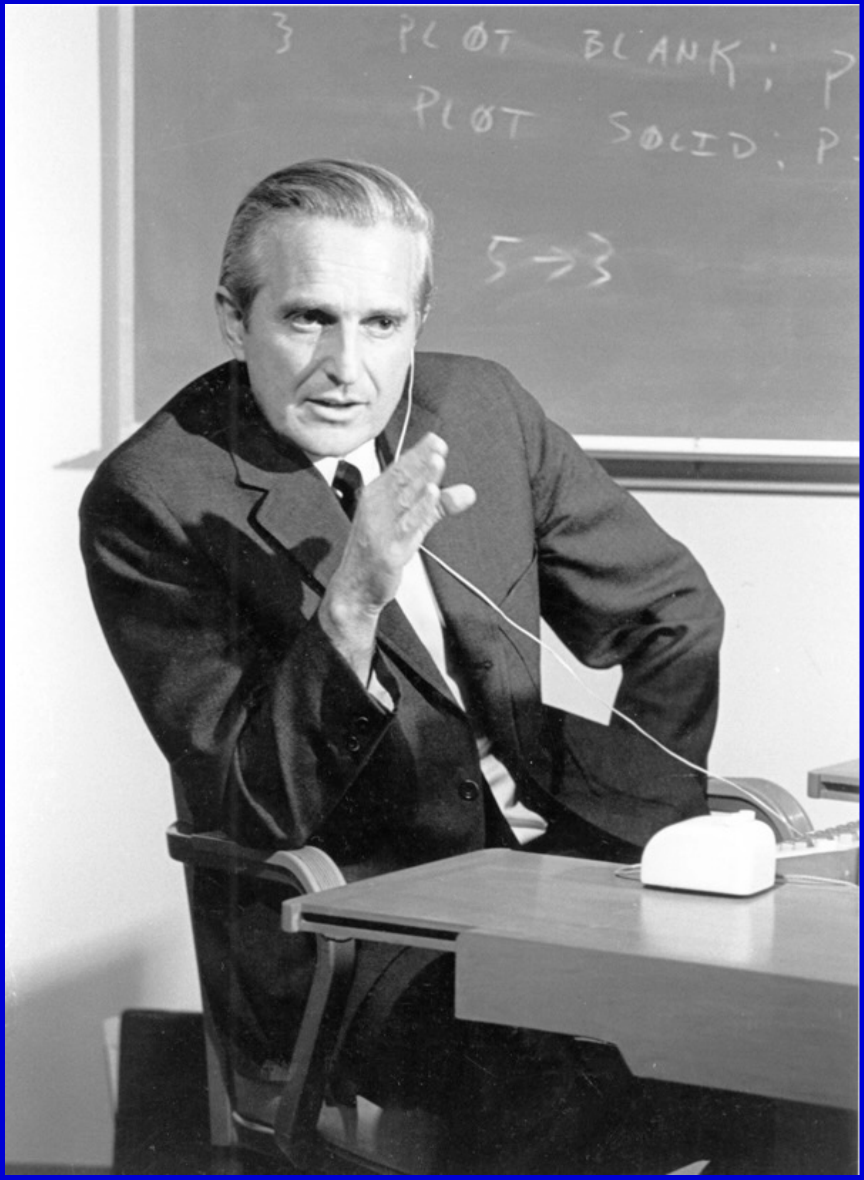
- Computing technology
  - Transistors
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Time sharing
  - Artificial intelligence programming in LISP
  - Adventure game
  - Altair BASIC
- Predecessors - PDP-6 (First time sharing computer designed from bottom up) ~ Successors - Ten On A Desk (TOAD)

DEC System

- KI-10 (DEC System-10) 1971 ran TOPS-10
  - Magnetic core memory ~ 16K - 4096K ~ 32 bits
  - 1 microsecond instruction cycle
- KL-10 (DEC System-20) 1974 ran TOPS-10 + TOPS-20
  - Magnetic core (later semiconductor) memory ~ 32K - 4096K ~ 36 bit
  - 500 nanosecond instruction cycle, 1.8 MIPS
- KS-10 (DEC System-2020) 1979
  - Semiconductor memory ~ 256K - 512K ~ 36 bit
  - 3 microsecond instruction cycle, 300 KIPS
  - Intended for office rather than datacenter

- The Living Computer Museum

Douglas Engelbart



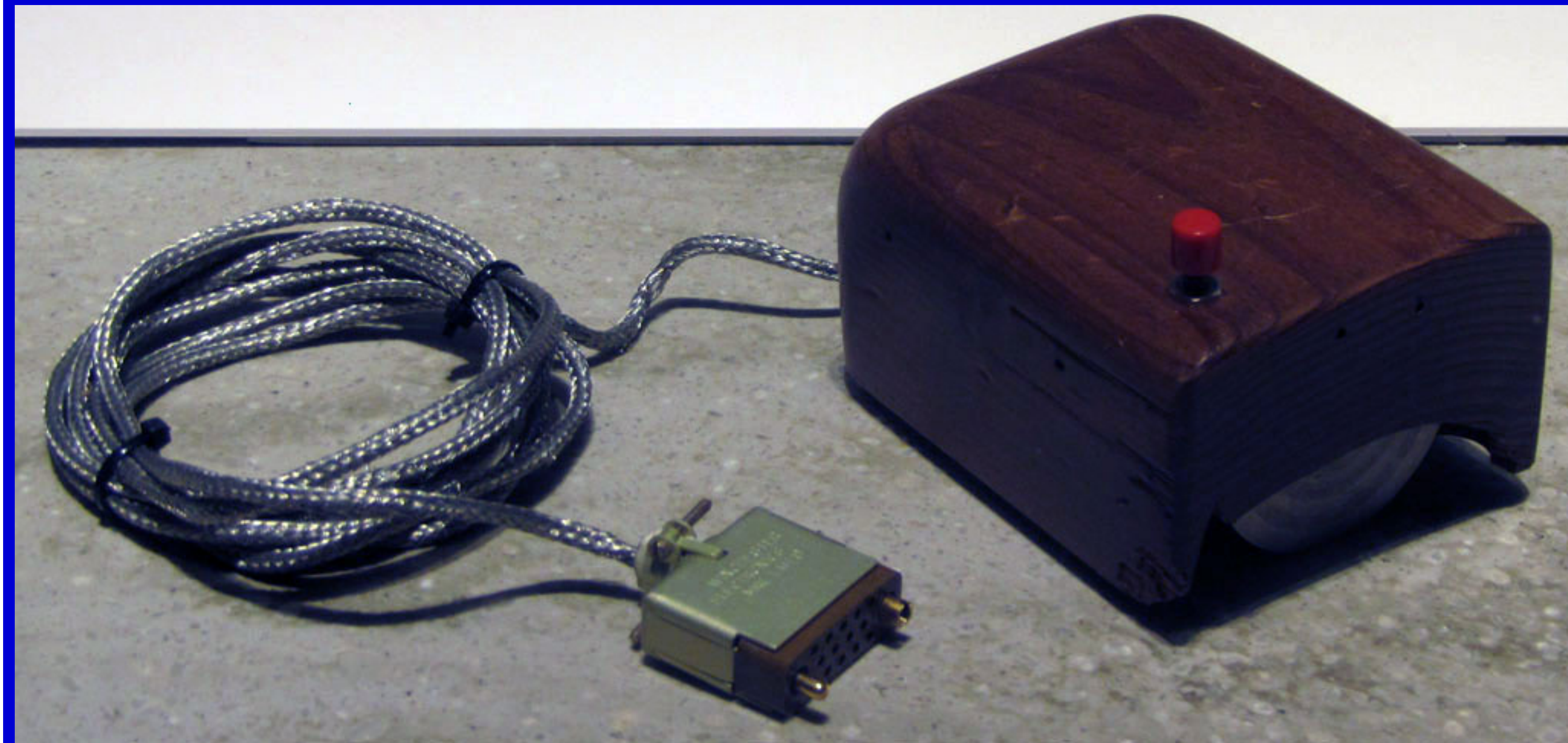
From Wikimedia Commons

Person - Douglas Engelbart

- Significance
  - Pioneer in the field of human computer interaction
  - Vision was to use computers, interfaces, networks to amplify human intelligence to help mankind survive
  - Computers would make people think + work faster, more effectively, more collectively = augmentation of human intellect for the good of whole human race
  - Wanted to augment humanity's intelligence

    "[Engelbart's] aspirations included nothing less than the development via the interface between computers and their users, of a new kind of person, one better equipped to deal with the increasing complexities of the modern world." - Thierry Bardini
  - Believed computer should be a bicycle, rather than a tricycle, for mankind
  - Work effectively ended with end of timesharing / advent of personal computer which turned users back into isolated islands of information
- Profession
  - Computer scientist
- Places worked
  - Stanford Research Institute
- Years of work
  - 1962 - 2013
- Things worked on
  - Influenced by "As We May Think"
  - 1968 Fall Joint Computer Conference in San Francisco Mother of All Demos - showed for the first time the mouse, hypermedia, video conferencing, groupware

First Mouse



For Douglas Engelbart

Thing / Hardware - Prototype
Engelbart Mouse

- **Firsts / Achievements / Uniqueness / Significance**
  - Demonstrated it was more efficient pointer than light pen
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Stanford Research Institute (SRI) ~ 1964 ~ USA
- **People involved (Designer)**
  - Douglas Engelbart (designer), Bill English (builder)
- **Type**
  - Computer peripheral
- **Price / Cost**
  - Text
- **Size**
  - Text

Thing / Hardware - Prototype Engelbart Mouse

- Computing technology
  - Had knife-edge wheels and one button
- Computing speed (in MIPS)
  - N/A
- Primary memory type / technology ~ Size ~ Word length
  - N/A
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Pointing device
- Predecessors - Light pen ~ Successors - Computer mice

Place - oN-Line System (NLS)

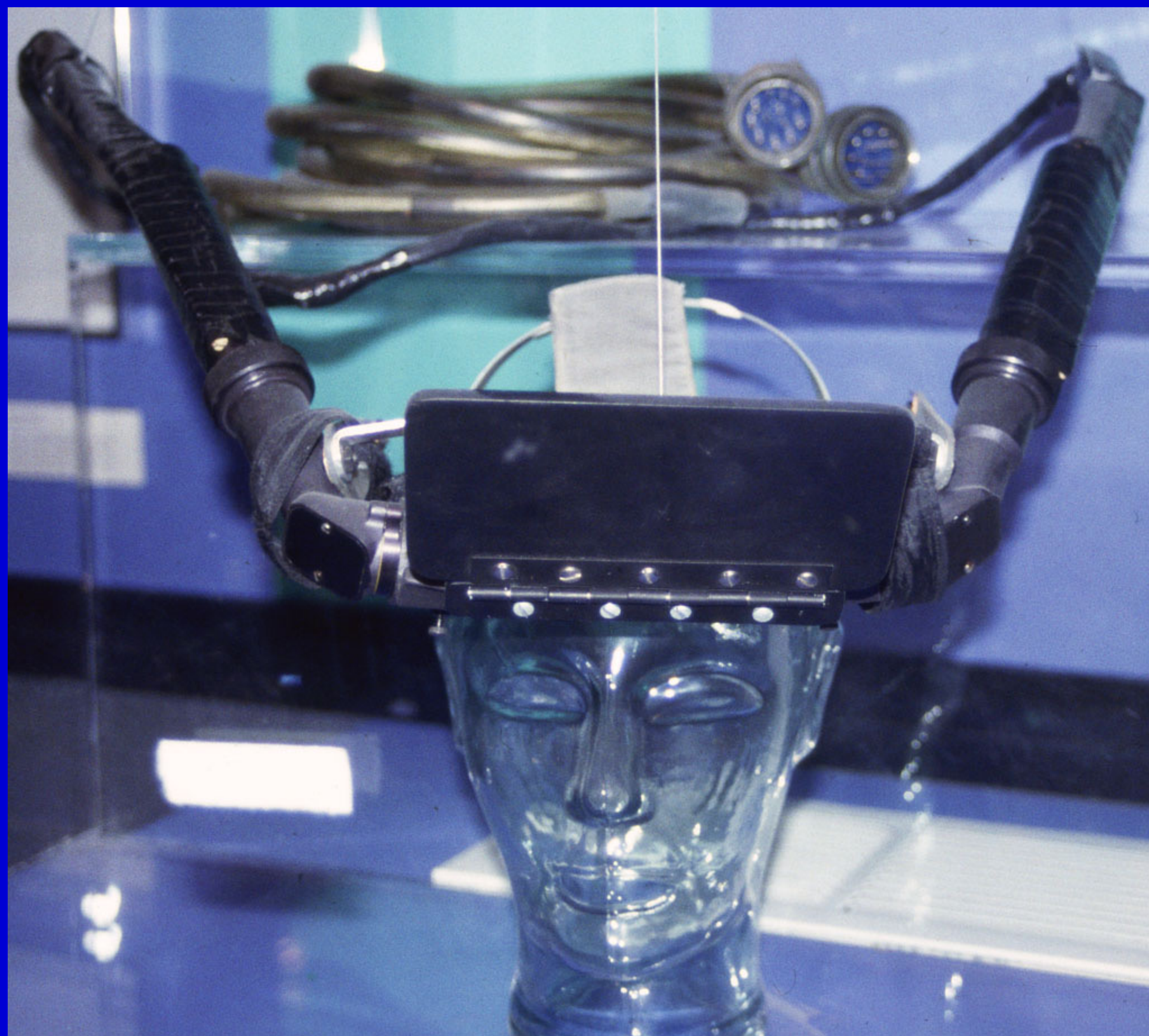
- Significance
  - First implementation of a hypertext system
  - Attempt to "augment human intellect" + "boost the collective IQ of groups"
- Location
  - Stanford Research International, Palo Alto, California
- Definition
  - A computer collaboration system
- People who worked there
  - Douglas Englebart
- Things created there
  - The Mother of All Demos

Douglas Engelbart's Vision

- Believed human potential needs to grow exponentially to meet challenges to humanity's survival
- Foresaw computer technologies as augmenting + amplifying people's abilities and intellect rather than replacing them
  - [AI researchers foresaw computer technologies as replacing humans]
- Had developed graphical user interfaces, spreadsheets, video conferencing, email, personal workstations that were connected to a time-shared central computer in the 1960's
  - When personal computer emerged in 1970's all his work was disregarded by personal computer industry + his funding dried up
  - Personal computer industry reinvented all his work over next two decades

- Tom Foremski, Silicon Valley Honors the Life and Work of Doug Engelbart, ZDNet, Dec 14, 2013

Ivan Sutherland's Experimental Vision System



Thing / Hardware - Ivan Sutherland's Experimental Vision System

- Firsts / Achievements / Uniqueness / Significance
  - First virtual reality headset
- Place Produced (Company / Institution) ~ Year ~ Country
  - Harvard ~ 1966 ~ USA
- People involved (Designer)
  - Ivan Sutherland
- Type
  - Virtual reality headset
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Ivan Sutherland's Experimental Vision System

- Computing technology
  - Helmet attached to device known as the Sword of Damocles which hung from ceiling + tracked movements of user's head
  - As user's head moved, computer would change images in front of users eyes
  - Images from a DEC PDP-1 minicomputer were projected through mirrors to a pair of small screens in front of the users eyes
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Text
- Predecessors - N/A ~ Successors - Virtual reality headsets

History of Virtual Reality

- 1968
  - Ivan Sutherland's Experimental Vision System
- Mid 1980's
  - Jaron Lanier / VPL Research - popularizes term Virtual Reality
  - Nintendo Virtual Boy
  - Sega VR headset
- 1990's
  - Virtuality arcade games
- 1998 - 2012 - Dark ages
  - Sim sickness / virtual reality sickness - due to conflict between visual / auditory systems + vestibular system -> nausea
- 2014 - Oculus Rift
  - Immersive, transporting, revolutionary
  - Non-nauseating due to higher screen resolution + higher frame rate + less jitter
  - Provides presence - a deep pleasure that is not verisimilitude - a euphoria

- Virginia Heffernan, Virtual Reality Fails its Way to Success, New York Times Magazine, Nov. 14, 2014

Oculus Rift


fullsail.edu
Graduate
CREDITS
COLDPLAY
ESPN
BEYONCÉ
MADONNA
THE AVENGERS
SONY
DRAKE
KELLY CLARKSON
MTV
LIL WAYNE
VH1
WWE
ELECTRONIC ARTS
PIXAR
LADY GAGA
DISNEY
THE DARK KNIGHT RISES


Development Kit 2

Thing / Hardware - Oculus Rift

- Firsts / Achievements / Uniqueness / Significance
  - First virtual reality headset to provide presence?
- Place Produced (Company / Institution) ~ Year ~ Country
  - Oculus VR ~ 2016 ~ USA
- People involved (Designer)
  - Palmer Luckey
- Type
  - Virtual reality headset
- Price / Cost
  - $599 + high end PC
- Size
  - 6" wide ~ Weighs 1 pound

Thing / Hardware - Oculus Rift

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - N/A
- Primary memory type / technology ~ Size ~ Word length
  - N/A
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Games, movies, simulations
- Predecessors - Many failed headsets of 1990's ~ Successors - N/A

The Upside of Virtual Reality

"Virtual reality is, essentially, a hack on the human sensory system" - Brendan Iribe, CEO of Oculus

- Virtual reality = building convincing computer-generated worlds
- Failed in 1990's due to users suffering from nausea + headaches (from low frame rates + low resolution screens) + equipment being heavy + bulky
- Will succeed in 201x's due to better graphics (resolution + frame rate), better screens, improved sensors to keep track of what user is doing + reduce lag - all of these are commoditized in smart phones
- But, to create presence, the headset must obscure user's view of the real world…

- Grand Illusions, The Economist, Aug. 29, 2015

The Downside of Virtual Reality

- By definition, everything inside a virtual world is tracked
  - The more precisely + comprehensively your body + behavior are tracked, the better your experience is
- Therefore, a virtual world is a total surveillance state

"This comprehensive tracking of your behavior inside these worlds could be used to sell you things, to redirect your attention, to compile a history of your interests, to persuade you subliminally, to quantify your actions for self-improvement, to personalize the next scene, and so on. If a smartphone is a surveillance device we voluntarily carry in our pocket, then VR will be a total surveillance state we voluntarily enter."

- Kevin Kelly, The Untold Story of Magic Leap, the World's Most Secretive Startup, Wired, April 2016

Cyberspace Definition

"Cyberspace. A consensual hallucination experienced daily by billions of legitimate operations in every nation, by children being taught mathematical concepts...A graphical representation of data abstracted from the banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the non-space of the mind, clusters and constellations of data. Like city lights, receding..."

- William Gibson, Neuromancer, 1984

Personal Case Study - Tech Model Railroad Club

- Role - Birthplace of hacking
- Story
  - Attended an Open House in Building 20 in 1994
  - Saw + heard the relay-based computer operating

Personal Case Study - Michigan Terminal System (MTS) Operating System

- Role
  - Timesharing on an Amdahl 470 (IBM 370-class) mainframe in 1982
- Story
  - 200-300 simultaneous users
  - We had email, social networking, word processing, laser printing, games, multiplayer games

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- What is the computational challenge faced by computer scientists and engineers in the early 1960's?
- What is a hacker, where did they come from, why are they important?
- Why was the Tech Model Railroad Club an important place in the history of computing?
- Before 1960 how were computers controlled and what was good about it and what was bad about?
- What challenges did computers have to overcome in order to become interactive?
- Why was MIT the place to be for interactivity in the late 1950's / early 1960's?
- What is the significance of the Whirlwind and PDP-1 computers in addressing these challenges?
- What were some of the first interactive peripherals and how did they change people's perception of computers?
- What were some of the first interactive apps and how did they change people's perception of computers?
- What is timesharing and how did it affect the number of people who had regular access to a computer?
- Who was Douglas Engelbart and what role did he play in the development of the computer?
- Have we fulfilled Douglas Engelbart's vision for Augment?
- Is Siri (also from SRI) and Google Voice the heirs to Engelbart's NLS - do they help to augment human intellect?
- Should computer technologies augment humans or replace humans?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
- Simulations

Conclusion

"People who are really serious about software should make their own hardware"

- Alan Kay, computer scientist

Conclusion

"I think that hackers - dedicated, innovative, irreverent computer programmers - are the most interesting and effective body of intellectuals since the framers of the U.S. Constitution...No other group that I know of has set out to liberate a technology and succeeded. They not only did so against the active disinterest of corporate America, their success forced corporate America to adopt their style in the end. In reorganizing the Information Age around the individual, via personal computers, the hackers may well have saved the American economy...The quietest of all the '60's sub-subcultures has emerged as the most innovative and powerful."

- Stewart Brand, Founder Whole Earth Catalog

Topic 9

Computers as Minis

Personalized Computers

Song

Slide text

Thematic Quote

"In the era of the miniskirt and the Mini Cooper, this machine [the PDP-8] came to be called a "mini-computer," a name that was retroactively applied to (relatively) small, inexpensive and easily used computers."

- Living Computer Museum

The Painting

Our Father in Heaven

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - DEC PDP-8 transistorized module
- Year
  - 1965
- Story

The Question

- Why did successful minicomputer vendors not become successful microcomputer vendors?

MIT Infinite Corridor

Place - Massachusetts Institute of Technology (MIT)

- Significance
  - Intellectual and academic hub of Route 128
- Location
  - Cambridge, Massachusetts
- Definition
  - Private university founded in 1861
- People who worked there
  - Vannevar Bush
- Things created there
  - Tech Model Railroad Club, Hackers, Whirlwind, TX-0, Digital Equipment Corporation, Lisp, Project MAC, Apollo Guidance Computer, Free Software Movement, Media Lab

Place - Route 128

- Significance
  - East Coast analog to Silicon Valley
- Location
  - Northwest suburbs of Boston
- Definition
  - MIT's tech corridor
- People who worked there
  - Alumni of MIT Project Whirlwind
- Things created there
  - Minicomputer industry

Place - Digital Equipment Corporation (DEC)

- Significance
  - DEC philosophy of computing
    - Encourage users to educate themselves
    - Shared with them
    - Encouraged users to modify, extend, enhance machines…but its users were engineers + scientists as opposed to IBM's users
- Location
  - Boston, Massachusetts
- Definition
  - Original successful minicomputer company, though they called them "Programmed Data Processors" to avoid appearance of competing with IBM
- People who worked there
  - Ken Olsen, Gordon Bell
- Things created there
  - PDP and VAX minicomputers, DEC System mainframe computers, AltaVista search engine

DEC PDP-1

Thing / Hardware - Programmed Data Processor-1 (PDP-1)

- **Firsts / Achievements / Uniqueness / Significance**
  - Built to spread MIT vision of computing to the world which was stated by Ken Olsen to be a philosophy of one person, for one computer, using the computer in an interactive fashion as exemplified by Whirlwind and the TX-0
  - Digital's goal in creating commercial versions of these machines was to create a small, simple fast computer that was cheap
  - Digital founded with $70,000 of venture capital, wanted to avoid going head-to-head with IBM so built programmed data processors rather than computers
  - First commercial computer that focused on interaction with human user rather than efficient use of computer cycles ~ First commercial computer designed to interact with a single user
  - First commercially available minicomputer that had lower cost, compact size, equal or better performance than mainframe
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Digital Equipment Corporation (DEC) ~ 1960 ~ USA
- **People involved (Designer)**
  - Ben Gurley, Ken Olsen + Harlan Anderson
- **Type**
  - Minicomputer
- **Price / Cost**
  - $110,000 for a machine with 4K of RAM ~ Short word length made it cheaper
- **Size**
  - Weight = 1 ton

Thing / Hardware - Programmed Data Processor-1 (PDP-1)

- Computing technology
  - Transistors - First computer designed to take advantage of transistors from ground up, on clean sheet of paper
- Computing speed (in MIPS)
  - 100,000 adds / second
- Primary memory type / technology ~ Size ~ Word length
  - Magnetic core ~ 4 kilobytes ~ 18 bit words
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - The large CRT so intrigued the early hackers at MIT that they wrote the first video game, "SPACEWAR!" to take advantage of it.
  - "Brought computing out of the computer room and into hands of users" - Jamie Parker Pearson
  - Total of 50 machines were built
- Predecessors - Whirlwind + TX-0 + TX-2 interactive computers ~ Successors - PDP-8

DEC PDP-8

PDP-8 Classic

PDP-8E

Thing / Hardware - PDP-8

- Firsts / Achievements / Uniqueness / Significance
  - By sharing details of its design + operating characteristics, it encouraged other companies to embed it in their products
  - The PDP-8 ushered in the era of the affordable minicomputers
- Place Produced (Company / Institution) ~ Year ~ Country
  - Digital Equipment Corporation ~ 1965 ~ USA
- People involved (Designer)
  - Text
- Type
  - Minicomputer
- Price / Cost
  - $18,000 for basic system
- Size
  - 20.5" x 20.5" x 32"

Thing / Hardware - PDP-8

- Computing technology
  - First models used transistors, later models used integrated circuits
- Computing speed (in MIPS)
  - 333,333 adds / second
- Primary memory type / technology ~ Size ~ Word length
  - Magnetic core ~ 4 kilobytes ~ 12 bit word
- Secondary memory type / technology ~ Size
  - DECtape
- Uses / Applications / Software
  - Inexpensive + simple tool for factories and labs
  - Over 10,000 made
- Predecessors - PDP-1 ~ Successors - PDP-11

Data General NOVA

Thing / Hardware - Data General NOVA

- Firsts / Achievements / Uniqueness / Significance
  - DEC's main competitor was Data General, formed when Edson de Castro's design for the successor to the PDP-8 was passed over by DEC, so he formed his own company to produce the Nova
  - Personal favorite of Steve Wozniak
- Place Produced (Company / Institution) ~ Year ~ Country
  - Data General ~ 1969 ~ USA
- People involved (Designer)
  - Edson de Castro
- Type
  - Minicomputer
- Price / Cost
  - $9,200 - half the price of competitive machines, therefore made computing more accessible to more people
- Size
  - 7" x 23" x 25" ~ Weight = 50 pounds

Thing / Hardware - Data General NOVA

- **Computing technology**
  - Integrated circuits - Medium Scale Integration
  - Composed of a small number of large circuit boards vs. DEC's computers composed of large number of small circuit boards
- **Computing speed (in MIPS)**
  - 384,615 adds / second, 3.6 microsecond instruction cycle, 160 KIPS, 1.5 MHz
- **Primary memory type / technology ~ Size ~ Word length**
  - Magnetic core ~ 4K to 32K ~ 16 bit
- **Secondary memory type / technology ~ Size**
  - Text
- **Uses / Applications / Software**
  - Text
- **Predecessors - PDP-8 ~ Successors - Data General Eclipse (Soul of a New Machine)**

DEC PDP-11

Thing / Hardware - PDP-11/20

- Firsts / Achievements / Uniqueness / Significance
  - Architecture was more like a mainframe computer than a minicomputer
- Place Produced (Company / Institution) ~ Year ~ Country
  - DEC ~ 1970 ~ USA
- People involved (Designer)
  - Gordon Bell
- Type
  - Minicomputer
- Price / Cost
  - $10,800
- Size
  - Text

Thing / Hardware - PDP-11/20

- Computing technology
  - Text
- Computing speed (in MIPS)
  - 833,333 adds / second
- Primary memory type / technology ~ Size ~ Word length
  - Magnetic core ~ 4K ~ 16 bit
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Text
- Predecessors - PDP-8 ~ Successors - VAX-11/780

DEC VAX 11/780

Thing / Hardware - VAX-11/780

- Firsts / Achievements / Uniqueness / Significance
  - Culturally compatible with PDP-11 ~ Used for business + science
  - Single operating system for all machines in product line ~ Achieved scale by clustering
  - Rivaled much more expensive mainframe computers in performance
  - Made DEC second largest computer company after IBM
- Place Produced (Company / Institution) ~ Year ~ Country
  - Digital Equipment Corporation ~ 1976 ~ USA
- People involved (Designer)
  - Gordon Bell
- Type
  - Super-minicomputer
- Price / Cost
  - $120,000 - $160,000
- Size
  - Text

- Dag Spicer, Gordon Bell, IEEE Annals of the History of Computing, Jan-Mar 2015

Thing / Hardware - VAX-11/780

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - 1 million instructions / second (MIPS)
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 1 megabyte ~ 32 bit word
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Text
- Predecessors - PDP-11 ~ Successors - DEC Alpha, Sun-1

- Dag Spicer, Gordon Bell, IEEE Annals of the History of Computing, Jan-Mar 2015

Person - Tom West

- Significance
  - Protagonist of "Soul of a New Machine"
  - "A good man in a storm"
    - Intense, charismatic, creative, autodidact, made ordinary things special, contrarian, could fix anything, good coordinator
  - "Signing up" - convinced Hardy Boys + Microkids to "sign up" + ran interference for them
  - Pinball metaphor for how he motivated people - If you win at this level, then your reward is that you get to play again at the next level, but guess what: The next level is more difficult
- Profession
  - Computer engineer
- Places worked
  - Data General
- Years of work
  - 1970's - 1998
- Things worked on
  - Lead the team that built Data General Eclipse MV / 8000 32-bit minicomputer (code name Eagle) that was backward compatible with 16-bit Eclipse + would be competitor to DEC VAX
  - Data General One full screen laptop
  - Data General Clariion RAID data storage (sold to EMC)
  - Data General THiiN SiteStak Web server appliance

- Tracy Kidder, The Soul of a New Machine
- Lawrence Peters, A Good Man in a Storm: An Interview With Tom West, Academy of Management Executive, Nov. 2002
- Evan Ratliff, O Engineers!, Wired, Dec. 2000
- Bryan Marquard, Tom West: Engineer Was the Soul of Data General's New Machine, Boston Globe, May 22, 2011

Last Gasps of Minicomputer Non-Adapters
History Repeats Itself…

- If you don't adapt you die
  - Wang - was vaporized
  - Data General - Tom West had invented home Web server appliance
  - DEC - invented AltaVista - the best search engine before Google
- Is an Innovator's Dilemma issue
  - Teams inside these companies had the future in their fingers, but management let it get away
- Failed to understand the emergence of the personal computer market
  - They had the resources but lacked the imagination and therefore failed to deal with changes in the environment

Personal Case Study - Computer Analyst / System Operator VAX 11/780

- Role - The minicomputer of choice in the mid 1980's
- Story
  - In 1984-1985 I helped oversee the day to day operation of the Wayne State University's Department of Computer Science VAX 11/780 which ran DEC's VMS operating system and then ran a version of UNIX, known as Eunice, on top of it

Ad - See Topic 21 Computers in the Arts

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- Why was the Massachusetts Institute of Technology and Route 128 important places in the history of computing?
- What was the computational challenge faced by the computer industry / minicomputer vendors as the 1960's dawned?
- What is the significance of the PDP-1 and PDP-8 in addressing these challenges?
- Compare and contrast IBM and DEC
- What makes an individual computer, and / or a computer company a success? Why does one company usually dominate the market? What does it do better than the others?
  - Is it technology / applications / marketing / support / reliability / ecosystem of supporting software + hardware companies / user groups / fans / spreading of fear, uncertainty, doubt?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History - Chapter 4 The Chip and Silicon Valley
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
  - Kidder, Tracy - Soul Of A New Machine
  - Levy, Steven - Hackers
- Fiction
- Movies
- Simulations

Conclusion

"There is no reason anyone would want a computer in their home."

- Ken Olsen - Founder, President, Chairman of DEC, 1977

Topic 10

Computers and Philosophers

Song

Slide text

Thematic Quote

"The engines of the 19th century industrial revolution were amplifiers for our physical bodies. The computers of the 20th century information revolution are amplifiers for our minds."

- Len Shustek, Chairman, Computer History Museum

The Painting

Painting Name

- Artist's Name

(Location of painting)

Artifact

- Name
  - Chip with a microscope
- Year
  - Early 1970's
- Story

- Name
  - Intersil 6100 / Harris HM-6100 processor (H D1-6120-2)
- Year
  - Mid 1970's
- Story
  - PDP-8 on a chip

The Question

How can a discipline that revolves around 1's and 0's have a philosophy?

One Definition of Philosophy

"The study of the theoretical basis of a particular branch of knowledge or experience."

- Google Search / Dictionary

Alan Turing

From Wikipedia

Person - Alan Turing

- Significance
  - Turing Machine - universal computing machine
  - Turing Test - test of a machine's ability to exhibit intelligent behavior indistinguishable from that of a human
  - Shortened World War II by several years due to his work on breaking Enigma + Tunny codes
- Profession
  - Mathematician
- Places worked
  - Bletchley Park, National Physical Laboratory, University of Manchester
- Years of work
  - 1938 - 1954
  - Convicted of gross indecency in 1952, sentenced to chemical castration, committed suicide 2 years later
- Things worked on
  - 1936 - "On Computable Numbers" - Mathematical description of a "machine" (now a Turing machine) that could in principle solve any mathematical problem that could be presented to it in symbolic form. Was mathematical proof that it was possible to build computer that could solve any class of problem
    - Idea was of a universal computing machine
    - Offers modern theoretical basis for computer science

  "Turing's machine had a memory of infinite capacity, which Turing described as a tape of arbitrary length on which symbols could be written, erased or read…The machine he described, and the method by which it was instructed to solve a problem, was the first theoretical description of the fundamental quality of computers. That is, a computer can be programmed to perform an almost infinite range of operations if human beings can devise formal methods of describing those operations. The classical definition of machine is of a device that does one thing and one thing well; a computer is by contrast a universal machine, whose applications continue to surprise its creators."

  - Paul E. Ceruzzi, Computing a Concise History, p. 26

  - German Enigma code + Bombes to break it, Germany Tunny code, SIGSALY
  - Pilot ACE computer

Turing Timeline

- 1936 - "On Computable Numbers" paper - introduced concepts of algorithms + computing machines
- 1940 - anti-Enigma bombes at Bletchley Park which by 1943 were cracking 84,000 Enigma messages / month
- 1941 - Broke naval Enigma code
- 1942 - Developed method for cracking Tunny messages (Turingery) which was seed for Tunny-cracking algorithms used in Colossus
- 1946 - Design of Automatic Computing Engine (ACE), early stored program computer, at National Physical Laboratory
- 1949 - Worked on software needed to drive Manchester Mark 1 stored program computer
- 1950 - "Computing Machinery and Intelligence" paper where he proposed Turing Test

- Vint Cerf, Alan Turing: Why the Tech World's Hero Should Be a Household Name, BBC News, Jun 17, 2012
- Jack Copeland, Alan Turing: The Codebreaker Who Saved Millions of Lives, BBC News, Jun 18, 2012
- Simon Lavington, Alan Turing: Is He Really the Father of Computing?, BBC News, Jun 19, 2012

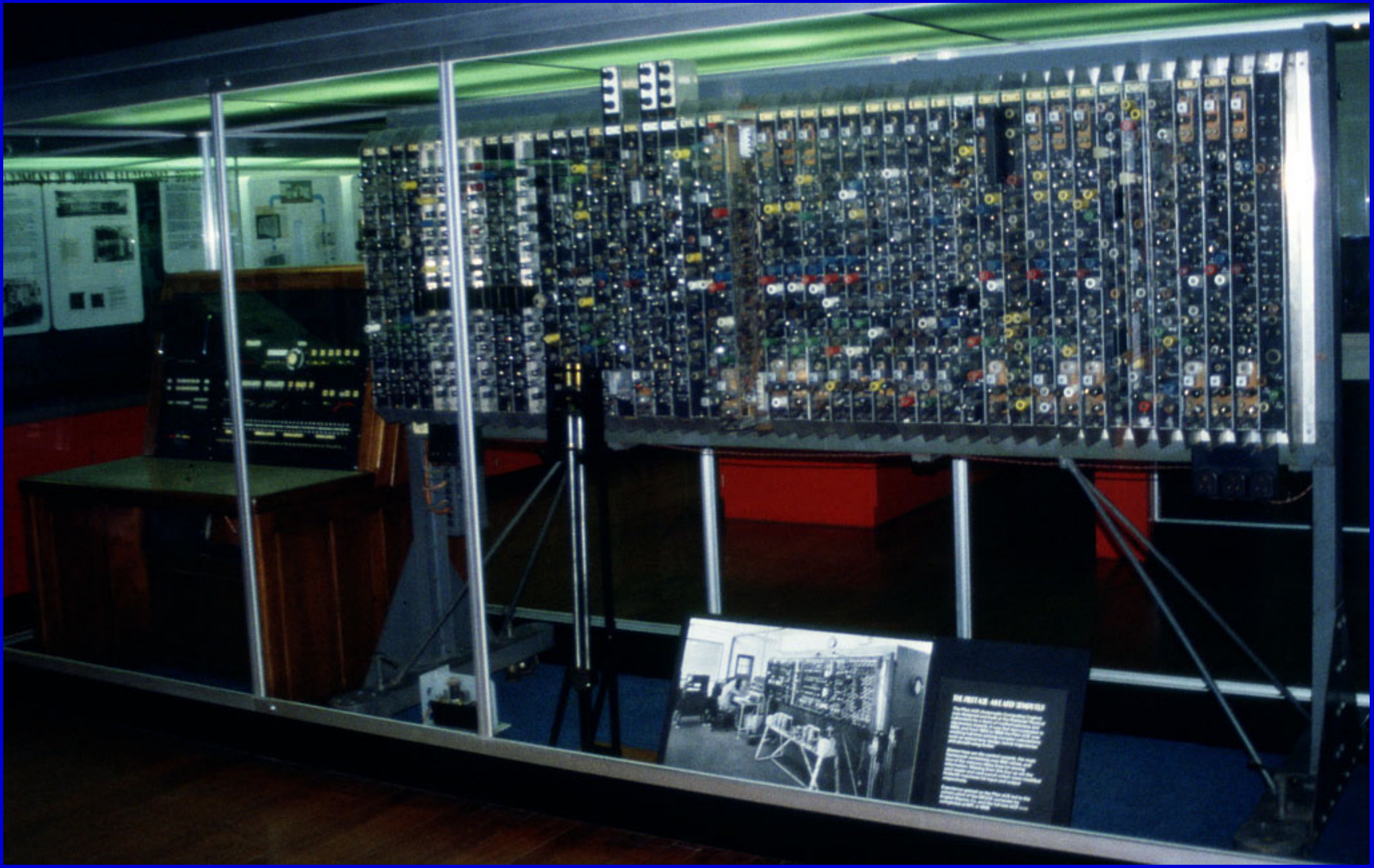
Thing / Hardware - Turing Machine

- **Firsts / Achievements / Uniqueness / Significance**
  - **A universal computing machine**
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - **Cambridge University ~ 1936 ~ England**
- **People involved (Designer)**
  - **Alan Turing**
- **Type**
  - **Universal computing machine**
- **Price / Cost**
  - **N/A**
- **Size**
  - **N/A**

Thing / Hardware - Turing Machine

- Computing technology
  - N/A
- Computing speed (in MIPS)
  - N/A
- Primary memory type / technology ~ Size ~ Word length
  - Tape ~ ∞ ~ N/A
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Solve any computable problem
- Predecessors - N/A ~ Successors - All subsequent computers

Pilot ACE



Thing / Hardware - Pilot Automatic Computing Engine (ACE)

- Firsts / Achievements / Uniqueness / Significance
  - One of earliest stored program computers (contemporary of Manchester Mark 1 + EDSAC)
- Place Produced (Company / Institution) ~ Year ~ Country
  - National Physical Laboratory ~ 1950 ~ United Kingdom
- People involved (Designer)
  - Alan Turing, James Wilkinson, Harry Hurley
- Type
  - General purpose computer
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Pilot ACE

- **Computing technology**
  - 800 vacuum tubes ~ Used 1/3rd electronic equipment of contemporary British computers
- **Computing speed (in MIPS)**
  - 1 MHz ~ Faster than other contemporary British computers by factor of 5
- **Primary memory type / technology ~ Size ~ Word length**
  - Mercury delay lines ~ 128 ~ 32 bit words
- **Secondary memory type / technology ~ Size**
  - Drum memory of 4096 words added in 1954
- **Uses / Applications / Software**
  - Did floating point arithmetic for optical lens design, bomb trajectories, wing flutter~ Was difficult to program
- **Predecessors - N/A ~ Successors - ACE, DEUCE was commercial version**

John Von Neumann

- See Topic 7 Computers in the Electronic Era

Andy Grove, Robert Noyce, Gordon Moore

From Wikimedia Commons

Person - Gordon Moore / Moore's Law

- Significance
  - Moore's Law - 1965
    - "Cramming more components onto integrated circuits"- Electronics, Volume 38, Number 8, April 19, 1965
      - Storage capacity of computer memory chips doubles every 18 months
      - Number of transistors that can be put on a semiconductor doubles every 18 months
      - Number of components that can be put on a computer chip doubles every 18 months while price remains same
        - Means computer power doubles every 18 months
    - Practically this means transistor density is continually increasing which means computing power goes up just as costs and energy consumption go down
    - This enormous quantitative growth leads to a qualitative change
- Profession
  - Chemist
- Places worked
  - Shockley Semiconductor, Fairchild Semiconductor, Intel
- Years of work
  - 1950's - 1990's
- Things worked on
  - Semiconductors

Moore's Law Illustrated

- Intel 4004 in 1971 - first microprocessor
  - 12 mm square ~ Contains 2,300 transistors ~ Width of transistors = 10,000 nanometers
- Intel Xeon Haswell E-5 in 2014
  - Contains 5 billion transistors ~ Width of transistors = 22 nanometers
- Intel Skylake in 2016
  - 120 mm square ~ Width of transistors = 14 nanometers (= 100 atoms wide)
- Transistors used to get better as they got smaller - smaller transistor is turned on + off with less power at greater speeds than large one so you could use more + faster transistors without needing more power or generating more heat
- But now making transistors smaller no longer makes them energy efficient so while transistors are still getting smaller they are not getting cheaper + faster
  - Rate of doubling of number of electronic components that can be placed on an integrated circuit has gone from 18 to 24 to 30 months today
  - Laws of classical physics no longer apply as transistors get smaller
  - Moore's Second Law
    - Cost of chip fabrication facility doubles every four years as it becomes more + more difficult to etch transistors on chips
  - Economics will kill Moore's Law before physics does

- Double, Double, Toil and Trouble, The Economist, Mar. 12, 2016

Limits to Moore's Law

- Used to be when you would scale to smaller feature size, good things automatically happened - chips would go faster + consume less power
- But by early 2000's, when transistors shrunk to 90 nanometers across, automatic benefit began to fail because electrons had to move faster + faster through circuits that were smaller + smaller thus chips began to get too hot
- Solutions were to stop increasing microprocessor clock rates (which were frozen in 2004) + put multiple processors (cores) on each chip (currently 4 + 8 today)
- Today transistors on top of the line microprocessors are 14 nanometers across
- By early 2020's transistors will be 2-3 nanometers (10 atoms) across and this will be a limit because at this scale electron behavior will be governed by quantum uncertainties that will make transistors hopelessly unreliable

- M. Waldrop, More Than Moore, Nature, Feb. 11 2016

How Many Transistors Will $1 Buy?

- 1982 - several thousand
- 2002 - 2.6 million
- 2012 - 20 million

  - When Silicon Leaves the Valley, The Economist, Mar. 8, 2014

"If there was ever a creator of wealth on a fantastic scale, ever a changer of custom and social values, ever a determinant of where our culture is headed and why, it's Moore's Law."

- Robert X. Cringely

Gordon Bell

From Wikimedia Commons

Person - Gordon Bell / Bell's Law

- Significance
  - Bell's Law (1972) - "Roughly every decade a new, lower priced computer class forms based on a new programming platform, network, and interface resulting in new usage and the establishment of a new industry."
    - Technology enables two evolutionary paths - constant performance with decreasing cost, or constant price with increasing performance
- Profession
  - Computer engineer
- Places worked
  - DEC, NSF, Microsoft Research
- Years of work
  - 1960 - Present
- Things worked on
  - PDP-1, PDP-11, VAX, The Computer Museum, MyLifeBits

Fred Brooks

From Wikimedia Commons

Person - Fred Brooks / Brooks's Law

- Significance
  - Brooks's Law (1975) - Adding manpower to a late software project makes it later

    "Nine women can't make a baby in one month"
  - "The Mythical Man Month: Essays on Software Engineering"

    "The Bible of Software Engineering - everybody quotes it, some people read it, and a few people go by it." - Fred Brooks
- Profession
  - Software engineer
- Places worked
  - IBM
- Years of work
  - 1956 - present
- Things worked on
  - IBM 360 software

Jerry Pournelle

From Wikimedia Commons

Person - Jerry Pournelle / Pournelle's Law

- Significance
  - "One user, one CPU"
- Profession
  - Science fiction writer, journalist
- Places worked
  - Boeing, Byte Magazine
- Years of work
  - 1965 - present
- Things worked on
  - Byte Magazine's User's Column
  - "Good Enough"

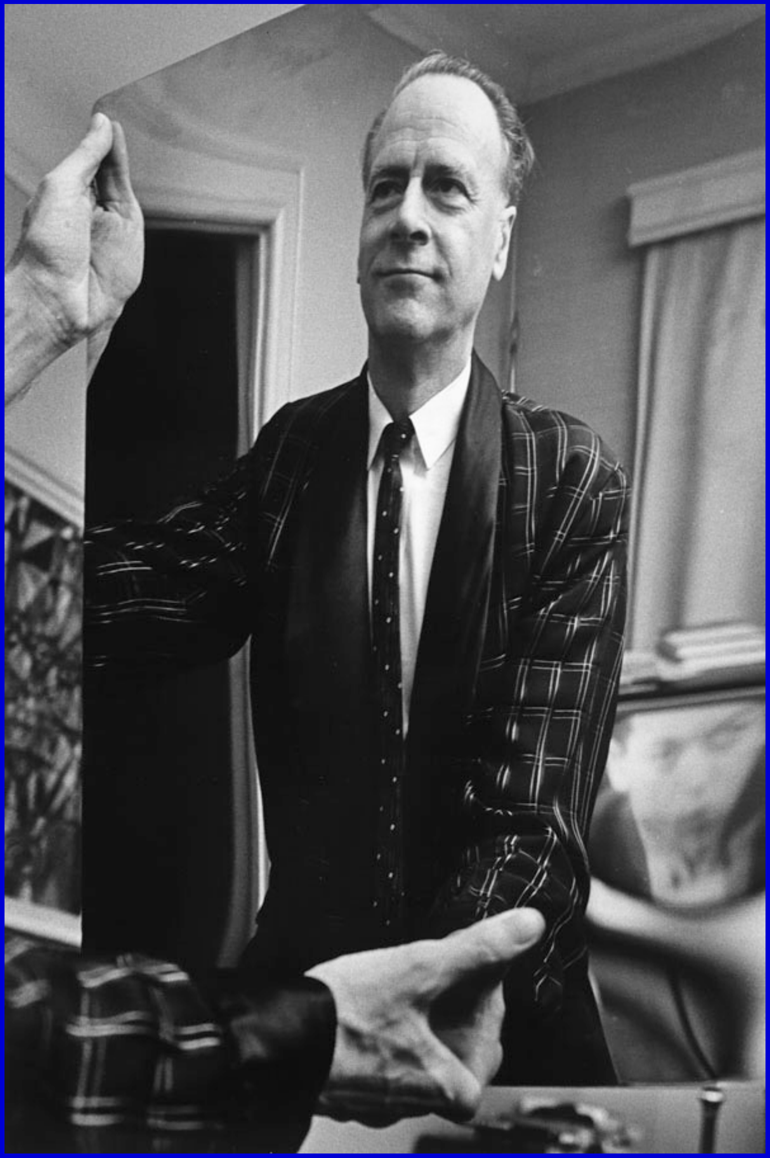
Robert Metcalfe

From Wikimedia Commons

Person - Bob Metcalfe / Metcalfe's Law

- Significance
  - Metcalfe's law - The value of a telecommunications network is proportional to the square of the number of connected users of the system
- Profession
  - Electrical engineer
- Places worked
  - Xerox PARC, 3Com
- Years of work
  - 1973 - present
- Things worked on
  - Co-inventor of Ethernet networking protocol at Xerox PARC in 1973
  - Founded 3Com Corporation in 1979 to commercially market Ethernet

Marshall McLuhan



From Wikimedia Commons

Person - Marshall McLuhan

- Significance
  - Media philosopher, coined the terms "The medium is the message" and "The global village"
- Profession
  - Professor
- Places worked
  - Founder of the Center for Culture and Technology at the University of Toronto, Canada
- Years of work
  - 1960's-1980's
- Things worked on
  - His books include The Gutenberg Galaxy, Understanding Media, and The Medium is the Message

Quotes of Marshall McLuhan

"With the satellites as a proscenium arch around the planet, the planet itself is now a stage on which everyone can do his thing."

"The medium or process of our time - electronic technology - is reshaping and restructuring patterns of social interdependence and every aspect of our personal life. It is forcing us to reconsider and reevaluate practically every thought, every action, and every institution formally taken for granted. Everything is changing - you, your family, your neighborhood, your job, your government, your relationship to "the others.""

"If we understand the revolutionary transformations caused by new media, we can anticipate and control them; but if we continue in our self-induced subliminal trace, we will be their slaves."

"When you put an electric system, or field, around you, you enlarge your own nervous system. Just as a wheel extends your foot, the "wired planet" now extends our nerves."

"In the electric environment of information, all events are simultaneous. There is no time or space separating events. Information and images bump against each other every day in massive quantities, and the resonance of this interfacing is like the babel of a village or tavern session."

"The family circle has widened. The world pool of information fathered by electric media - movies, Telstar, flight - far supposes any possible influence mom and dad can now bring to bear. Character no longer is shaped by two earnest, fumbling experts. Now, all the world's a sage."

Personal Case Study - Bob Metcalfe

- Role - Co-inventor of Ethernet
- Story
  - Served with him on The Computer Museum's Workshop on Virtual Museums in April 1995 and then dined with him in his home
  - Found him to be a great leader of the group, and a great listener + synthesizer of what was being said, and a gracious host

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- Who was Turing and what role did he play in the development of the computer?
- Describe Moore's Law, Brook's Law, and Metcalfe's Law
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
- Simulations

Conclusion

"Technology is anything that wasn't around when you were born"

- Alan Kay, computer scientist

Topic 11

Computers on the Desktop

Personal Computers

Song

Slide text

Thematic Quote

"The easiest way to predict the future is to invent it

Build what you use. Use what you build.

You let what you build change you, then you move on"

- Xerox Palo Alto Research Center (PARC)

Thematic Quote

"We shape our tools and afterwards our tools shape us"

- Marshall McLuhan, philosopher

The Painting

Computer Hardware / Homebrew and Inside IBM

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - Apple II computer
- Year
  - 1981
- Story
  - My first personal computer

The Question

What most influenced the development of the personal computer: people, places, or things?

Place - Northern California
Power to the People!

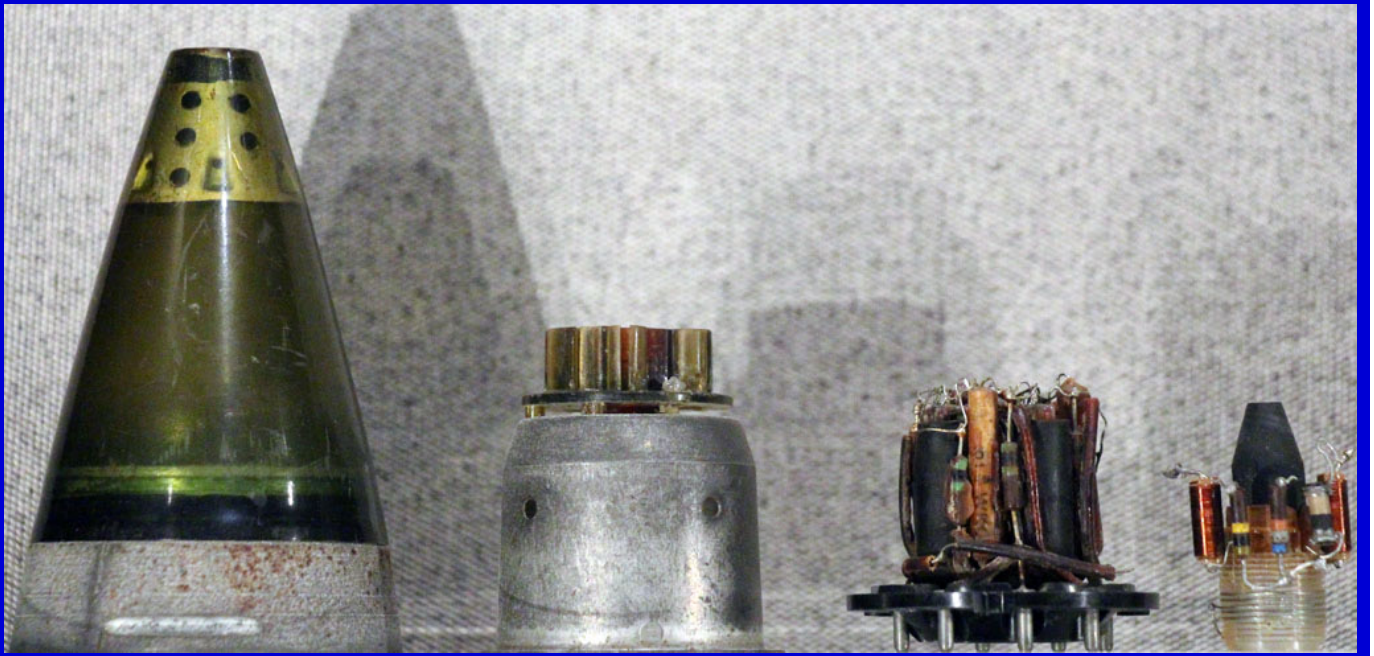
- Significance
  - The counter culture hated The Man and centralized systems of power + oppression - so rejected time sharing + embraced personal computer
  - The promise of the individual, power to the people, and the radical self-sufficiency that ruled the counter culture became enshrined in the promise of the personal computer
- Location
  - San Francisco Bay Area
- Definition
  - The center of the counter-culture
- People who worked there
  - Hippies
- Things created there
  - The personal computer industry

- John Markoff, What the Dormouse Said: How the Sixties Counterculture Shaped the Personal Computer Industry, 2005

Key Challenge Facing the US + UK in the 1940's

- How do you shoot aircraft out of the sky with anti-aircraft artillery?

Proximity Fuse (Mark 53)



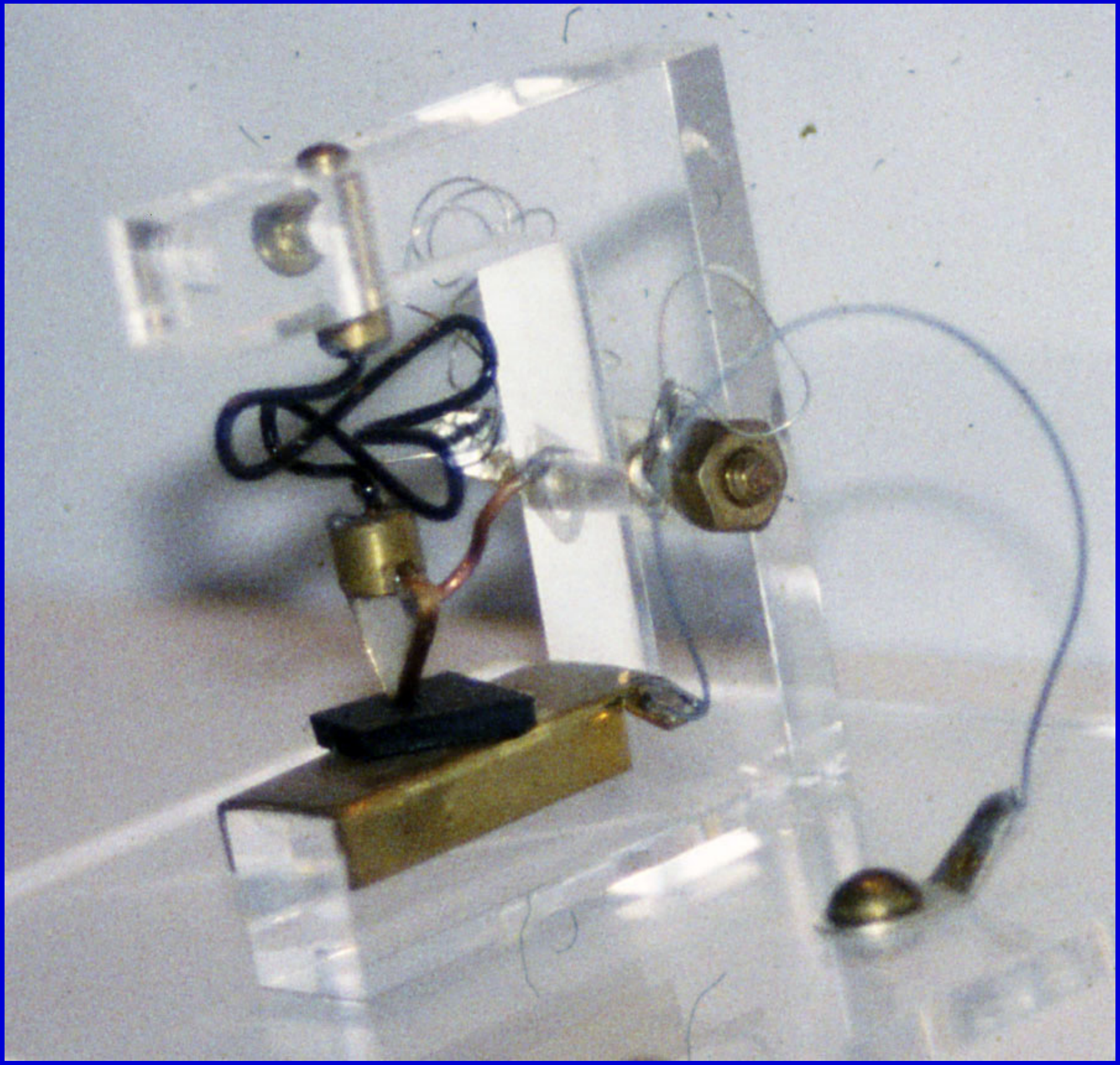
Thing / Hardware - Proximity Fuse

- Firsts / Achievements / Uniqueness / Significance
  - Work on this leads to drive to miniaturize and ruggedize vacuum tubes along with the development of printed circuit
- Place Produced (Company / Institution) ~ Year ~ Country
  - Applied Physics Laboratory at Johns Hopkins University ~ 1943 ~ USA
- People involved (Designer)
  - James Van Allen (amongst many others)
- Type
  - Sensor
- Price / Cost
  - Text
- Size
  - Ice cream cone

Thing / Hardware - Proximity Fuse

- Computing technology
  - Vacuum tubes
  - Small, battery-powered radar device that detonated shell when return signal was strong enough, about 60 feet
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - N/A
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Exploded a shell based upon distance from, not contact with, target - thus increasing effectiveness of anti-aircraft fire
- Predecessors - Unguided anti-aircraft shells ~ Successors - Surface to air missiles

First Transistor



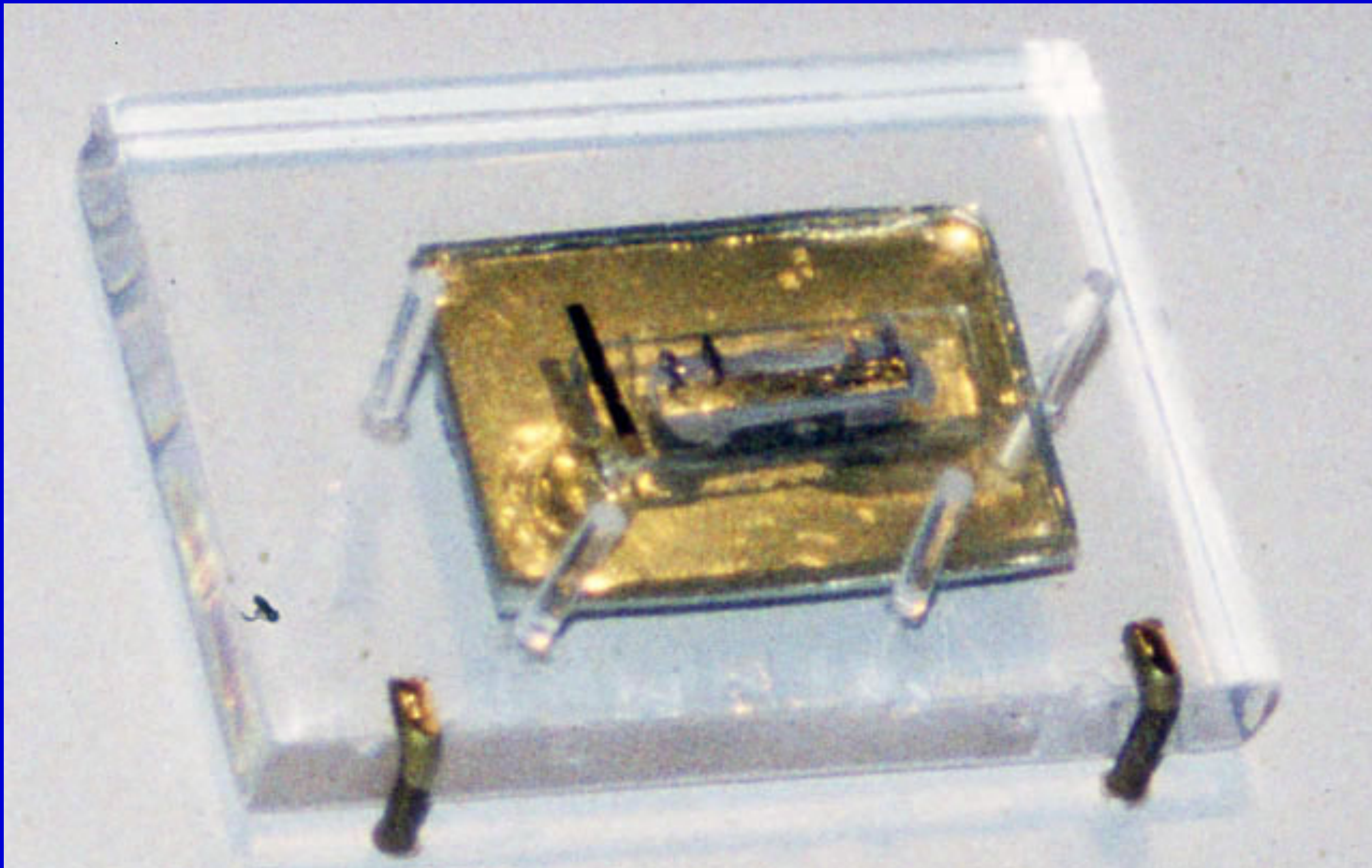
Person - William Shockley

- Significance
  - 1947 - Develops first transistor
    - 1956 - Wins Nobel Prize along with Walter Brattain and John Bardeen
  - 1956 - Helps to found Silicon Valley by moving back to his hometown of Palo Alto to start Shockley Semiconductor
- Profession
  - Physicist
- Places worked
  - ATT Bell Labs, Shockley Semiconductor
- Years of work
  - 1945-1960
- Things worked on
  - Transistors, semiconductors

Two Key Challenges Facing US in 1960's

- How do you drop a nuclear warhead in a pickle barrel from 10,000 miles away?
- How do you land a man on the Moon and return him safely?
- …fortunately for us, the solution to both involved computers

Kilby Integrated Circuit



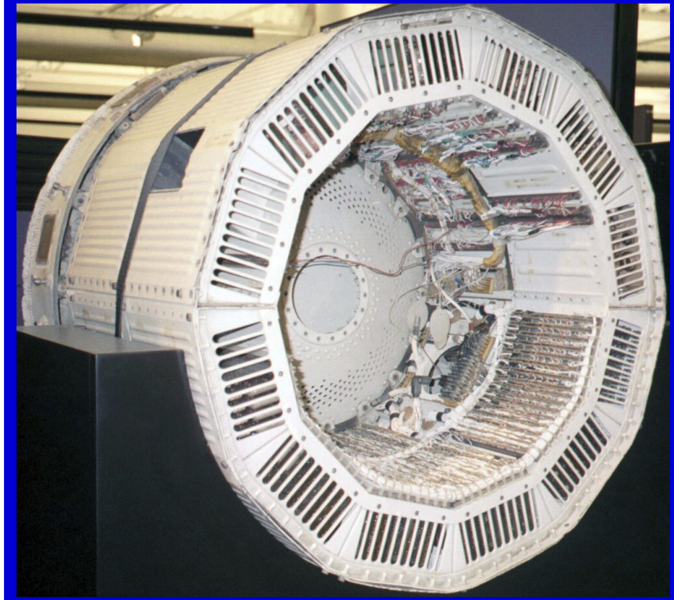
Thing / Hardware - Integrated Circuit

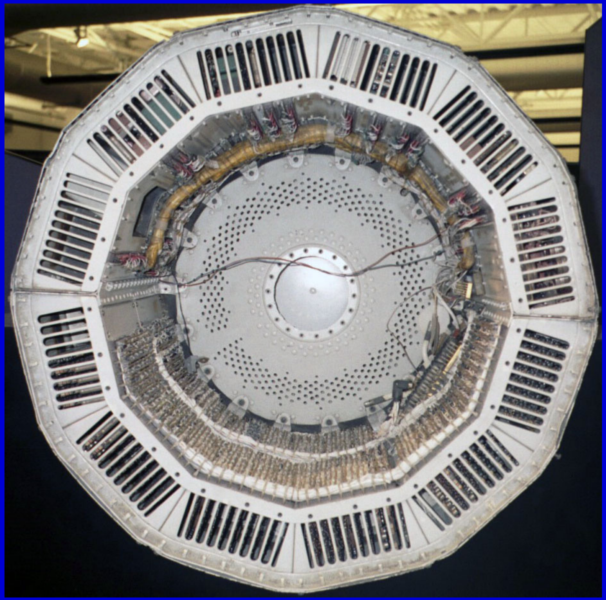
- 1930's + 1940's - Tubes used
  - Switching done by electrons, excited by hot filament, moving at high speeds in vacuum
  - Tended to burn out + failure of 1 tube amongst thousands would stop computer
- 1947 - Transistor invented
  - Took 10 years to make them as cheap, reliable, uniform as vacuum tubes
- Late 1950's - Integrated Circuit invented
  - Jack Kilby (winner of 2000 Nobel Prize in Physics) of Texas Instruments makes prototype in 1958 - 3 transistors on a chip of germanium
  - Robert Noyce of Fairchild Semiconductor in 1959 makes prototype on silicon + invents process making it practical to make integrated circuit
- Developing method of placing many individual transistors on sliver of material = integrated circuit
- Chips manufactured via photolithography allowed for mass production with decreasing cost like printing paper, but more delicate, with poorer yield

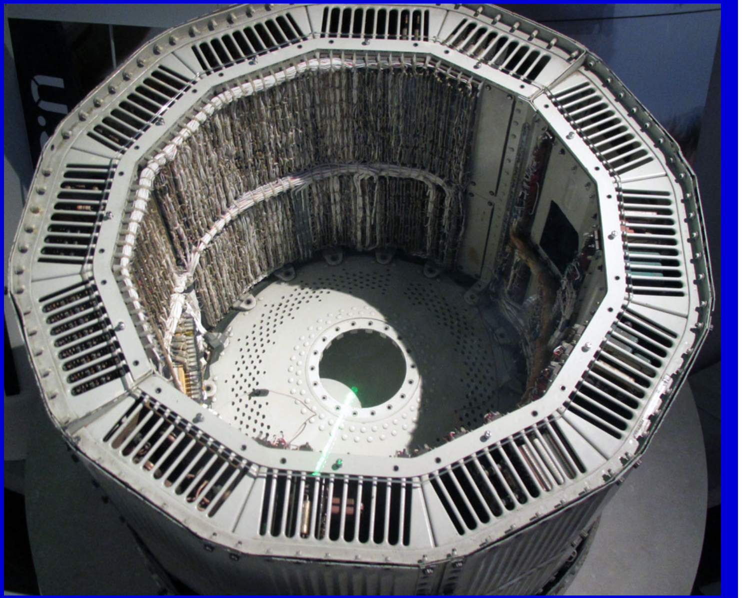
Thing / Hardware - Integrated Circuit

- Mid 1960's
  - Integrated circuits become competitive with discrete circuits (transistors) and became key to minicomputer
- 1962-1965
  - Minuteman II intercontinental ballistic missile (ICBM) guidance system was largest consumer of integrated circuits helping integrated circuits to become cheap and rugged, Apollo spacecraft guidance system was second largest consumer of integrated circuits
- Improvements in photolithography
  - Mid 1960's - Small scale integration (SSI) - tens of transistors / chip
  - Late 1960's - Medium scale integration (MSI) - hundreds of transistors / chip
  - 1970's - Large scale integration (LSI) - thousands of transistors / chip
  - 1980's - Very large scale integration (VLSI) - hundreds of thousands of transistors / chip
  - 1990's - Ultra large scale integration (ULSI) - millions of transistors / chip
  - 2010's - billions of transistors / chip
- A custom designed circuit was a better circuit…but it lost out to the integrated circuit
- Reason for integrated circuit's triumph was it offered good enough performance at dramatically lower price, was more reliable, smaller, consumed less power

Minuteman-I Guidance Ring / Computer







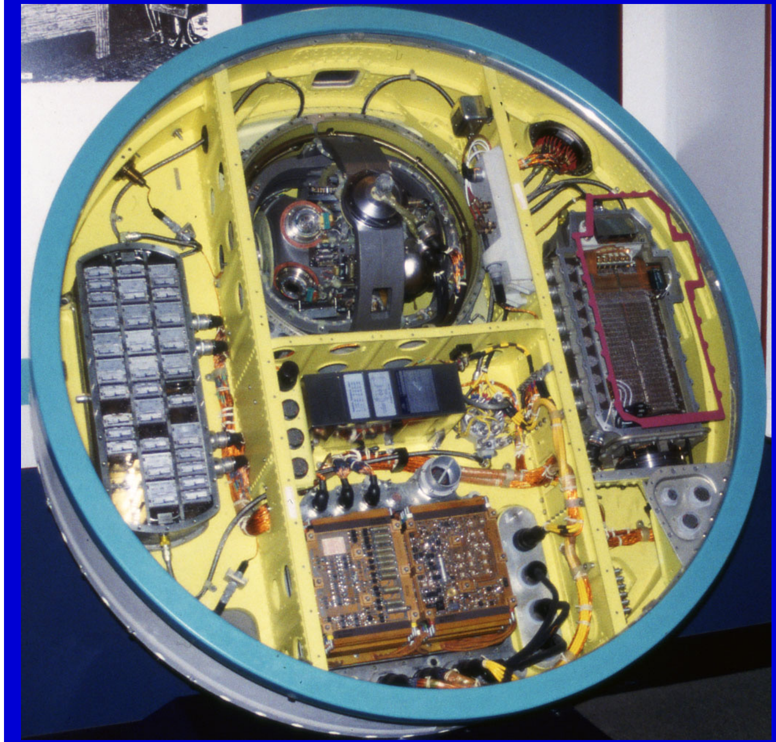
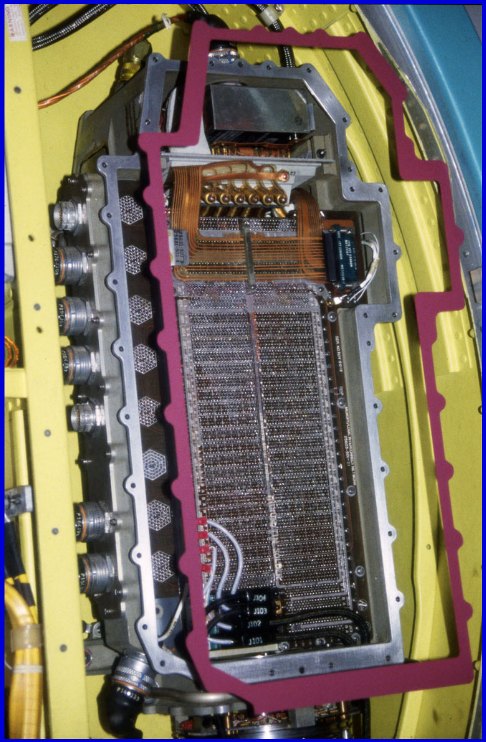
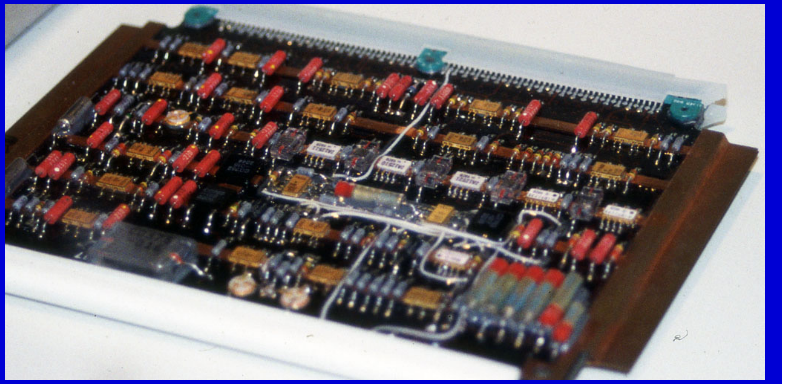
Thing / Hardware - Minuteman I Guidance Computer

- Firsts / Achievements / Uniqueness / Significance
  - Guidance system for first accurate US Intercontinental Ballistic Missile
- Place Produced (Company / Institution) ~ Year ~ Country
  - Autonetics Division of North American Aviation ~ 1960 ~ USA
- People involved (Designer)
  - Text
- Type
  - Text
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Minuteman I Guidance Computer

- Computing technology
  - Transistors
- Computing speed (in MIPS)
  - 12.8 kHz
- Primary memory type / technology ~ Size ~ Word length
  - Magnetic disk ~ 5,454 words ~ 24 bit
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Had to be rugged to withstand missile launch
- Predecessors - N/A ~ Successors - N/A

Minuteman-III Guidance Ring

Guidance Ring   Computer   Board

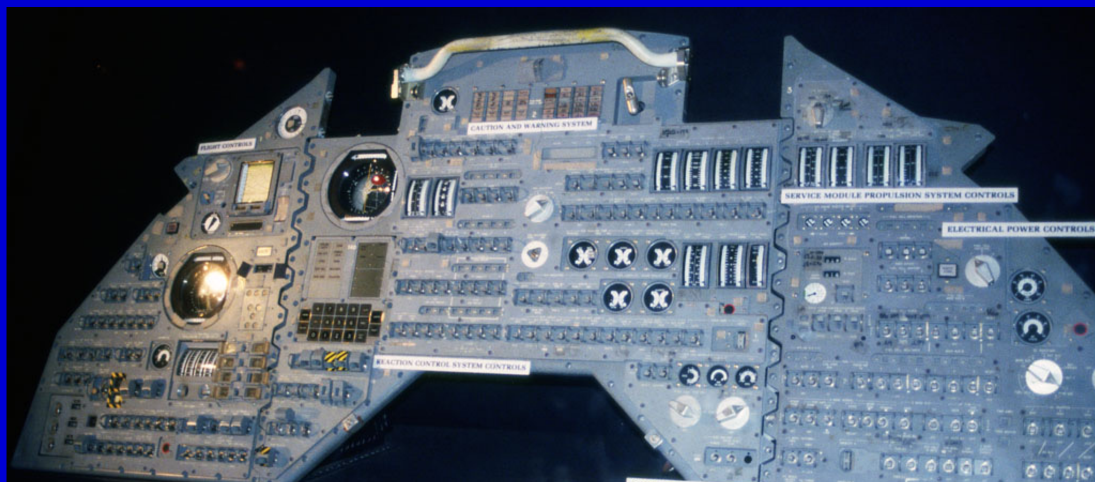
Thing / Hardware - Minuteman III Guidance Computer

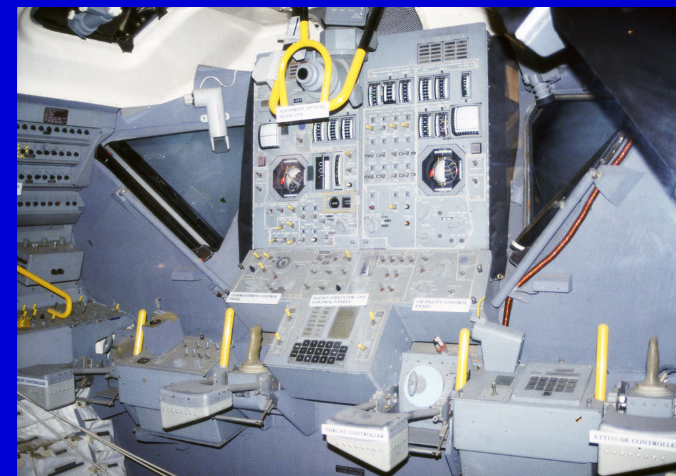
- Firsts / Achievements / Uniqueness / Significance
  - Minuteman II Intercontinental Ballistic Missile had first guidance system using integrated circuits, this is a more advanced version of that one
- Place Produced (Company / Institution) ~ Year ~ Country
  - Autonetics Division of North American Aviation ~ Year ~ USA
- People involved (Designer)
  - Text
- Type
  - Text
- Price / Cost
  - Text
- Size
  - Text

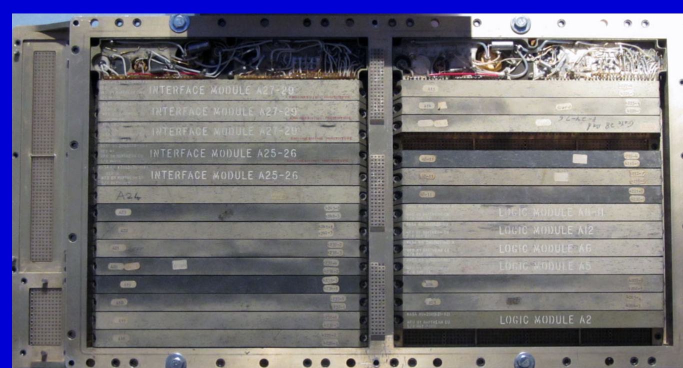
Thing / Hardware - Minuteman III Guidance Computer

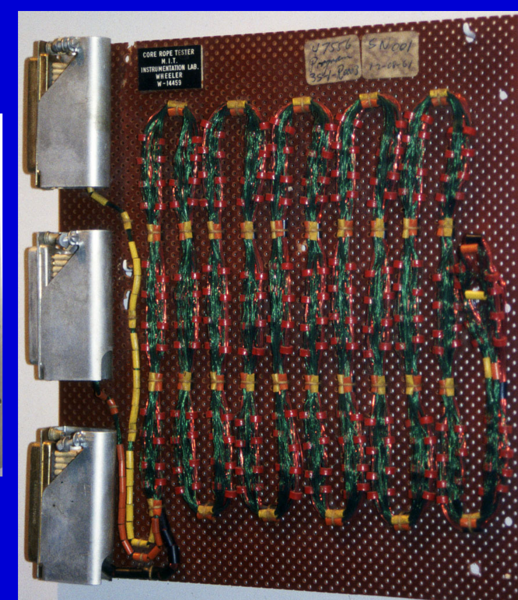
- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Text
- Predecessors - Minuteman II ~ Successors - Peacekeeper

Apollo Guidance Computer









Top - Command Module control panel, Lunar Module control panel

Bottom - Guidance + Navigation computer (GNC), GNC logic module, Core rope memory

Thing / Hardware - Apollo Guidance Computer

- Firsts / Achievements / Uniqueness / Significance
  - Made possible President Kennedy's dream of "landing a man on the Moon and returning him safely to the Earth"
- Place Produced (Company / Institution) ~ Year ~ Country
  - MIT Instrumentation Laboratory (Designed) + Raytheon (Produced) ~ 1965 ~ USA
- People involved (Designer)
  - Charles Stark Draper, Eldon Hall
- Type
  - Guidance computer
- Price / Cost
  - Text
- Size
  - 6" x 24" x 16"
  - Weight = 70 pounds

Thing / Hardware - Apollo Guidance Computer

- **Computing technology**
  - Integrated circuits from Fairchild Semiconductor
- **Computing speed (in MIPS)**
  - Clock speed was 11.7 milliseconds ~ 20 microsecond / add
- **Primary memory type / technology ~ Size ~ Word length**
  - Magnetic core rope ~ 36K words of ROM + 2K words of RAM ~ 16 bit [24K ROM + 4K RAM magnetic core rope]
- **Secondary memory type / technology ~ Size**
  - Text
- **Uses / Applications / Software**
  - To monitor, steer, communicate with guidance system ~ In Command Module - navigation, In Lunar Module - landing
  - 10,500 keystrokes required to complete lunar mission
  - Strict software engineering practices to avoid bugs -> Still had 1201 and 1202 program alarms on Apollo 11 final descent due to rendezvous radar being inadvertently left on
- **Predecessors - N/A ~ Successors - N/A**

Apollo 11 Moon Landing Transcript

102:38:26 Armstrong: (With the slightest touch of urgency) Program Alarm.

102:38:28 Duke: It's looking good to us. Over.

102:38:30 Armstrong: (To Houston) It's a 1202.

102:38:32 Aldrin: 1202. (Pause)

102:38:42 Armstrong (onboard): (To Buzz) What is it? Let's incorporate (the landing radar data). (To Houston) Give us a reading on the 1202 Program Alarm.

102:38:53 Duke: Roger. We got you...(With some urgency in his voice) We're Go on that alarm.

102:38:59 Armstrong: Roger. (To Buzz) 330.

...

102:42:19 Aldrin: Program Alarm. (Pause) 1201

102:42:24 Armstrong: 1201. (Pause) (onboard) Okay, 2000 at 50.

102:42:25 Duke: Roger. 1201 alarm. (Pause) We're Go. Same type. We're Go.

...

Computing Case Study Summary - Saturn Launch Vehicle Digital Computer (LVDC)

- Goal
  - Autopilot Saturn V rocket from launch into Earth orbit insertion and then perform a trans-lunar injection burn
- Center of Gravity (Strategy)
  - Provide digital guidance system for launch vehicle, updating itself 25 times per second
- Technology / Equipment
  - Located in Instrument Unit in S-IVB stage of Saturn I + Saturn V rockets
  - Used semiconductors for logic + magnetic cores for memory
  - Operated 1 million times slower than 2012-era microprocessor
  - Computing power of Saturn V rocket was equivalent to a (very) dumb mobile phone
- Training ~ Leadership ~ Morale
- Tactics
  - Used triple-redundant logic + voting system for 99.6% reliability
- Intangibles ~ Mistakes
  - Computing support for lunar missions provided on the ground by Real-Time Computer Complex at NASA's Manned Spacecraft Center + consisted of a primary + backup mainframe computer, at first IBM 7094-11 + then IBM System/360 Model 75J computers which were augmented with extra memory in the form of IBM 2361 Core Storage Units which contained half a megabyte of RAM
- Outcome
  - Worked every time
  - This computer got us to the Moon ~ The computers we have today should take us far beyond…

    - IBM Archives

Computing Case Study Summary - Space Shuttle General Purpose Computers

- Goal
  - Provide fly by wire flight control system to shuttle orbiter during launch, orbit, landing
- Center of Gravity (Strategy)
  - Use proven mainframe technology
- Technology / Equipment
  - 5 IBM System / 4 Pi computers (AP-101), descendants of IBM System / 360 mainframes with 32 bit processor, first core and then semiconductor memory, and capable of 480,000 instructions / second
- Training ~ Leadership ~ Morale
- Tactics
  - 4 of the computers operated redundantly in sync cross checking each other 500 times / second
  - 1 of the computers with independently written software served as a backup if the 4 computers could not agree
- Intangibles ~ Mistakes
- Outcome
  - Worked great

    - IBM and the Space Shuttle, IBM Archives

Computing Case Study Summary - Mars Curiosity Rover

- Goal
  - Land on Mars + then explore it safely
- Center of Gravity (Strategy)
  - Meticulous attention to detail
- Technology / Equipment
  - 2 computers
- Training / Leadership / Morale
  - High level of training for hardware engineers + programmers
  - Leadership experienced
  - High morale
- Tactics
  - Extraordinary measures taken in hardware + software design to ensure spacecraft reliability + that system can be debugged + repaired from millions of miles away
- Intangibles
  - Embedded software for spacecraft designed for one-of-a-kind device with uncommon array of custom-built peripherals
  - Code targets one user (mission) ~ For most critical parts of mission code is used once
  - Software can be difficult to test in accurate representation of environment in which it must operate ~ Must work first time
- Mistakes
  - Software that controls interplanetary spacecraft must have a high standard of reliability, any small mistake can lead to loss of mission
- Outcome
  - Spacecraft performed flawlessly in delivering Curiosity to surface of Mars + in exploration of planet

- Gerard Holzmann, Mars Code, Communications of the ACM, Feb. 2014

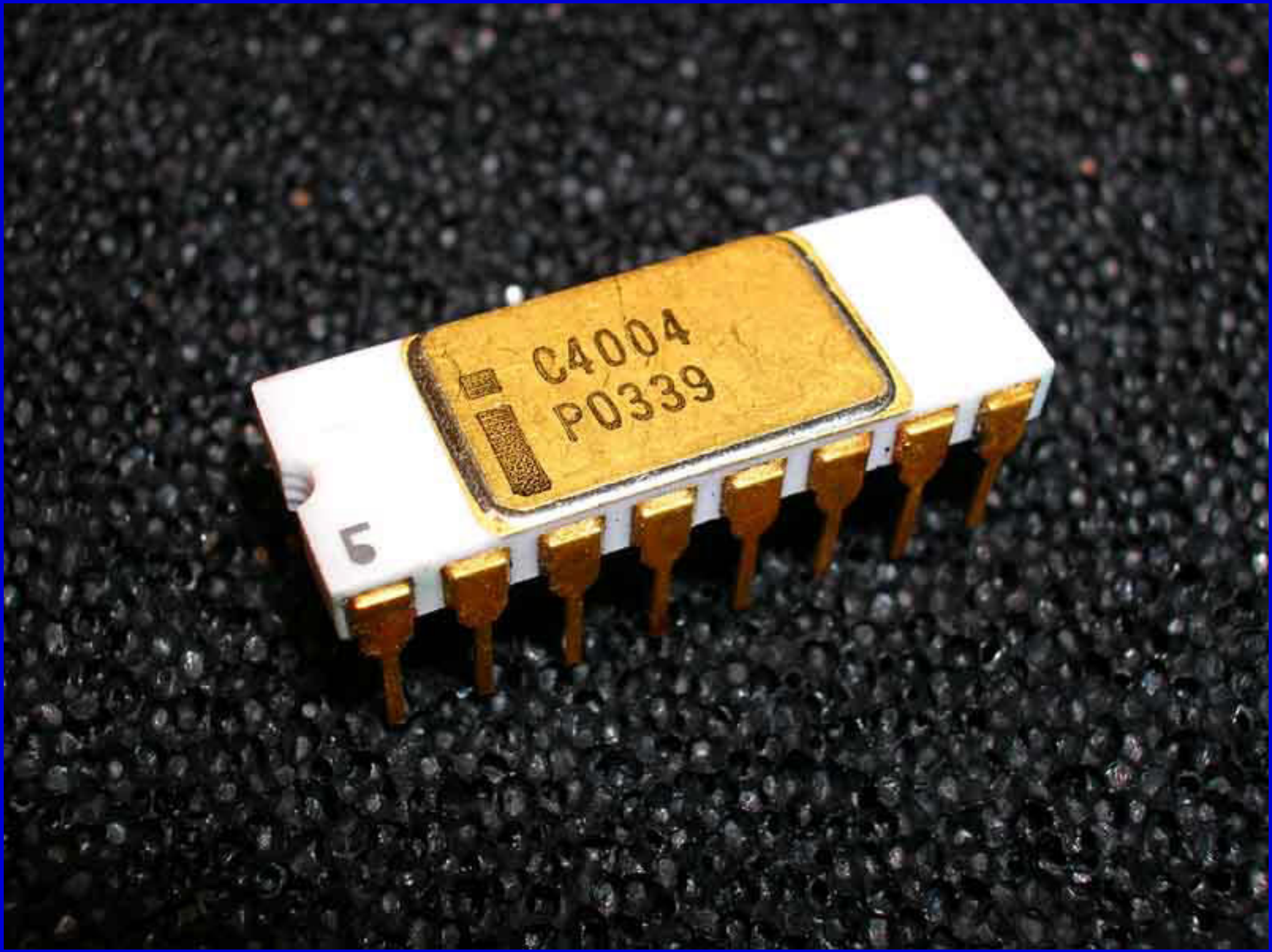
Thing / Hardware - Intel 1103 Memory Chip

- Firsts / Achievements / Uniqueness / Significance
  - Stored 1,024 bits of information ~ Magnetic core memory became obsolete
- Place Produced (Company / Institution) ~ Year ~ Country
  - Intel ~ 1970 ~ USA
- People involved (Designer)
  - Text
- Type
  - Memory chip
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Intel 1103 Memory Chip

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - N/A
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 1024 bits ~ Text
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Use it for primary memory
- Predecessors - Magnetic core memory ~ Successors - Flash memory

Intel 4004



From Wikimedia Commons

Thing / Hardware - Intel 4004 Microprocessor

- Firsts / Achievements / Uniqueness / Significance
  - First microprocessor, developed for use in BUSIMCOM 141-PF calculator
  - BUSICOM sold rights for it back to Intel, allowing Intel to diversify from memory chips to microprocessors
- Place Produced (Company / Institution) ~ Year ~ Country
  - Intel ~ 1971 ~ USA
- People involved (Designer)
  - Ted Hoff, Stan Mazor, Federico Faggin, Masatoshi Shima
- Type
  - Microprocessor
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Intel 4004 Microprocessor

- **Computing technology**
  - Integrated circuits ~ Had 2,300 transistors
  - Contained all computer components (central processing unit, memory, input / output)
- **Computing speed (in MIPS)**
  - 60,000 calculations / second
- **Primary memory type / technology ~ Size ~ Word length**
  - N/A
- **Secondary memory type / technology ~ Size**
  - N/A
- **Uses / Applications / Software**
  - General purpose microprocessor
- **Predecessors - N/A ~ Successors - Intel 8008 / 8080 / 8088 / x86**

Thing / Hardware - Intel 8080 Microprocessor

- Firsts / Achievements / Uniqueness / Significance
  - Used in Altair 8800 computer
  - First microprocessor to have enough power to form basis of first general purpose microcomputer
- Place Produced (Company / Institution) ~ Year ~ Country
  - Intel ~ 1974 ~ USA
- People involved (Designer)
  - Ted Hoff
- Type
  - Microprocessor
- Price / Cost
  - Text
- Size
  - Chip is ¼" square, whole package is 2 1/8" x 5/8" x 3/8"

Thing / Hardware - Intel 8080 Microprocessor

- Computing technology
  - Integrated circuits ~ Contained 5,000 transistors + other circuits
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - N/A
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - First generation of microcomputers (Altair 8800, S-100 bus, Tandy TRS-80)
- Predecessors - Intel 4004, Intel 8008 ~ Successors - Intel 8088

Popular Electronics January 1975

From Wikimedia Commons

Ed Roberts

From Wikimedia Commons

Person - Ed Roberts

- Significance
  - Founder of the first commercial microcomputer company, MITS, selling the Altair
  - Creator of first commercially successful personal computer - the Altair 8800 - in 1975
- Profession
  - Electrical engineer
- Places worked
  - Micro Instrumentation and Telemetry Systems (MITS)
- Years of work
  - 1970-1977
- Things worked on
  - Altair 8800

Altair 8800

INTE PROT MEMR INP MI OUT HLTA STACK WO INT
STATUS
D7 D6 D5 D4 D3 D2 D1 D0
WAIT HLDA
A15 A14 A13 A12 A11 A10 A9 A8 A7 A6 A5 A4 A3 A2 A1 A0
SENSE SW.
Data
Address
OFF
ON
STOP
SINGLE STEP
EXAMINE
DEPOSIT
RESET
PROTECT
UNPROTECT
AUX
AUX
ALTAIR 8800 COMPUTER

Thing / Hardware - Altair 8800

- Firsts / Achievements / Uniqueness / Significance
  - Featured on cover of January 1975 Popular Electronics magazine
  - First commercial general purpose microcomputer ~ Most popular of computer kits built by hobbyists
  - Named after a planet in Star Trek TOS
  - Had an open 100-line bus structure - This "Altair bus" later evolved into the S-100 bus, a long time industry standard bus for microcomputers
  - Micro-Soft Corporation was founded by Bill Gates and Paul Allen in order to develop a BASIC interpreter for this machine
- Place Produced (Company / Institution) ~ Year ~ Country
  - Micro Instrumentation and Telemetry Systems (MITS) ~ 1975 ~ USA
  - In 1977 MITS sold out to Pertec, who stopped producing Altairs in 1978
- People involved (Designer)
  - Ed Roberts
- Type
  - Microcomputer
- Price / Cost
  - Kit - $395, Assembled with 256 bytes of RAM - $498
- Size
  - 17" x 18" x 7"

Thing / Hardware - Altair 8800

- Computing technology
  - Integrated circuits, Intel 8080 microprocessor
  - Input was performed by toggling switches in binary and output was supplied by the blinking lights on the console
- Computing speed (in MIPS)
  - 2 MHz, 2 microsecond instruction cycle, 500 KIPS
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 256 bytes (1,024 bytes) to 64 kilobytes ~ 8 bit word
- Secondary memory type / technology ~ Size
  - 8" floppy disk
- Uses / Applications / Software
  - Micro-Soft BASIC by Bill Gates + Paul Allen
- Predecessors - N/A ~ Successors - The personal computer industry

Bill Gates

From Wikimedia Commons

Person - Bill Gates

- Significance
  - Co-founder with Paul Allen of world's largest personal computer software company

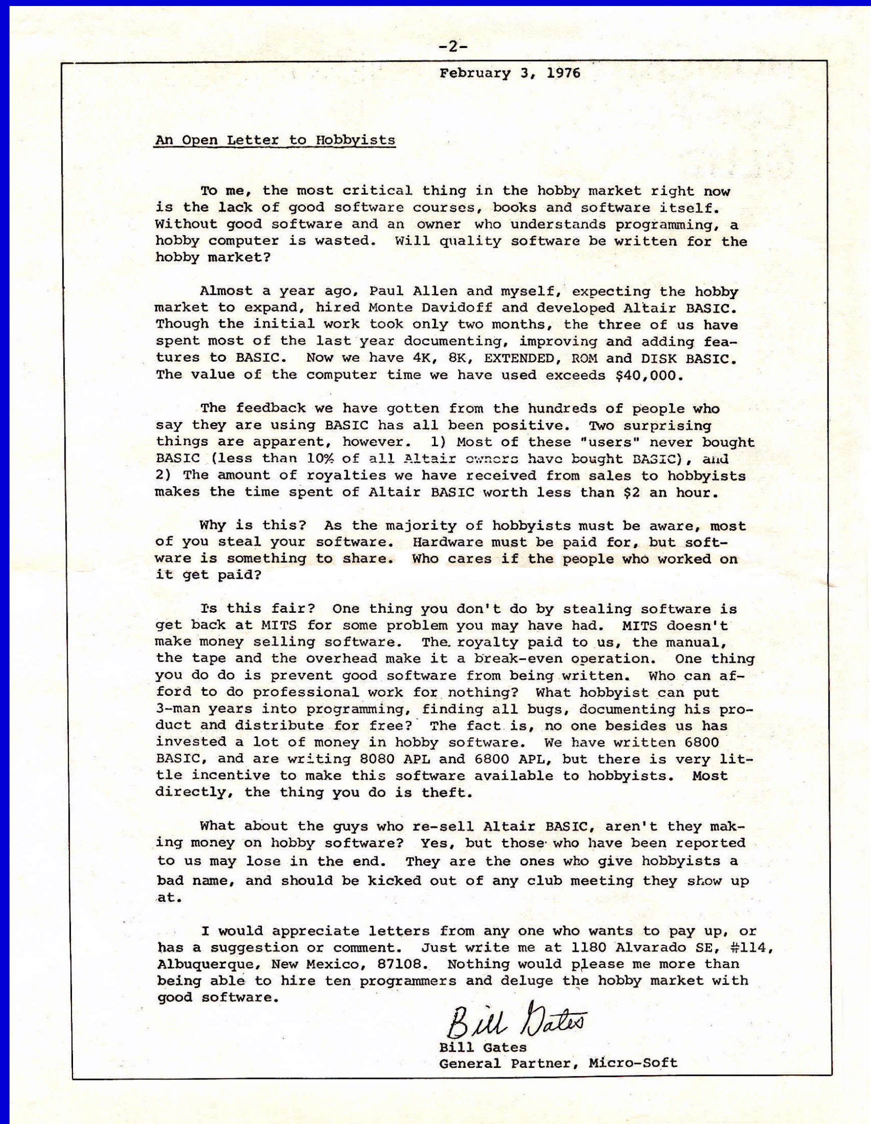
  "One could argue that Gates's greatest contribution to the world was not Microsoft, or the MS-DOS or Windows operating systems, or the Office productivity applications that hundreds of millions of people use. It was his role as the first champion of the concept that software itself had value." - Brent Schlender and Rick Tetzeli, Becoming Steve Jobs, p. 75
- Profession
  - Computer programmer, businessman
- Places worked
  - Microsoft
- Years of work
  - 1975 - 2008
- Things worked on
  - Microsoft BASIC

The Vision

"A computer on every desk and in every home running Microsoft software."

- Microsoft, 1977

Bill Gates Letter to Hobbyists



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February 3, 1976

An Open Letter to Hobbyists

To me, the most critical thing in the hobby market right now is the lack of good software courses, books and software itself. Without good software and an owner who understands programming, a hobby computer is wasted. Will quality software be written for the hobby market?

Almost a year ago, Paul Allen and myself, expecting the hobby market to expand, hired Monte Davidoff and developed Altair BASIC. Though the initial work took only two months, the three of us have spent most of the last year documenting, improving and adding features to BASIC. Now we have 4K, 8K, EXTENDED, ROM and DISK BASIC. The value of the computer time we have used exceeds $40,000.

The feedback we have gotten from the hundreds of people who say they are using BASIC has all been positive. Two surprising things are apparent, however. 1) Most of these "users" never bought BASIC (less than 10% of all Altair owners have bought BASIC), and 2) The amount of royalties we have received from sales to hobbyists makes the time spent of Altair BASIC worth less than $2 an hour.

Why is this? As the majority of hobbyists must be aware, most of you steal your software. Hardware must be paid for, but software is something to share. Who cares if the people who worked on it get paid?

Is this fair? One thing you don't do by stealing software is get back at MITS for some problem you may have had. MITS doesn't make money selling software. The royalty paid to us, the manual, the tape and the overhead make it a break-even operation. One thing you do do is prevent good software from being written. Who can afford to do professional work for nothing? What hobbyist can put 3-man years into programming, finding all bugs, documenting his product and distribute for free? The fact is, no one besides us has invested a lot of money in hobby software. We have written 6800 BASIC, and are writing 8080 APL and 6800 APL, but there is very little incentive to make this software available to hobbyists. Most directly, the thing you do is theft.

What about the guys who re-sell Altair BASIC, aren't they making money on hobby software? Yes, but those who have been reported to us may lose in the end. They are the ones who give hobbyists a bad name, and should be kicked out of any club meeting they show up at.

I would appreciate letters from any one who wants to pay up, or has a suggestion or comment. Just write me at 1180 Alvarado SE, #114, Albuquerque, New Mexico, 87108. Nothing would please me more than being able to hire ten programmers and deluge the hobby market with good software.

Bill Gates

Bill Gates
General Partner, Micro-Soft

From Wikimedia Commons

Thing / Software - Microsoft BASIC

- Firsts / Achievements / Uniqueness / Significance
  - Lingua franca for early personal computer programmers who wanted to write their programs in a higher level language
- Place Produced (Company / Institution) ~ Year ~ Country
  - Micro-Soft ~ 1975 ~ USA
- People involved (Programmer)
  - Bill Gates + Paul Allen
- Type
  - Computer language
- Price / Cost
  - Text
- Computer and operating system it runs on
  - All personal computers starting with the Altair
- Computer language written in
  - Assembly language
- Memory required
  - Text
- Predecessors - Dartmouth BASIC ~ Successors - Visual BASIC

Place - Homebrew Computer Club

- Significance
  - Ground zero for the development of the microcomputer
- Location
  - Stanford University
- Definition
  - "Call to order this meeting of the Homebrew Computer Club, which does not officially exist."
  - Met regularly to share ideas and individual's designs for personal computers
- People who worked there
  - Driven by idealistic vision of 1960's counterculture - Lee Felsenstein, Steve Wozniak, Steve Jobs
- Things created there
  - The microcomputer industry

Homebrew Computer Club
Structure of Meetings

- Moderated by Lee Felsenstein
  - Mapping session (asking questions / stating interests / sharing rumors + plans)
  - Formal presentation
  - Debug (corrections)
  - Random access (connect with people with common interests)

"Give help to others"

- Motto of the Homebrew Computer Club

Steve Wozniak

From Wikimedia Commons

Person - Steve Wozniak

- Significance
  - Technical talents he contributed to Apple Computer at its beginning
  - Co-founder of Apple Computer with Steve Jobs
- Profession
  - Computer engineer
- Places worked
  - Atari, HP, Apple
- Years of work
  - 1976 - 1987
- Things worked on
  - Apple I, Apple II

First Sighting in the Wild

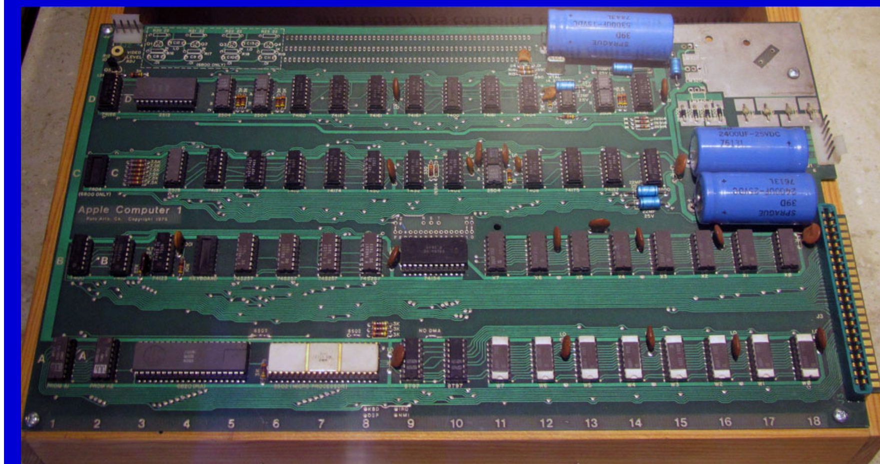
"At a booth marked 'Apple Computer, Inc.,' we paused to chat with the young man in charge, who introduced himself as Steven Jobs, the company's vice-president for operations. Mr. Jobs was pleased at the turnout for the exhibition. "I wish we'd had these personal machines when I was growing up," he said. "People have been hearing all sorts of things about computers during the past ten years through the media. Supposedly, computers have been controlling various aspects of their lives. Yet, in spite of that, most adults have no idea of what a computer really is, or what it can or can't do. Now for the first time, people can actually buy a computer for the price of a good stereo, interact with it, and find out all about it. It's analogous to taking apart 1955 Chevies. Or consider the camera. There are thousands of people across the country taking photography courses. They'll never be professional photographers. They just want to understand what the photographic process is all about. Same with computers. We started a little personal-computer manufacturing company in a garage in Los Altos in 1976. Now we're the largest personal computer company in the world. We make what we think of as the Rolls-Royce of personal computers. It's a domesticated computer. People expect blinking lights, but what they find is that it looks like a portable typewriter, which, connected to a suitable readout screen is able to display in color. There's a feedback it gives to people who use it, and the enthusiasm of the users is tremendous. We're always asked what it can do, and it can do a lot of things, but in my opinion the real thing it is doing right now is to teach people how to program the computers."

Recalling Mr. Jobs' wish that he had had such machines when he was growing up, we asked him if he would mind telling us his age.

"Twenty-two," Mr. Jobs said.

- The Talk of the Town (describing the First Annual Personal Computing Expo in New York City), The New Yorker, Nov. 14, 1977

Apple II



Apple I motherboard (above) / Apple II (below)

Apple II system

Thing / Hardware - Apple II

- Firsts / Achievements / Uniqueness / Significance
  - Technology - Open architecture ~ Color graphics ~ Floppy disk
  - Appearance - Elegant design ~ Attractively packaged ~ Professionally marketed
  - Apple I design offered to HP, they turned it down
- Place Produced (Company / Institution) ~ Year ~ Country
  - Apple ~ 1977 ~ USA
- People involved (Designer)
  - Steve Wozniak
- Type
  - Microcomputer
- Price / Cost
  - $1,200 entry level with 4K of RAM
  - Apple I cost $666.66 for blank printed circuit board, parts kit, 16 page assembly manual - you added power supply, keyboard, storage system, display - approximately 200 were sold
- Size
  - 15" x 17" x 4"

Thing / Hardware - Apple II

- **Computing technology**
  - Integrated circuits - MOS 6502 microprocessor
  - A total system was configured with motherboard, switching power supply, keyboard, case, manual, a pair of game paddles, AC powercord, and cassette tape with the computer game "Breakout."
- **Computing speed (in MIPS)**
  - 1 MHz, 1 microsecond instruction cycle, 1 MIPS
- **Primary memory type / technology ~ Size ~ Word length**
  - Integrated circuits ~ 4 to 48 kilobytes ~ 8 bits
- **Secondary memory type / technology ~ Size**
  - 5.25" Floppy disk ~ 143 kilobytes
- **Uses / Applications / Software**
  - Applesoft BASIC + Integer BASIC
  - VisiCalc, the first spreadsheet, was the killer app
  - Had huge software library, especially in education
- **Predecessors - Apple I ~ Successors - Apple III, Macintosh**

IBM 5100

Attribution unknown

IBM 5110

Thing / Hardware - IBM 5100

- Firsts / Achievements / Uniqueness / Significance
  - First IBM attempt at a personal computer
- Place Produced (Company / Institution) ~ Year ~ Country
  - IBM ~ 1975 ~ USA
- People involved (Designer)
  - Text
- Type
  - Personal computer
- Price / Cost
  - $20,000 with 64K of RAM
- Size
  - 50 pounds

Thing / Hardware - IBM 5100

- Computing technology
  - Integrated circuits ~ Program All Logic in Memory (Palm) microprocessor from IBM that emulated a subset of the IBM System/360 instruction set and the IBM System/3 instruction set
- Computing speed (in MIPS)
  - Very slow
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits
- Secondary memory type / technology ~ Size
  - ¼" tape cartridge built-in that held 200K
- Uses / Applications / Software
  - IBM System/360 APL interpreter + IBM System/3 BASIC interpreter
- Predecessors - None ~ Successors - IBM System/23 Datamaster and then IBM PC

IBM PC

Thing / Hardware - IBM Personal Computer (PC)

- **Firsts / Achievements / Uniqueness / Significance**
  - Set industry standard for personal computers due to 1) open hardware architecture, 2) ease of licensing of its MS-DOS operating system which allowed creation of clone industry 3) creation of powerful software tools for it
  - Used outside (of IBM) microprocessor, operating system, hardware
  - Sold commercially rather than through IBM's sales force
  - IBM name sold it throughout business world ~ Legitimized PC business + use of PCs in business
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - IBM ~ August 1981 ~ USA
- **People involved (Designer)**
  - Don Estridge
- **Type**
  - Microcomputer
- **Price / Cost**
  - $1595 and up
- **Size**
  - 19.5" x 16" x 5.5"
  - 1 cubic foot
  - Weighed 48 pounds
  - Power consumed was 150 watts with monitor

Thing / Hardware - IBM Personal Computer (PC)

- Computing technology
  - Integrated circuits ~ Intel 8088 processor with 16 bit words, and an instruction set of 116 instructions - processor fed data 8 bits at a time from the bus
  - PC-DOS operating system by Microsoft who then licensed it to others as MS-DOS who made software compatible clones
  - Input / output devices were keyboard, printer, CRT, RS232C port
- Computing speed (in MIPS)
  - 4.77 MHz ~ 210 nanosecond instruction cycle, 330 KIPS
  - The IBM-PC has 1/11 the processing speed of a standard 1991 personal computer. It's clock rate is 4.77 million cycles per second allowing it to do 240,000 additions per second
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits RAM of 16K expandable to 256K and 40K of ROM ~ 16 bits
- Secondary memory type / technology ~ Size
  - 5.25" floppy disk ~ 160 kilobytes
  - Cassette tape, 1 or 2 160K floppy drives, hard drives
- Uses / Applications / Software
  - Lotus 1-2-3 spreadsheet was the killer app
  - Shipped with EasyWriter word processor, VisiCalc spreadsheet, 3 business programs - Accounts Payable / Account Receivable / General Ledger, Dow-Jones communications program for tracking stock portfolios, Adventure game
- Predecessors - Apple II ~ Successors - IBM-XT, IBM-AT, Wintel

Place - Xerox Palo Alto Research Center (PARC)

- **Significance**
  - Defined what a computer could do and how we would interact with them
- **Location**
  - Palo Alto, California
- **Definition**
  - Research + Development facility for Xerox, charged with designing what would come after paper, the paperless office
- **People who worked there**
  - 50 / 100 best computer science people in the world
- **Things created there**
  - Bitmapped graphics
  - What you see is what you get (WYSIWYG) printing
  - Windows, Icons, Menus, Pointer (WIMP) graphic user interface
  - Personal computer - Alto
  - Local area networking - Ethernet
  - Laser printer - Dover
  - Object oriented programming
  - Viruses / worms

Xerox Alto

Thing / Hardware - Xerox Alto

- **Firsts / Achievements / Uniqueness / Significance**
  - Prototype / interim Dynabook - First example of what a workstation and ultimately a personal computer would look and function like
  - Windows Icons Menu Pointer (WIMP) interface with bitmapped display
  - Connected to Ethernet + laser printer
  - Software built on Smalltalk + object oriented programming
  - The first workstation computer to have a mouse for input, to be connected to a local area network (Ethernet), and to have a windows and icon graphical user interface
  - Influence first on Apple Lisa, most importantly on Apple Macintosh and thus Windows
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Xerox PARC ~ 1973 ~ USA
- **People involved (Designer)**
  - Butler Lampson, Chuck Thacker, Alan Kay
- **Type**
  - Workstation, personal computer
- **Price / Cost**
  - About 1,000 produced for use inside Xerox, not commercially available, could have cost $40,000 as a product
  - Commercialized as Xerox Star in 1981 for $16,000 - too expensive
- **Size**
  - Display / keyboard / mouse = 18.5" x 16" x 21" + Processor = 27.75" x 28" x 22.5"

Thing / Hardware - Xerox Alto

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - 0.3 MIPS, 170 nanosecond instruction cycle, variable number of instructions / second
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 64 - 256 kilobytes ~ 16 bit
- Secondary memory type / technology ~ Size
  - Hard disk ~ 2.5 megabytes
- Uses / Applications / Software
  - Word processing, graphics, teaching children programming via Smalltalk
- Predecessors - Dynabook ~ Successors - Xerox Star, Apple Lisa, Apple Macintosh

Apple Macintosh

Macintosh 128K **LaserWriter Plus**

Thing / Hardware - Macintosh

- Firsts / Achievements / Uniqueness / Significance
  - Bring computing to individuals on their terms
  - Take it out of the box, plug it in, use it
  - First commercial windows / icon / menus / pointer (WIMP) interface in a personal computer - made mouse a standard computer component
  - Mass-market popularization of the graphical user interface. Allowed the easy combination of text and graphics into a single document
- Place Produced (Company / Institution) ~ Year ~ Country
  - Apple ~ 1984 ~ USA
- People involved (Designer)
  - Jef Raskin, Steve Jobs, Burrell Smith, Andy Hertzfeld, Bill Atkinson
- Type
  - Microcomputer
- Price / Cost
  - $2,495
- Size
  - 10" x 14" x 11" ~ 0.8 cubic feet
  - Weight was 20 pounds
  - Power consumed was 75 watts

Thing / Hardware - Macintosh

- **Computing technology**
  - Integrated circuits ~ Motorola 68000 microprocessor with a word length of 16 bits and an instruction set with 56 instructions with 14 addressing modes. The architecture consisted of internal 32 bit data and address registers, an external 24 bit address bus, and an external 16 bit address bus
  - Input was via keyboard and mouse. Output was via printer, CRT, and 2 serial communication ports
- **Computing speed (in MIPS)**
  - 8 MHz, 128 nanosecond instruction cycle, 750 KIPS
  - Macintosh had 1/5th the computational power of an average 1991 personal computer. Its clock rate was 7.8336 million cycles per second and its calculation speed was 500,000 additions per second
- **Primary memory type / technology ~ Size ~ Word length**
  - Integrated circuits ~ 128 kilobytes of RAM and 60 kilobytes of ROM ~ 16 bits
- **Secondary memory type / technology ~ Size**
  - 3.5" floppy disk ~ 400 kilobytes
- **Uses / Applications / Software**
  - MacWrite, MacPaint, Hypercard
  - Aldus PageMaker - desktop publishing was the killer app
- **Predecessors - Xerox Alto and Apple Lisa ~ Successors - Evolution of the Macintosh**

"The Mac is the first computer good enough to be criticized"

- Alan Kay, computer scientist

Thing / Hardware - Apple Laserwriter

- Firsts / Achievements / Uniqueness / Significance
  - WYSIWG printing for masses via PostScript printing software that made it easy to combine text and graphics into attractive output
  - Led to desktop publishing revolution
- Place Produced (Company / Institution) ~ Year ~ Country
  - Apple Computer + Canon ~ 1985 ~ USA
- People involved (Designer)
  - Text
- Type
  - Laser printer
- Price / Cost
  - $6,995
- Size
  - 11.5" x 18.5" x 16.2", weighs 77 pounds

Thing / Hardware - Apple Laserwriter

- Computing technology
  - Integrated circuits ~ Motorola 68000 microprocessor
- Computing speed (in MIPS)
  - 12 MHz
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 1.5 megabytes ~ 32 bit
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Output device for Aldus PageMaker, the Macintosh's killer app
- Predecessors - Xerox 9700 ~ Successors - All personal computer laser printers

The Killer App and Personal Computers

- Altair 8800
  - Person - Ed Roberts of MITS
  - Killer App - Micro-Soft BASIC language by Bill Gates + Paul Allen
- Apple II
  - Person - Steve Wozniak + Steve Jobs of Apple
  - Killer App - VisiCalc spreadsheet by Dan Bricklin + Bob Frankston
- IBM PC
  - Person - Bill Gates of Microsoft who supplied PC-DOS which he resold as MS-DOS, creating the PC clone industry and thus the Wintel monopoly
  - Killer App - Lotus 1-2-3 spreadsheet / graphing / database by Mitch Kapor
- Macintosh
  - Person - Steve Jobs who lead a team of pirates to create an insanely great machine
  - Killer App - Aldus PageMaker desktop publishing

- Robert X Cringely, Triumph of the Nerds

Some Perspectives

Comparisons From Computer History Museum Revolution Exhibit

Computer Name	Produced By	Year	Speed	Memory size	Memory type	Memory Width	Cost
ENIAC	U of Pennsylvania	1945	5,000 adds/second	20 words	Vacuum tubes	10 bit decimal	$487,000
UNIVAC I	Remington-Rand	1951	525 microseconds/add	1,000 words	Mercury delay line	72 bit decimal	$950,000
Whirlwind	MIT	1951	125,000 adds/second	6,144 words	Core	16 bit	
JOHNNIAC	RAND	1953		1,024 words	Selectron tubes	40 bit	$470,000
Little Character	Control Data Corporation	1958		64 words	Core	6 bit	
Minuteman Guidance Computer	Autonetics North American Aviation	1960	12.8 kHz	5,454 words	Magnetic disk	24 bit	
PDP-1	DEC	1960	100,000 adds/second	4K	Core	18 bit	$120,000
Stretch	IBM	1961	714,000 adds/second	256K	Core	64 bit	$8 million
NTDS	Remington-Rand UNIVAC	1962	9.6 microseconds/add	32K words	Core	30 bit	$500,000
LINC	MIT	1962	62,500 adds/second	2K words	Core	12 bit	$43,600
IBM System/360 Model 30	IBM	1964	34,500 adds/second	64KB	Core	8 bit	$133,000
CDC 6600	Control Data Corporation	1964	3 MFLOPS	64KW(fast)+2 MW(slow)	Core	60 bit	$10 million
PDP-8	DEC	1965	333,333 adds/second	4K	Core	12 bit	$18,000
Apollo Guidance Computer	MIT	1967	20 microseconds/add	2K RAM + 36K ROM	Core	16 bit	
Nova	Data General	1969	384,615 adds/second	4K	Core	16 bit	$9,200
Interface Message Processor (IMP)	BBN	1969		12K			$82,200
PDP-11/20	DEC	1970	833,333 adds/second	4K	Core	16 bit	$10,800
Alto	Xerox	1973	0.3 MIPS	64-256K	Semiconductor	16 bit	$40,000
Amdahl 470V/6	Amdahl	1975	3.5 MIPS	8MB (up to)		32 bit	$3.75 million
ILLIAC IV	DARPA/U of Illinois/Burroughs	1975	75 MFLOPS	16MW		64 bit	$31 million
Altair 8800	MITS	1975	2 mHz	1K	Semiconductor	8 bit	$439 (kit), $621 (assembled)
Cray-1A	Cray Research	1976	160 MFLOPS	32MB	Semiconductor	64 bit	$6-$10 million
Apple I	Apple	1976	1 mHz	4K	Semiconductor	8 bit	$666.66 (circuit board kit)
Apple II	Apple	1977	1 mHz	4K	Semiconductor	8 bit	$1,298
Personal Electronic Transactor (PET)	Commodore	1977	1 mHz	4K	Semiconductor	8 bit	$495
TRS-80	Radio Shack	1977	1.78 mHz	4K	Semiconductor	8 bit	$599
VAX 11/780	DEC	1978	1 MIPS	1MB(+)	Semiconductor	32 bit	$120,000-$160,000
Atari 800	Atari	1978	1.78 mHz	8K	Semiconductor	8 bit	$999
IBM-PC	IBM	1981	4.77 mHz	16K	Semiconductor	16 bit	$1,565
Sun-1	Sun	1982	10 mHz	256K	Semiconductor	16 bit	$8,900
Lisa 2	Apple	1984	5 mHz	1MB	Semiconductor	32 bit	$3,495
Macintosh	Apple	1984	8 mHz	128K	Semiconductor	16 bit	$2,495
Connection Machine-1	Thinking Machines	1985	2.5-10 GFLOPS	4K/CPU		1 bit	$2.5 million for 64K CPU
Cray-2	Cray Research	1985	488 MFLOPS / CPU	512MW		64 bit	$12-20 million
Pixar Image Computer	Pixar	1986	11.8 mHz	100MB	Semiconductor	32 bit	$135,000
Cray-3	Cray Computer Corporation	1995	474 mHz / 15 GFLOPS	2GW	Semiconductor	64 bit	$30 million

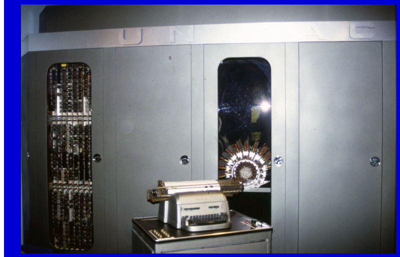
Some Perspectives

Comparisons From Computer History Museum Equipment Labels by Ron Mak

Computer Name	Produced By	Year	CPU Technology	Clock Speed / Memory Cycle Time	Memory Technology	Memory Size
JOHNNIAC	RAND	1953	Vacuum tubes	15 microseconds (0.067 MHz)	Magnetic core	4K 40-bit words
IBM 7030 Stretch	IBM	1961	Transistor	2 microseconds (0.5 MHz)	Magnetic core	16K-256K 64-bit words
CDC 6600	Control Data Corporation	1963	Transistor	100 nanoseconds (10 MHz)	Magnetic core	64K-256K 60-bit words
IBM System/360 Model 30	IBM	1964	Transistor	750 nanoseconds (1.33 MHz)	Magnetic core	Up to 64K
IBM System/360 Model 91	IBM	1966	Transistor	60 nanoseconds (16.7 MHz)	Magnetic core	Up to 6M
CDC 7600	Control Data Corporation	1969	Transistor	27.5 nanoseconds (36 MHz)	Magnetic core	65K (small core) + 512K (large core) 60-bit words
ILLIAC IV	Burroughs	1974	Emitter-coupled logic (ECL)	(13 MHz)	Semiconductor	2K 64-bit words per processor
Cray 1A	Cray Research	1975	Emitter-coupled logic (ECL)	12.5 nanoseconds (80 MHz)	Emitter-coupled logic (ECL)	1M 64-bit words
Cray 2 with 8 processors	Cray Research	1985	Emitter-coupled logic (ECL) + GaS	4.1 nanoseconds (244 MHz)	Emitter-coupled logic (ECL) + GaS	Up to 4G

Some Perspective

Computer calculating speeds compared to average 1991 PC





1951	1953	1964	1981	1984
UNIVAC-1	Whirlwind	IBM 360 Model 30	IBM-PC	Macintosh
1/4011	1/67	5.36 times	1/11	1/5

Cray-1M is 62 times more powerful than a 1991 PC

(Numbers from The Computer Museum People and Computers Exhibit)

An average PC in 2013 would be 500 times faster than a 1981 IBM-PC (Brian Kernighan)

Some Perspectives

The Computer Museum People and Computers Exhibit

Computer Name	Year	Speed	Calculating speed compared with 1991 PC	Cost	Size	Weight	Technology	Clock Rate	Primary Memory	Secondary Memory	Power Consumption
UNIVAC I	1951	1,900 adds/second	1/4011	$1 million	1,000 cubic feet for processor	16,7000 pounds	Vacuum tubes > 5,000	2.25 million cycles / second	Mercury delay lines - 1,000 words of 11 decimal digits	Magnetic tape 120,000 words / tape	125,000 watts
Whirlwind	1951	40,000 adds/second	1/67	$4.5 million	4,400 cubic feet	20,000 pounds	Vacuum tubes > 12,500	1 million cycles / second	Core - 6,144 16 bit words	Magnet drums 36,848 words, Magnetic tape 125,000 words/tape	160,000 watts
IBM 360 Model 30	1965	500,000 adds/second	1.5/1	$7,200 / month to rent	60 cubic feet	1,000 pounds	Discrete components on ceramic modules	0.5 million cycles / second	Core - 64K 32 bit words	Magnetic disk 29.2 megabytes / disk pack	10,000 watts
DEC PDP-8E	1971	375,000 adds/second	1/8	$5,000	2.2 cubic feet	90 pounds	Integrated circuits	0.725 million cycles / second	Core - 4K 12 bit words	Magnetic disk, Magnetic tape, Punched tape, Magnetic drum	500 watts
IBM-PC	1981	240,000 adds/second	1/11	$3,000	1 cubic foot	48 pounds	Integrated circuits	4.77 million cycles / second	Semiconductor - 16K-256K	Casette tape, 1 or 2 160K Floppy drives, Magnetic disk	150 watts
Cray-1M	1982	166,000,000 FLOPS	62/1	$4 million	58 cubic feet	5,300 pounds	Integrated circuits	83 million cycles / second	Semiconductor - Up to 4M 64 bit words	48 Magnetic disk storage units, Magnetic tapes	100,000 watts
Apple Macintosh 512	1984	500,000 adds/second	1/5	$2,500	0.8 cubic foot	20 pounds	Integrated circuits	7.83 million cycles / second	Semiconductor - 512K 16 bit words	Internal 800K floppy drive, External floppy drive, Magnetic disk	75 watts

Soviet Personal Computers

- NATO and Japan had export controls on technology to the Soviet Union + Warsaw Pact, which included semiconductor technology
- The Soviet Union resorted to large scale industrial espionage + reverse engineering to obtain semiconductor technology
- But Soviet industry was unable to manufacture semiconductor microprocessors + memory chips in quantities that would allow them to be available on open market
- So when in 1982, Radio magazine in Russia began publishing a series of articles on how to build your own Intel 8080-based personal computer called the Micro-80, the only way to get the chips was the black market where chips that were stolen from factories could be purchased
- Only a few hundred Micro-80's were built, but they had a similar effect in the Soviet Union that the Altair 8800 had in the U.S.
- But no computer clubs arose from this because it was almost impossible to get permission from the government to form such clubs
- Additionally the lack of modems and poor Soviet telephone network prevented the creation of an electronic bulletin board system as arose in the West
- The first personal computer that gained widespread use in the Soviet Union was the Sinclair ZX Spectrum which after 1985 could be exported to the Soviet Union and which was rapidly cloned

- Zbigniew Stachniak, Red Clones: The Soviet Computer Hobby Movement of the 1980's, IEEE Annals of the History of Computing, Jan.-Mar. 2015

Personal Case Study - IBM 5100

- Role
  - Portable computer introduced by IBM in 1975
- Story
  - I saw an ad for it in Scientific American in spring 1977 and told my English teacher I was going to get one of these some day and she looked at me like I was crazy
  - Really was a shrunken IBM System/370 mainframe and IBM System/3 minicomputer through the use of microcode

Personal Case Study - Jerry Pournelle

- Role
  - Computer journalist, writer of "User's Column" in Byte Magazine from 1979 - present
- Story
  - Met him at a conference at University of Iowa in November 1991
  - Found him to be data-driven, honest, and blunt - just like his columns

Personal Case Study - Lyceum Computers / Bill C

- Role
  - Early independent computer store in Warren, Michigan
- Story
  - Where I bought my first Apple II personal computer
  - Owner was a PhD in Biology who discovered computers while doing research and fell in love with them and tried to make a living out of it
  - Provided a personal, one to one approach to computer marketing, selling, and servicing…he knew his customers

Personal Case Study - Rick Inatome

- Role
  - Founder of Computer Mart, an early personal computer store chain in Michigan
- Story
  - Met him in 1981 as a friend's father was a consultant for him
  - A successful businessman, growing his small chain into Inacomp Computer Centers

Personal Case Study - Apple II

- Role
  - Early successful personal computer
- Story
  - Received one as high school graduation present in 1981 - 48K RAM with Microsoft 16K RAM Card
  - Choose it because a friend had one
  - Intended to use it to write games + play games
  - Accidentally brought home a word processor and showed it to my mother, her reaction to it was - "This makes the computer pay for itself"
  - Used it primarily for word processing and as a terminal for programming in college

Ad - See Topic 21 Computers in the Arts

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Bliss was it in that dawn to be alive,
But to be young was very heaven! - Oh! times,
In which the meagre, stale, forbidding ways
Of custom, law, and statue, took at once
The attraction of a country in romance!
When Reason seamed the most to assert her rights,
When most intent on making of herself
A prime Enchantress - to assist the work,
Which then was going forward in her name!
- William Wordsworth, French Revolution, As It Appeared To Enthusiasts At Its Commencement

Questions for Further Discussion

- What computational challenge did US+UK face in 1940's regarding aircraft?
- What computational challenges did the US face in the 1960's?
- What role did hippies play in the death of time sharing and the development of the personal computer?
- Why was the Homebrew Computer Club an important place in the history of computing?
- What is the significance of the Altair 8800, Apple II and IBM-PC?
- What computational challenges did personal computer makes face in the 1980's?
- What was the significance of the Xerox Alto and how did Xerox fumble the future?
- What is the significance of the Apple Macintosh?
- Do general purpose computers have a future? Or will they be made illegal by the Recording Industry Association of America (RIAA) and the Motion Picture Association of America (MPAA) since they allow you to do anything you want, including pirating
  - See Cory Doctorow on "The Coming Civil War Over General Purpose Computing"
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History - Chapter 5 The Microprocessor
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
  - Cringely, Robert X - Accidental Empires
- Fiction
  - Coupland, Douglas - Microserfs
- Documentaries
  - Steve Jobs The Lost Interview
  - Triumph of the Nerds: The Rise of Accidental Empires
- Movies
  - Pirates of Silicon Alley
- Simulations

Conclusion

"Only the paranoid survive"

- Andy Grove, CEO Intel

Topic 12

Computers on the Network
The Network is the Computer

Song

I am a lineman for the county
And I drive the main road
Searchin' in the sun for another overload
I hear you singin' in the wire
I can hear you through the whine
And the Wichita lineman is still on the line

- Glen Campbell, Wichita Lineman

Thematic Quote

"The network is the computer"

- Sun Microsystems

The Painting

Transmission Lines

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - ATT Rotary Phone
- Year
  - 1960's
- Story

The Question

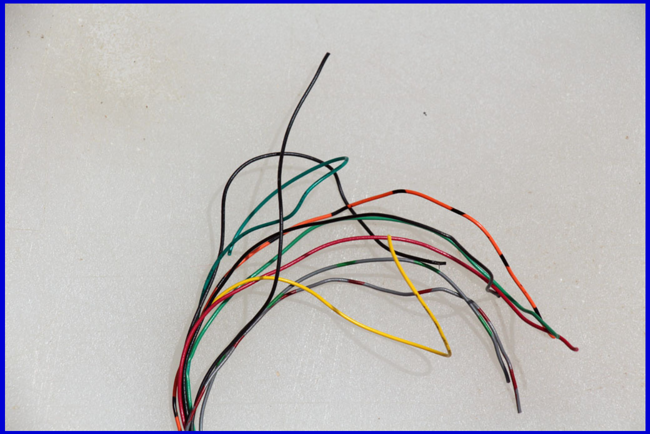
"What hath God wrought?"

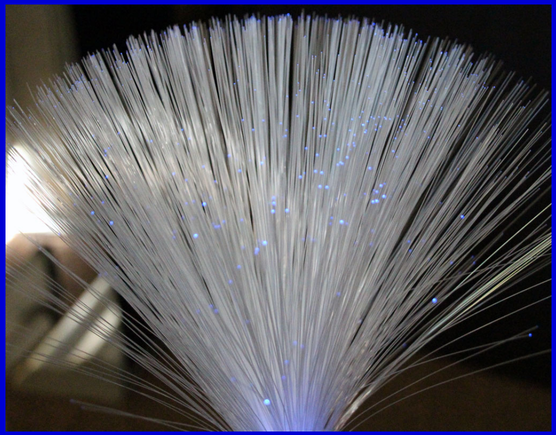
- First telegraph message sent by Samuel Morse, 1844

The Question

Where does your Internet come from?

Communication Substrates





Top - Twisted pair copper wire, Ethernet cable, Coaxial cable
Bottom - Fiber optic cable, Air

From Telegraph to the Internet

- 1844 - First official message sent between Baltimore and Washington on a telegraph line constructed by Samuel Morse and funded by the U.S. was - "What hath God wrought?"
- 1852 - Telegraph fire alarm systems are developed as fire warning systems. The first is in Boston. By pulling the lever, an alarm is sounded at a central office which notifies the fire department of which box was activated.
- 1865 - First transatlantic telegraph cable was laid.
- 1876 - "The telephone reminds me of a child, only it grows much more rapidly. What is before it in the future, no man can tell." Alexander Graham Bell, shortly after using his first working telephone.
- 1900 - The Marconi International Marine Communications Company was formed to sell wireless for maritime use. Wireless telegraphy, or radio, was the only way for ships at see to communicate outside of visual range. It was a boon to ships in distress.
- 1914 - First transcontinental US telephone line was completed, using 130,000 telephone poles.
- 1917 - Frequency division multiplexing, permitting a single communications link to carry multiple conversations, or streams of data, passed a field test staged with a pair of telephone wires between Maumee, Ohio and South Bend, Indiana.
- 1920 - November 2nd, 1920 KDKA, the first commercial radio station, initial broadcast broke the news of the election of the President.

- The Networked Planet, The Computer Museum

From Telegraph to the Internet

- 1934 - 1934 Communications Act required broadcasters to present fair programming in the public interest, convenience, and necessity...leading to the providing of services such as emergency alarms. This was different from publishers such as newspapers who operated under the principle of freedom of the press.
- 1939 - David Sarnoff, president of RCA, introduces commercial television at the 1939 World's Fair in New York City
- 1940 - First example of remote computer networking, September 9, 1940 a "computist" entered a problem on a teletype at the Mathematical Association of America meeting at Hanover, New Hampshire. A minute or so later, the teletype printed the solution provided by the Bell Labs Model 1 Calculator located in New York, more than 300 miles away.
- 1943 - Electronic code breaking of radio messages had a critical impact on the course of World War II. The British machine, Colossus, searched messages for patterns at the rate of 25,000 characters per second.
- 1948 - Claude Shannon's "The Mathematical Theory of Communication" showed engineers how to code data so that it could be checked for accuracy after transmission between computers.
- 1951 - Real time computing was achieved with the 1951 completion of Whirlwind build at MIT under the supervision Jay Forrester and Robert Everett. The computer processed data and displayed the results almost instantaneously on the computer screen.
- 1954 - TI designs the first pocket sized radio, made and marketed by Regency Electronics. It cost $50 and would play for 1,000 hours on its battery.

- The Networked Planet, The Computer Museum

From Telegraph to the Internet

- 1958 - SAGE - Semi Automatic Ground Environment - broke new ground as the first large scale communications network linking hundreds of radar stations in the USA and Canada. An operator could direct actions by pointing a light-gun to the screen. This was the forerunner of air traffic control systems.
- 1960 - ATT's 1960 Dataphone, the world's first commercial modem, was designed specifically to covert digital computer data to analog signals for transmission over the Bell System's long distance network.
- 1963 - ASCII - American Standards Code for Information Exchange was developed to permit machines from different manufacturers to exchange data
- 1964 - SABRE - Semi Automated Business Research Environment made its debut on the American Airlines reservation system. Linking 2000 terminals, in 65 cities, via telephone lines to 2 IBM 7090 mainframes to make reservations.
- 1966 - Acoustically coupled modems connected computers to the telephone network by means of a standard telephone handset
- 1968 - FCC rules in favor of Carter Electronics Corporation, which sold a device, the Carterphone. This ruling allowed any data device to be connected to the phone system, not just those made by ATT.
- 1969 - Portable terminals are marketed to businessmen, but not many are sold.

- The Networked Planet, The Computer Museum

From Telegraph to the Internet

- 1970 - The original BBN IMP.
- 1970 - The first ATM is installed in Valdosta, Georgia.
- 1973 - Robert M. Metcalfe describes in a memo what becomes Ethernet
- 1973 - SWIFT starts the mission of creating a shared, worldwide data processing and communications link in a common language for international financial transactions.
- 1975 - Telenet, the first commercial packet switching network and the brainchild of Larry Roberts, linked customers in 7 cities. Telenet was the first value-added-network (VAN), called this because of the extras they offered and charged for.
- 1976 - First description of TCP/IP protocol that became the international standard for networks
- 1976 - X.25 standard of packet switching, a means of dividing files into small parcels for transmission across networks was approved by the International Telecommunications Union.
- 1977 - SWIFT begins live service between 518 banks in 16 countries
- 1977 - ARPANet is officially launched in July 1977. This is the first time a number of computer networks were linked together.

- The Networked Planet, The Computer Museum

From Telegraph to the Internet

- 1977 - IBM DES data encryption standard key to unlock encrypted messages was approved by the U.S. government to guarantee confidentiality in agencies. Available to the public as well, DES provides 70 quadrillion combinations of codes.

- 1979 - Hayes Microcomputer Products Modems become the defacto standard for personal computer communications.

- 1980 - October 28, 1980 - the entire ARPANet goes down.

- 1980 - Computer worm was invented by John Shoch at Xerox PARC as a tool to increase computer efficiency. Shoch's small program searched a computer network for temporarily idle processors and put them to work. Worms were later adapted for more sinister purposes such as sucking up processor power or erasing information.

- 1981 - The French postal and telecommunications office launches Teletel, service. Subscribers were loaned terminals called Minitels to log on to the directory, entertainment and information services. By 1987, the subscribers numbered 6 million.

- 1982 - Novell demonstrates first networking of PC's and first network application (NSNIPES - a multiuser game) at the National Computer Conference in Houston by sharing files between CP/M workstations and IBM-PC's.

- 1983 - Stratus Computer launches the first 24 hour, remote worldwide, computer monitoring, diagnostic and service network called "Phone Home." Each system contains a modem that is used to contact Stratus technicians in case of a problems

- The Networked Planet, The Computer Museum

From Telegraph to the Internet

- 1983 - Novel ships Netware (previously Sharenet) a network operating system / file server software allowing users to share files and printers in a secure environment
- 1983 - DECTALK, a device that converted text to speech by means of a 10,000 word phonetic dictionary and several hundred rules of pronunciation was developed by Dennis Klatt. DEC marketed the product to answer telephone enquiries.
- 1984 - NSFNet created
- 1984 - Professor Fred Cohen of USC alerted the public that computer viruses can infect any computer connected to a contaminated device.
- 1986 - Cisco Systems ships ATX, the first multiprotocol router, a device that connects several networks together so they appear seamless to the user.
- 1986 - Novell ship FST Netware level 2 with TTS software that allows fault-tolerant PC networking to protect against data loss during hardware failure.
- 1988 - Internet worm burrows through the net
- 1989 - ARPANet expires to be replaced by the Internet. Internet connects more than 100,000 hosts.

- The Networked Planet, The Computer Museum

Communications Case Study Summary - Nike! (Victory!)

- Goal
  - Communicate news of Greek victory over Persians at Marathon to Athens
- Center of Gravity (Strategy)
  - Run 26 miles
- Technology / Equipment
  - Sandals
- Training / Leadership / Morale / Tactics
- Intangibles
  - Nike is Greek goddess of victory
  - Story appeared 600 years after the battle, not in Herodotus' History
- Mistakes
- Outcome
  - Phidippides drops dead after delivering message

Communications Case Study Summary - Admiralty Semaphores

- Goal
  - Long distance message conveyance in times of crisis
- Center of Gravity (Strategy)
  - Use the high ground (hill tops)
- Technology / Equipment
  - 1588 Spanish Armada - Used chain of huge bonfires on hilltops covering length + breadth of England which were lit when Armada was spotted - Each could be seen miles away
  - 1795 Napoleon threatened invasion - semaphore signal posts set up between Portsmouth + London
- Training / Leadership / Morale / Tactics
- Intangibles / Mistakes
  - How would semaphore system work at night?
- Outcome
  - Evolved into British railroad mechanical semaphore signaling

\- OS Nock, The Dawn of World Railways 1800-1850, p. 126

Communications Case Study Summary - Victorian Internet

- Goal
  - Speed up communication
- Center of Gravity (Strategy)
  - Connect the world with wires
- Technology / Equipment
  - 1790's - Optical / mechanical telegraphs developed by French
  - 1844 - "What hath God wrought?" - First telegraph message by Samuel Morse
  - 1850 - News that had taken a week to get from New York to Washington DC now took seconds
  - 1865 - First transatlantic cable, no longer had to wait 6 weeks to learn what was happening on other side of Atlantic
  - 1870s - world wide network
- Training / Leadership / Morale / Tactics
  - Required skilled operators to learn Morse code

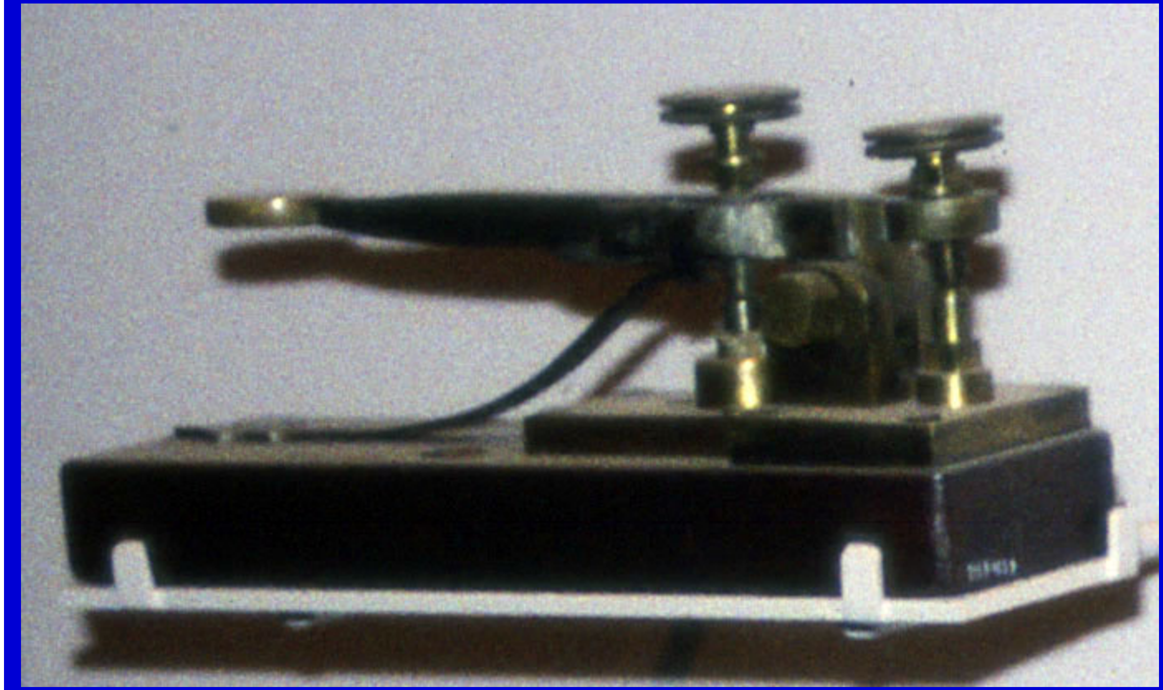
\- Tom Standage, The Victorian Internet

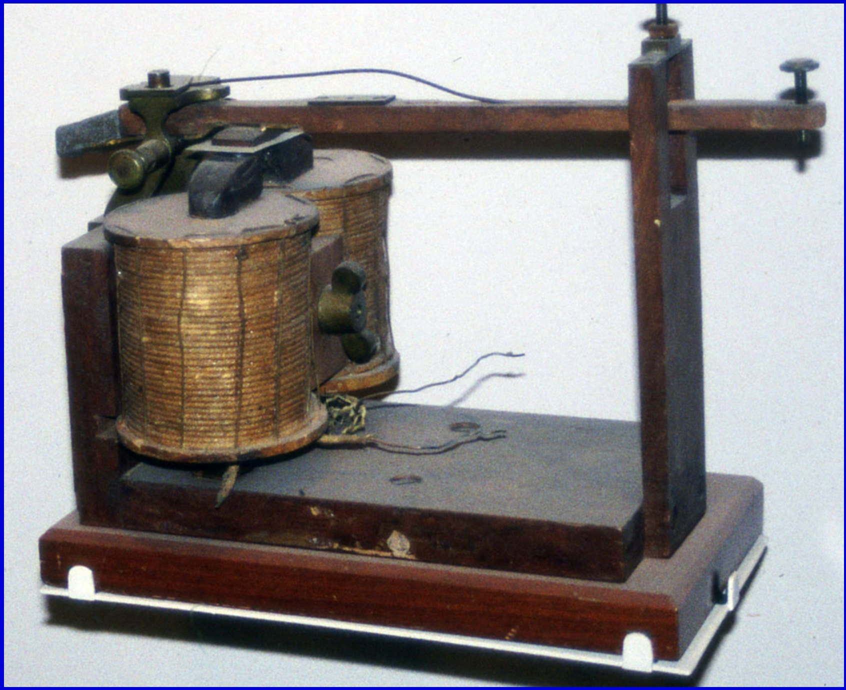
Communications Case Study Summary - Victorian Internet

- Intangibles / Mistakes
  - Commonalities between telegraphy in 19th century + Internet
    - Hype, skepticism, hackers, online romance, chat rooms, flaming, information overload, predictions of outbreak of world peace, speculative stock market bubbles in tech companies, cryptography usage, government regulation, address spaces
    - Sped up business, commerce, news gathering, war
- Outcome
  - Telegraph was Internet of its age
  - Telegraph caused greater changes in society than Internet did through speeding up communication
  - Militarily, centralizes C2 especially for Royal Navy
  - Evolves into telephone (speaking telegraph) that could by used by unskilled operators (everyone)

\- Tom Standage, The Victorian Internet

Early Morse Telegraph Key and Receiver





Thing / Hardware - Telegraph

- **Firsts / Achievements / Uniqueness / Significance**
  - Tele graph = distance writing in Greek
  - Transmit signals over wires
  - First instrument to transform information into electrical form and transmit it reliably over long distances
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Samuel Morse ~ 1844 ~ USA
- **People involved (Designer)**
  - Samuel Morse
- **Type**
  - Communications device
- **Price / Cost**
  - Text
- **Size**
  - Text

Thing / Hardware - Telegraph

- Computing technology
  - Text
- Computing speed (in MIPS)
  - N/A
- Primary memory type / technology ~ Size ~ Word length
  - N/A
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Sending telegraph message entailed going to telegraph office + writing out your message
  - Telegrapher than translated your message into Morse code, consisting of long and short electric pulses, dots and dashes
  - Message was sent using a telegraph key
  - Message was received electrically, listened to, + transcribed by telegrapher
  - Receivers existed that could record the Morse code onto paper tape
  - Killer app was news - especially business news + stock prices
- Predecessors - Optical telegraph ~ Successors - Telephone

Focused Case Study - T-Mail Background

- US Civil War influenced by three new technologies
  - Railroad expanded battlespace
    - Increased area from which troops could be sent to battlefield (see First Battle of Bull Run)
  - Rifled musket expanded killing power
    - Extended range + killing efficiency of soldier (see Pickett's Charge at Gettysburg)
  - Telegraph expanded national leader's reach
    - Eliminated physical distance as controlling factor in exchange of information, allowing coordination between disparate forces and national leadership
    - Allowed national leader to electronically monitor battle he was not present at for first time

\- Tom Wheeler, Mr. Lincoln's T-Mails

Focused Case Study - T-Mail Politics

- At beginning of Civil War all communication with Union military forces was in military hands
- In 1862 US Military Telegraph Corps - a civilian agency - was formed and placed in War Department across street from White House
  - All military traffic flowed through it, putting communication with Union military forces in civilian hands
  - Proximity to White House gave Lincoln easy access

- Tom Wheeler, Mr. Lincoln's T-Mails

Focused Case Study - T-Mail Technique

- War Department telegraph office, across street from White House, became Lincoln's situation room where he read all incoming traffic and sent his own outgoing traffic
  - Lincoln was a techie - an early adaptor - only president to hold a patent
  - Telegraph was his personal news service…a Big Ear to eavesdrop on what is going on and a Long Arm for projecting his leadership informed by newly gathered information
  - Allowed him to practice management by walking around with the telegraph doing the walking
  - …and yet his hierarchy of communications was first - face to face, second - written letter, and third - telegram

- Tom Wheeler, Mr. Lincoln's T-Mails

Focused Case Study - T-Mail Result

- Historical relationship between leader in the political capital and generals in the field was altered by Lincoln
  - Never before had commander in chief been able to issue orders + dialog with generals in almost real time without leaving capital
  - Lincoln used ability to read telegraph traffic to and from generals - even though it may have been addressed to others - as way to eavesdrop on headquarters tents of his armies
  - He developed this model of electronic leadership on his own
  - First national leader to project himself electronically ~ Helped him win the war

- Tom Wheeler, Mr. Lincoln's T-Mails

Focused Case Study - T-Mail Failure

- Confederacy did not benefit from telegraph because historically the South had discouraged industrialization which would be at odds with current Southern agricultural existence, including
  - Transportation (railroads)
  - Communication (telegraph)

- Tom Wheeler, Mr. Lincoln's T-Mails

Marconi Beach, Cape Cod

First wireless telegraph station in US

Wireless Telegraph Networks

- Cape Cod, Massachusetts was the site of Marconi's first transatlantic wireless telegraph station in America in 1902.
- This was America's first transcontinental wireless network node

Thing / Hardware - Telephone

- Firsts / Achievements / Uniqueness / Significance
  - Analog device that transmits human voice over wires
- Place Produced (Company / Institution) ~ Year ~ Country
  - Text ~ 1876 ~ USA
- People involved (Designer)
  - Alexander Graham Bell
- Type
  - Communications device
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Telephone

- **Computing technology**
  - **Text**
- **Computing speed (in MIPS)**
  - **N/A**
- **Primary memory type / technology ~ Size ~ Word length**
  - **N/A**
- **Secondary memory type / technology ~ Size**
  - **N/A**
- **Uses / Applications / Software**
  - **Alexander Graham Bell obtains patent on phone + defends it**
  - **Leads to wealthy regulated monopoly in US to provide telephone service**
- **Predecessors - Telegraph ~ Successors - Mobile phone**

Communications Case Study Summary - Whole Earth Catalog

- Goal
  - Democratize in 1968 "Access to tools and ideas," and thus change civilization
- Center of Gravity (Strategy)
  - Forsees how big computer networking will be, attempts to reproduce it in print technology
- Technology / Equipment
  - Printed a how-to manual / compendium / encyclopedia / literary review / opinionated life guide / collection of reader's reviews + recommendations of everything
- Training ~ Leadership ~ Morale
  - Stewart Brand
- Tactics
  - Deeply consumerist - full of stuff to buy - change the world by buying stuff
- Intangibles
  - Helped many new ideas first reach mainstream audience - organic farming, solar power, recycling, wind power, desktop publishing, mountain biking, midwifery, computers, etc.
- Mistakes
  - Promoted communes which never took off
- Outcome
  - Magnum opus of counterculture
  - Changed the world by making people visible to each other - just like the Internet did
  - (The Whole Earth Catalog was) "the Internet before the Internet. It was the book of the future. It was a Web in newsprint." - John Markoff

- Carole Cadwalladr, Stewart Brand's Whole Earth Catalog, the Book That Changed the World, The Guardian, May 5, 2013

"When I was young, there was an amazing publication called The Whole Earth Catalog, which was one of the bibles of my generation. It was created by a fellow named Stewart Brand not far from here in Menlo Park, and he brought it to life with his poetic touch. This was in the late 1960s, before personal computers and desktop publishing, so it was all made with typewriters, scissors and Polaroid cameras. It was sort of like Google in paperback form, 35 years before Google came along: It was idealistic, and overflowing with neat tools and great notions.

Stewart and his team put out several issues of The Whole Earth Catalog, and then when it had run its course, they put out a final issue. It was the mid-1970s, and I was your age. On the back cover of their final issue was a photograph of an early morning country road, the kind you might find yourself hitchhiking on if you were so adventurous. Beneath it were the words: "Stay Hungry. Stay Foolish." It was their farewell message as they signed off. Stay Hungry. Stay Foolish. And I have always wished that for myself. And now, as you graduate to begin anew, I wish that for you.

Stay Hungry. Stay Foolish."

- Steve Jobs, Stanford Commencement Speech

Teletext + Videotext

- Teletext services were one-way, transmitting information through television's vertical blanking interval
- Videotext services were two-way + interactive, transmitting information (email, chat, ecommerce, news, banking, pornography, information databases) from central databases through phone networks to dumb terminals

Communications Case Study Summary - Ceefax

- Goal
  - Give BBC viewers chance to check latest news, sports, weather, TV listings in pre-Internet era
- Center of Gravity (Strategy)
  - Give viewers access to same information coming into BBC newsroom as soon as it was received
- Technology / Equipment
  - Needed teletext-enabled TV to display information
- Training
  - None needed
- Leadership / Morale
  - Supported by BBC leadership
- Tactics
  - Transmit full pages of text information in spare lines transmitted on analog TV signal
- Intangibles
  - Praised by Plain English Campaign that calls for use of clear language in public communication
- Mistakes
  - Didn't try to make the leap to digital TV
- Outcome
  - World's first teletext service, from 1974 - 2012
  - Peak audience in 1990s with 20 million viewers checking it once a week
  - Disappeared with shutting down of analog TV signal in UK

    - John Hand, Ceefax Service to End After 38 Years on BBC, BBC News, Oct. 23, 2012

Minitel - 1

From Wikimedia Commons

Communications Case Study Summary - Minitel

- Goal
  - Political - computerize French society + ensure it's technological independence
  - Technological - Create nationwide computer based communications system in France in 1982
- Center of Gravity (Strategy)
  - Replace free government provided printed telephone directory with free government provided computer terminal that accessed online telephone directory (and many other resources) for all in France
- Technology / Equipment
  - Intelligent computer terminal with dial-up modem
  - All billing for services / ecommerce handled on your monthly phone bill with service providers getting a cut
- Training
  - Easy to use
- Leadership / Morale
  - Government of France provided funds + leadership
- Tactics
  - Telephone directory was killer app, then people would try other apps like banking, stock prices, weather, travel reservations, exam results, university applications

- Angelique Chrisafis, France Says Farewell to the Minitel - the Little Box that Connected a Country, The Guardian, Jun. 28, 2012
- Hugh Schofield, Minitel: The Rise and Fall of the France-Wide Web, BBC, Jun 28, 2012

Communications Case Study Summary - Minitel

- Intangibles
  - Rise of "Minitel Rose"- sex is always a killer app
  - In USA people said "The French are so far ahead, we are being left behind"…and then the Internet appeared
- Mistakes
  - Closed system, not interoperable with other computer networks
  - Had to ask permission from France Telecom to set up a service which eventually killed innovation
- Outcome
  - Deployed nationwide in France - put them online a decade ahead of everyone else
  - Heavily used - 9 million terminals at its height in mid-1990's, with 25 million users connecting to 23,000 services
  - Ecommerce grew up on it ~ Still generating high revenues in 2007
  - Tried to export it unsuccessfully to other countries because you had to buy the whole system to make it work
  - Overtaken by Internet + World Wide Web ~ Turned off in 2012

"Despite everything, there's a nostalgia for an era when France developed new ideas, took risks on ideas that didn't just look to the US or outside models: a time when we wanted to invent our own voice" - Valerie Schafer, author

- Angelique Chrisafis, France Says Farewell to the Minitel - the Little Box that Connected a Country, The Guardian, Jun. 28, 2012
- Hugh Schofield, Minitel: The Rise and Fall of the France-Wide Web, BBC, Jun 28, 2012

Minitel

- French Minitel from France Telecom (PTT) was world's first mass-market online ecosystem, generating up to $2 billion / year in revenue
- 3 keys to its success in France
  - To gain critical mass of users, terminals given out for free
  - First service was free online phone directory while threatening to stop printing the phone book
  - Introduction in 1984 of centralized billing system, "kiosk" that worked on a pay as you play model
    - Usage fee of a service was charged per minute + added to user's phone bill with PTT taking 33% cut, if you didn't pay your phone bill your phone was disconnected
    - Simple, transparent, convenient, efficient way to monetize a service
- In 1993 peak number of terminals reached (6.5 million) accounting for 90 million connection hours
- In 1994 peak number of services available (24,600)
- Release of Mosaic Web browser + privatization of Internet marked inflection point in Minitel's career which ended in June 2012
- Another example of walled garden that failed

\- Julien Mailand, 101 Online: American Minitel Network and Lessons From Its Failure, IEEE Annals of the History of Computing, Jan-Mar 2016

Thing / Hardware - Packet Switching

- Firsts / Achievements / Uniqueness / Significance
  - Predates ARPANet
- Place Produced (Company / Institution) ~ Year ~ Country
  - Text
- People involved (Designer)
  - Text
- Type
  - Text
- Price / Cost
  - Text
- Size
  - Text

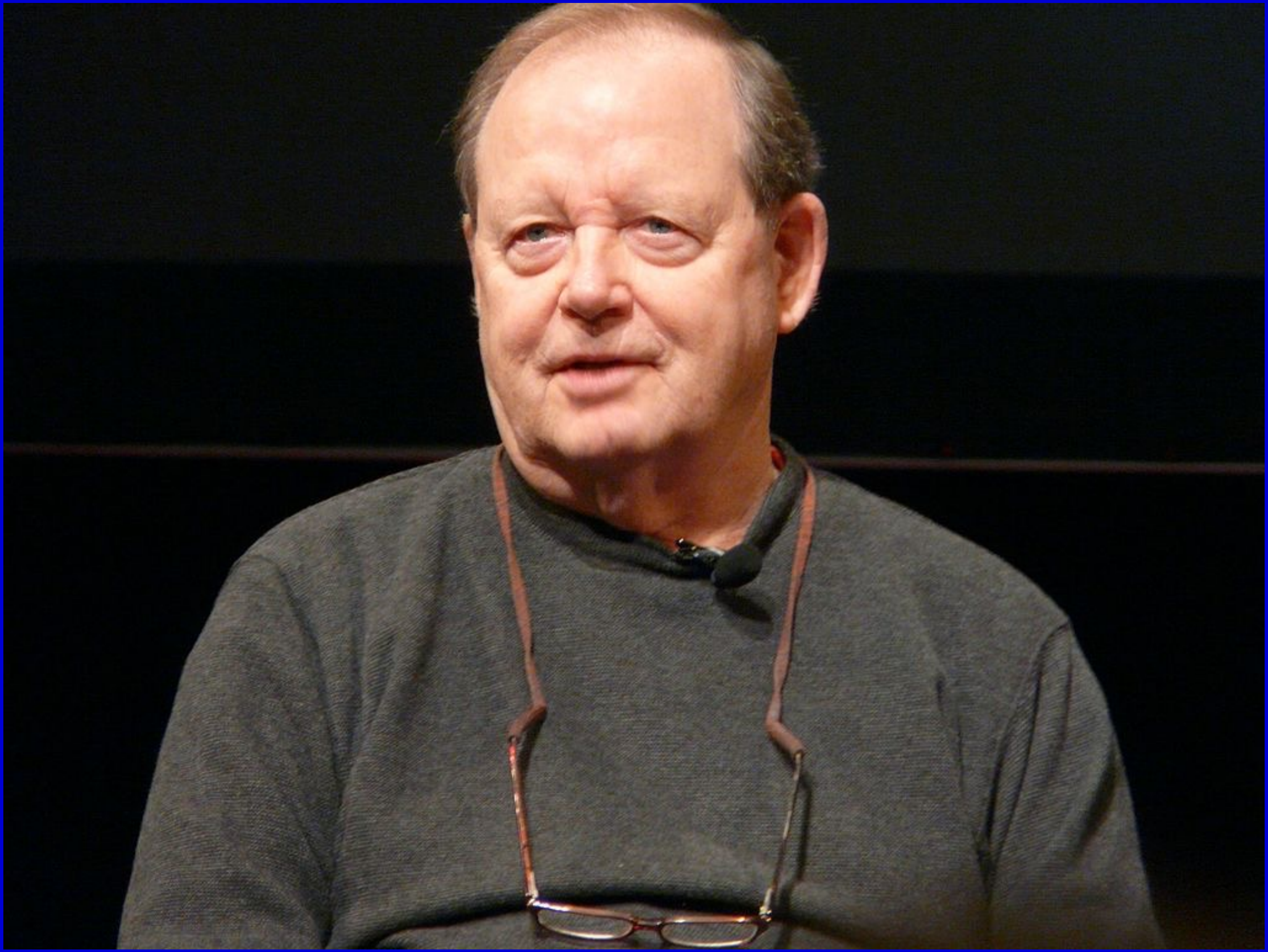
Thing / Hardware - Packet Switching

- Computing technology
  - A technique for dividing a data transfer into small chunks, called packets, which are separately addressed and sent to their destination and can travel over separate channels if necessary and are then reassembled at their destination
  - The antithesis of ATT opening a dedicated circuit for data transfer
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Text
- Predecessors - Dedicated circuit of telephony ~ Successors - N/A

"There ought to be one terminal that goes anywhere you want to go."

- Robert Taylor, computer scientist

Robert Taylor



From Wikimedia Commons

Person - Robert Taylor

- Significance
  - Funder extraordinaire ~ "You could call me a research planner"
- Profession
  - Psychologist
- Places worked / Years of work / Things worked on
  - 1963 at NASA - helped fund Douglas Engelbart which led to his development of the mouse
  - 1966 at ARPA - "There ought to be one terminal that goes anywhere you want to go" - got funding to start ARPANet
  - 1968 - Licklider JCR and Taylor, RW. The Computer as a Communications Device. Science and Technology (Apr. 1968) - how computer networks might transform society
  - 1971 at Xerox PARC - got funding for Alto personal computer
  - 1995 - at DEC Systems Research Laboratory - helped fund AltaVista, the first search engine that worked

Communications Case Study Summary - ARPANET

- Goal
  "There ought to be one terminal that goes anywhere you want to go." - Bob Taylor
- Center of Gravity (Strategy)
  - Packet switching
- Technology / Equipment
  - Interface Message Processors (IMPs) [= today's routers] running at 56Kbits per second handle networking independently from mainframe computers
    - Leads to network being independent of the computers it connects
- Training ~ Leadership ~ Morale ~ Tactics
  - Turned on in 1969 ~ 113 nodes by 1983 when it was split into MILNET (68 nodes) and ARPANET (45 nodes) ~ Turned off in 1989 (superseded by NSFNet)
  - Network applications - remote login to computers, file transfer, e-mail(!)
- Intangibles ~ Mistakes
  - Was designed to survive network losses due to unreliability of IMPs + network links ~ Not directly designed to be resistant to nuclear war
- Outcome
  - World's first operational packet switching network
  - Predecessor of Internet

Place - ARPANet

- Significance
  - Designed to ensure reliable communications in time of international crisis or war
  - Method of connecting computers at national + international levels
  - Lays foundation for computer networking
- Location
  - Advanced Research Projects Agency (ARPA) ~ 1969 ~ USA
- Definition
  - 1969 - first computers linked together
  - 1971 - 15 computers on it
  - 1972 - First public demonstration at conference in 1972 - Bob Metcalfe demo to ATT officials
  - 1977 - 60 computers on it
  - 1983 - TCP / IP protocols by Vint Cert + Robert Kahn
- Networking speed
  - Initially connected mainframe computers via telephone lines at 56 Kbps
- People who worked there
  - Paul Baran of RAND
- Things created there
  - Basis was packet switching + protocols
  - TCP manages assembly of packets into messages and ensures original message was received
  - IP passes packets from one node to another

ARPANet's Early Applications

- File transfer (FTP)
- Remote login (Telnet)
- Email

- Which became the most popular, to everyone's surprise?
  - Email, because people want to communicate
  - Never bet against an app that allows people to communicate

Thing / Software - Messaging / Message / Mail

- **Firsts / Achievements / Uniqueness / Significance**
  - Provided ability to communicate between using the telephone + sending a postal letter as telephone answering machines did not really exist
  - @ sign used because it was the only preposition on keyboard
  - At time of introduction, ARPANet consisted of ~ 28 nodes with ~ 1,000 - 2000 users
  - Succeeded because it was a low impact application that used very few computer resources
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - BBN ~ Late 1971 first message sent / January 1972 first TENEX distribution ~ USA
- **People involved (Programmer)**
  - Ray Tomlinson
- **Type**
  - Email program
- **Price / Cost**
  - Free with TENEX distribution
- **Computer and operating system it runs on**
  - DEC PDP-10 running TENEX
- **Computer language written in**
  - Assembly language, 400 lines of code
- **Memory required**
  - Text
- **Predecessors - CPYNET (Copy Net) to transfer files + SNDMSG (Send Message) to compose message / give it an address / send it ~ Successors - All email systems**

- Dag Spicer, Raymond Tomlinson: Email Pioneer Part 1, IEEE Annals of the History of Computing, Apr.-Jun. 2016

Facing Evil

After building the IMP, Metcalfe wrote a pamphlet called *Scenarios for the Arpanet* - a tract the author now calls "the first *Internet for Dummies."* Compiled for a 1972 Arpanet conference, *Scenarios* was an introduction to the applications accessible on the system and was intended to convince nontechnical types of the network's usefulness. The three-day Arpanet coming-out party, held in the ballroom at the Washington Hilton, was important in shaping Metcalfe's worldview: that there are innovators and there are troglodytes, and the troglodytes are pretty much a lost cause.

Because of his authorship of *Scenarios,* Metcalfe was asked to demo the Arpanet for a group of AT&T execs attending the confab. The pre-breakup phone monopoly had already begun lobbying against the Internet, fearful that a packet-switched network would eventually eclipse its own circuit-switched system.

"I'm sitting at a terminal, this graduate student with a huge red bushy beard, giving a tour of this network to 10 executives from AT&T, all of whom were wearing pinstripe suits ... and in the middle of my demo - for the one time in the whole three days - the system crashed. And I looked up. And they ... were happy ... that it crashed. They were smiling. This was my life's work. My crusade. And these guys were happy that it didn't work. I saw that there are people who will connive against innovation. They're hostile to it. And that has shaped my behavior ever since." - Bob Metcalfe, inventor of Ethernet

The Tao of the Internet Engineering Task Force (IETF)
Foundations of the Internet

"We reject kings, presidents and voting. We believe in rough consensus and running code."

- David Clark, Internet Engineering Task Force

"Be conservative in what you send and liberal in what you accept."

- Jon Postel, Internet Engineering Task Force

The Internet Has a Physicality To It

"Mr Blum's book…is a timely antidote to oft-repeated abstractions about "cyberspace" or "cloud computing." Such terms gloss over the face that, just like the pipes that carry water, the tubes that carry bits are reliant on old-fashioned, low-tech spadework, human contact and the geographical reality in which all that exists."

- Mapping the Tubes, The Economist, June 23, 2012

- The Internet is a globe spanning tangle of wires, cables, routers, computers, cooling fans and data centers

  - Andrew Blum, Tubes: A Journey to the Center of the Internet

The Internet Has a Geography

"Geography still matters to us because ultimately cyber is supported by physical devices, physical networks, physical connections. So I care about submarine and terrestrial cable routes, although they're often difficult to map exactly. Those cables run through a number of chokepoints, and they get damaged quite frequently; they're very vulnerable. Internet exchanges and major telephone links [show] there is a lot of critical infrastructure underneath the Internet which is important to understand, to map and to know about. And satellite ground stations are another vulnerability in the global information infrastructure."

- David Ferbrache, Head of Cyberspace Policy and Plans, British Ministry of Defense

Submarine Cables

- 1898 - Spanish American War - US cut Spain's submarine cables and cut Spain off from the world
- 1914 - World War I - United Kingdom cut Germany's submarine cables and cut them off from the world
  - Forced Germany to communicate via wireless telegraphy which could be easily intercepted
  - By owning and controlling the only world-wide submarine cable network (The All Red Line), the United Kingdom forced all other countries to send their messages over it, and by forcing those countries to send their messages unencoded over it (except for certain diplomatic messages), the United Kingdom had the world's greatest intelligence network
- 1939 - World War II - (unknown)
- 1970's+1980's - Cold War - US submarines physically tapped Soviet Union submarine cables in Operation Ivy Bells
- War on Terror - US tapped underground cables in US and sent data to NSA, when this was outlawed, US turned to capturing US data flowing across submarine cables as Google / Facebook / Microsoft backed up their US data centers to their overseas data centers
- Today - Russians are assumed to be tapping submarine cables today in the Atlantic while US is tapping submarine cables worldwide with submarine USS Jimmy Carter
- Today - 99% of world's trans-oceanic data goes through submarine cables (not through satellites)

- Stephenson, Neal - Mother Earth Mother Board, Wired, December 1996
- Starosielski, Nicole - The Undersea Network
- Blum, Andrew - Tubes: A Journey to the Center of the Internet
- Reed Winkler, Jonathan - Silencing the Enemy: Cable-Cutting in the Spanish-American War, War on the Rocks, Nov. 6, 2015
- Kennedy, Paul - Imperial Cable Communications and Strategy, 1870-1914
- Reed Winkler, Jonathan - Nexus: Strategic Communications and American Security in World War I, English Historical Review, Oct. 1971

The New SLOCs

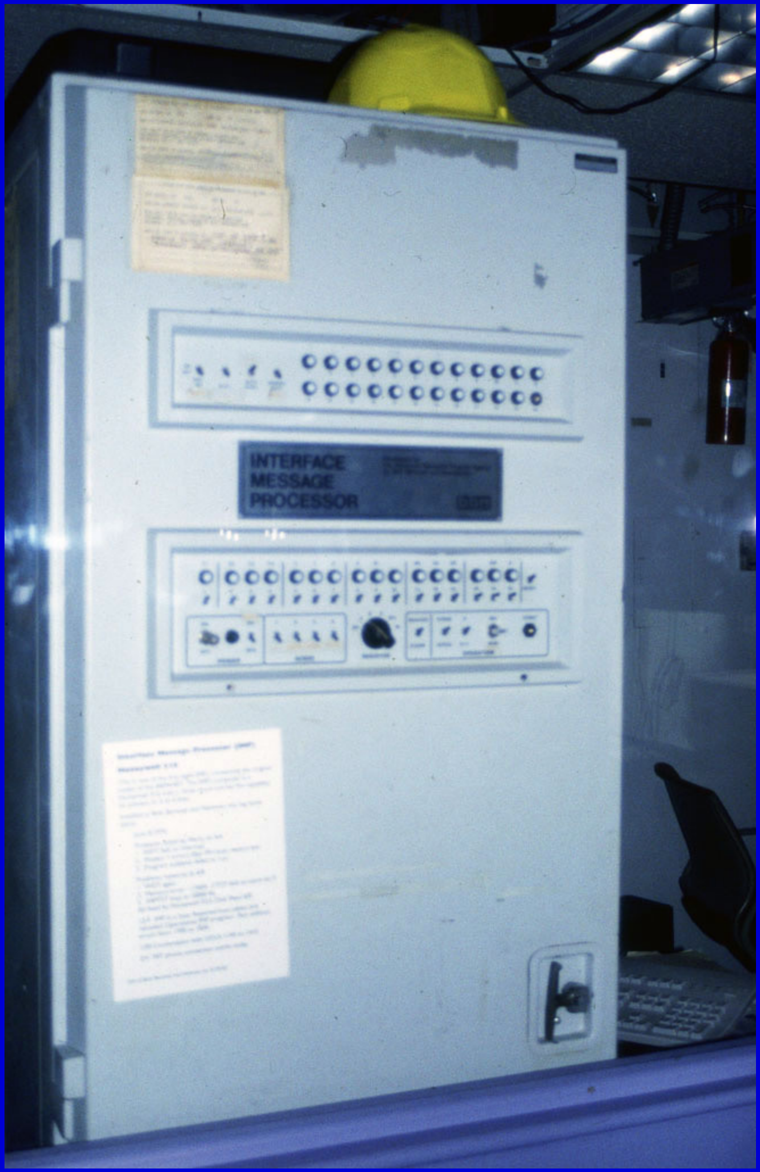
- Sea lines of communications (SLOCs) - traditionally they refer to ships carrying cargos
- Naval power is all about protecting commerce and SLOCs
- Submarine cables are digital SLOCs
- US has decided it must secure the sovereignty of its telecommunications infrastructure against malign foreign actors, hence the desire to keep China / Huawei out of the US 5G infrastructure, and a desire to keep them out of allies 5G infrastructure, especially 5 Eyes 5G infrastructure
- Will the US pursue a similar stance of sovereignty over the submarine cables that US data travels over?
  - US needs to ensure the sovereignty of undersea cable networks and the data flowing across them to protect the US and its allies
  - In 2020 US blocks submarine cable being built by Facebook and Google from connecting to China's submarine cable network
- Data is the new oil!

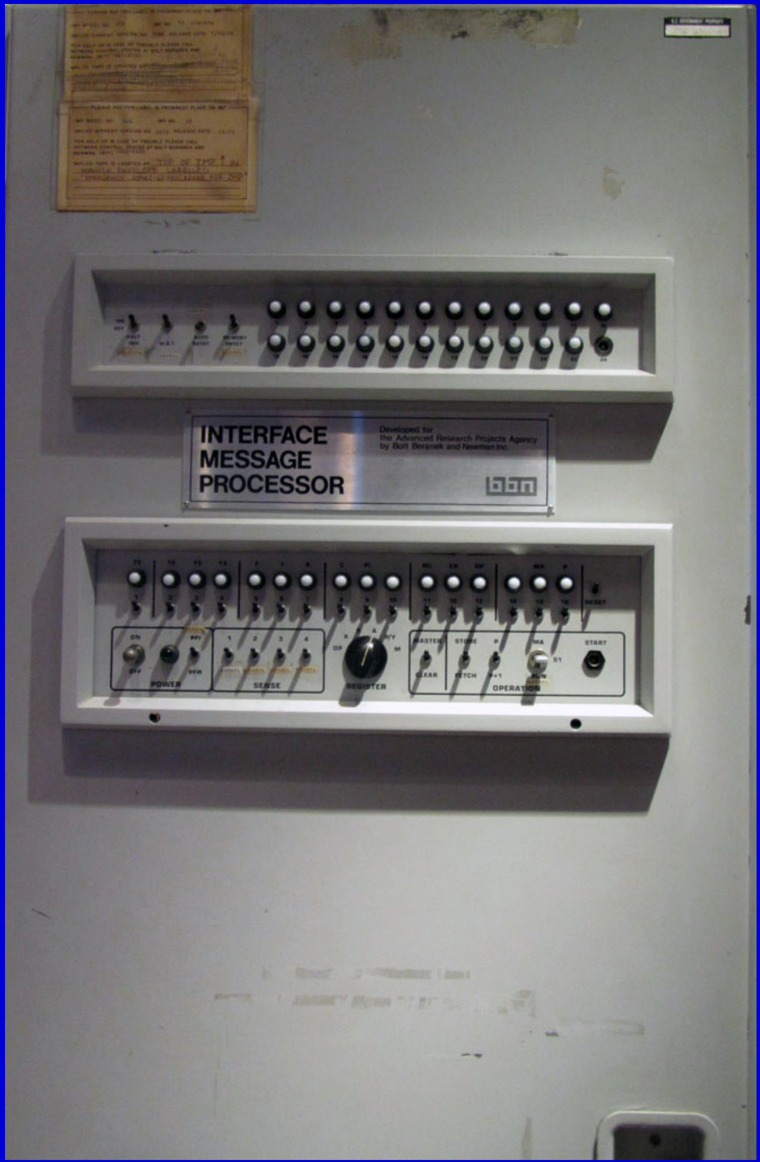
"Today, another 120 years later, we take wires completely for granted. This is most unwise. People who use the Internet (or for that matter, who make long-distance phone calls) but who don't know about wires are just like the millions of complacent motorists who pump gasoline into their cars without ever considering where it came from or how it found its way to the corner gas station. That works only until the political situation in the Middle East gets all screwed up, or an oil tanker runs aground on a wildlife refuge. In the same way, it behooves wired people to know a few things about wires - how they work, where they lie, who owns them, and what sorts of business deals and political machinations bring them into being."

- Neil Stephenson, science fiction writer, from http://www.wired.com/wired/archive/4.12/ffglass_pr.html "Mother Earth Mother Board"

- **But the Internet has no beautiful aesthetic to it like previous great civil engineering Roman aqueducts or hydroelectric dams**

BBN Interface Message Processor (IMP)





Thing / Hardware - Interface Message Processor (IMP)

- **Firsts / Achievements / Uniqueness / Significance**
  - Was packet switching node of ARPANet - was interface between ARPANet and a computer that wished to connect to it
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Bolt Berenak and Newman ~ 1970 ~ USA
- **People involved (Designer)**
  - Frank Heart + Severo Ornstein (hardware), Bill Crowther (programming), Bob Kahn (system design)
- **Type**
  - Computer network adaptor / connector
- **Price / Cost**
  - $82,200
- **Size**
  - Refrigerator sized

Thing / Hardware - Interface Message Processor (IMP)

- Computing technology
  - Built around a Honeywell DDP-516 computer
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Magnetic core ~ 12,000 words ~ 16 bit word
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Network router - could connect to 4 - 6 other IMPs
- Predecessors - N/A ~ Successors - All routers that follow

Place - NSFNet

- Significance
  - Continuation + evolution of ARPANet to a self-sustaining commercial Internet - serves as a bridge between ARPANet + Internet
- Location
  - International
- Definition
  - 1983 - ARPANet divides into MILNET + ARPANet
  - 1986 - NSFNet links 5 supercomputer centers
    - Adopted TCP/IP
    - Made network general purpose + available to all researchers
    - Create high speed backbone to connect regional + local networks
  - 1987 - NSFNet backbone is a T1 at 1.5 Mbs
  - 1988 - Connections allowed to commercial networks for research purposes - MCIMail, Compuserve, Sprint
  - 1990 - 200 universities connected + government networks along with interconnections to BITNET + Usenet
  - 1990 - ARPANet decommisioned
  - 1992 - NSFNet backbone is a T3 at 45 Mbs
  - 1992 - Commercial use of Internet allowed
- Networking speed
  - 56,000 - 45 million bits per second
- People who worked there
  - N/A
- Things created there
  - The Internet as we know it

Place - Because Its There Network (BITNET)

- Significance
  - Served as introduction for most non-computer science academics to cyberspace
- Location
  - International
- Definition
  - 1981 - connect IBM mainframes at universities via phone lines because IBM mainframes were the most common computers on campus outside of computer science compartments
  - Store and forward network
  - Services - email, discussions (LISTSERVS), file transfer
  - Crucial in linking liberal arts faculty who otherwise had no access to ARPANet
- Networking speed
  - 9,600 bits per second
- People who worked there
  - Ira Fuchs + Greydon Freeman
- Things created there
  - LISTSERV

Place - Usenet

- Significance
  - Served as introduction for computer scientist academics to cyberspace
- Location
  - International
- Definition
  - 1980 - connected computers running Unix via phone lines via a store + forward network
  - Distributed ARPANet + Usenet discussion forum
  - Highly technical discussions - for science + engineering faculty
- Networking speed
  - 9,600 bits per second
- People who worked there
  - Tom Truscott + Jim Ellis
- Things created there
  - Newsgroups - Human-Nets, SF-Lovers

Sun-1

Thing / Hardware - Sun-1

- Firsts / Achievements / Uniqueness / Significance
  "The real precursor for the Sun was the Xerox Alto" - Andy Bechtolsheim
  - Wanted to build an Alto-like computer using less-expensive, off-the-shelf parts
  - Standards based - Ethernet / Multibus / BSD Unix
  - First practical workstation you could buy
  - Windows / icon / menus / pointer (WIMP) interface with bitmapped display
  - 3M machine - 1 MIPS processor, 1 megabyte of memory, 1 million pixels display
- Place Produced (Company / Institution) ~ Year ~ Country
  - Stanford University, then Sun Microsystems ~ 1981 ~ USA
- People involved (Designer)
  - Andy Bechtolsheim (designer), Bill Joy (software), Scott McNealy (management), Vinod Khosla (CEO)
- Type
  - Workstation
- Price / Cost
  - $8,900
- Size
  - 17 7/8" x 24" x 19 3/8"

Thing / Hardware - Sun-1

- Computing technology
  - Integrated circuits ~ Motorola 68000 microprocessor
- Computing speed (in MIPS)
  - 10 MHz
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 256 kilobytes ~ 16 bit
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Scientific computing, financial modeling, engineering
- Predecessors - Alto ~ Successors - Sun-2 + Advanced personal computers (Wintel + Macintosh)

Place - Wide Area Information Service

- Significance
  - First technique for making information searchable on Internet
- Location
  - WAIS, Silicon Valley
- Definition
  - Was decentralized search - your client went out and searched each individual WAIS server running on a Connection Machine
  - Business model was paying for content - publishers (Wall Street Journal, Encyclopaedia Brittanica) ran servers + you paid for their information
- People who worked there
  - Brewster Kahle
- Things created there
  - WAIS server + WAIS client
  - Sale of business help pay for Alexa Internet whose sale paid for Internet Archive

Brewster Kahle

From Wikimedia Commons

Person - Brewster Kahle

- Significance
  - Information archivist - creator of "The Library of Everything"
- Profession
  - Computer engineer, computer scientist, digital librarian
- Places worked
  - Thinking Machines, WAIS, Alexa Internet, Internet Archive
- Years of work
  - 1983 - present
- Things worked on
  - Connection Machine, Wide Area Information Server, Alexa Internet, Wayback Machine

Communications Case Study Summary - Gopher

- Goal
  - Create campus wide information service at University of Minnesota in 1991
- Center of Gravity (Strategy)
  - Connect computers with information together + make the information discoverable
- Technology / Equipment
  - Client / server model
- Training ~ Leadership ~ Morale
  - Team of 6 did the work
- Tactics
  - Gopherspace contained text only, was browseable + searchable
- Intangibles
  - Rejected for use on campus due to politics (did not use mainframe) so released into wild
- Mistakes
  - In 1993 University of Minnesota says for-profit users of Gopher will need to pay licensing fee - users felt betrayed having to pay for software while programmers felt betrayed that users would not pay for software
- Outcome
  - First viral Internet software
  - By 1992 there were hundreds of Gopher servers ~ Used by Tim Berners Lee to promote World Wide Web
  - By 1994 World Wide Web passes Gopher in traffic and leaves it in the dust

- Tim Gihring, Obsolesced: The Rise and Fall of the Gopher Protocol, MinnPost, Aug. 2016

NeXT Machine

Thing / Hardware - NeXT Machine

- Firsts / Achievements / Uniqueness / Significance
  - First workstation aimed at consumer market
  - Ultimately too expensive to become successful
- Place Produced (Company / Institution) ~ Year ~ Country
  - NeXT Computer ~ 1988 ~ USA
- People involved (Designer)
  - Steve Jobs
- Type
  - Workstation
- Price / Cost
  - $6,500
- Size
  - Text

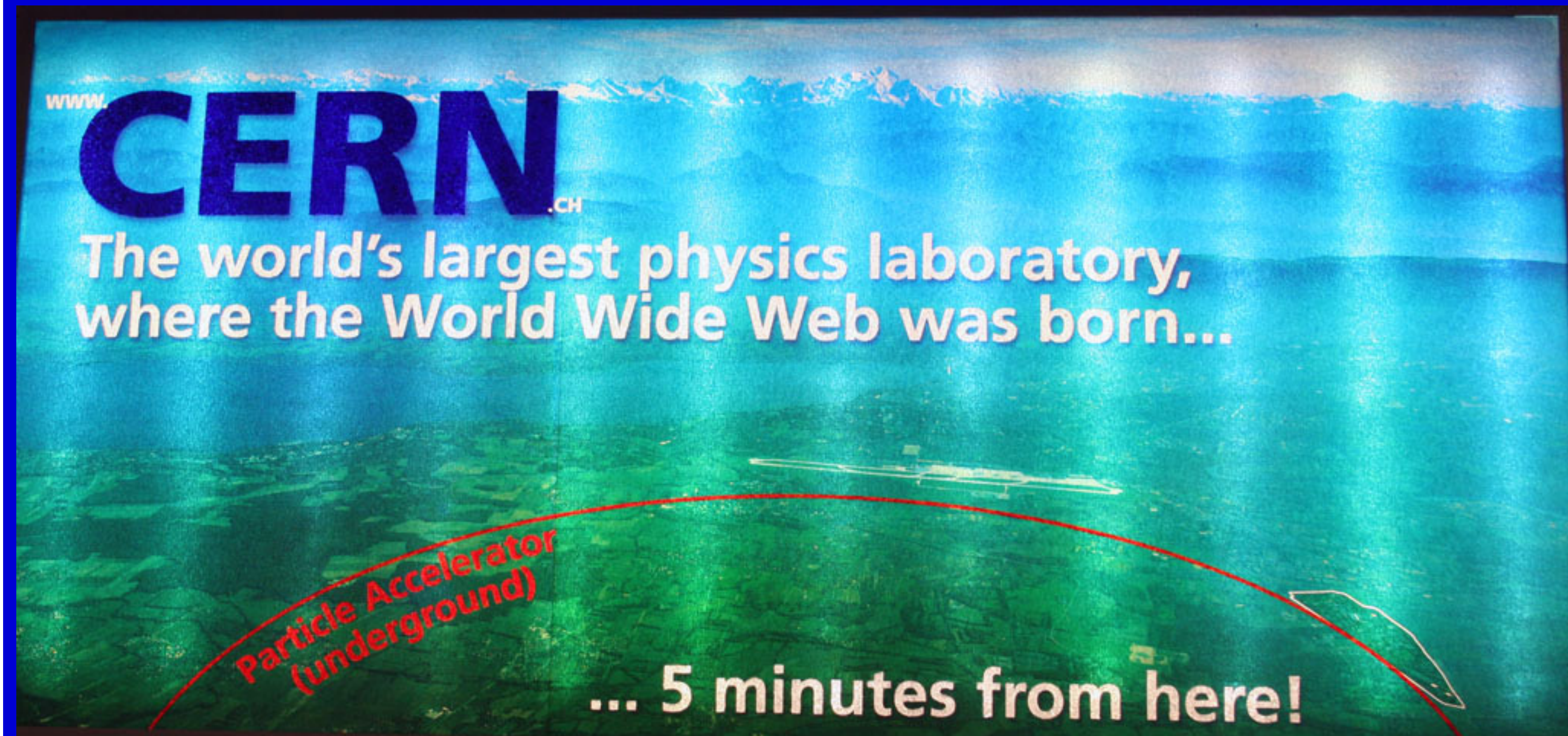
Thing / Hardware - NeXT Machine

- **Computing technology**
  - Integrated circuits ~ Motorola 68030 microprocessor
  - Operating system was NeXTSTEP which becomes MacOS X
- **Computing speed (in MIPS)**
  - 25 MHz
- **Primary memory type / technology ~ Size ~ Word length**
  - Integrated circuits ~ 8 megabytes ~ 16 bits
- **Secondary memory type / technology ~ Size**
  - 256 megabyte magneto optical drive
- **Uses / Applications / Software**
  - World Wide Web browser and editor and server created on it by Tim Berners-Lee at CERN
- **Predecessors - Macintosh ~ Successors - Macintosh**

Place - World Wide Web

- Significance
  - First successful implementation of networked hypertext
  - First Web site was info.cern.ch
  - On April 30, 1993 CERN made source code available on royalty free basis
- Location
  - CERN, Switzerland
- Definition
  - Started in 1989 and released in 1991 - 3 components
    - Uniform resource locator (URL) - takes you to a computer anywhere on Internet
    - Hypertext transport protocol (HTTP) - sits on top of TCP / IP, facilitates file exchange amongst machines
    - Hypertext markup language (HTML) - allows simple creation of Web pages
- Networking speed
  - 56,000 - 1.5 million bits per second
- People who worked there
  - Robert Cailliau (gave administrative + technical support), Tim Berners-Lee
- Things created there
  - Web server + Web browser + Web editor on NeXT computer

CERN


www.CERN.CH
The world's largest physics laboratory,
where the World Wide Web was born...
Particle Accelerator
(underground)
... 5 minutes from here!

Tim Berners-Lee

From Wikimedia Commons

Person - Tim Berners-Lee

- Significance
  - Inventor of the World Wide Web
- Profession
  - Computer scientist
- Places worked
  - CERN, MIT
- Years of work
  - 1989 - present
- Things worked on
  - World Wide Web

Thing / Software - Mosaic

- Firsts / Achievements / Uniqueness / Significance
  - First graphical Web browser
  - Microsoft licensed it, transformed it into Internet Explorer
  - Team then formed Netscape, first commercial Web browser
- Place Produced (Company / Institution) ~ Year ~ Country
  - National Center for Supercomputer Applications (NCSA) University of Illinois ~ 1992 ~ USA
- People involved (Programmer)
  - Marc Andreessen, Kim Stephenson (Macintosh)
- Type
  - Web browser
- Price / Cost
  - Free
- Computer and operating system it runs on
  - Wintel, Macintosh
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - WWW from CERN ~ Successors - Netscape Navigator, Microsoft Internet Explorer

Place - Netscape

- Significance
  - Made Internet available not just to scientists but to everyone
  - Netscape browser included 1) Secure Socket Layers (SSL) for ecommerce, 2) Cookies to track user's interactions with Web site over successive screens
  - First dot com success - stock doubled in value on opening day of Initial Public Offering (IPO) in August 1995 which set off Internet bubble
  - Was destroyed by Microsoft who bundled Internet Explorer with Windows

  "We made a difference, we invented cookies and pioneered downloading software from the Internet, yet Netscape is an asterisk in business history. Maybe the best way to think about it is as a classic tech story: a company creates, invents, succeeds - and gets bypassed." - Peter Currie, Netscape CFO
- Location
  - Silicon Valley
- Definition
  - Software company
- People who worked there
  - Mark Andreessen, Jim Clark
- Things created there
  - Netscape Navigator, in 1994, was first commercial graphical browser for Web, free for individuals but businesses needed to pay for it, quickly gained 90% market share
    - Code was ultimately open sourced and became Mozilla

      - Tad Friend, Tomorrow's Advance Man, New Yorker, May 18, 2015

Why Did the World Wide Web Triumph Over Gopher?

- It was free / had no licensing fees which fit the Internet community's sensibilities
  - Gopher was well established, but University of Minnesota got greedy and started charging licensing fees which offended Internet community's sensibilities

  "It is said that despite its many glaring (and occasionally fatal) inaccuracies, the Hitchhiker's Guide to the Galaxy itself has outsold the Encyclopedia Galactica because it is slightly cheaper, and because it has the words "DON'T PANIC" in large, friendly letters on the cover."

  - Hitchhiker's Guide to the Galaxy
- It was graphical
  - It inspired people's creativity

Why Did The Internet Triumph Over the Information Superhighway / Interactive TV?

- The Internet and World Wide Web were sideshows to the telcos
  - Bob Metcalfe story on his ARPAnet demo to ATT executives in 1972
  - An ATT executive telling me in 1995 how "their" version of the Internet would be superior
- The Internet's triumph was an example of "Not by strength, but by guile"

Place - Yahoo!

- Significance
  - Web came with no index
  - Yahoo! was first index of browseable Web ~ Guide to Web ~ Portal to Web
- Location
  - Stanford University ~ 1994 ~ USA
- Definition
  - Yet Another Hierarchical Officious Oracle
- People who worked there
  - Jerry Yang + David Filo
- Things created there
  - Model for human indexing of Web which worked well until Web growth became exponential

Place - AltaVista

- Significance
  - Web came with no index
  - First search engine that really worked on account of its fast web crawler (Scooter) that comprehensively crawled the Web and the fast DEC Alpha hardware it ran on
- Location
  - Digital Equipment Corporation Network Systems Laboratory and Western Research Laboratory ~ 1995 ~ USA
- Definition
  - Best of first generation search engines which worked by full text indexing of Web pages with search result rankings based on statistical analysis of words in Web page
- People who worked there
  - Text
- Things created there
  - Built as showcase for Alpha microprocessors by DEC, but what really made it special was its software…DEC could have recreated itself as an Internet company but instead they fumbled the future and were acquired by Yahoo in 2003

"Altavista is new proof that sufficient quantitative change can be qualitative change"

- Bob Metcalfe, Infoworld, January 15, 1996

"Google's mission is to organize the world's information and make it universally accessible and useful."

- Google

Place - Google

- Significance
  - Web came with no index
  - Altavista, built by DEC as showcase for Alpha microprocessors, was first search engine that really worked but DEC fumbled the future
  - Google, by focusing only on search, became best search engine to navigate the searchable Web
- Location
  - Stanford University ~ 1997 ~ USA
- Definition
  - A googol is the number 10^100
- People who worked there
  - Larry Page + Sergei Brin
- Things created there
  - PageRank algorithm for search delivers best search results - ranks results based on how many other Web sites link to a Web site / citation frequency indexing

TomTom Mapping Car

Main mapping data provider for Apple Maps + Uber

What Geography Means to the Internet

- Internet land grab consists of 3 battles over 3 conceptual territories
  - What? - won by Google's search algorithms
  - Who? - won by Facebook
  - Where? - battle is still going on and location-awareness will be built into everything

    "One thing for sure can be said about location-awareness: maps are required. Tomorrow's map, integrally connected to everything that moves (the keys, the tools, the car), will be so fundamental to their operation that the map will, in effect, be their operating system. A map is to location-awareness as Windows is to a PC. And as the history of Microsoft makes clear, a company that controls the operating system controls just about everything. So the competition to make the best maps, the thinking goes, is more than a struggle over who dominates the trillion-dollar smartphone market; it's a contest over the future itself."

- Adam Fisher, Google's Road Map to Global Domination, New York Times Magazine, Dec. 15, 2013

Internet Archive

Place - Internet Archive

- Significance
  - Web is fragile - Average life of a Web page is 100 days before they change or disappear
  - Keeps a copy of nearly the entire World Wide Web since 1996
  - Motto - "Universal Access to All Knowledge"
- Location
  - San Francisco, California
- Definition
  - *The* archive of the Web - The Internet's memory
  - In 2015, archives 1 billion Web pages a week, has 430 billion Web pages overall which is 20 petabytes of data (1 petabyte = 1 million gigabytes)
- People who worked there
  - Brewster Kahle
- Things created there
  - Wayback Machine

- Jill Lepore, The Cobweb, The New Yorker, Jan. 26, 2015

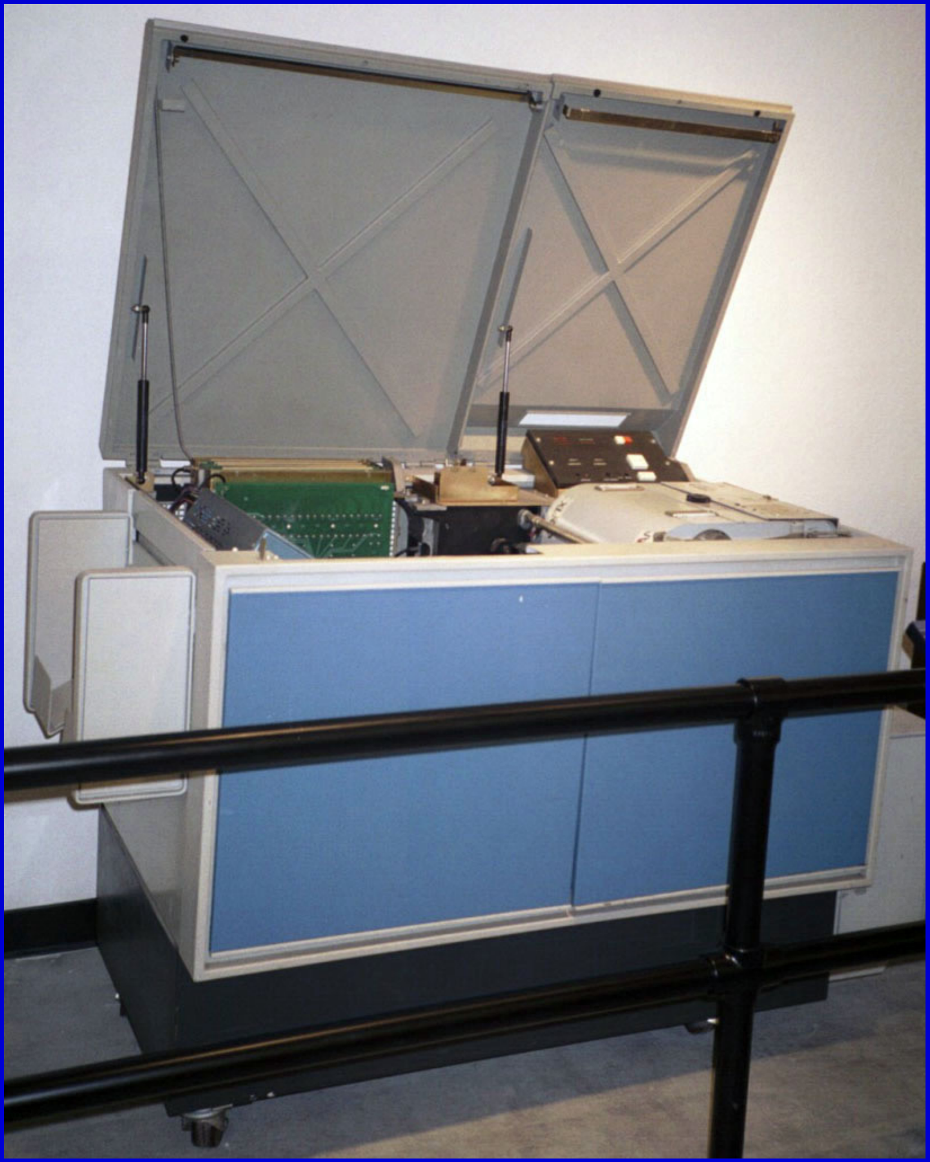
Thing / Hardware - Ethernet

- Firsts / Achievements / Uniqueness / Significance
  - Method of connecting computers at a local level
  - Was a way of sharing computer resources, data, programs without sacrificing performance
- Place Produced (Company / Institution) ~ Year ~ Country
  - Xerox PARC ~ 1973 ~ USA
- People involved (Designer)
  - Robert Metcalfe, David Boggs
- Type
  - Computer network adaptor / connector
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Ethernet

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - Networking speed = 3 megabits / second on Alto
- Primary memory type / technology ~ Size ~ Word length
  - N/A
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Linked Altos at Xerox PARC to allow sharing of data, programs, resources
  - Was especially designed to send data to Dover laser printer
- Predecessors - ALOHAnet ~ Successors - High speed Ethernet (up to 100 gigabytes / second)

Xerox Dover Laser Printer



Thing / Hardware - Dover Laser Printer

- **Firsts / Achievements / Uniqueness / Significance**
  - Prototype for Xerox's first commercial laser printer, the Xerox 9700
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Xerox ~ 1976 ~ USA
- **People involved (Designer)**
  - Gary Starkweather
- **Type**
  - Laser printer
- **Price / Cost**
  - Text
- **Size**
  - Text

Thing / Hardware - Dover Laser Printer

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - Printed 120 pages per minute
- Primary memory type / technology ~ Size ~ Word length
  - Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Printer for Xerox Alto, first printer to deliver WYSIWYG printing
- Predecessors - N/A ~ Successors - Xerox 9700 laser printer

Thing / Hardware - WiFi

- Firsts / Achievements / Uniqueness / Significance
  - Wireless Ethernet
- Place Produced (Company / Institution) ~ Year ~ Country
  - Text ~ 1990's ~ USA
- People involved (Designer)
  - Text
- Type
  - Computer network adaptor / connector
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - WiFi

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - Networking speed = 802.11b = 11 megabits / second
- Primary memory type / technology ~ Size ~ Word length
  - N/A
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Text
- Predecessors - Wired Ethernet ~ Successors - Currently 802.11n = 150 megabytes / second

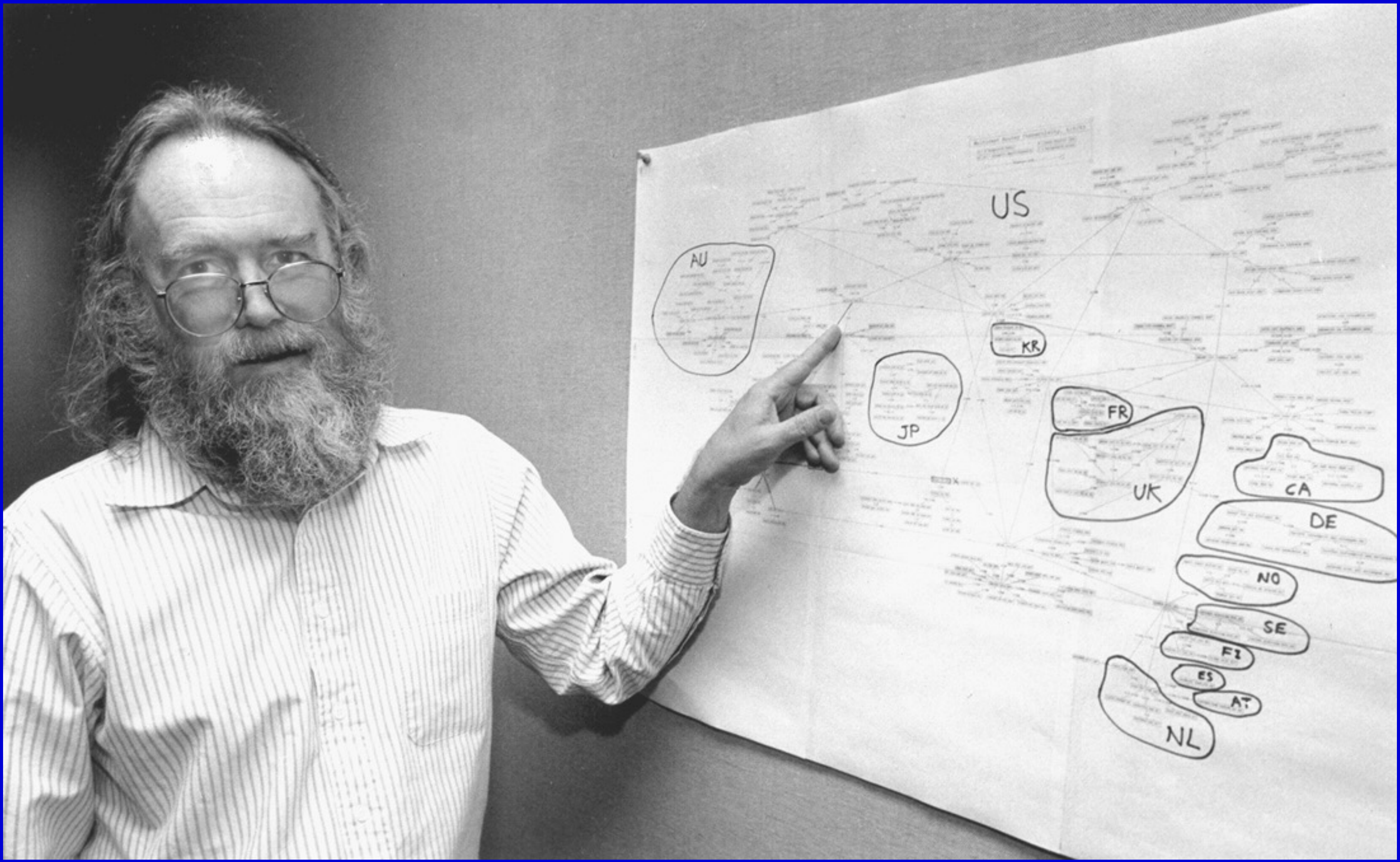
The Killer App and the Internet

- Time - Dawn
  - Place - Bolt, Beranek and Newman
  - Person -
  - Computer - Interface Message Processor
  - Killer App - Email
- Time - Morning
  - Place - Xerox
  - Person - Bob Metcalfe - goes on to found 3Com
  - Computer - Alto with Ethernet
  - Killer App - File sharing / printing locally
  - [See also Sun for workstations + Cisco for internetworking]
- Time - Afternoon
  - Place - CERN
  - Person - Tim Berners-Lee
  - Computer - NeXT machine + World Wide Web
  - Killer App - Web browser - NCSA Mosaic by Marc Andreessen, then Netscape, then Microsoft Internet Explorer

Who Oversees the Internet?
Internet Governance Past, Present, and Future

- Past
  - Jon Postel
- Present
  - ICANN
- Future
  - A Balkanized Internet?

Jon Postel



From Wikimedia Commons

Person - Jon Postel

- Significance
  - God of the Internet
- Profession
  - Computer scientist
- Places worked
  - Information Sciences Institute at University of Southern California
- Years of work
  - 1969 - 1998
- Things worked on
  - Editor of the Request for Comment (RFC) document series
  - Administering Internet Assigned Numbers Authority

The End of the Internet

- US created Internet in 1969 + administered it since then with light touch through IANA + ICANN
- Snowden revelations caused US to lose moral high ground required to administrate it
- What happens next?

The End of the Internet

- **Fierce + rising geopolitical conflict over control of Internet threatens to create balkanized system**
  - **"The Splinternet" - Eric Schmidt of Google**

"If the long history of international commerce tells us anything, it is this: free trade is neither a natural nor an inevitable condition. Typically, trade has flourished when a single, dominant country has provided the security and will to sustain it. In the absence of a strong liberal ethos, promoted and enforced by a global leader, states seem drawn, as if by some spell, toward a variety of machinations (tariffs, quotas, arcane product requirements) that provide immediate advantages to a few domestic companies or industries-and that lead to collective immiseration over time."

- Gordon Goldstein, The End of the Internet? The Atlantic, Jul. 2014

The End of the Internet

- Governments that do not favor free flow of information (China, Russia, Brazil + many others) want to see Internet Balkanized to make it easy to prevent access to certain Web sites
  - Want switch from ICANN, established by US in 1998 and administered in US Department of Commerce…
  - …To International Telecommunications Union (ITU) of UN, which was created in 1865 as International Telegraph Convention

- John Markoff, Viewing Where the Internet Goes, New York Times Dec. 30, 2013

Personal Case Study - First Connection to ARPANet / Usenet - crashed mailer gateway

- Role
  - In 1983 the Merit Computer Network was connected to the ARPANet through an email gateway
- Story
  - The first day it was made available, I immediately signed up for a dozen ARPANet mailing lists including SF-Lovers, Human-Nets
  - The next day I received an email from the creator of the email gateway, sarcastically congratulating me from crashing the gateway due to the volume of the mailing lists I was reading
  - I learned a tremendous amount from these mailing lists as they enlarged my community of practice from within my university to the entire world

Personal Case Study - MacWorld 1993 Newton Launch + Mosaic Launch

- Role
  - First consumer handheld computer
- Story
  - August 1993 - bought Apple Newton first day it was available in Boston's Symphony Hall
  - Later in the conference, at the MacSciTech meeting, saw early demonstration of NCSA Mosaic Web browser for Mac.
  - Immediately realized the World Wide Web, not Gopher, was the future of Internet and had Virtual Hospital digital library changed from Gopher to World Wide Web

Personal Case Study - Volunteer Exhibit Designer

- Role
  - "The Networked Planet: Traveling the Information Highway" - first museum exhibit on the Internet at The Computer Museum in 1994
- Story
  - Displayed Virtual Hospital digital medical library
  - One of the other exhibits was an "E-Mail the President" kiosk, one of the other exhibit designers used it to jokingly send an e-mail threatening the President's life, the Secret Service arrived a week later to investigate but he was able to avoid discovery…today he would be been caught via CCTV and prosecuted
  - On opening night, had dinner with Gordon Bell's investment portfolio manager

Personal Case Study - A Replacement for the Internet

- Role
  - ATT's inability to understand Internet
- Story
  - At party in mid 1995
  - ATT junior executive tells me he was just at a big meeting that demonstrated ATT's replacement for Internet and he insisted that the Internet will never amount to anything and that ATT has got something better…

Personal Case Study - Touching the Internet in 1988

- Role
  - Visitor
- Story
  - At ARPA contractor in suburban Washington DC, I got to reach out and touch an ARPANET Interface Message Processor (IMP)
    - Now called a router
    - A physical manifestation of ARPANET

      "Touching the cloud"

Personal Case Study - Einar B

- Role
  - Works for American Registry for Internet Numbers (ARIN), passing out Internet addresses
- Story
  - Former Cold War US Army intelligence, fluent in Russian
  - After graduating from university, announced one day he was "getting into this Internet thing" and bought a Linux box and started learning C
  - Next thing he did was get a job working for ARIN
  - …his own personal peace dividend

Personal Case Study - Eugene Miya

- Role
  - Creator of the term "Frequently Asked Question (FAQ)" on the Internet
- Story
  - Met him at a conference in 2001
  - He was wearing a Google t-shirt before most people knew what Google was
  - Was a Yoda-like figure

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- What was the first world wide communications network and what did it share in common with the Internet?
- Timesharing connected computer users together, personal computers broke them apart. What was the computational challenge Xerox PARC identified and addressed in the mid 1970's to reunite computer users?
- Was Minitel a viable vision of the future, where people paid for online services?
- What is different between how the telephone system worked (dedicated circuit) vs. how the ARPANet + Internet works (packet switching)?
- What is the significance of the Interface Message Processor (IMP)?
- What is the significance of the ARPANet?
- What was the ARPANet's first killer app, and why?
- Today, is the Internet an abstract thing (cyberspace / cloud) or a real physical thing?
- Why, where, how and by whom was the World Wide Web born, and why did it succeed?
- Where does your Internet come from? Can you draw a map of your local Internet?

- Does the unregulated / lightly regulated Internet have a future? Or will it become heavily regulated / balkanized by the Recording Industry Association of America (RIAA) and the Motion Picture Association of America (MPAA) and national governments since it allows you to do anything you want, including pirating, cyberwar, etc.
- Who should govern the Internet - The US or the United Nations?
- Will the fate of the Internet follow the fate of radio - see "Empire of the Air: The Men Who Made Radio"
- If access to and or possession of oil was a key geopolitical variable of the 20th Century, will access to and or possession of information be a key geopolitical variable of the 21st century?
- Being that the largest Internet companies are from the US (Google, Facebook, Twitter, Microsoft) will this alter the course of the US Empire and / or change world history?
- Part of the reason the 20th Century was a US Century was its ascendency in mass production, aviation, space and computer technology. Will the US ascendency in Internet technology, typified by US companies such as Google, Microsoft, Facebook, Twitter lead to the 21st Century being a US Century as well?
- How will the US ascendency and dominance of these technologies alter the course of the US Empire and or change world history?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History - Chapter 6 The Internet and World Wide Web and Chapter 7 Conclusion
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
  - Standage, Tom - The Victorian Internet
- Fiction
- Movies
- Simulations

Conclusion

"To my way of thinking, the ARPANet is the best investment this country has ever made, other than probably the Louisiana Purchase"

- Sandy Lerner, Founder of Cisco

Topic 13

Computers in Your Hand

Ubiquitous Computing

Song

Slide text

Thematic Quote

**"In the beginning, there were no computers.
Then there were computers.
Then they disappeared."**

- John Seely Brown, computer scientist, Xerox PARC

The Painting

Future Computers?

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - Raytheon AN/PRC-6 handy-talkie, successor to Motorola SCR-536 handy-talkie of 1941
- Year
  - 1950
- Story

- Name
  - Cambridge Z88 laptop computer
- Year
  - 1988
- Story

- Name
  - Newton handheld computer
- Year
  - 1993
- Story

- Name
  - Motorola StarTAC mobile phone
- Year
  - 1996
- Story

- Name
  - Pregnancy calculator volvelle
- Year
  - 1996
- Story

The Question

Will computers eventually disappear from sight?

BUSICOM Calculator

From Wikimedia Commons

Thing / Hardware - First Electronic Calculator - BUSICOM

- Firsts / Achievements / Uniqueness / Significance
  - First device to use first microprocessor, Intel 4004, which was created for this machine
- Place Produced (Company / Institution) ~ Year ~ Country
  - Busicom ~ 1971 ~ Japan
- People involved (Designer)
  - Text
- Type
  - Calculator
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - First Electronic Calculator - BUSICOM

- Computing technology
  - Integrated circuits ~ Intel 4004 microprocessor
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Text
- Predecessors - Electromechanical calculators ~ Successors - HP-35

HP-35

From Wikimedia Commons

Thing / Hardware - HP-35

- Firsts / Achievements / Uniqueness / Significance
  - First popular scientific calculator
  - Must fit inside a shirt pocket (William Hewlett)
  - Steve Wozniak sold his to help finance Apple
- Place Produced (Company / Institution) ~ Year ~ Country
  - Hewlett Packard ~ 1972 ~ USA
- People involved (Designer)
  - Text
- Type
  - Scientific calculator
- Price / Cost
  - $395
- Size
  - 3 1/4 " x 5 ¾" x 1"

Thing / Hardware - HP-35

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Did floating point and reverse Polish notation (RPN)
- Predecessors - Slide rule ~ Successors - N/A

Osborne-1

Thing / Hardware - Osborne I

- Firsts / Achievements / Uniqueness / Significance
  - First portable computer ~ Fit under airplane seat ~ Weighed 28 pounds
- Place Produced (Company / Institution) ~ Year ~ Country
  - Osborne Computer ~ 1981 ~ USA
- People involved (Designer)
  - Adam Osborne, Lee Felsenstein
- Type
  - Portable computer (luggable computer)
- Price / Cost
  - $1795
- Size
  - 11.3" x 20" x 14"
  - Weighed 24 pounds

Thing / Hardware - Osborne I

- Computing technology
  - Integrated circuits - Zilog Z80 microprocessor ~ 5" display
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 64 kilobytes ~ 8 bits
- Secondary memory type / technology ~ Size
  - 5.25" floppy disk ~ 90 kilobytes
- Uses / Applications / Software
  - First microcomputer to come with $2,000 worth of bundled software - word processor, database, spreadsheet, BASIC
- Predecessors - Xerox NoteTaker ~ Successors - KayPro

Tandy Model 100

From Wikimedia Commons

Thing / Hardware - Tandy TRS-80 Model 100

- Firsts / Achievements / Uniqueness / Significance
  - First laptop - 4 pounds in weight
  - Built in modem to transfer work out
  - Last production software written by Bill Gates
- Place Produced (Company / Institution) ~ Year ~ Country
  - Tandy (Kyocera) ~ 1983 ~ USA
- People involved (Designer)
  - Text
- Type
  - Laptop computer
- Price / Cost
  - $800
- Size
  - 8.5" x 12" x 2"

Thing / Hardware - Tandy TRS-80 Model 100

- Computing technology
  - Integrated circuits ~ Intel 80C85 microprocessor
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 8 kilobytes ~ 8 bits
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Journalists for word processing, database, BASIC language
- Predecessors - Osborne I ~ Successors - Clamshell laptops

Compaq Portable

From Wikimedia Commons

Thing / Hardware - Compaq Portable

- Firsts / Achievements / Uniqueness / Significance
  - First IBM PC clone created by reverse engineering IBM PC BIOS
  - Certified by being able to run Lotus 1-2-3 and Microsoft Flight Simulator
- Place Produced (Company / Institution) ~ Year ~ Country
  - Compaq ~ 1983 ~ USA
- People involved (Designer)
  - Text
- Type
  - Portable computer
- Price / Cost
  - $3,590
- Size
  - Weighed 28 pounds

Thing / Hardware - Compaq Portable

- Computing technology
  - Integrated circuits ~ Intel 8088 microprocessor
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 128 kilobytes ~ 16 bits
- Secondary memory type / technology ~ Size
  - 5.25" floppy disk drives (2) ~ 320 kilobytes
- Uses / Applications / Software
  - Text
- Predecessors - Osborne I, Xerox NoteTaker ~ Successors - N/A

Motorola SCR-536 Handy-Talkie

Thing / Hardware - Motorola SCR-536 Handy-Talkie

- **Firsts / Achievements / Uniqueness / Significance**
  - First hand-held, self-contained handy-talky two-way radio with range of few hundred feet to 1 mile
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Galvin Manufacturing (Motorola) ~ 1940 ~ USA
- **People involved (Designer)**
  - Don Mitchell
- **Type**
  - Hand-held radio transceiver
- **Price / Cost**
  - Text
- **Size**
  - 13 x 3.5 x 3.1 inches ~ 5 pounds in weight

Thing / Hardware - Motorola SCR-536 Handy-Talkie

- Computing technology
  - 5 vacuum tubes, dry battery powered which lasted ~ 1 day ~ 40" antenna when pulled out turned it on
- Computing speed (in MIPS)
  - N/A
- Primary memory type / technology ~ Size ~ Word length
  - N/A
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - AM communication, 6 per rifle company - 1 in each of 3 rifle platoons, 2 in weapons platoon, 1 for CO
  - 130,000 used in World War II
- Predecessors - None ~ Successors - Raytheon AN/PRC-6

Motorola DynaTAC

From Wikimedia Commons

Thing / Hardware - Motorola DynaTAC

- Firsts / Achievements / Uniqueness / Significance
  - 1950's - mobile telephone services for autos - had severe limitations in form of limited number of allocated channels and radios had to be powerful and large
  - 1969 - Pioneering cell phone on Amtrak Metroliner train between New York City + Washington DC
  - 1973 - First call on handheld phone made by Martin Cooper of Motorola to colleague at Bell Labs
- Place Produced (Company / Institution) ~ Year ~ Country
  - Motorola ~ 1973 ~ USA
- People involved (Designer)
  - Martin Cooper
- Type
  - Mobile telephone
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Motorola DynaTAC

- Computing technology
  - Integrated circuits
  - Cellular service breaks up a region into small areas called cells with phones in each cell using frequencies that can be used without interference by other phones in other cells since they operate at low power
  - Technique works by transferring call from one cell to another as caller moves
  - Requires database of phone subscribers, way to measure relative strengths of their signals relative to nearby towers and switching method to hand over the call from one cell to another
- Computing speed (in MIPS)
  - N/A
- Primary memory type / technology ~ Size ~ Word length
  - N/A
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Transmit voice over the air
- Predecessors - Telephone ~ Successors - iPhone

Motorola MicroTAC Elite

From Wikimedia Commons

The First Practical Mobile Phone

- Noticed at meeting of CEOs of computer companies that half of them had a Motorola MicroTAC Elite in their pockets
  - When asked why they had this phone CEOs replied "they just used it and didn't have to think about it" - the ultimate accolade when it comes to technology
- In reality had small size, light weight, great battery profile, answering machine - no need for any other phone in your life
  - Had Li ion battery that didn't need management + lasted forever allowing it to remain on all day to receive calls + make calls

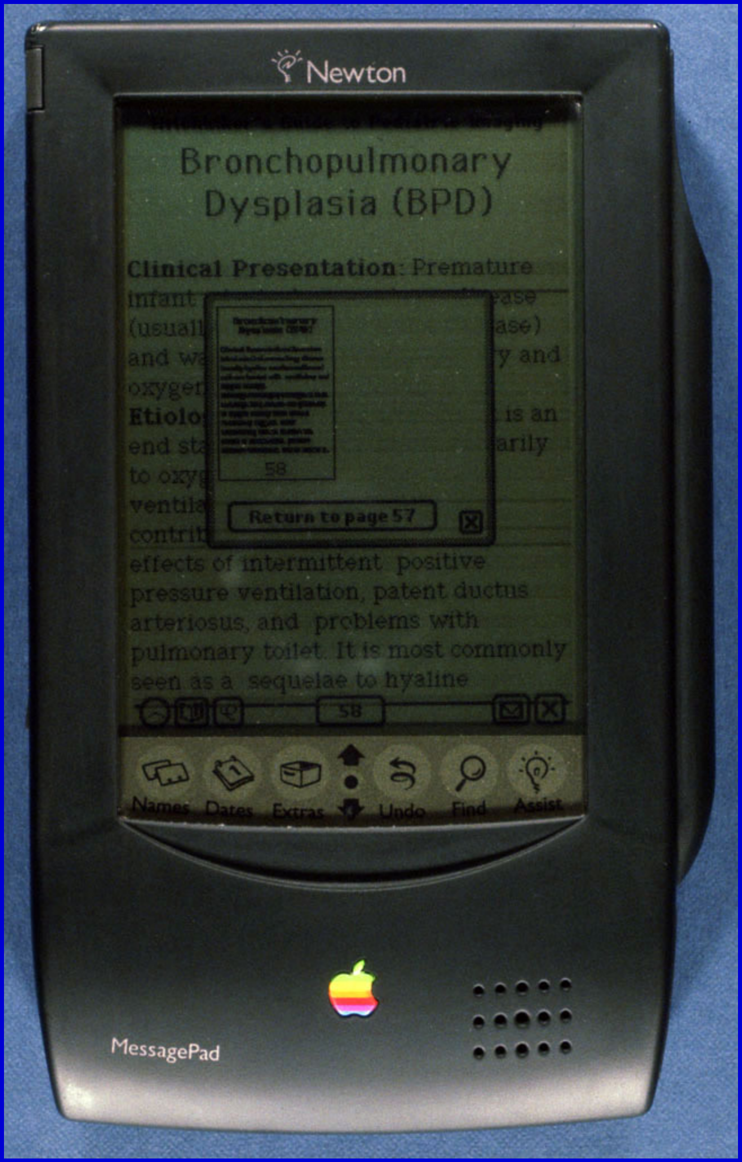
- Stewart Alsop, Until I Find the Right PDA, I Intend to Keep a Cellular Phone in my Shirt Pocket, InfoWorld, Jan. 22, 1996

Place - Schaumburg, Illinois

- Significance
  - Headquarters of Motorola
- Location
  - Illinois
- Definition
  - Ground zero for mobile communication devices from handy-talkie to mobile phone
  - Still a mecca for hams
- People who worked there
  - Bob Galvin
- Things created there
  - Motorola created industries - automobile radios, two way radios, special mobile radio services, paging, cellular telephones, microprocessors, satellite telephones

    - Karen Frenkel, A Conversation with Bob Galvin, Interactions, July 1994

Apple Newton MessagePad



Thing / Hardware - Newton

- Firsts / Achievements / Uniqueness / Significance
  - First consumer handheld computer / PDA
  - Handwriting recognition input was ridiculed
- Place Produced (Company / Institution) ~ Year ~ Country
  - Apple Computer ~ 1993 ~ USA
- People involved (Designer)
  - Text
- Type
  - Personal digital assistant
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Newton

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ Text ~ Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Personal organization - address book, to do list, calendar, notebook, eBooks
- Predecessors - N/A ~ Successors - Palm Pilot

Thing / Hardware - Palm Pilot

- Firsts / Achievements / Uniqueness / Significance
  - Most successful personal digital assistant
  - Simple easy to use interface
  - Spinoff company - Handspring - added cell phone to it in 2002
- Place Produced (Company / Institution) ~ Year ~ Country
  - Palm ~ 1996 ~ USA
- People involved (Designer)
  - Jeff Hawkins, Donna Dubinsky
- Type
  - Personal digital assistant
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Palm Pilot

- Computing technology
  - Integrated circuits ~ Motorola 68328 Dragonball (Motorola 68000 32 bit microprocessor)
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ Text ~ Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Personal organization - address book, to do list, calendar, notebook, eBooks
- Predecessors - Apple Newton ~ Successors - iPhone

Thing / Hardware - iPhone

- Firsts / Achievements / Uniqueness / Significance
  - First mobile phone to emphasize Web browser and Internet access as primary function of phone rather than afterthought
  - First successful combination of phone, personal digital assistant, and Internet access in one device
  - First app store to allow anyone to create mobile phone apps, creating new industry
- Place Produced (Company / Institution) ~ Year ~ Country
  - Apple Computer ~ 2007 ~ USA
- People involved (Designer)
  - Steve Jobs ~ Jonathan Ive
- Type
  - Mobile phone
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - iPhone

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 128 megabytes ~ 32 bits
- Secondary memory type / technology ~ Size
  - Flash ~ 4 - 16 gigabytes
- Uses / Applications / Software
  - Ultimately > 2 million iOS apps by 2016
- Predecessors - Mobile phones ~ Successors - Android

iPhone

- iPhone changed the world
  - Transformed cellphone industry
  - Provided platform for new software industry - mobile apps
  - Upended personal computer industry
  - Changed the way we receive + process information by subsuming into one device in your pocket, the book, newspaper, telephone, radio, tape recorder, camera, video camera, compass, television, VCR, DVD, personal computer, cellphone, videogame, iPod

- Fred Vogelstein, And Then Steve Said, 'Let There Be an iPhone', New York Times Magazine, Oct. 6, 2014

Thing / Hardware - iPad

- **Firsts / Achievements / Uniqueness / Significance**
  - First successful tablet computer
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Apple ~ 2010 ~ USA
- **People involved (Designer)**
  - Jonathan Ive, Steve Jobs
- **Type**
  - Tablet computer
- **Price / Cost**
  - Text
- **Size**
  - 4.5 x 2.4 x 0.5 inches

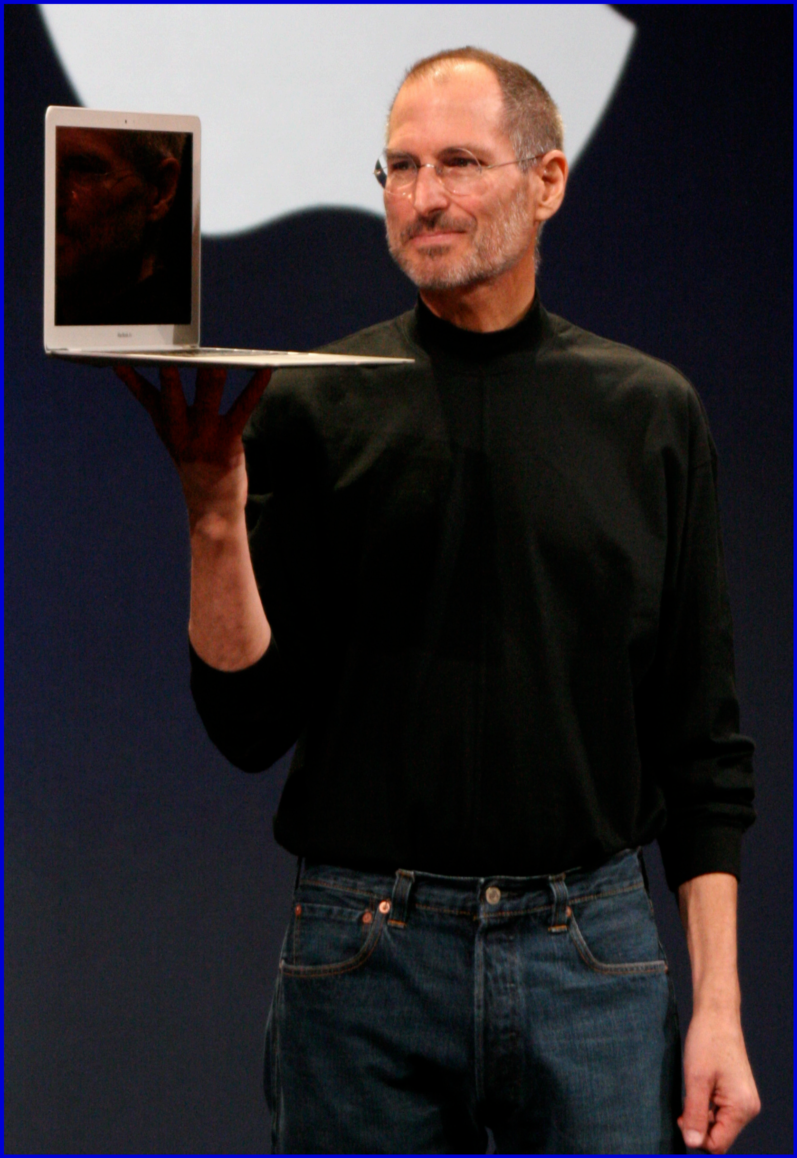
Thing / Hardware - iPad

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ Text ~ Text
- Secondary memory type / technology ~ Size
  - Flash memory ~ Text
- Uses / Applications / Software
  - Consumption of content
- Predecessors - iPhone ~ Successors - Android

"My theory about the turnaround of Apple is that what they have accomplished is relatively underappreciated. Mac, iPhone, and iPad are all Unix supercomputers packaged into a consumer form factor. That's basically what they did. That's the part that nobody talks about, because everybody's so design-obsessed. That iPhone sitting in your pocket is the exact equivalent of a Cray XMP supercomputer from twenty years ago that used to cost ten million dollars. It's got the same operating system software, the same processing speed, the same data storage, compressed down to a six-hundred-dollar device. That is the breakthrough Steve achieved. That's what these phones really are!"

- Marc Andreessen from an interview in 2014 quoted in Brent Schlender and Rick Tetzeli, Becoming Steve Jobs, p. 365

Steve Jobs



From Wikimedia Commons

Person - Steve Jobs

- Significance
  - Vision of limitless potential of personal computing
- Profession
  - Entrepreneur, inventor, marketer
- Places worked
  - Atari, Apple, NeXT, Pixar, Apple
- Years of work
  - 1976 - 2011
- Things worked on
  - Apple I, Apple II, Macintosh, NeXT Machine, iMac, iPod, iPhone

Inside the Mind of Steve Jobs

"One thing that Gates told me in that interview was he didn't understand why Jobs had gone back to Apple at all. "Why would he do that?" Bill asked. "He has to know that he can never win."

...

In Steve Jobs' mind, he has already won. Those of us who last for a few decades in this business find our own kind of peace and Steve Jobs' is best exemplified by the George Herbert quote, "Living well is the best revenge." Apple's future as a boutique computer company is secure. He dominates Apple completely. When he doesn't feel like being a high tech mogul, he can be a movie mogul, something Gates will never be. In Steve's mind, he has the best of everything. Apple software is cooler than Windows will ever be. Palo Alto, where Jobs lives, is trendier than Seattle. Even Jobs' plane, a Gulfstream V, is cooler than Gates' Challenger 604. It goes on and on. Gates has never even considered this latter point, but I'll guarantee you that Jobs has, and he revels in it."

- Robert X. Cringely, The Best Revenge: Why the New iMacs Will Be Successful No Matter What They Look Like, Jan. 10, 2002

Inside the Mind of Steve Jobs

"Whenever I ate with Steve, he insisted on paying for me, which I thought was a little odd. Even if we went in together and he selected something quick like premade sushi, and I ordered a pizza in the wood-burning pizza oven, he would wait for me at the cash register for 10, 15 minutes. I felt so awkward. Finally, I told him. "Seriously, I can pay for myself, so please don't stand there and wait for me." He said, "Scott, you don't understand. You know how we pay by swiping your badge and then it's deducted from your salary? I only get paid a dollar year! Every time I swipe we get a free meal!" Here was this multibillionaire putting one over on the company he founded, a few dollars at a time."

- Scott Forstall, Senior Vice President of software at Apple, 1997-2012

- Steve Levy, An Oral History of Apple's Infinite Loop, Wired, Sept. 16, 2018

"It's in Apple's DNA that technology alone is not enough. We believe that it is technology married with the humanities that yields us the results that make our hearts sing."

- Steve Jobs

Why Steve Jobs Succeeded - Quotes From Steve Jobs

"It's really hard to design products by focus groups. A lot of times, people don't know what they want until you show it to them."

"Simple can be harder than complex. You have to work hard to get your thinking clean to make it simple. But it's worth it in the end because once you get there, you can move mountains."

"When you're a carpenter making a beautiful chest of drawers, you're not going to use a piece of plywood on the back, even though it faces the wall and nobody will ever see it. You'll know it's there, so you're going to use a beautiful piece of wood on the back. For you to sleep well at night, the aesthetic, the quality, has to be carried all the way through."

"I'm as proud of many of the things we haven't done as the things we have done. Innovation is saying no to a thousand things."

"It's more fun to be a pirate than to join the navy."

"Your work is going to fill a large part of your life, and the only way to be truly satisfied is to do what you believe is great work. And the only way to do great work is to love what you do."

"Real artists ship"

10 Lessons From Steve Jobs That Every Marketer Must Learn

- Find good mentors
- Make a great product
- Stand for something
- Spend money
- Create experiences
- Keep secrets and build mystery
- Find an enemy
- Turn customers into evangelists
- Don't talk about products
- Use pictures, not words

- Dan Lyons, 10 Lessons From Steve Jobs That Every Marketer Must Learn, HubSpot, June 3, 2013

Poem

sometimes I feel like a great chef
who has devoted his entire life
to monastic study of the art of cooking
& gathered the finest ingredients
& built the most advanced kitchen
& prepared the most exquisite meal
so perfect, so delicious, so extraordinary
more astounding than any meal ever created
yet each day i stand in my window
& watch ninety-seven percent of the world
walk past my restaurant
into the mcdonald's
across the street.
- Fake Steve Jobs (aka Dan Lyons), oPtion$

"The lesson is that people are hungry for meaning, and they will go to great lengths to find it. Look at how far you came. Look what you put yourself through. Look at everyone around you in America. It's the wealthiest country that has ever existed in the history of the planet. Yet it's also the most miserable. Nobody is happy. How does that make sense? People have big cars, big houses, plenty to eat. Nothing works. They go to church. They go to shrinks. They drink, they take drugs. Or, like you, they give away all their possessions and fly to India. Only there's no answer here, either. As you are discovering today."

...

"Now let me leave you with a thought. America is all about commerce. That's what America is good at. Someone is going to figure out a way to create material things and to imbue them with a sense of religious significance. I don't know how this will happen. But it will happen because it needs to happen. God on the one hand and products on the other. Whoever weaves these together will become more powerful than you can imagine."

- Krishna Neeb Baba to Fake Steve Jobs in Dan Lyons, oPtion$, p. 186

Thinking Different

"The world needs sociopaths. Who else ever gets anything done? Sociopaths are the ones who create, who lead, who inspire, who motivate. Was Buddha a sociopath? No doubt. Gandhi? Crazy as a loon. Same for Picasso, and Hemingway, and John Lennon. Geniuses like us may not be entirely pleasant, but let's face it, we're necessary."

- Fake Steve Jobs in Dan Lyon's oPtion$ p. 247

- Steve Jobs was often described as being "mercurial"
  - But isn't Mercury the winged messenger of the Gods on Olympus?

Thing / Software - Android

- Firsts / Achievements / Uniqueness / Significance
  - Most widely used smartphone platform
- Place Produced (Company / Institution) ~ Year ~ Country
  - Google ~ 2008 ~ USA
- People involved (Programmer)
  - Andy Rubin
- Type
  - Mobile phone / tablet operating system
- Price / Cost
  - Text
- Computer and operating system it runs on
  - All Android devices - Largest installed based of any operating system
- Computer language written in
  - C ~ Kernal is based on Linux
- Memory required
  - Text
- Predecessors - Linux + iOS ~ Successors - N/A

Communications Case Study Summary - Global Positioning System (GPS)

- Goal
  - Provide location information instantly to anyone, anytime, anywhere
- Center of Gravity (Strategy)
  - Trilateration using signals from space rather than from land
  - Accurate to ~ 15 meters
- Technology / Equipment
  - 24 satellite constellation transmitting microwave signals
- Training ~ Leadership ~ Morale ~ Tactics
  - Ubiquitous receivers use signals from at least 3 satellites to automatically determine location, speed, direction, time
- Intangibles ~ Mistakes
  - Jamming
  - Can we operate without it?
- Outcome
  - Designed in 1970's ~ Tested in 1980's ~ Operational in 1990's
  - Ubiquitous usage for location-based services + targeting

Shift to the Mobile Internet

- If > 30 years old, primary computing device is desktop or laptop
  - Internet is experienced though single app = Web browser
  - Tablet replaces desktop / laptop + still experience Internet through Web browser
- If < 30 years old, primary computing device is mobile phone
  - Internet is experienced through numerous apps
  - Don't use Web browser, Web not important, leads to narrowing of information sources used

- Owen Williams, Smartphones: The Silent Killer of the Web As You Know It, The Next Web, May 5, 2014

Paper Apps

- App is interface for manipulating a dataset
- Antikythera Mechanism was a series of analog brass apps
- Astrolabes were brass analog apps for knowing the time and position of planets + stars
- In 11th century the volvelle was developed as a paper analog app
- In 19th century volvelles were popularized as calculation apps that could be used for advertising - flight computer, nuclear bomb effects computer, diet calculator

- Adam Rothstein, The Original Mobile App Was Made of Paper, Vice, Nov. 16, 2015

To App or Not To App
That Is The Question

- **Apps - if < 30 years old**
  - **Pros**
    - Polished user interface
  - **Cons**
    - Usually not free
    - Not interoperable
    - Small number of apps
- **Web - if > 30 years old**
  - **Pros**
    - Usually free
    - Interoperable
    - Large number of Web sites
  - **Cons**
    - Unpolished user interface

- Owen Williams, Smartphones: The Silent Killer of the Web As You Know It, The Next Web, May 5, 2014

Death of the Web

- Web is dying + this has far reaching implications
  - On phones, 86% of time spent on apps, 14% spent on Web
  - Apps are faster + easier to use than Web, but Web was open and apps are not
- Web was invented by academics whose goal was exposing + sharing information, so Web was made open and controlled by standards bodies + became a commons
  - Lack of payment system was bug forcing Web to depend on advertising
  - Result was anyone could put up Web page or launch new service + anyone could access it
  - Result was biggest creator + destroyer of wealth ever seen
- App stores are closed walled gardens which are controlled by centralized gatekeepers
  - Search on app stores is broken so discovery of new interesting apps very difficult

"The history of computing is companies trying to use their market power to shut out rivals, even when it's bad for innovation and the consumer."

"The Web was a historical accident, an anomalous instance of a powerful new technology going almost directly from a publicly funded research lab to the public."

"in the transition to a world in which services are delivered through apps, rather than the Web, we are graduating to a system that makes innovation, serendipity and experimentation that much harder for those who build things that rely on the Internet."

- Christopher Mims, The Web is Dying; Apps are Killing it. Wall Street Journal, Nov. 17, 2014

Analog Photography
From Long Exposure Giant Cameras to Snapshots with Pocket Cameras

- Wet plate photography was very difficult
  - Used large cameras on tripods for long exposures + chemistry lab
- 1870's dry plate photography arrives
  - Now possible to take small camera anywhere, without chemicals, without tripod + take image without asking permission
  - Dry plates + affordable cameras from Kodak democratized photography
  - Led to snapshot craze which led to backlash as people objected to being "Kodaked" by "camera fiends"
    - People feel photography constituted an invasion of personal privacy
- Efforts to ban snapshot cameras failed, instead new social norms arose to govern use of snapshot cameras
  - Initial outrage can give way to acceptance if broader benefits of new technology can be demonstrated
- Parallels to current worries about cameras on smartphones and Google Glass

- Tom Standage, A First-Timer's Foray Into Wet-Plate Photography, Medium, Dec. 9, 2015

Panopticon

"The unexamined life is not worth living"

- Socrates

- In "The Circle" by Dave Eggers, the world's first "transparent man" is described
  - Someone who records every moment of his life + makes all his actions visible to anyone who cares to look
- "Life logging"
  - Digitally recording your life with eye to endless re-examination
  - Patterns in such data will reveal opportunities to be healthier, happier, more effective = "Quantified self" movement

- The People's Panopticon, The Economist, Nov. 16, 2013

The Disappearing Computer
Ubiquitous Computing

- Post desktop model of human-computer interaction in which information processing has been thoroughly integrated into everyday objects + activities
- Can be defined as machines that fit the human environment instead of forcing humans to fit the machines' environment
- Father was Mark Weiser of Xerox PARC in 1988

> "Ubiquitous computing names the third wave in computing, just now beginning. First were mainframes, each shared by lots of people. Now we are in the personal computing era, person and machine staring uneasily at each other across the desktop. Next comes ubiquitous computing, or the age of calm technology, when technology recedes into the background of our lives."
>
> \- Mark Weiser

"Mark Weiser had this profound idea that computing would disappear into everyday objects, and everyday objects would become magic"

\- John Markoff

- First person to commercialize this idea was Steve Jobs with iPod

Personal Case Study - App Developer for Newton

- Role
  - First consumer handheld computer
- Story
  - Soon after purchase of Newton in August 1993 began developing a medical eBook for it using the Newton Book Maker
  - Came to the attention of software company creating Newton eBooks who wanted Virtual Hospital digital library content for their eBooks, they wined us and dined us and drove us around Boston to a company party at their hotel suite and then dinner at Union Oyster House in a limo at MacWorld 1994…my friend from Germany who was visiting us asked me, "Do you live like a rockstar all the time?

Personal Case Study - Neil O

- Role
  - Engineer at Motorola working on mobile phones, Patent lawyer at Lucent and Research in Motion
- Story
  - Question - How are you?
  - Answer - I am maximizing shareholder value

Ad - See Topic 21 Computers in the Arts

- Company
- Year
- Story

Class Simulation

- Topic aspects

Questions for Further Discussion

- What was the first practical laptop computer?
- What was the computational challenge that Apple successfully addressed with the creation of the iPhone?
- What made Steve Jobs unique and successful?
- What is ubiquitous computing?
- Being that the main purpose of ubiquitous computing is to access the Internet: Will the way you access the Internet in the future be open or closed? i.e. a Web browser using open Web standard HTML 5 vs. dedicated apps?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
  - Lyons, Daniel - Options: The Secret Life of Steve Jobs
- Movies
- Simulations

Conclusion

"When the Mac first came out, Newsweek asked me what I [thought] of it. I said: Well, it's the first personal computer worth criticizing. So at the end of the presentation [unveiling the iPhone in 2007], Steve came up to me and said: Is the iPhone worth criticizing? And I said: Make the screen five inches by eight inches, and you'll rule the world."

- Alan Kay, computer scientist

Topic 14

Computers and Speed

Supercomputing

Song

Slide text

Thematic Quote

"You have zero privacy anyway. Get over it."

- Scott McNealy, Sun Microsystems

The Painting

Number Crunching

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - CRAY swag
- Year
  - 1988
- Story

The Question

Why is there always a need for greater computing speed?

Three Phases of Supercomputing

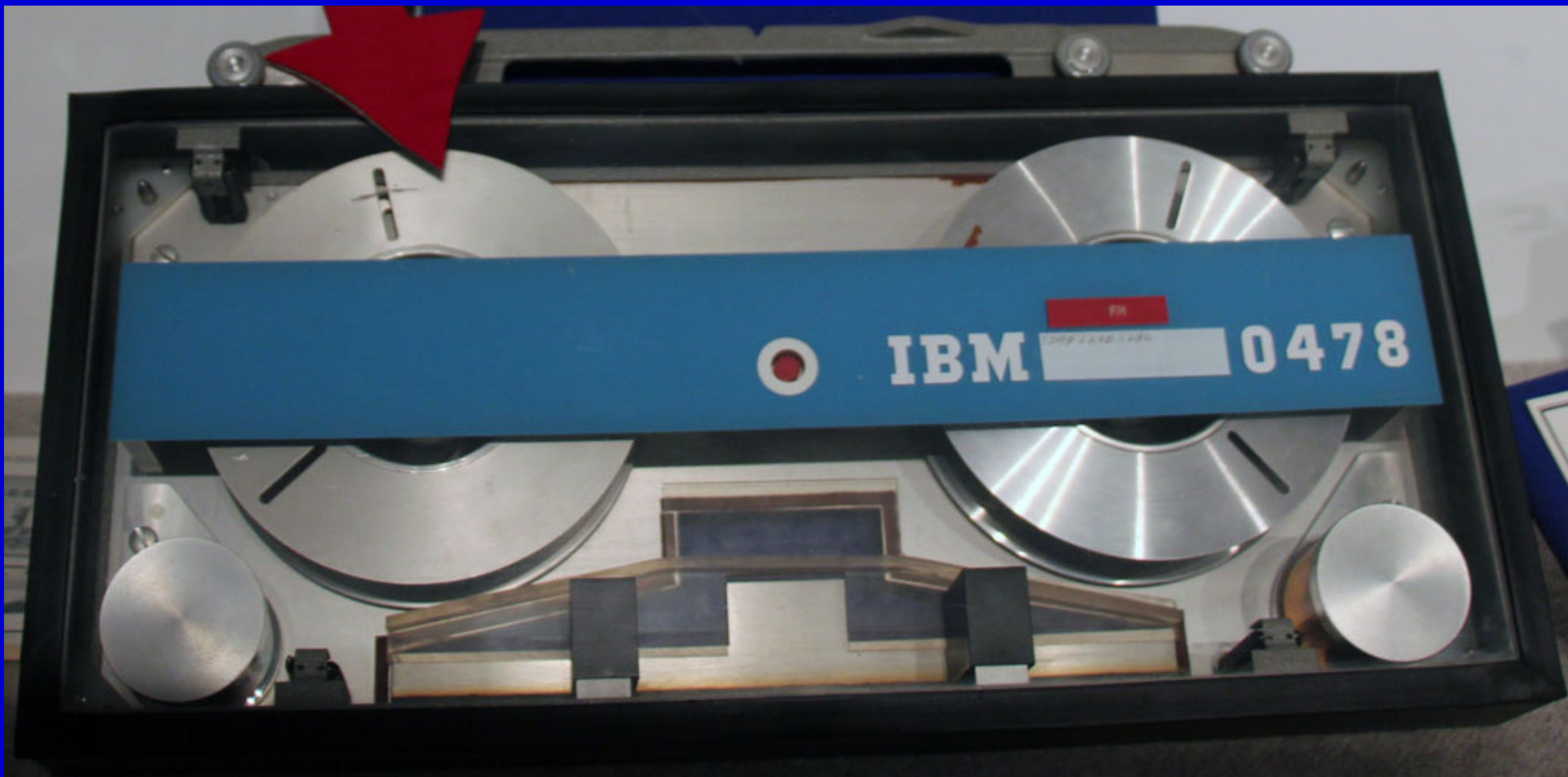
- 1960's - Fast, sequential machines built by UNIVAC, IBM Stretch, CDC 6600 + 7600
- Mid 1970's - Supercomputers (Cray-1, etc.) with vector processing and then with multiprocessors with vector processing
- Mid 1990's to present - Massively parallel computer clusters based on up to a million microprocessors tied together by very fast network and coordinated by software

Challenges in Design of Supercomputers

- Keeping circuitry close together so delays caused by wiring are minimized
- Getting heat out so circuits don't overheat

IBM Model 7030 Stretch

IBM Stretch-Harvest
Tractor magnetic tape storage system



Thing / Hardware - IBM 7030 Stretch

- Firsts / Achievements / Uniqueness / Significance
  - One of the first supercomputers which was intended to stretch the bounds of known hardware + software technology and offer fastest computation speed of any contemporary computer
  - Was supposed to be 100 times faster than any other computer (IBM 704), ended up 50-200 times faster
  - Commercial failure - too expensive and not fast enough but had amazing technology such as microprogramming that ultimately aided IBM System / 360
  - Showed need for miniaturization of parts if computer was going to reach its potential
- Place Produced (Company / Institution) ~ Year ~ Country
  - IBM ~ 1961 ~ USA
- People involved (Designer)
  - Red Dunwell
- Type
  - Proto supercomputer
- Price / Cost
  - $8,000,000
- Size
  - 2,500 square feet ~ Weighed 40,000 pounds

Thing / Hardware - IBM 7030 Stretch

- **Computing technology**
  - First IBM computer with transistors
  - Slow memory access time imposed overall limits on computation speed which was overcome by use of interleaved core memories, instruction look up units and overlapping fetch and execute instructions. - These developments in parallel processing and multiprogramming helped to speed up machine tremendously
- **Computing speed (in MIPS)**
  - 714,000 adds / second (500 KIPS)
- **Primary memory type / technology ~ Size ~ Word length**
  - Magnetic core ~ 256 kilowords ~ 64 bit
- **Secondary memory type / technology ~ Size**
  - Text
- **Uses / Applications / Software**
  - Nuclear weapons design at Los Alamos National Labs, code breaking at NSA
  - In 1962 delivered Stretch-Harvest to NSA - used to harvest intelligence from intercepted communications around the world - used to break wire-wheel cryptographic codes - processed 4 million bytes / second - its TRACTOR magnetic tape storage system was world's first completely automatic tape system - retired in 1976
- **Predecessors - N/A ~ Successors - IBM System 360, Cray-1**

Seymour Cray

From Wikimedia Commons

Person - Seymour Cray

- Significance
  - Father of supercomputing
  - Had great aesthetic sense in his designs
- Profession
  - Electrical engineer + Amateur tunnel digger
- Places worked
  - Engineering Research Associates (ERA), Control Data Corporation (CDC), Cray Research, Cray Computer
- Years of work
  - 1965-1996
- Things worked on
  - NTDS at Remington Rand UNIVAC
  - CDC 6600 + CDC 7600 (first supercomputers) at Control Data Corporation
  - Cray-1 + Cray-2 at Cray Research
  - Cray-3 + Cray-4 based on gallium arsenide technology at Cray Computer
    - End of Cold War and shrinking defense budgets contracted the supercomputing field, no Cray-3 or Cray-4's were ever sold, Cray Computer filed for bankruptcy in March 1995 without ever selling a computer

CDC Supercomputers

CDC 6600

CDC 7600

Thing / Hardware - CDC 6600

- Firsts / Achievements / Uniqueness / Significance
  - 10 times faster than any other computer - fastest computer in the world 1964-1969
  - First machine to be called supercomputer
- Place Produced (Company / Institution) ~ Year ~ Country
  - Control Data Corporation ~ 1964 ~ USA
- People involved (Designer)
  - Seymour Cray
- Type
  - Supercomputer
- Price / Cost
  - $10 million
- Size
  - Text

Thing / Hardware - CDC 6600

- **Computing technology**
  - 10 fold increase in logic density achieved using revolutionary "cordwood" packaging of transistors cooled by freon
  - Supercomputers are all about packaging + plumbing
  - Each wire used in system was trimmed to specific length to achieve required transmission time delay for electrical signals
  - Wired together by women with needlepoint experience
- **Computing speed (in MIPS)**
  - 3 million floating point operations / second (MFLOPS)
- **Primary memory type / technology ~ Size ~ Word length**
  - Magnetic core ~ 64,000 words fast + 2 million words slow ~ 60 bit
- **Secondary memory type / technology ~ Size**
  - Text
- **Uses / Applications / Software**
  - Simulating nuclear explosions, weather forecasting
- **Predecessors - N/A ~ Successors - CDC 7600**

"Last week, Control Data…announced their 6600 system. I understand that in the laboratory...there are only 34 people including the janitor. Of these, 14 are engineers and 4 are programmers...Contrasting this modest effort with our vast development activities, I fail to understand why we have lost our industry leadership position by letting someone else offer the world's most powerful computer."

- Thomas J. Watson Jr., CEO of IBM

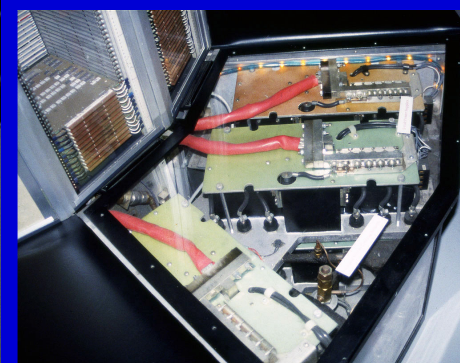
"I think Mr. Watson has answered his own question."

- Seymour Cray, Control Data Corporation

Cray-1

CPU

Circuit modules



Power supply + Liquid Freon

Thing / Hardware - CRAY-1

- Firsts / Achievements / Uniqueness / Significance
  - Was world's fastest computer for 5 years
  - Vector processing
  - Each was hand wired and took a year to assemble
  - Brilliance in packaging - circular design to minimize distances signal must travel over wires
- Place Produced (Company / Institution) ~ Year ~ Country
  - Cray Research ~ 1976 ~ USA
- People involved (Designer)
  - Seymour Cray
- Type
  - Supercomputer
- Price / Cost
  - $5 million ($6 - $10 million)
- Size
  - 6' high x 7' in diameter

Thing / Hardware - CRAY-1

- Computing technology
  - Integrated circuits ~ Freon cooled
- Computing speed (in MIPS)
  - 160 million floating point operations / second (MFLOPS)
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 1 megabyte (32 megabytes) ~ 64 bit
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Nuclear weapons design, cryptography, weather system modeling, aircraft design
  - World's most expensive loveseat
- Predecessors - CDC 6600 + 7600 ~ Successors - Cray-2

Cray-2

CPU (to left and behind) and Cooling Tower (front)

Thing / Hardware - Cray-2

- Firsts / Achievements / Uniqueness / Significance
  - Unusual cooling scheme using non-conductive liquid called Fluorinert to cool dense stacks of circuit boards
  - Smaller and 12 times faster than Cray-1, had up to 8 processors
- Place Produced (Company / Institution) ~ Year ~ Country
  - Cray Research ~ 1985 ~ USA
- People involved (Designer)
  - Seymour Cray
- Type
  - Supercomputer
- Price / Cost
  - $12-20 million
- Size
  - Text

Thing / Hardware - Cray-2

- Computing technology
  - Text
- Computing speed (in MIPS)
  - 488 million floating point operations / second (MFLOPS) / CPU
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 512 megawords ~ 64 bit
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Simulated nuclear fusion, computational fluid dynamics
- Predecessors - Cray-1 ~ Successors - Cray-3
  - Cray - 3 used gallium arsenide semiconductors, Seymour Cray had to form Cray Computer Corporation to build it, was canceled due to end of Cold War

Cray-3 "Brick"

CPU section

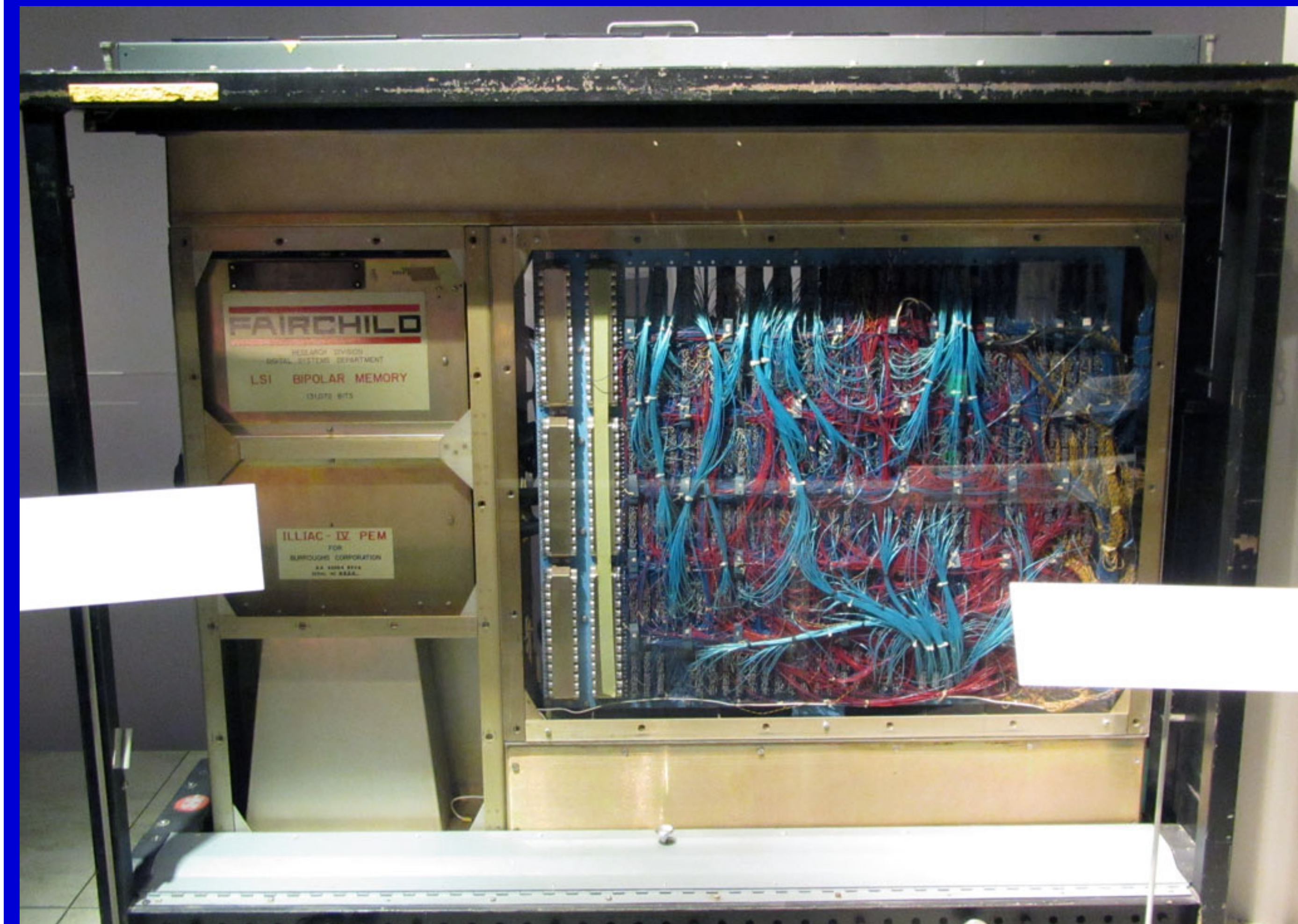
Thing / Hardware - Cray-3

- Firsts / Achievements / Uniqueness / Significance
  - A computation that took the Cray-3 1 second would have taken ENIAC 67 years
- Place Produced (Company / Institution) ~ Year ~ Country
  - Cray Computer Corporation ~ 1995 ~ USA
- People involved (Designer)
  - Seymour Cray
- Type
  - Supercomputer
- Price / Cost
  - $30 million
- Size
  - Consumed 90,000 watts of power ~ Cooled by Fluorinert

Thing / Hardware - Cray-3

- Computing technology
  - Used unproven technology of gallium arsenide instead of silicon for circuitry ~ Had to invest in company making circuitry
  - Modules in brick are multilayer sandwich of printed circuit boards with 69 electrical layers and 4 layers of gallium arsenide circuitry
- Computing speed (in MIPS)
  - 474 mHz / 15 billion floating point operations per second (GFLOPS)
- Primary memory type / technology ~ Size ~ Word length
  - Semiconductor ~ 2 GW ~ 64 bit
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Only 1 built
- Predecessors - Cray-2 ~ Successors - Massively parallel machines based on microprocessors

ILLIAC IV



One of 64 processing elements with memory ~ 10 megabyte hard drive is 3 feet high

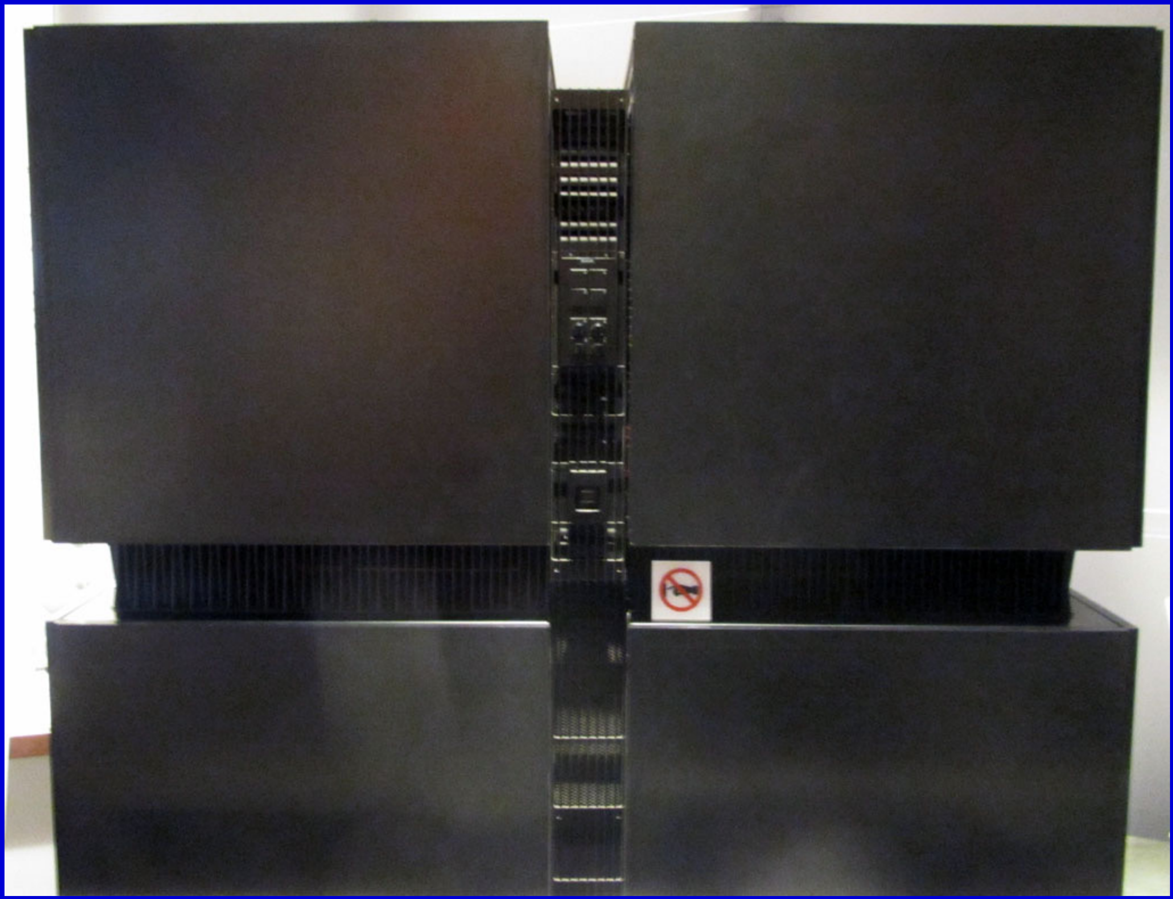
Thing / Hardware - ILLIAC IV

- Firsts / Achievements / Uniqueness / Significance
  - Pioneer massively parallel computer
  - Try to make one fast computer out of bunch of slow ones that all execute same program in lock step on different data
  - All processing elements had their own local memory + executed same instruction simultaneously ~ It worked but was not a great idea
- Place Produced (Company / Institution) ~ Year ~ Country
  - DARPA / University of Illinois / Burroughs ~ 1975 ~ USA
- People involved (Designer)
  - Text
- Type
  - Supercomputer with massive parallelism - Single Instruction Multiple Data
- Price / Cost
  - $31 million
- Size
  - Text

Thing / Hardware - ILLIAC IV

- Computing technology
  - Had 64 processors ~ Was supposed to have 256 processors
  - First computer to use semiconductor memory
- Computing speed (in MIPS)
  - 75 million floating point operations / second (MFLOPS)
- Primary memory type / technology ~ Size ~ Word length
  - Semiconductor from Fairchild (2K chips) ~ 16M words ~ 64 bits
- Secondary memory type / technology ~ Size
  - Hard disks
- Uses / Applications / Software
  - NASA used it for fluid dynamics, digital image processing, weather forecasting
  - Too expensive ~ Had many technical problems
  - Many of first parallel programming languages ran on it
- Predecessors - N/A ~ Successors - Connection Machine CM-1

Connection Machine CM-1



Thing / Hardware - Connection Machine CM-1

- Firsts / Achievements / Uniqueness / Significance
  - Pioneered massively parallel supercomputing
- Place Produced (Company / Institution) ~ Year ~ Country
  - Thinking Machines ~ 1985 ~ USA
- People involved (Designer)
  - Danny Hillis
- Type
  - Massively parallel supercomputer - Single Instruction Multiple Data
- Price / Cost
  - Text
- Size
  - $2.5 million for 64K CPU machine

Thing / Hardware - Connection Machine CM-1

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - 2.5 - 10 billion floating point operations / second (GFLOPS)
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 4K / CPU ~ 1 bit
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Text
- Predecessors - ILLIAC IV ~ Successors - N/A

State of Supercomputing in 2016
In Floating Point Operations Per Second (FLOPS)

- Modern PC speed in 2016 is < 1 gigaFLOPs (billion FLOPs = 10EE9)
  - ASCI Red (Intel) supercomputer in 1997 broke 1 teraFLOPs in 1997 (trillion FLOPS = 10EE12))
  - Roadrunner (IBM) supercomputer in 2008 broke 1 petaFLOPs in 2008 (quadrillion FLOPS = 10EE15)
  - exaFLOPs barrier should be broken in 2020 (quintillion FLOPS = 10EE18)
- In 2016
  - China's Tianhe-2 supercomputer is fastest at 33.86 petaFLOPS
  - In 2016 US's Titan supercomputer is second fastest at 17.59 petaFLOPs
    - Has 710 terabyes of system memory
    - Has hybrid architecture of 299,088 16-core AMD Opteron CPUs + 18,688 NVIDIA Tesla K20 GPU accelerators + Gemini interconnect
- Challenges going forward - optimizing computational efficiency through new architectures / algorithms / programs + reducing power consumption + improving cooling

- Anika Torruella, Power Hungry: Supercomputers Face a Demanding Future, HIS Jane's International Defense Review, Apr. 2016

Computing Case Study Summary - SETI@Home - SETI + Citizen Science

- Goal
  - Detect a signal from an extraterrestrial civilization
- Center of Gravity (Strategy)
  - Acquire data from Arecibo radio telescope
- Technology / Equipment
  - Personal computers using their spare capacity are networked together
- Training ~ Leadership ~ Morale
  - Started in 1999, has attracted > 6 million users
- Tactics
  - Personal computers using their spare capacity process data acquired by SETI's radio telescopes, looking for signals
- Intangibles
  - Disadvantage is that processing is not done real-time, data is months old when it is processed so when signal is found it is an old signal that can't be acted upon
- Mistakes
- Outcome
  - Is a virtual supercomputer

- The Wow Factor, The Economist, Mar. 10, 2012
- John Markoff, In Search for Alien Life, Researchers Enlist Human Minds, New York Times, Mar. 20, 2012
- Alex Lux, Little Green Men, @CHM, Oct. 19, 2012

Computing Case Study Summary - SETI

- Goal
  - Find radio signal from extraterrestrial civilization
- Center of Gravity (Strategy)
  - Allen Telescope Array to gather data ~ Computers to process data
- Technology / Equipment
  - Allen Telescope Array of 42 antennas will speed up search substantially
    - Looked at ~ 1,000 stars in last decade, in next decade will look at 1 million stars
  - Computers following Moore's Law
    - You double your computing power every 18 months that you use to search the data you gather for signals, thus you are doubling the speed of your SETI search every 18 months
- Training ~ Leadership ~ Morale
- Tactics
- Intangibles ~ Mistakes
- Outcome
  - SETI's search follows Moore's Law
    - By tying Moore's Law to the search, lets you run the experiment faster every year, so the chance you may find something keeps getting better each year
  - Quantity has a quality all its own
  - Sufficient quantitative change can be qualitative change

Computing Case Study Summary - SETILive - SETI + Citizen Science

- Goal
  - Detect a signal from an extraterrestrial civilization
- Center of Gravity (Strategy)
  - Acquire data from Allen Telescope array radio telescope targeted at Kepler detected exoplanets
- Technology / Equipment
  - Uses pattern recognition capabilities of human's brains
- Training ~ Leadership ~ Morale
  - Started in 2012, has attracted 100,000 users over 2 years
- Tactics
  - Humans look at waterfall plots of data trying to detect true signal amidst noise from stars or humans in real-time
  - You have 90 seconds to find signal, if signal is found, telescope is retargeted within 3 minutes to look again for signal
- Intangibles
  - Human analysis of data is form of machine learning for the system to fine-tine its signal-finding algorithms
- Mistakes
- Outcome
  - Ran for 2 years until it ran out of funds

- The Wow Factor, The Economist, Mar. 10, 2012

- John Markoff, In Search for Alien Life, Researchers Enlist Human Minds, New York Times, Mar. 20, 2012

- Alex Lux, Little Green Men, @CHM, Oct. 19, 2012

Computing Case Study Summary - Google

- Date - The present
- Goal

  "Google's mission is to organize the world's information and make it universally accessible and useful."
- Center of Gravity (Strategy) [Deliver results in]
  - Delivers results with sub second response time - ultimately wants to do so at speed of light
  - Search has 4 components - comprehensiveness, relevance, speed, user experience
- Technology / Equipment
  - Googleplex = Logistics, logistics, logistics
    - Today there are 25 data centers, each is the size of 3 football fields = 3 * (100 x 50 meters) = 15,000 square meters
    - Each data center holds tens of thousands of computer servers located near hydroelectric power
    - Own their own fiber network

- Markofff John + Hansell Saul, Hiding in Plain Sight, Google Seeks More Power, New York Times, June 14, 2006

Computing Case Study Summary - Google

- Training ~ Leadership ~ Morale
  - The apex of the pyramid in Silicon Valley
- Tactics [Interface]
  - Free text search tied to page rank
- Intangibles [Indexes]
  - Googol = 1×10^{100}
  - Indexes "tens of billions (10^9) of pages" in June 2007
- Mistakes
  - Heat!
- Outcome
  - Number one search engine running away from rivals
  - Google CEO Eric Schmidt has long described the company's collection of massive data centers around the world as the world's largest supercomputer

- Markofff John + Hansell Saul, Hiding in Plain Sight, Google Seeks More Power, New York Times, June 14, 2006

The Data Center is the Computer

"In the early 1950's a person could walk inside a computer and by 2010 a single computer (or cluster) with millions of processors will have expanded to the size of a building."

- Gordon Bell, computer engineer

- Gordon Bell, Bell's Law for the Birth and Death of Computer Classes, Communications of the ACM, Jan 2008 pp.86-94

"The data center is now the computer"

- Luis Barroso, computer engineer, Google

…companies like Google are now hiring computer architects

- David A. Patterson, The Data Center is the Computer, Communications of the ACM, Jan. 2008, p.105

Google is the Walk-Through Computer

- ~ Dozen data centers with "hundreds of thousands" of servers
- Indexes 20 billion Web pages / day
- Handles 3 billion search queries / day
- Conducts millions of ad auctions in real time
- Services 425 million Gmail accounts
- Plays millions of YouTube videos / day
- Has its own Red Team (Site Reliability Engineering Team) to attack Google in Disaster Recovery Testing
- Google's network + data centers are ultimate competitive advantage
  - http://www.google.com/about/datacenters/

- Steven Levy, Google Throws Open Doors to Its Top-Secret Data Center, Wired, Oct. 2012

Google Data Center, Council Bluffs, Iowa

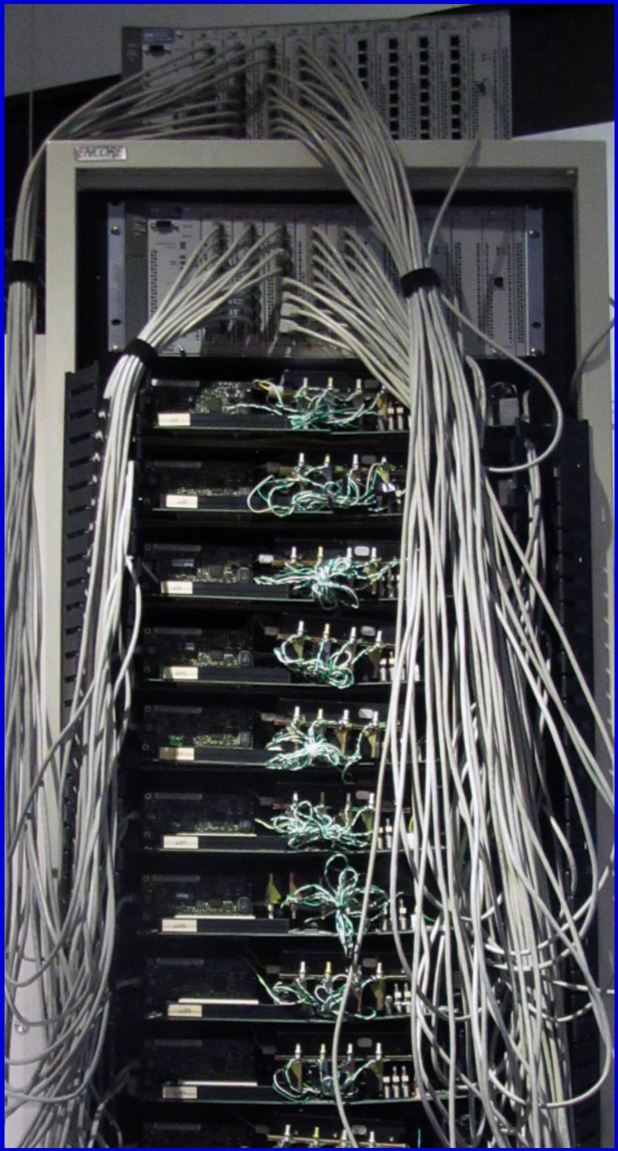
Google Data Centers

Where the.

Internet lives.

www.google.com/about/datacenters/gallery/

Google Server



1 of 30 racks of the initial Google production servers

Thing / Hardware - Google Cloud Computer / First Production Server

- Firsts / Achievements / Uniqueness / Significance
  - Low cost modular basis of Google's computing infrastructure
- Place Produced (Company / Institution) ~ Year ~ Country
  - Google ~ 1999 ~ USA
- People involved (Designer)
  - Larry Page + Sergey Brin
- Type
  - Server
- Price / Cost
  - $3,590
- Size
  - Text

Thing / Hardware - Google Cloud Computer / First Production Server

- Computing technology
  - Integrated circuits ~ Built using off-the shelf PCs with Intel 8088 microprocessors
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 128 kilobytes
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - This is one of the 30 racks of the initial Google servers
- Predecessors - Proprietary expensive servers from Sun, IBM, etc. ~ Successors - N/A

Before Bitcoin There Was Digicash

- Digicash's mission - change the world via introduction of anonymous digital money technology where ease of electronic transactions is combined with elegant anonymity of paying cash
- Wild card in era of digital money is anonymity - because there is a dichotomy between privacy + traceability
- Leads to question whether digital case can become anonymous as real cash is + if so, should it?
  - In a world where all money is electronic + traceable you have a very potent crime-fighting weapon

"In one direction lies unprecedented scrutiny and control of people's lives; in the other, secure parity between individuals and organizations. The shape of society in the next century may depend on which approach predominates." - David Chaum, founder of Digicash, 1992

- Steven Levy, E-Money (That's What I Want), Wired, Dec. 1994

Thing / Software - Bitcoin

- **Firsts / Achievements / Uniqueness / Significance**
  - First successful digital currency
  - Not issued by central bank but created by public key cryptographic software running on computer network
  - Number of Bitcoins in circulation has fixed upper limit so central bank can't inflate their value away by issuing more
  - Allows for anonymous peer to peer transfers directly between users without middlemen
  - Depends on distributed system of trust, based on transaction ledger which is cryptographically verified + jointly maintained by currency's users in permanent + fully public ledger (blockchain)
  - Amount of computing power consumed by its transaction-verification system (blockchain), which has side effect of mining new Bitcoins, is astronomical
  - 3 weakness - not as secure + anonymous as it seems, mining system that insures integrity of system + increases Bitcoin supply has caused computational arms race, distributed-ledger system becoming unwieldy
  - In 2015 Bitcoin processes 7 transactions / second, but Visa processes 10,000 transactions / second

- The Bitcoin Bubble, The Economist, Nov. 30, 2013

- Bitcoin Under Pressure, The Economist, Nov. 30, 2013

- The Magic of Mining, The Economist, Jan 10, 2015

Thing / Software - Bitcoin

- Place Produced (Company / Institution) ~ Year ~ Country
  - Unknown ~ 2008 ~ Unknown
- People involved (Programmer)
  - Satoshi Nakamoto (pseudonym)
- Type
  - Digital currency
- Price / Cost
  - Free to join as a Bitcoin miner
- Computer and operating system it runs on
  - Custom built mining rigs that went from CPUs to GPUs to ASIC (application specific integrated circuits)
  - Now requires huge amount of computational power to mine 1 Bitcoin
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - Digicash ~ Successors - Many other blockchain-based systems

\- The Bitcoin Bubble, The Economist, Nov. 30, 2013

\- Bitcoin Under Pressure, The Economist, Nov. 30, 2013

\- The Magic of Mining, The Economist, Jan 10, 2015

The Power of the Blockchain

- Blockchain is peer-to-peer ledger which creates + records agreement on contentious issues with aid of cryptography
- Blockchain is heart of Bitcoin and can power many other systems beyond digital currency
- We've always needed central bodies to settle vital questions
- But blockchain - a piece of incorruptible mathematics in computer code - allows people to settle problems without the authorities - allows you to run complex system with no central control
- This leads to decentralized systems which will slash overheads, improve security, remove weakest link of greedy, corruptible, imperfect humans
- Blockchain is public + infallible, a reliable + trustworthy record of who owns what
- Bitcoin is the first use of the blockchain
  - Form of money based on cryptographic proof instead of trust
  - Number of coins in circulation is finite at 21 million
  - No debt is possible, no complex derivatives, no untrustworthy middlemen
- Blockchains could also power domain names, social media, email, file storage…and perhaps government
- If the blockchain is impossible to corrupt it will be impossible to police

\- Matthew Sparkes, The Coming Digital Anarchy, Daily Telegraph, Jun. 9, 2014

Blockchain as Trust Machine

- Blockchain is machine for creating trust - way of making + preserving truths
- Is shared, trusted, public ledger that everyone can inspect but no single user controls, and its participants collectively keep the ledger up to date, amended only according to strict rules + general consensus
  - Bitcoin's blockchain prevents double spending + keeps track of transactions continuously, thus making possible a currency without central bank
- Trust becomes a matter of coding…

\- The Trust Machine, The Economist, Oct. 31, 2015

\- The Great Chain of Being Sure About Things, The Economist, Oct. 31, 2015

Personal Case Study - General Motor Research Laboratories (GMRL)

- Role
  - As an undergraduate student in Computer Science
- Story
  - Took field trip to see GMRL's new Cray-1
  - They had got it because it was the trendy thing to do…
  - …but what exactly were they going to do with it?...it certainly did not help slow or stop their decline
  - …and we did not get to sit on it…

Personal Case Study - David C

- Role
  - Engineer at General Motors Research Labs
- Story

Personal Case Study - Sharan K

- Role
  - Engineer at Cray Research, Silicon Graphics, General Motors High Performance Computing, Intel, DataSwing
- Story
  - The times they are a changing…

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- What computational challenges have to be overcome by supercomputer designers in their quest for speed?
- What are the three phases supercomputers have gone through?
- What have been the killer apps for supercomputers?
- What is the largest supercomputer in the world today and how does it work?
- What is a virtual currency (i.e. Bitcoin), how is it created (hint: think supercomputing), what is it used for, in what ways is it a good thing and a bad thing?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
- Simulations

Conclusion

"When an elderly but distinguished scientist says something is possible, he's more than likely right; when he says something is impossible, he's almost certainly wrong"

- Arthur C. Clarke, author

Topic 15

Computers as Thinking Machines

Artificial Intelligence

Song

どうもありがとうミスターロボット (dōmo arigatō misutā Robotto)
また会う日まで (mata au hi made)
どうもありがとうミスターロボット (dōmo arigatō misutā Robotto)
秘密を知りたい (himitsu wo shiritai)

The lyrics translate into English as follows:

Thank you very much, Mr. Robot
Until the day (we) meet again
Thank you very much, Mr. Robot
I want to know your secret

- Styx, Mister Roboto

Thematic Quote

Date: Tue 20 Nov 84 17:36:43-PST

From: Richard Treitel <TREITEL@SUMEX-AIM.ARPA

Subject: quote {:-)

Attributed to Marvin Minsky (someone tell me if it's wrong)

"I'll bet the human brain is a kludge."

Date: Mon, 26 Nov 1984 03:27 EST

From: MINSKY%MIT-OZ@MIT-MC.ARPA

Subject: Re: Quote, V2 #161

I certainly have suggested that the human brain is a kludge, in the sense that it consists of many complex mechanisms, accumulated over the course of evolution, a lot of which are for correcting the bugs in others. However, this is not a useful quotation for public use, because outside of engineering, the word "kludge" is not in the general language. There isn't even any synonym for it. The closest phrase might have been "Rube Goldberg device" -- but that, too, is falling out of use. Anyway, a Rube Goldberg device did not have the right sense, because that cartoonist always drew machines which were complicated serial devices with no loops and, hence, no way to correct bugs. My impression is that a "kludge" is a device which actually usually works, but not in accord with neat principles but because all or most of its bugs have been fixed by adding ad hoc patches and accessories. By the way, the general language has no term for "bug" either. Programmers mean by "bug" the mechanism responsible for an error, rather than the surface error itself. The lack of any adequate such word suggests that our general culture does not consider this an important concept. It is no wonder, then, that our culture has so many bugs.

The Painting

Technological Breakthrough and Intelligent Reflections and Artificial Intelligence

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - ELIZA at www.chayden.net/eliza/Eliza.html
- Year
  - 1966
- Story

The Question

Thanks to advances in artificial intelligence and robotics, is a new species, Robo Sapiens, emerging?

Talos

From Wikimedia Commons

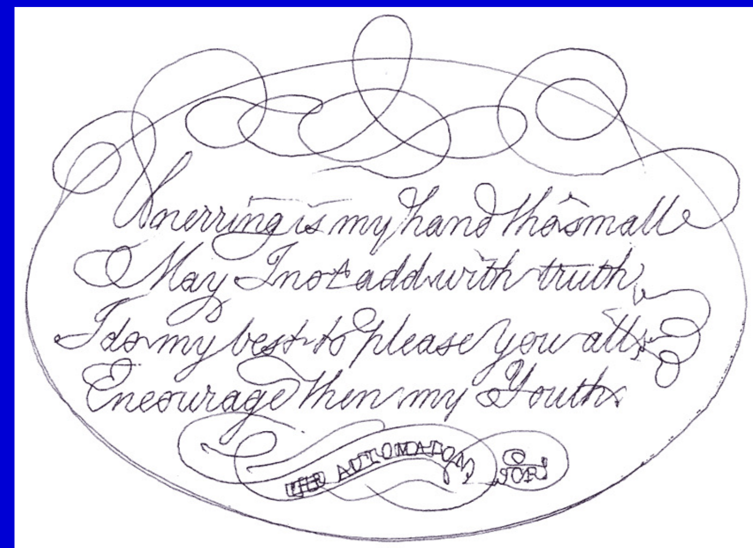
Thing / Hardware - Talos

- Firsts / Achievements / Uniqueness / Significance
  - First robot in human mythology
  - Sun God of Crete, given to King Minos of Crete to protect Crete + Europa from any invader
  - Defeated by Medea, travelling with Jason and the Argonauts, by persuading him to remove nails from ankles
- Place Produced (Company / Institution) ~ Year ~ Country
  - Mount Olympus ~ 4,000 BC ~ Ancient Greece
- People involved (Designer)
  - Zeus
- Type
  - Automaton
- Price / Cost
  - N/A
- Size
  - Giant

Thing / Hardware - Talos

- **Computing technology**
  - **Made of bronze ~ Single vein from neck to ankles carried his life-blood of liquid metal / ichor which was prevented from leaking out by a nail in ankles**
- **Computing speed (in MIPS)**
  - **N/A**
- **Primary memory type / technology ~ Size ~ Word length**
  - **N/A**
- **Secondary memory type / technology ~ Size**
  - **N/A**
- **Uses / Applications / Software**
  - **Travelled around Crete 3 times / day, threw rocks at enemy ships to sink them, if enemies landed on Crete would make his body hot and embraced his enemies + burned them**
  - **Also ensured divine laws were being followed on Crete**
- **Predecessors - N/A ~ Successors - N/A**

Maillardet's Draughtsman-Writer Automaton



Automaton (left) and Poem (right above) and Drawing (right below) created by Automaton

From Wikimedia Commons

Thing / Hardware - Maillardet's Draughtsman-Writer Automaton

- Firsts / Achievements / Uniqueness / Significance
  - Demonstrates man's efforts to imitate life by mechanical means
  - Largest memory of any known automaton
  - Inspiration for "The Invention of Hugo Cabret"
- Place Produced (Company / Institution) ~ Year ~ Country
  - London ~ 1800 ~ England
- People involved (Designer)
  - Henri Maillardet (trained with Pierre Jaquet-Droz)
  - May have been owned + demoed by Johann Maelzel who also demoed Mechanical Turk
- Type
  - Automaton is mechanical figure made of very complicated clockwork which can do amazing things
- Price / Cost
  - Text
- Size
  - Text

Thing / Hardware - Draughtsman-Writer Automaton

- Computing technology
  - Brass gears
- Computing speed (in MIPS)
  - N/A
- Primary memory type / technology ~ Size ~ Word length
  - Cams (brass disks) which serve as ROMS which are turned by clockwork motor, 3 steel fingers follow their irregular edges, fingers translate movement of cams into side to side + front and back + up and down movement's of doll's writing hand through complex system of levers + rods that produce markings on paper
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Can write 4 drawings + 3 poems
- Predecessors - N/A ~ Successors - N/A

Peacock Automaton

Thing / Hardware - Peacock Automaton

- Firsts / Achievements / Uniqueness / Significance
  - Demonstrates man's efforts to imitate life by mechanical means
- Place Produced (Company / Institution) ~ Year ~ Country
  - London ~ 1781 ~ England
- People involved (Designer)
  - James Cox assisted by Friedrich Jury
- Type
  - Automaton is mechanical figure made of very complicated clockwork which can do amazing things
- Price / Cost
  - 11,000 roubles
- Size
  - Life sized animals

Thing / Hardware - Peacock Automaton

- Computing technology
  - Brass gears
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - 3 sets of cams (brass disks) which serve as ROMS which are activated once an hour by the clock - first the owl moves, then the peacock moves, then the cockerel moves and then it crows
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Birds behave as if alive + sing
  - Serves as symbol of continuity of life -peacock represents cosmos + unity of appearance + disappearance of all that exists, owl is sign of night / quiet / wisdom, cockerel's crowing announces sunrise + is symbol of birth of light / life / resurrection
- Predecessors - N/A ~ Successors - N/A

Mechanical Turk

From Wikimedia Commons

Mechanical Turk

- Chess playing automaton, made by Wolfgang von Kempelen, for Hapsburg Archduchess Maria Theresa in 1770
  - Beat everyone, including Napoleon
  - Admired by Benjamin Franklin in 1783 and Charles Babbage in 1819, three years before he started Difference Engine
- No one could figure out how it worked
  - In 1857 it was revealed that there was a concealed operator inside
- By arriving in middle of Industrial Revolution, raised questions about possibility of creating machines that could think

  "Unlike the new machines of the Industrial revolution, which replaced human physical activity, this fragment of the Difference Engine, like the Turk, raised the possibility that machines might eventually be capable of replacing mental activity too."

- Tom Standage, The Turk: The Life and Times of the Famous Eighteenth-Century Chess-Playing Machine

Characteristics of Human Intelligence That Artificial Intelligence Tries to Model

- Perception
- Recognition
- Learning
- Speech
- Deduction

or

- Perception
- Cognition (planning and thinking)

or

- Seeing
- Understanding
- Planning

Three Phases of Artificial Intelligence

- 1960's + 1970's - General purpose systems that model characteristics of human intelligence
- 1980's - Expert systems - systems that could perform narrowly designed tasks with great expertise by following rules
- 1990's to today - Probability based systems to work in messy uncertain real world coupled with computers learning from their experience (machine learning)

Thing / Software - Eliza

- Firsts / Achievements / Uniqueness / Significance
  - First practical demonstration of Turing test
- Place Produced (Company / Institution) ~ Year ~ Country
  - MIT ~ 1964 ~ USA
- People involved (Programmer)
  - Joseph Weizenbaum
- Type
  - Psychoanalyst
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Text
- Computer language written in
  - SLIP list processing language
- Memory required
  - Text
- Predecessors - N/A ~ Successors - N/A

Rise and Fall of Expert Systems

- Expert systems definition - computer systems that can reason over knowledge
- Expert systems failed in 1980's because it was difficult to capture and maintain a mathematization of a domain
- The promise of Watson is that it can reason over unstructured information, in the form that humans are creating it in textbooks and articles in natural language
- If we have a computer that can reason over natural language it can scale and do useful things without a lot of work on our part
- Watson will never be as precise as an expert system - it won't have a chain of reasoning - it will deliver explanations in your words
- Why medical expert systems have not been widely adopted so far - primary reason is that they are very narrow and hard to keep up to date and don't show you the context for the rules - they don't let you judge the evidence, which is changing all the time
- We don't want to take judgment away from humans, we want to enable better judgment and provide the content that persuades them
- Prior expert systems are brittle and narrow and don't give you the kind of information you are comfortable with
- Watson is not rules based

- A Computer Called Watson - Presentation at the Computer History Museum on Nov 11, 2011 by David Ferrucci - starting at 42:30 minutes

Marvin Minsky

From Wikimedia Commons

Person - Marvin Minsky

- Significance
  - Co-founded MIT AI Laboratory ~ Champion of the hackers at MIT
  - Questioned everything, observations were quirky + innovative + made perfect sense

    "Eventually, I have come to know a lot of geniuses, but Marvin is the only genius I know who is so smart it's scary" - Patrick Henry Winston, AI researcher
- Profession
  - Professor of computer science
- Places worked
  - Massachusetts Institute of Technology
- Years of work
  - 1950's - 2016
- Things worked on
  - Artificial intelligence
  - Society of the Mind = human intelligence is derived from thousands of simple agents working together
  - Proteges - Danny Hillis, Ray Kurzweil, Ivan Sutherland

- Steven Levy, Marvin Minsky's Marvelous Meat Machine, Medium Backchannel, Jan. 26, 2016

Place - MIT AI Lab

- Significance
  - Pioneering lab for artificial intelligence research
- Location
  - Cambridge, Massachusetts
- Definition
  - Where people, theory, hardware, software came together to begin to build intelligent machines
- People who worked there
  - Marvin Minsky, John McCarthy, Richard Stallman
- Things created there
  - LISP computer language, LISP Machine, Stanford AI Lab (SAIL), Free GNU Software Foundation

Thing / Software - Deep Blue

- Firsts / Achievements / Uniqueness / Significance
  - First computer to win regulation chess match against a World Champion
- Place Produced (Company / Institution) ~ Year ~ Country
  - IBM ~ 1997 ~ USA
- People involved (Programmer)
  - Text
- Type
  - Chess computer
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Text
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - N/A ~ Successors - Watson

Watson

From Wikipedia

Thing / Software - Watson

- Firsts / Achievements / Uniqueness / Significance
  - First computer to win a general question answering game show (Jeopardy)
- Place Produced (Company / Institution) ~ Year ~ Country
  - IBM ~ 2011 ~ USA
- People involved (Programmer)
  - David Ferrucci
- Type
  - Answers questions asked in natural language
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Text
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - Deep Blue ~ Successors - N/A

From Search Engine to Question Answering System Through Artificial Intelligence

- Artificial Intelligence
  - Arises not through rules but through statistics
- Example question answering systems
  - Watson - IBM
    - Inspiration - computer on Star Trek
    - Interface - natural language processing
    - Approach - statistical computation - using hundreds of statistical algorithms simultaneously, then chooses best answer from amongst them
    - Hardware - very fast, lots of memory

- Clive Thompson, What is IBM's Watson? New York Times Magazine, June 20, 2010
- James Bamford, The New Thought Police, for PBS Nova Feb 3, 2009
- Steven Levy, The AI Revolution is On, Wired, Jan 2011

From Search Engine to Question Answering System Through Artificial Intelligence

- Example question answering systems
  - Aquaint (Advanced Question Answering for Intelligence) - NSA
    - Approach - inhale all public information on Internet along with all personal information on your phone calls, credit card receipts, social networking posts, GPS tracks, cell phone geolocation, Internet searches. library loan records, EZPass toll records
    - Goal - Use this information to know where people are, what they are doing, what they are thinking

      "We are building HAL" - Former NSA researcher
    - Part of the surveillance-industrial complex
      - Big Brother is beginning to watch everything you do

- Clive Thompson, What is IBM's Watson? New York Times Magazine, June 20, 2010
- James Bamford, The New Thought Police, for PBS Nova Feb 3, 2009
- Steven Levy, The AI Revolution is On, Wired, Jan 2011

From Search Engine to Question Answering System Through Artificial Intelligence

- Example question answering systems
  - WolframAlpha computational knowledge engine
    - For the rest of us…

- Clive Thompson, What is IBM's Watson? New York Times Magazine, June 20, 2010
- James Bamford, The New Thought Police, for PBS Nova Feb 3, 2009
- Steven Levy, The AI Revolution is On, Wired, Jan 2011

"People ask me if this is HAL. HAL's not the focus; the focus is on the computer on 'Star Trek,' where you have this intelligent information seeking dialogue, where you can ask follow-up questions and the computer can look at all the evidence and tries to ask follow-up questions. That's very cool."

"The computer on 'Star Trek' is a question-answering machine. It understands what you're asking and provides just the right chunk of response that you needed. When is the computer going to get to a point where the computer knows how to talk to you? That's my question."

"Wouldn't it be great to be able to communicate with the computer like Captain Picard or Captain Kirk does on "Star Trek," where you can fluently dialogue with an information-seeking computer that can understand what you're asking, ask follow up questions, and get exactly at the information that you need? That would be incredible. That's kind of this motivating vision, and whether Watson loses or not in this big game is really not the point. The point is we were able to take a step forward in that direction, and I think that's what we're most excited about."

- David Ferrucci, PhD, IBM, principal investigator DeepQA / Watson

What Does Artificial Intelligence Really Mean?

- Software we know how to write is very orderly
  - Most computer programs are organized like a well-run army, with layers of commanders, each layer passing instructions down to the next
- Software we want to write would be adaptable - for that, hierarchy of rules seems like wrong idea.

  "The entire effort of artificial intelligence is essentially a fight against computers' rigidity" - Douglas Hofstadter
- Expert systems foundered because of their brittleness as their approach was fundamentally broken
  - Machine translation - standard approach put linguists and translators together + try to convert their expertise into rules for program to follow - fails because no set of rules can ever wrangle a human language; language is too big and too variable; for every rule obeyed, a rule is broken.
- IBM in 1988 Candide machine translation project turned to machine learning
  - Used 2.2 million pairs of sentences from bilingual proceedings of Canadian parliamentary debates to learn English <-> French translation
- Machine learning is about data, data, data
  - Engineering is what counts in a world where translation is an exercise in data-mining at a massive scale.
- Machine learning is easy compared to real AI

  "We constantly underestimate - we did in the '50s about AI, and we're still doing it - what is really going on in the human brain." - David Ferrucci, IBM
- Why don't researchers study real AI

  "Really what I want to do is build computer systems that do something. And I don't think the short path to that is theories of cognition." - David Ferrucci, IBM

  "I thought he (Hofstadter) was tackling a really hard problem, and I guess I wanted to do an easier problem." - Peter Norvig, Google
- "We could draw this curve: as we gain more data, how much better does our (machine learning) system get? And the answer is, it's still improving-but we are getting to the point where we get less benefit than we did in the past. - Peter Norvig, Google

- James Somers, The Man Who Would Teach Machines to Think, The Atlantic, Nov. 2013

What Does Artificial Intelligence Really Mean?

- Early triumph for artificial intelligence in 1981 - Doug Lenat taught his AI program Eurisko to play the game Traveller and it won the national tournament for the game
  - Insight was that if computers were to reach true AI + tackle big problems on their own they need more than raw speed - they need common sense
- Lenat has spent 35 years building a "common sense engine" called Cyc - system to digitally codify all basic concepts humans take for granted using symbolic logic
  - Built by philosophers, 1 logical + mundane rule at a time, currently has 15 million rules
- Cyc's utility remains an enigma, but NSA has used it to help identify terrorist threats by monitoring communications traffic
- Is opposite of Google's approach of machine learning by using neural networks to seek patterns in vast amounts of digital data
  - …but Google is evolving in direction of Cyc with its Knowledge Graph project
- Final outcome may be machine learning + symbolic logic complement each other

"(Cyc's) way ahead of its time. We have to somehow get back to symbolic reasoning if we're ever going to have machines that can communicate with humans."

- Erik Mueller, computer scientist who helped create IBM's Watson

- Cade Metz, One Genius' Lonely Crusade to Teach a Computer Common Sense, Wired, Mar. 2016

Laws of Robotics

- Asimov's 3 Laws of Robotics to prevent robots from harming people in any circumstance
  - 1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
  - 2. A robot must obey orders given it by human beings except where such orders would conflict with the First Law.
  - 3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

Shakey

Thing / Hardware - Shakey

- Firsts / Achievements / Uniqueness / Significance
  - First machine to pursue AI technologies such as planning, navigation, machine vision, speech recognition
  - Utilized advances in computer vision, language processing, planning and learning to understand instructions + direct its actions
- Place Produced (Company / Institution) ~ Year ~ Country
  - SRI International ~ 1969 ~ USA
- People involved (Designer)
  - Charles Rosen
- Type
  - Mobile robot with cameras + touch sensors to see + sense + respond to its environment, controlled by remote computer
- Price / Cost
  - $750,000
- Size
  - Text

Thing / Hardware - Shakey

- Computing technology
  - Shakey's sensors included television camera, laser ranger, bump sensor
  - Sensor information collected + transmitted wirelessly to DEC PDP-10 and PDP-15 computers which processed information + radioed back commands that told Shakey where to move
  - Moving Shakey 1 meter using this system took approximately 30 minutes
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Equipped with sensing devices, and driven by problem-solving software called STRIPS, Shakey was able to find out information about its environment and use it to plan and follow a route
  - Perform reconnaissance missions that would normally require human intelligence
- Predecessors - N/A ~ Successors - DARPA Robotics Challenge

ASIMO

Thing / Hardware - Advanced Step in Innovative Mobility (ASIMO)

- Firsts / Achievements / Uniqueness / Significance
  - Designed to operate in real-world environments
  - Can kick a football, walk up and down stairs, run at ~ 4 miles per hour
  - Has vision and hearing
- Place Produced (Company / Institution) ~ Year ~ Country
  - Honda ~ 2000 ~ Japan
- People involved (Designer)
  - Text
- Type
  - Robot
- Price / Cost
  - Text
- Size
  - 4 feet 3 inches tall, weighs 119 pounds

Thing / Hardware - Advanced Step in Innovative Mobility (ASIMO)

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Multifunctional mobile assistant designed to help those who lack full mobility to improve their quality of life
- Predecessors - Honda E-series and P-series robots ~ Successors - N/A

Human-Robot Interaction (HRI)

- A spin-off of Human-Computer Interaction
- Studies factors that make robots work well with humans + how humans view their robotic counterparts
- Discoveries
  - Robot's behavior can have bigger impact on its relationship with humans than its design
  - Many of the rules that govern human relationships apply equally well to human-robot relations
  - People will read emotions + motivations into a robot's behavior that far exceed the robot's capabilities
  - …by employing these lessons as we build robots we can blur the line between tools and beings…

- Maggie Koerth-Baker, How Robots Can Trick You Into Loving Them, New York Times Magazine, Sept 22, 2013

Personal Case Study - ASIMO

- Role
  - Honda's robot
- Story
  - Tried to meet ASIMO in Akihibara, Tokyo, Japan - but "ASIMO is not home" in 2008
  - Finally met him in Osh Kosh, Wisconsin in 2013

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- Is an automaton artificially intelligent?
- Is the goal of computing in general, or artificial intelligence in specific to create a) a mechanical replacement for a human being or b) a tool that works in symbiosis with humans as an extension of human mental facilities?
- What are the computational challenges facing researchers in artificial intelligence?
- What are the three phases that artificial intelligence has gone through?
- What are Asimov's Laws of Robotics and how hard will they be to implement?
- Could you ever love - or at least develop affection for - a robot?
- What robot impresses you the most - and why?
- Do you agree or disagree with Ken Jenning's statement - "I for one welcome our new computer overlords"
- Should we continue down the path of building what may become our successors?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
  - 2001: A Space Odyssey
- Simulations

"Thinking is a matter of degree. I think you say something thinks when you don't know how it works. And the more you understand and make these programs, the better they get at learning and figuring things out. But there isn't any point at which they think. That is just a sort of social word for a certain quality of performance. It's not clear that people think too."

- Marvin Minsky, professor

Conclusion

"Couple years ago I wrote that new Turing Test is social bots you can't tell aren't human. Seems to be happening."

- Steven Levy, journalist, via Twitter in 2013

Conclusion

"As soon as it works, no one calls it AI anymore"

- John McCarthy, computer scientist

Topic 16

Computers for Communicating

Social Networking

Song

Slide text

Thematic Quote

"A computer is a communications device first, second, and third"

- Alan Kay, computer scientist

Thematic Quote

"The Net interprets censorship as damage and routes around it"

- John Gilmore, computer scientist

The Painting

Extraterrestrial Contact

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - Hayes 1200 baud Smartmodem
- Year
  - 1982
- Story

- Name
  - AOL floppy disk
- Year
  - Early 1990's
- Story

The Question

Is access to the Internet a human right?

Future of Social Media: A Historical Perspective - 1

- Romans
  - Passed info to their social network by sharing personal letters, speeches, and books with recommendations + comments
  - Scribes were an enabling infrastructure - if you thought info was important you had your scribe make personal copy for you - way to increase bandwidth was get faster scribe
  - Posted graffiti on walls of each others houses
- Christians
  - Early adopters to social media, helped fuel rise of Christianity
  - St. Paul's open letters (epistles) used to organize + spread Christianity and are still being reposted 2000 years later

- Tom Standage at Drupalcon 2011

Future of Social Media: A Historical Perspective - 2

- Martin Luther
  - Was prototypical blogger, published pamphlets commenting on sorry state of Catholic Church selling indulgences, responding to every post about him
  - Catholic Church's quandry (same quandry corporations have today) was do we dignify him by responding or do we ignore him?
  - You can track his traffic stats
  - He used social media to successfully take on biggest authority in his day - Catholic Church
- Governments realized power of publishing / social media from Luther, regulated trade of printing
  - But English Civil War leads to chaos and anyone could print - and did - Roundheads vs. Cavaliers
  - Then we see rise of coffee houses which leads to rise of (amongst other things) scientific revolution, scientific journals and the first open source movement

- Tom Standage at Drupalcon 2011

Future of Social Media: A Historical Perspective - 3

- Idea of Freedom of Speech and Expression
  - Allows people to figure things out themselves
  - Born in England, spreads like wildfire to U.S. and helps fuel American Revolution through publication of Tom Paine's Common Sense which was distributed via social connections
- Conclusion
  - Past is filled with examples of social distribution of media where info was passed <u>horizontally</u> between people through copying, sharing, recommending, and commenting
  - Invention of steam printing press and the penny paper (New York Sun in 1833) leads to rise of mass media + professional journalists which aggregates an audience and delivers it to advertisers - info is now passed <u>vertically</u> from central source to people
  - Rise of Web 2.0 / social media is taking us back to our past

- Tom Standage at Drupalcon 2011

Ben Franklin
Social Media Pioneer At All Levels

- Created content (1722)
  - Wrote pseudonymous Letters to the Editor of the New England Courant newspaper
    - Newspapers were social media of this time
- Launched platform (1729)
  - Publisher of Pennsylvania Gazette newspaper
- Refined infrastructure (1753)
  - Deputy Postmaster General for American colonies
    - Increased mail route frequency + allowed free exchange of newspapers within + between colonies

- Tom Standage, Benjamin Franklin, Social Media Pioneer, Medium, Dec. 10, 2013

Writing on the Wall
In a Nutshell…

- Social media = media you get from other people
- Social media environments have existed for millennia + do not require digital technology to operate
- Social media environments in past were decentralized + created community as people passed information to others by copying it / recommending it / commenting on it
  - People passed on what they thought was important + this was form of self-expression
  - This is true from Roman times to 18th century newspapers whose readers formed a community for discussion + debate
- Centralized media emerges in 19th century with mass-circulation newspapers printed by steam printing presses which were filled with articles written by reporters and thus readers became a market for ads
- Today's social media environments represent a return to the ways things used to be
- Social media has always been criticized
  - Coffee houses in late 1600's, where people went to read + discuss latest news, were criticized as time wasters - but turned out to spawn advances in science + commerce

- Tom Standage: LibraryThing Author Interview, LibraryThing, Oct. 2013

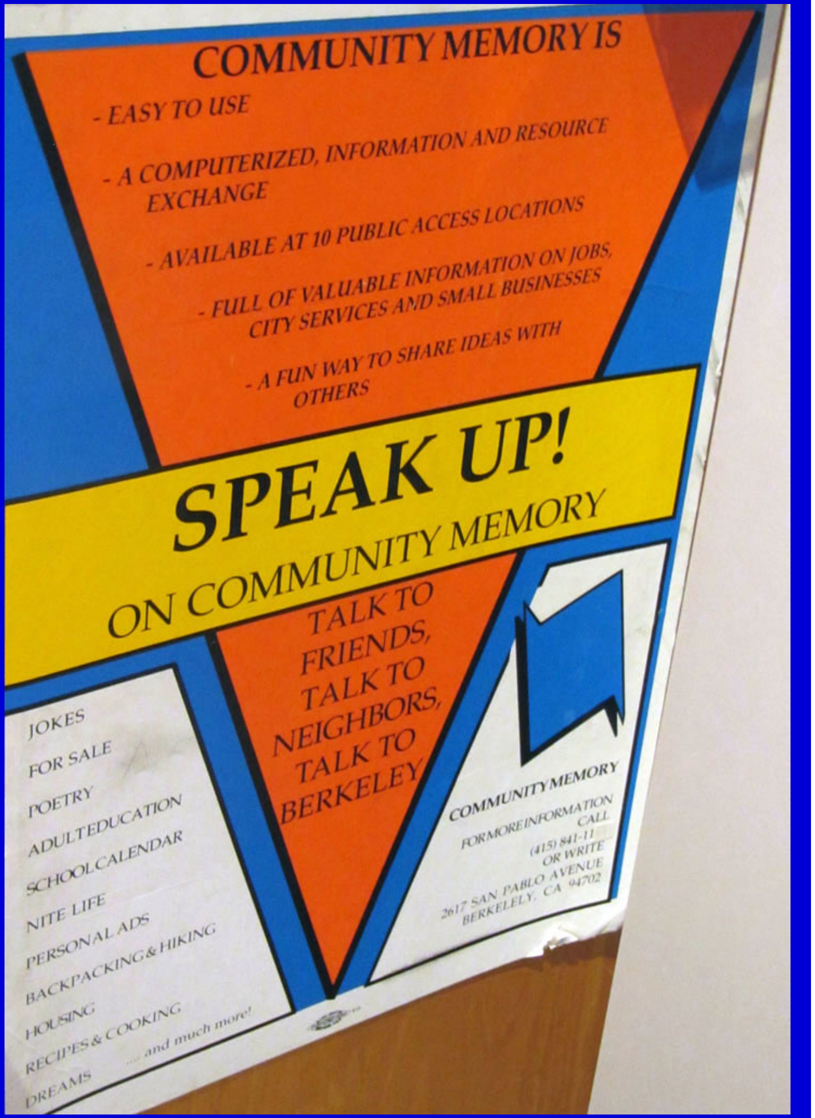
Coffee House

Coffee Fueled the Information Exchanges of the 17th and 18th Centuries

- **Coffee houses sprang up around Europe ~ 1650**
- **Functioned as information exchanges**
  - **Lively and often unreliable sources of information**
  - **Were centers of scientific education, literary and philosophical speculation, commercial innovation, political fermentation**
  - **Were specialized by interests ~ Provided a forum for education, debate, self-improvement - "penny universities"**
- **Collectively formed the Internet of the Enlightenment era**

- Tom Standage, The Internet in a Cup, The Economist, Dec 18, 2003

Community Memory



Place - Community Memory

- Significance
  - First computer social network in 1973
  - Offered bulletin boards, messages, classified ads
- Location
  - Berkeley, California
- Definition
  - Was bulletin board system with terminals connecting to mainframe
- Networking speed
  - 110 bits per second
- People who worked there
  - Efrem Lipkin (software), Mark Szpakowski (user interface), and Lee Felsenstein (hardware)
- Things created there
  - Proof that computer could serve as a general communications medium

Place - Bulletin Board System (BBS)

- Significance
  - Served as introduction for early adopters to cyberspace
- Location
  - Local to you
- Definition
  - Accessed via free local phone call, free to use
  - Services - chat with sysop, discussions, software downloads, email
  - Loosely interlinked national / international footprint (FidoNet)
    - Store + forward messages at night when long distance rates were low
  - Not on Internet - were pre-Internet
  - For non academics
- Networking speed
  - 300 - 1,200 bits per second
- People who worked there
  - Tom Jennings (FidoNet)
- Things created there
  - Beginnings of software piracy

Place - Walled Gardens

- Significance
  - Served as introduction for most to cyberspace
- Location
  - National
- Definition
  - Charged monthly fee or hourly fee
  - Services - chat, discussions, software downloads, email, news, dating, online games
  - Not on Internet at their beginning
  - For non academics
- Networking speed
  - 300 - 56,000 bits per second
- People who worked there
  - Steve Case - AOL
- Things created there
  - America On Line (AOL), BIX, Compuserve, eWorld, GENIE, Prodigy, Source

Thing / Software - Confer II

- **Firsts / Achievements / Uniqueness / Significance**
  - **Advanced + influential computer conferencing / social networking software**
  - **Each conference composed of a number of items, the responses to each item were organized chronologically, every time you re-entered a conference you were shown all the new items and responses since your last visit so it was easy to keep up on discussions**
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - **Advertel Communication Systems**
- **People involved (Programmer)**
  - **Bob Parnes**
- **Type**
  - **Computer conferencing / social networking that was text oriented + command driven**
- **Price / Cost**
  - **Hourly fee for use**
- **Computer and operating system it runs on**
  - **IBM System 370 mainframe + Michigan Terminal System (MTS) connected to Merit Network and later Telenet giving it world-wide access**
- **Computer language written in**
  - **FORTRAN**
- **Memory required**
  - **Text**
- **Predecessors - EIES ~ Successors - WELL-style systems: Caucus, PicoSpan**

Place - The Whole Earth Lectronic Link (WELL)

- Significance
  - Well known virtual community
  - More of a social experiment than business proposition
  - No anonymity ~ You own your own words
  - Insanely time-consuming and hard to manage / moderate the community
  - Demonstrated importance of linking physical meetings to virtual meetings
- Location
  - First local to San Francisco Bay, then national via Internet, never more than several thousand members
- Definition
  - Defined for many the potential of online communication
- Networking speed
  - 300 - 56,000 bits per second
  - Initially in 1985 run on a VAX minicomputer using Picospan software
- People who worked there
  - Stewart Brand
- Things created there
  - A true online Salon

- Katie Hafner, The WELL: A Story of Love, Death and Real Life in the Seminal Online Community

Place - Facebook

- Significance
  - Latest walled garden (you must be on it to use it) - biggest ever
  - Largest current example of Social Web with > 1 billion daily active users in June 2016
- Location
  - Harvard University ~ 2004 ~ USA
- Definition
  - Entices you to tell it everything about you - your interests, likes, friends - and then it monetizes you to advertisers
- People who worked there
  - Mark Zuckerberg
- Things created there
  - Social graph - "the global mapping of everybody and how they're related" - Facebook

Mark Zuckerberg

From Wikimedia Commons

Person - Mark Zuckerberg

- Significance
  - Founder of first commercially successful social network
- Profession
  - Computer programmer
- Places worked
  - Facebook
- Years of work
  - 2004 - present
- Things worked on
  - Facebook

Computing Case Study Summary - Social Networking From Battlefield to Home Front

- Goal
  - Stay in touch with friends + family while deployed
- Center of Gravity (Strategy)
  - Use Facebook
- Technology / Equipment
  - PC with high speed Internet connection
- Training / Leadership / Morale
  - Raised morale for all involved
- Tactics
  - Daily wall posts of activities and photo uploads of patients treated + procedure performed / living quarters / area of operations
- Intangibles / Mistakes
  - How does this affect operational security?
  - Is there any reason to write letters home anymore?
- Outcome
  - A Special Forces medic in the Kurdish area of Iraq in 2008-09 stayed in close touch with family, fiancée and friends on daily basis

The Corruption of Social Media

- What you want:
  - A social media platform that does not pick winners
  - You read what you are subscribed to, in the order it was sent
    - (Think Really Simple Syndication (RSS))
- What you get
  - A social media platform that does pick winners through an algorithm that shows the "best" results
  - You read what the social media platform wants you to read
  - You can't see the algorithm
  - You can't trust the algorithm because once there is an algorithm, there is somebody willing to pay money to skew the algorithm + this is how social media platforms makes money

The Ultimate Social Network?

- Philosophies
  - All that happens must be known
  - Passion, participation, transparency
  - Secrets are lies
  - Sharing is caring
  - Privacy is theft
- Result

  "Once it's mandatory to have an account, and once all government services are channeled through the Circle, you'll have helped create the world's first tyrannical monopoly. Does it seem like a good idea to you that a private company would control the flow of all information? That participation, at their beck and call, is mandatory?"

  - Kalden / Ty to Mae p. 401 in The Circle by Dave Eggers

The Dark Side of Social Media

"Evan Williams is the guy who opened up Pandora's box. Until he came along, people had few places to go with their overflowing emotions and wild opinions, other than writing a letter to the newspaper or haranguing the neighbors.

Mr. Williams...set everyone free, providing tools to address the world. In the history of communications technology, it was a development with echoes of Gutenberg.

And so here we are in 2017. How's it going, Mr. Williams?"

"I think the Internet is broken...I thought once everybody could speak freely and exchange information and ideas, the world is automatically going to be a better place. I was wrong about that." - Evan Williams, co-creator of Blogger, Twitter founder, Medium founder

- David Streitfeld, The Internet is Broken: @ev is Trying to Salvage It, New York Times, May 20, 2017

Business Model of Google + Facebook

- Wrong
  - Customer - You
  - Product - Search, email, social networking, etc.
  - Cost - free
- Right
  - Customer - Advertisers
  - Product - You and all your personal information
  - Cost - Very high to advertisers, very high to you for giving up your privacy

- Google + Facebook, et.al. are not altruistic public services - they are advertising companies
  - Their users are not customers - they are the product - you hand them all your data for free, in exchange you use their services for free, they monetize your data

"If the service is free, then you are the product"

"If you are not paying, then you are the product"

- Anonymous Silicon Valley truism

From Open to Closed

- The history of the great communication technologies of 20th Century - telephone, movies, radio, television - shows them all undergoing the same recurring cycle in their evolution
- Each technology started out as open, creative, chaotic + diverse
  - This lead to utopian visions of future; but all wound up being captured by industrial interests

    - Tim Wu, The Master Switch: The Rise and Fall of Information Empires

- Tom Naughton, Tim Wu: The Internet is Like the Classic Story of the Party That Went Sour, The Guardian, Jan. 8, 2017

History of the Attention Industry

Businesses That Harness Our Attention to Sell to Advertisers

"In an information-rich world, the wealth of information means a dearth of something else: a scarcity of whatever it is that information consumes. What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention and a need to allocate that attention efficiently among the overabundance of information sources that might consume it."

- Herbert Simon, computer scientist + economist

- Attention merchant business model modus operandi: Draw attention with free stuff + resell it

  "The ideal is to get right up to the creepy line and not cross it." - Eric Schmidt, Google CEO

- Examples
  - 1833 - New York Sun newspaper by Benjamin Day - sensational content + low price
  - 1860 - Paris billboard ads by Jules Cheret - Posters of scantily-clad females cavorting over product
  - 1930's - 1990's - Broadcast media
  - 2000's -> present - Internet - Google, Facebook, etc.
- Humans often rebel against the attention merchants (think ad-blockers today), leading to some regulatory intervention, but usually are eventually brought back to heel by the industry

  - Tim Wu, The Attention Merchants

- Tom Naughton, Time Wu: The Internet is Like the Classic Story of the Party That Went Sour, The Guardian, Jan. 8, 2017

"To some students of modern technological history, the Internet's fall from grace follows an inevitable historical script. As Tim Wu argued in his 2010 book, 'The Master Switch,' all the major information technologies of the 20th century adhered to a similar developmental pattern, starting out as the playthings of hobbyists and researchers motivated by curiosity and community, and ending up in the hands of multinational corporations fixated on maximizing shareholder value. Wu calls this pattern the Cycle, and on the surface at least, the Internet has followed the Cycle with convincing fidelity. The Internet began as a hodgepodge of government-funded academic research projects and side-hustle hobbies. But 20 years after the Web first crested into the popular imagination, it has produced in Google, Facebook and Amazon - and indirectly, Apple - what may well be the most powerful and valuable corporations in the history of capitalism."

- Steven Johnson, Beyond the Bitcoin Bubble, New York Times Magazine, Jan. 16, 2018

The Fate of the Web?

"The story of industrial revolutions, after all, is a story of battles over control. A technology is invented, it spreads, a thousand flowers bloom, and then someone finds a way to own it, locking out others. It happens every time.

…

Indeed, there has hardly ever been a fortune created without a monopoly of some sort, or at least an oligopoly. This is the natural path of industrialization: invention, propagation, adoption, control.

…

As Jonathan L. Zittrain puts it in The Future of the Internet - And How to Stop It, "It is a mistake to think of the Web browser as the apex of the PC's evolution." Today the Internet hosts countless closed gardens; in a sense, the Web is an exception, not the rule."

- Chris Anderson and Michael Wolff, The Web is Dead. Long Live the Internet. Wired, August 2010

Surveillance Capitalism

"Surveillance is the business model of the Internet. We build systems that spy on people in exchange for services. Corporations call it marketing."

"I like to think of this as a feudal model. At a most fundamental model, we are tenant farming for companies like Google. We are on their land producing data."

"The NSA woke up and said 'Corporations are spying on the Internet, let's get ourselves a copy.'"

"Fundamentally we have reached the golden age of surveillance because we are all being surveilled ubiquitously."

"I think this is the issue (ignoring privacy + security in favor of rapid innovation) by which we will be judged when our grandchildren read the history of the early days of the Internet."

- Bruce Schneier, security expert

- Fahmida Rashid, Surveillance is the Business Model of the Internet, Security Week, Apr. 9, 2014

TANSTAAFL

- TANSTAAFApp
- (There Ain't No Such Thing As A Free App)

"Huge wads of money are being made by tech entrepreneurs and investors off users' unpaid labor, the results of which are sold to advertisers or used to attract other users. Our search behavior, book reviews and mortgage applications have become fodder for a small elite in charge of "Siren Servers," systems that know far more than ordinary people do, creating an oppressive information inequality. (As in myth, these Sirens are irresistible but ultimately pernicious.)"

- Steven Levy, An Economy of Microserfs, Wall Street Journal, May 30, 2013

"One of the most remarkable branding tricks of the 21st century has been the way that Silicon Valley has managed to persuade us that they're not like other companies. I mean, when you think about banks, or big pharma, oil, you imagine them as driven only by profit. And yet Silicon Valley, we imagine, is different. They are puffed up with social purpose to improve the world, that they're the good guys."

- Jamie Bartlett, Secrets of Silicon Valley

Google is "in the extraction industry." Its business model is "to extract as much personal data from as many people in the world at the lowest possible price and to resell that data to as many companies as possible at the highest possible price."

- Jonathan Taplin, Move Fast and Break Things: How Facebook, Google, and Amazon Cornered Culture and Undermined Democracy

"I hope this book doesn't come across as fueled by anger, but I don't want to deny my anger either. The tech companies are destroying something precious. . . . They have eroded the integrity of institutions-media, publishing-that supply the intellectual material that provokes thought and guides democracy. Their most precious asset is our most precious asset, our attention, and they have abused it."

- Franklin Foer, World Without Mind: The Existential Threat of Big Tech

- Elizabeth Kolbert, Who Owns the Internet? The New Yorker, Aug. 28, 2017

"(Tristan) Harris (executive director of the Center for Humane Technology) believes that, just as the environmental crisis was wrought by extractive energy companies, so has an attentional crisis been wrought by extractive technology companies."

- Andrew Marantz, Silicon Valley's Crisis of Conscience, New Yorker, Aug. 26, 2019

What Hath God Wraught?

"The thought process that went into building these applications, Facebook being the first of them, was all about: 'How do we consume as much of your time and conscious attention as possible? That means that we need to sort of give you a little dopamine hit every once in a while, because someone liked or commented on a photo or a post or whatever. And that's going to get you to contribute more content, and that's going to get you... more likes and comments."

"When Facebook was getting going, I had these people who would come up to me and they would say, 'I'm not on social media.' And I would say, 'OK. You know, you will be. I don't know if I really understood the consequences of what I was saying, because [of] the unintended consequences of a network when it grows to a billion or two billion people and, it literally changes your relationship with society, with each other. It probably interferes with productivity in weird ways. God only knows what it's doing to our children's brains."

As for his own habits, Mr Parker said he no longer used social media as it was "too much of a time sink".

- Sean Parker, Facebook's founding president

What Hath God Wraught?

"We have created tools that are ripping apart the social fabric of how society works."

He advised people take a "hard break" from social media, describing its effect as "short-term, dopamine-driven feedback loops."

"We curate our lives around this perceived sense of perfection, because we get rewarded in these short term signals: Hearts, likes, thumbs up. We conflate that with value and we conflate it with truth, and instead what it really is is fake, brittle popularity that's short term and leaves you even more vacant and empty before you did it. You don't realise it but you are being programmed.

- Chamath Palihapitiya, who worked as Facebook's vice president for user growth

The View From Zuck

""When I asked him about the company's errors, he was candid about his personal failings. Maybe it was a mistake to distance himself from the policy issues that would cause Facebook so much trouble. Maybe in his competitive zeal to crush Twitter, he made the News Feed too susceptible to viral garbage. Maybe he didn't pay enough attention to the things in Sandberg's domain. The split of their duties made sense originally, as he sees it, but now he is determined to devote more energy to things like content moderation and policy.

But a worse sin, he believes, would have been timidity.

"I just think I take more chances, and that means I get more things wrong," he told me. "So in retrospect, yeah, we have certainly made a bunch of mistakes in strategy, in execution. If you're not making mistakes, you're probably not living up to your potential, right? That's how you grow."

...He conceded that some of those mistakes have had terrible consequences but insisted that you had to look beyond the present. "Some of the bad stuff is very bad, and people are understandably very upset about it-if you have nations trying to interfere in elections, if you have the Burmese military trying to spread hate to aid their genocide, how can this be a positive thing? But just as in the previous industrial revolution or other major changes in society that were very disruptive, it's difficult to internalize that, as painful as some of these things are, the positive over the long term can still dramatically outweigh the negative. You handle the negative as well as you can.

He added: "Through this whole thing I haven't lost faith in that. I believe we are one part of the internet that's part of a broader arc of history. But we do definitely have a responsibility to make sure we address these negative uses that we probably didn't focus on enough until recently."

He still believes that Facebook is doing good. "I couldn't run this company and not do things that I thought were going to help push the world forward," says the man who some think has done as much destruction to that world as anyone in business. Facebook may have to change, but Zuckerberg thinks it's on the right path.""

- Steve Levy, Inside Mark Zuckerberg's Lost Notebook, Wired, March 2020

And We Are All Paying the Price

"Here's how I see it: Facebook, as well as Twitter and Google's YouTube, have become the digital arms dealers of the modern age.

All these companies began with a gauzy credo to change the world. But they have done that in ways they did not imagine - by weaponizing pretty much everything that could be weaponized. They have mutated human communication, so that connecting people has too often become about pitting them against one another, and turbocharged that discord to an unprecedented and damaging volume.

They have weaponized social media. They have weaponized the First Amendment. They have weaponized civic discourse. And they have weaponized, most of all, politics.

Which is why malevolent actors continue to game the platforms and why there's still no real solution in sight anytime soon, because they were built to work exactly this way. And ever since, they have grown like some very pernicious kudzu and overtaken their inventors' best efforts at control. Simply put, the inventors became overwhelmed by their own creations, which led to what I can only describe as a casual negligence, which led to where we are now."

Kara Swisher, The Expensive Education of Mark Zuckerberg and Silicon Valley, New York Times, Aug 2, 2018

What Hath God Wraught?

"I think about that (the movie 'The Jerk') and when the kids are looking at the digital screen and different pictures are coming up and there's grandpa - me - am I going to be hated by them for what we created? Or are we going to be like Alexander Graham Bell?"

- Tony Fadell, iPhone hardware team

"And, yeah, by the way, Microsoft, Apple, Cisco, Google et al, they are all the blood brothers of Huawei in China - because they are intelligence assets posing as commercial operations. They are surveillance marketers. They give you free stuff in order to spy on you and pass that info along the value chain. Personal computers can have users, but social media has livestock…

Computers were invented as crypto-ware and spy-ware and control-ware. That's what Alan Turing was all about. That's where computing came from, that's the scene's original sin, and also its poisoned apple."

- Bruce Sterling, The Ecuadorian Library

"We fear we are slowly moving toward the era of universal mind monitoring without having recognized and considered it in those terms. And those are the terms in which we should understand battles about the right to use effective cryptography. That wonderful gadget in your pocket is not a phone. It is a prosthetic part of your mind-which happens to also be able to make telephone calls. We need to think of it as such, and ask again which parts of our thoughts should be categorically shielded against prying by the state."

- Andrew Conway and Peter Eckersley, When Does Law Enforcement's Demand to Read Your Data Become a Demand to Read Your Mind?, Communications of the ACM, Sept. 2017

"There's no question China has been trying to crackdown on the Internet. Good luck! That's sort of like trying to nail Jell-O to the wall."

- President Bill Clinton, 2000

"China has the world's biggest nail gun"

- Jason Ng, Chinese Internet Scholar, 2012

Five Myths About The Chinese Internet

- 1. Censorship means the Chinese are left in the dark
  - "Nope...for the most part, Chinese Internet users are cosmopolitan, educated, and informed. Many use, or at least know they can use, circumvention technology like VPNs (Virtual Private Networks) to access blocked content"
- 2. It's the government that censors.
  - "This is true -- to a point. The government maintains the Great Firewall and hires Internet police as well as wumaodang, or "50-cent party members" -- people paid to influence Internet discussion by writing social media posts extolling the government's position on issues...But beyond this, the government has roped private companies into carrying out most of their own censoring."
- 3. No one is allowed to criticize the government.
  - "False...censorship was focused on what the study calls posts with "high collective action potential" -- that is, posts that "represent, reinforce, or spur social mobilization, regardless of content.""
- 4. Internet censorship is carried out in a blanket fashion.
  - "Unlikely...the censorship employs a variety of different methods. These include connection resetting (which returns an error message that usually occurs when a site is down or has moved to a different address); redirection to China (typing in Skype.com from within China will take you to Skype.tom.com, its local partner which is subject to Chinese regulations); DNS poisoning (wherein the Internet service provider changes the DNS record of the blocked site, taking one to a dummy web server hosting a block page, which could contain malware); throttling (severely slowing down a site in lieu of blocking it outright, often done to Gmail in China); and timing out (when the site tries to load for so long that the browser gives up; indistinguishable from a genuine technical problem)."
- 5. The Internet will lead to democracy.
  - "Dream on...the Internet is not enough in the absence of the right political, social, and economic factors."

    - Eveline Chao, Five Myths About the Chinese Internet, Foreign Policy, November 20, 2012

China and the Internet Today

"The Chinese government has spent a huge amount of effort on making sure that its internet is different, not just that freedom of expression is limited but also that the industry that is built around it serves national goals as well as commercial ones"

"The party has achieved something that few had thought possible: the construction of a distinct national internet. The Chinese internet resembles a fenced-off playground with paternalistic guards. Like the internet that much of the rest of the world enjoys, it is messy and unruly, offering diversions such as games, shopping and much more. Allowing a distinctly Chinese internet to flourish has been an important part of building a better cage. But it is constantly watched over and manipulated."

"Central-government ministries have invested in two pillars of control: the Great Firewall, a Western name for a system of blocking foreign websites, starting in the late 1990s, which some believe has cost as much as $160 million; and Golden Shield for domestic surveillance and filtering, begun in 1998 by the Ministry of Public Security and estimated to have cost more than $1.6 billion so far."

"The party applies the same strict rules online as it has done on the ground since the Tiananmen Square crackdown of 1989: do not jeopardize social stability, do not organize and do not threaten the party."

- Special Report: China and the Internet, The Economist, April 6, 2013

Behind the Great Firewall of China (Golden Shield)

- Prevents information harmful to Communist party from entering China
  - Allows China to have economy connected to outside world but its political culture is closed off from Western values of free speech + democracy
- China wants to make its vision of "Internet Sovereignty" a model for world
  - Strikes correct balance between "freedom and order" + between "openness and autonomy" = "cyber-governance with Chinese characteristics"
- Internet is thriving in China
  - 25% of world's online population is behind Golden Shield
  - China is world leader in e-commerce, accounting for 40% of global total
  - 4 of top 10 Internet companies in world ranked by market capitalization are Chinese

- Simon Denyer, China's Scary Lesson to the World: Censoring the Internet Works, Washington Post, May 23, 2016

Behind the Great Firewall

- Golden Shield is giant mechanism of censorship + surveillance blocking tens of thousands of Web sites deemed hostile to Communist Party including Facebook, YouTube, Twitter, Instagram, Google
  - Chinese search engine Baidu has its results heavily censored
- Screws on virtual private networks (VPNs) that tunnel under the Golden Shield are being tightened
  - VPNs essential for businesses to do business

"China has achieved this (keeping out harmful ideas while not damaging its global connectivity). It can communicate with the outside world, meanwhile Western opinion cannot easily penetrate as ideological tools." - Chinese state owned Global Times Newspaper

"The Internet is as much a tool for control, surveillance and commercial considerations as it is for empowerment." - Roger Creemers, law professor

- Simon Denyer, China's Scary Lesson to the World: Censoring the Internet Works, Washington Post, May 23, 2016

The Great Firewall Advances

"The People's Republic of China is the largest, most powerful and arguably most brutal totalitarian state in the world. It denies basic human rights to all of its nearly 1.4 billion citizens. There is no freedom of speech, thought, assembly, religion, movement or any semblance of political liberty in China. Under Xi Jinping, "president for life," the Communist Party of China has built the most technologically sophisticated repression machine the world has ever seen. In Xinjiang, in Western China, the government is using technology to mount a cultural genocide against the Muslim Uighur minority that is even more total than the one it carried out in Tibet. Human rights experts say that more than a million people are being held in detention camps in Xinjiang, two million more are in forced "re-education," and everyone else is invasively surveilled via ubiquitous cameras, artificial intelligence and other high-tech means.

None of this is a secret. Under Xi, China has grown markedly more Orwellian; not only is it stamping its heel more firmly on its own citizens, but it is also exporting its digital shackles to authoritarians the world over. Yet unlike the way we once talked about pariah nations - say East Germany or North Korea or apartheid South Africa - American and European lawmakers, Western media and the world's largest corporations rarely treat China as what it plainly is: a growing and existential threat to human freedom across the world."

- Farhad Manjoo, Dealing With China Isn't Worth the Moral Cost, New York Times, Oct. 9, 2019

Communications Case Study Summary - Arab Spring 2011

- Goal
  - Overcome misgovernance + pervasive sense of humiliation in Muslim world
  - Freedom, upward mobility, and a future for their young
- Center of Gravity (Strategy)
  - Give Muslim world competent, accountable, democratic government that will over time give them the future they desire
- Technology / Equipment
  - Web 2.0 Weapons of Mass Collaboration to organize + communicate - Facebook, Twitter, YouTube, Text messages

Communications Case Study Summary - Arab Spring 2011

- Training
  - None
- Leadership
  - Smart Mobs ~ Bottom up
- Morale
  - Becoming progressively emboldened
- Tactics
  - Civil disobedience
  - Al Jazeera inspired people toward democracy - stopped focusing on the problems, started focusing on the solutions - convinced the people that they are the solution

Communications Case Study Summary - Arab Spring 2011

- Intangibles
  - Now comes the hard part once you win - see the movie *The Candidate* - "What do we do now?"
- Mistakes
  - Can't the U.S. realize this is what victory looks like in the Long War?
- Outcome

  The Arab world today, is now "a collection of failed states who add nothing to humanity or science" because "people were taught not to think or to act, and were consistently given an inferior education. That will change with democracy."

  - Mohamed ElBaradei, Egyptian Nobel laureate

Personal Case Study - BBS's / Hacking / GM Paint Computer

- Role
  - BBS's were initial means of connecting personal computing hobbyists together
- Story
  - I would read messages about how to hack into computers on local BBS's
  - One day I hacked into one of these computers and was confronted with a message along the lines of "Welcome to the General Motors painting computer. Specify the color you would like to paint the next car on the assembly line…"
  - I immediately logged off and have never done this again…

Personal Case Study - Confer II

- Role
  - Pioneer computer conferencing system on the Michigan Terminal System (MTS) on the Merit Computer Network
- Story
  - From 1982-1985, as an undergraduate, I participated in numerous Confer II conferences, mainly on the topic of computing, and learned a tremendous amount about computer science from participating in these communities of practice
  - Experienced then all the issues / challenges faced by us today with social networking

Personal Case Study - Moderator on Byte Information Exchange (BIX)

- Role
  - An early commercial walled garden run by Byte Magazine
- Story
  - Volunteered at National Computer Conference 1985 to moderate the "Uses of Computers in Medicine" conference
  - My conference, and BIX overall, really never reached critical mass…

Personal Case Study - Being Doxed

- Role
  - Publisher of medical educational information on Internet
- Story
  - Members of a disease foundation took offense to a Web page that listed a medical mnemonic that helps physicians remember the clinical manifestations of the disease
  - They contacted the author of the page with polite suggestions as to where they could learn more about the disease and impolite suggestions as to what they could do to themselves...they eventually went up the org chart to the head of the hospital demanding that the Web page be removed but at that time (February 2000) the head of the hospital did not know what the Internet was
  - Situation was resolved by removing the offending mnemonic
  - Root of doxing is society now filled with "the perpetually aggrieved"

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- What is the pre-digital history of social media?
- What computational challenges do social networks face?
- What is the significance of Community Memory?
- What is the significance of the Well?
- What is a "Walled Garden?"
- What does Google / Facebook / etc. know about me?
- What is the business model of Google / Facebook and is it benign or evil?
- In the future, will content on the Internet be stored in open, interoperable Web sites or in walled gardens?
- Is access to the Internet a human right?
- Instead of being the most powerful free speech device ever made, is the Internet instead the most powerful censorship device ever made?
  - Refer to Michael Anti TED Talk on social media in China and articles on Libyan government use of social media to fight rebels
- Who are the most likely censors on the Internet - countries (China and Iran) or companies like Google with its robotic censorship
  - Refer to awards ceremony where Google robots blocked display of video clips
- Can the Internet be controlled by a foreign country?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
  - Hafner, Katie - The Well
  - Rheingold, Howard - The Virtual Community
- Fiction
- Movies
- Simulations

Conclusion

"They trust me - dumb f*cks"

- Mark Zuckerberg, founder of Facebook

Conclusion
From Reference to Self-Referential

"The subsequent rise and growth of social networks has been obviously been quite phenomenal for all of us. The one thing that is a disappointment to me in this entire scope of what is going on is GeoCities was about giving people the opportunity to share their passions about subject matter, whatever it was, whether it was sports or knitting or finance or watch collecting or fashion that you had the forum, a very big forum, to share your knowledge and people would then find that and now everything has become so self-referential and that to me is something that I think we've lost and I hope we get back which is I never thought GeoCities was going to be a celebration of the self. I thought and I intended it to be a celebration of what you have to contribute in terms of your knowledgebase to the community and I'm not sure we're headed back to that, but that to me was what was so exciting about it."

- David Bohnett, co-founder of proto-social network GeoCities in talk at Computer History Museum, Sept. 21, 2016

Conclusion

"I have a foreboding of an America in my children's or grandchildren's time - when the United States is a service and information economy; when nearly all the manufacturing industries have slipped away to other countries; when awesome technological powers are in the hands of a very few, and no one representing the public interest can even grasp the issues; when the people have lost the ability to set their own agendas or knowledgeably question those in authority; when, clutching our crystals and nervously consulting our horoscopes, our critical faculties in decline, unable to distinguish between what feels good and what's true, we slide, almost without noticing, back into superstition and darkness...

The dumbing down of American is most evident in the slow decay of substantive content in the enormously influential media, the 30 second sound bites (now down to 10 seconds or less), lowest common denominator programming, credulous presentations on pseudoscience and superstition, but especially a kind of celebration of ignorance"

— Carl Sagan, The Demon-Haunted World: Science as a Candle in the Dark

Topic 17

Computers and Languages

Tower of Babel

Song

Slide text

Thematic Quote

"Programming is the ART of telling a computer what to do."

- James A. Merritt

Thematic Quote

"I think everybody in this country should learn how to program a computer because it teaches you how to think"

- Steve Jobs

Thematic Quote

"The future comprises two types of people - those who know how to program and those who must obey the machines created by them"

- Anonymous Silicon Valley refrain

The Painting

Smalltalk and Forth

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - Basic Approach to BASIC
- Year
  - 1977
- Story
  - My first programming book

- Name
  - IBM System 370 Reference Summary
- Year
  - 1965
- Story
  - My machine language programming crutch

The Question

Should everyone learn to program? Is coding the new second language?

Is Coding the New Second Language?

- Kids may know their way around a computer, but in order to get a job in the new economy, they will have to know how to write a program, not just use one

- Coding, programming, and computer science will be the language of the 21st century.

"In a world that's increasingly run on technology, computer science is a liberal art that every student should be exposed to."

- Hadi Partovi, Code.org

"But being a consumer of technology - using a device - is using someone else's code. What we need for tomorrow is students who know how to adapt computers to their own use and for their own interests"

- Chris Stephenson, executive director at Computer Science Teachers Association

- Peg Tyre, Is Coding the New Second Language?, Smithsonian Magazine, May 24, 2013

Should Everybody Learn to Code?

- Yes

  "Code has become the 4th literacy. Everyone needs to know how our digital world works, not just engineers."

  - Mark Surman, executive director of Mozilla Foundation

  - A study from Carnegie Mellon University predicted in 2012 there would be 90 million workers in the US, with 55 million of them using spreadsheets + databases which can be considered programming
  - Because it is everywhere in society, because it takes the mystery out of technology, because it allows students to control - rather than just consume - technology
- No
  - Instead people should learn computational thinking, which helps people to think abstractly and break a problem down into smaller pieces
  - So instead of teaching people to code, instead teach them computer science problem solving skills = pre-coding

- Esther Shein, Should Everybody Learn to Code?, Communications of the ACM, Feb. 2014
- Should Coding be the New Foreign Language Requirement?, Edutopia, Oct. 30, 2013

Computational Thinking

- Extending computer science principles to other disciplines
  - Helps to break down the elements of any problem
  - Determine their relationships to each other and the greater whole
  - Devise algorithms to arrive at automated solution

- Yasmin Kafai + Quinn Burke, Computer Programming Goes Back to School, Phi Delta Kappan, Sep 2013

Concept of an Algorithm

- Definition

  "A finite set of rules, which gives a sequence of operations for solving a specific type of problem"

  - Donald Knuth

  "Like a recipe to cook a dish, only every step is precisely defined so that a machine can carry the steps out. Implied is that these steps be completed in a finite amount of time"

  - Paul Ceruzzi

Algorithms

- First known algorithm found on clay tablets near Baghdad, dating to ~ 2500 BC, records Sumerian instructions for how to equally divide grain harvest between a varying number of men
- Algorithms encode knowledge about the world into simple rules that computers can follow, thus producing faster decisions
- Algorithms are step by step procedures for performing calculations whose power comes from the fact that they are at the center of all computer programs and the logic embedded in the algorithms determines what the programs do - thus algorithms are the secret sauce of the digital world
- But as algorithms become a bigger part of our lives, they should be transparent so we can debate the rules they are imposing on us

The Algorithmic State

"Their (algorithms) popularity relies on the notion they are objective, but the algorithms that power the data economy are based on choices made by fallible human beings. And, while some of them were made with good intentions, the algorithms encode human prejudice, misunderstanding, and bias into automatic systems that increasingly manage our lives. Like gods, these mathematical models are opaque, their workings invisible to all but the highest priests in their domain: mathematicians and computer scientists. Their verdicts, even when wrong or harmful, are beyond dispute or appeal."

- Cathy O'Neil, How Algorithms Rule Our Working Lives, The Guardian, Sep. 1, 2016

"Weapons of math destruction"

Algorithms that are secret, important and harmful

- Cathy O'Neil, data scientist

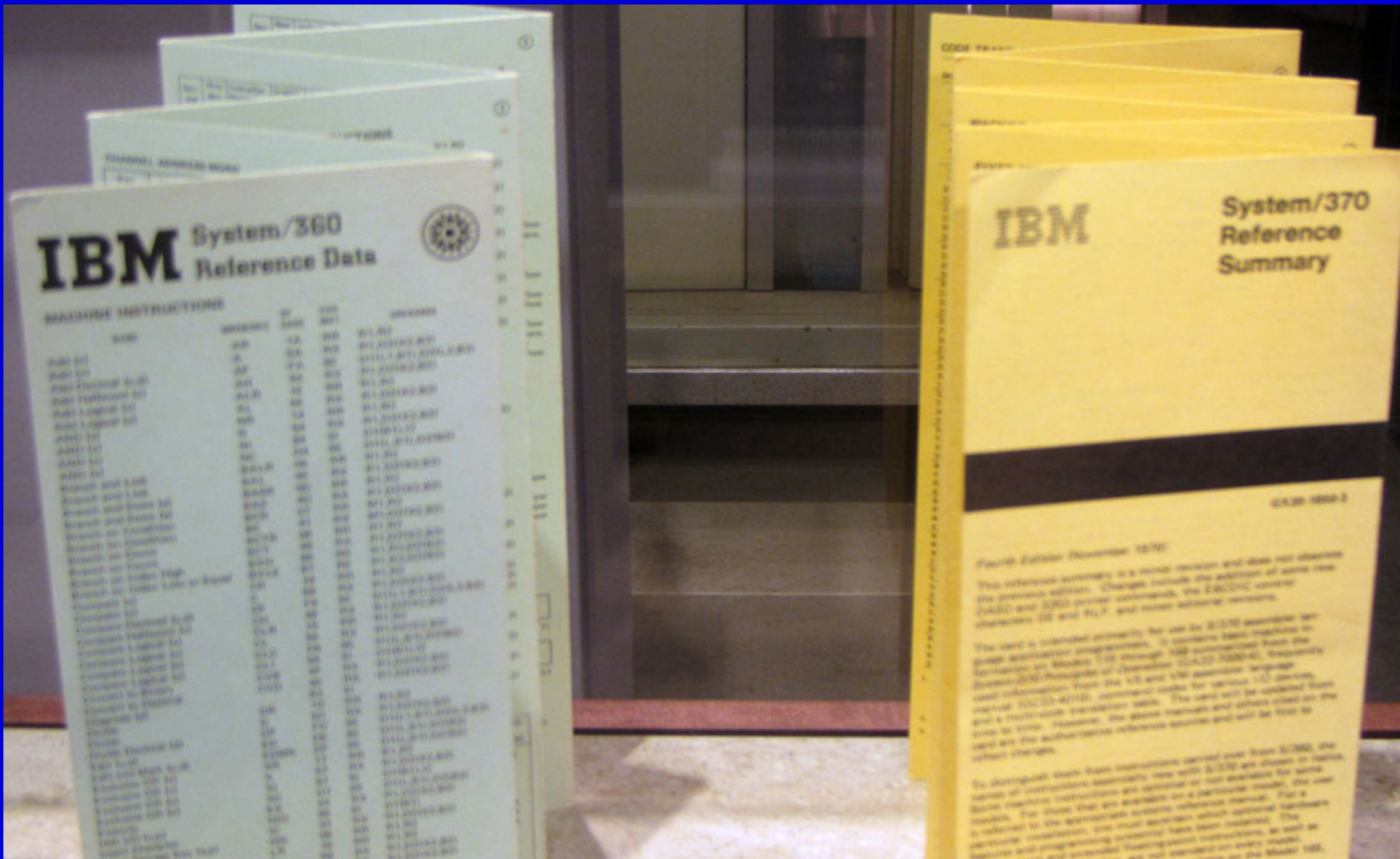
The Algorithmic State

- An algorithmic take over is occurring
  - "The tyranny of algorithms" - the machines are taking over
    - Algorithmic trading on Wall Street - algorithms, not humans, do the trading
    - PageRank from Google - decides what you are going to read on Web
    - Story about movie industry awards show that put trailer videos on YouTube and YouTube tagged them for copyright infringement and would not play them during the live broadcast

"Power tends to corrupt and absolute power corrupts absolutely."

\- Lord Acton

IBM System 360 Assembler Programming Guides



Thing / Software - Assembler

- Firsts / Achievements / Uniqueness / Significance
  - Programming as close as possible to hardware of computer creates the fasting running program
- Place Produced (Company / Institution) ~ Year ~ Country
  - Text
- People involved (Programmer)
  - Text
- Type
  - Text
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Text
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - N/A ~ Successors - N/A

Thing / Software - FORTRAN
FORmula TRANslation

- Firsts / Achievements / Uniqueness / Significance
  - First widespread scientific + engineering computer language
  - Compiler generated machine code was as efficient + fast as machine code humans wrote
- Place Produced (Company / Institution) ~ Year ~ Country
  - IBM ~ 1957 ~ USA
- People involved (Programmer)
  - John Backus
- Type
  - Language compiler
- Price / Cost
  - Text
- Computer and operating system it runs on
  - IBM 704 computer at first
- Computer language written in
  - Assembler
- Memory required
  - Text
- Predecessors - N/A ~ Successors - Various versions of FORTRAN

Thing / Software - COBOL
Common Business Oriented Language

- Firsts / Achievements / Uniqueness / Significance
  - 1960 - Program written in COBOL runs on 2 computers from 2 different vendors - programs no longer must be done separately for each brand of computer
  - Developed for business ~ Designed to be readable by humans
  - Backed by Department of Defense ~ US government would not purchase or lease computers that could not handle COBOL
- Place Produced (Company / Institution) ~ Year ~ Country
  - Conference on Data Systems Languages (CODSYL) ~ 1959 ~ USA
- People involved (Programmer)
  - Grace Murray Hopper
- Type
  - Language compiler
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Ran on all major mainframe computers
- Computer language written in
  - Assembler
- Memory required
  - Text
- Predecessors - N/A ~ Successors - Various versions of COBOL

Thing / Software - BASIC
Beginners All purpose Symbolic Instructional Code

- **Firsts / Achievements / Uniqueness / Significance**
  - Goal was teach undergraduates to program / help anybody become computer literate by creating a language that is as approachable as possible
  - By 1967, 80% of Dartmouth students + 40% of faculty had used it
  - Made it easy to write small improvisational programs
  - Software professionals denigrated it for the GOTO statement which led to spaghetti code
  - Worked perfectly on personal computers, was unavoidable as you were dumped directly into BASIC when you turned on first personal computers, so was really the personal computer's first killer app
  - Single most influential book of BASIC era = 101 BASIC Computer Games by David Ahl
  - Microsoft BASIC became balkanized when implemented on various different personal computers so in 1983 Kemeny + Kurtz came up with a new universal BASIC = True BASIC
  - When commercial software became available, need for BASIC decreased as you could buy software rather than create it
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Dartmouth University ~ 1964 ~ USA
- **People involved (Programmer)**
  - John Kemeny + Thomas Kurtz

  "Our vision was that every student on campus should have access to a computer, and any faculty member should be able to use a computer in the classroom whenever appropriate." - John Kemeny

- Harry McCracken, Fifty Years of BASIC, the Programming Language That Made Computers Personal, Time, Apr. 29, 2014

Thing / Software - BASIC
Beginners All purpose Symbolic Instructional Code

- **Type**
  - Dartmouth BASIC was a language compiler, later BASICs were language interpreters
- **Price / Cost**
  - Text
- **Computer and operating system it runs on**
  - First on General Electric 235 mainframe computer system with 16K of 20 bit words of memory running the Dartmouth Time Sharing System (DTSS) operating system
  - Ultimately ran on all early personal computers, starting with Micro-Soft BASIC for Altair 8800 in 1975
  - Microsoft BASIC -> Visual BASIC -> GW-BASIC -> QBASIC
- **Computer language written in**
  - Assembler
- **Memory required**
  - On General Electric 235 mainframe computer system Dartmouth BASIC used 16K of 20 bit words of memory
  - On early personal computers, Microsoft BASIC used 3K of 8 bit words
- **Predecessors - FORTRAN ~ Successors - Various versions of BASIC**

- Harry McCracken, Fifty Years of BASIC, the Programming Language That Made Computers Personal, Time, Apr. 29, 2014

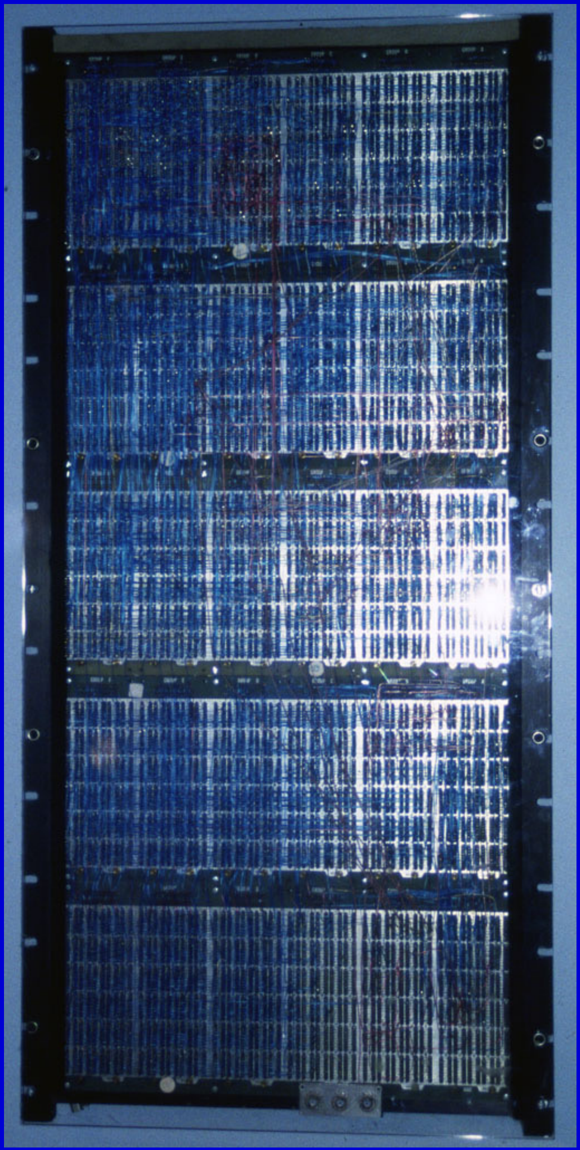
Thing / Software - C

- Firsts / Achievements / Uniqueness / Significance
  - Underlying language of UNIX operating system
- Place Produced (Company / Institution) ~ Year ~ Country
  - Bell Labs ~ 1973 ~ USA
- People involved (Programmer)
  - Dennis Ritchie
- Type
  - Language compiler
- Price / Cost
  - Free
- Computer and operating system it runs on
  - Almost every computer since 1975
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - FORTRAN ~ Successors - C++

Thing / Software - LISP (List Processing)

- Firsts / Achievements / Uniqueness / Significance
  - The favored programming language for artificial intelligence research
- Place Produced (Company / Institution) ~ Year ~ Country
  - MIT ~ 1958 ~ USA
- People involved (Programmer)
  - John McCarthy
- Type
  - Language interpreter
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Text
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - N/A ~ Successors - Logo, Prolog

LISP Machines



CONS-1 Backplane

Symbolics LISP Machine

Thing / Hardware - CONS-1 LISP Machine

- Firsts / Achievements / Uniqueness / Significance
  - First computer specifically designed to optimize running programs written in LISP language
- Place Produced (Company / Institution) ~ Year ~ Country
  - MIT AI Lab ~ 1973 work started ~ USA
- People involved (Designer)
  - Richard Greenblatt, Thomas Knight
- Type
  - Workstation
- Price / Cost
  - $50,000
- Size
  - Text

Thing / Hardware - CONS-1 LISP Machine

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - Text
- Primary memory type / technology ~ Size ~ Word length
  - Text
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - AI software
- Predecessors - PDP-10 ~ Successors - CADR + Symbolics + LISP Machine Inc. LISP Machines

Thing / Software - Logo

- Firsts / Achievements / Uniqueness / Significance
  - Designed to teach computer programming to children
  - Couple children with programming to help them better learn mathematical thinking
- Place Produced (Company / Institution) ~ Year ~ Country
  - Bolt, Beranek, Newman ~ 1967 ~ USA
- People involved (Programmer)
  - Seymour Papert
- Type
  - Language interpreter
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Most early personal computers
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - LISP ~ Successors - Scratch

Future of Programming

- Our theories about how things work is influenced by the technology surrounding us, thus now we view the world as a computer which can be coded

  "We have come to see life itself as something ruled by a series of instructions that can be discovered, exploited, optimized, maybe even rewritten." - Jason Tanz

  "It is becoming clear that all living cells that we know of on this planet are DNA-software-driven biological machines." - Craig Venter, biologist

- The ability to write code becomes a language granting insider status to those who speak it, giving them access to levers of power

  "If you control the code, you control the world." - Marc Goodman, futurist

- Jason Tanz, Soon We Won't Program Computers. We'll Train Them Like Dogs, Wired, May 2016

Future of Programming

- Traditional programming entails writing explicit step by step instructions for computer to follow
  - Programmers are like gods, authoring laws that govern computer systems
  - Leads to cult of engineer that says human experience can be reduced to series of comprehensible instructions
- Machine learning "programming" entails training the computer's neural network by showing it lots of examples rather than writing instructions for it
  - Downside is you never know exactly how neural network accomplishes its tasks as its operations are opaque
  - Programmers are like parents or dog trainers
  - The code that runs the world may defy human analysis

- Jason Tanz, Soon We Won't Program Computers. We'll Train Them Like Dogs, Wired, May 2016

Future of Programming

- **Rise of machine learning takes us from Age of Enlightenment to Age of Entanglement**

  "As our technological and institutional creations have become more complex, our relationship to them has changed. Instead of being masters of our creations, we have learned to bargain with them, cajoling and guiding them in the general direction of our goals. We have built our own jungle, and it has a life of its own." - Danny Hillis, computer scientist, writing in Journal of Design and Science

"And now, 80 years after Alan Turing first sketched his designs for a problem-solving machine, computers are becoming devices for turning experience into technology. For decades we have sought the secret code that could explain and, with some adjustments, optimize our experience of the world. But our machines won't work that way for much longer-and our world never really did. We're about to have a more complicated but ultimately more rewarding relationship with technology. We will go from commanding our devices to parenting them." - Jason Tanz

[See also The Lifecycle of Software Objects, a novella by Ted Chiang]

- Jason Tanz, Soon We Won't Program Computers. We'll Train Them Like Dogs, Wired, May 2016

Personal Case Study - / Learning Programming

- Role
  - Waterloo FORTRAN IV, a version of FORTRAN designed to teach structured programming
- Story
  - Second language I learned in 1981, taught to me by a high school math teacher who was a strong advocate of structured programming
  - Programmed via remote job entry with cards on an HP-2000 minicomputer; later my programming partner loaned me a dumb terminal so I could program at home
  - Set me on my lifelong path of being a computer scientist

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- Why was there such a long gap between BASIC as a language to write simple programs to solve simple problems on first generation of personal computers and a tool to do the same on tablets some day?
  - (Although we could say that Hypercard on the Macintosh was a short-lived bridge between them)
- What is an algorithm?
- Is the "Tyranny of Algorithms" a good thing or bad thing?
- How could we go about making key algorithms in life transparent?
- What computational challenges are faced by the designers of computer languages?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
- Simulations

Conclusion

"God is in the details"

- Mies van der Rohe, architect

Conclusion

"It has long been an axiom of mine that the little things are infinitely the most important"

- Sir Arthur Conan Doyle, author

Topic 18

Computer Operating Systems

By Your Command

Song

Slide text

Thematic Quote

"Given enough eyeballs, all bugs are shallow"

- Eric S. Raymond

The Painting

The Programming Route

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - Introduction to MTS
- Year
  - 1981
- Story
  - How to use and program an operating system

The Question

Why are our computers so insecure?

Timeline of Operating Systems

- 1950-1960 - Batch systems
  - One job at a time
- 1960 - 1975 - Interactive systems
  - Many users on multiple systems constantly interacting, communicating, sharing resources
- 1975 - 2005 - Desktop systems
  - Distributed systems to manage work in an office
- 2005 - present - Cloud-mobile systems
  - Manage all aspects of one's life, work, social relations

- Peter Denning, Fifty Years of Operating Systems, Communications of the ACM, Mar. 2016

8 Principles for Operating Systems

- Interactive computing (time sharing)
- Hierarchical file systems
- Fault tolerant structures
- Interrupt systems
- Automated overlays (virtual memory)
- Multiprogramming
- Modular programming
- Controlled information sharing

- Peter Denning, Fifty Years of Operating Systems, Communications of the ACM, Mar. 2016

8 Principles in Practice

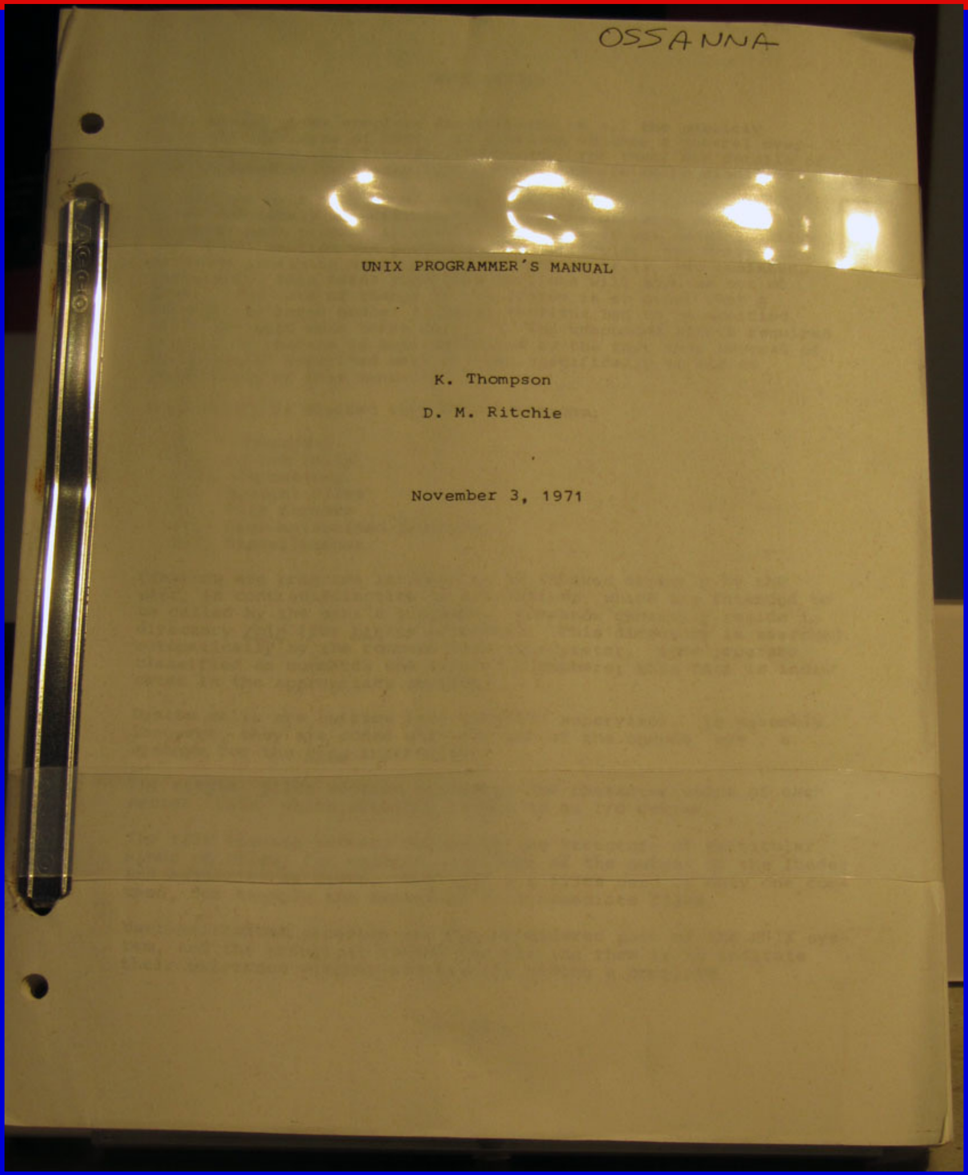
- MIT Multics (1964-1968)
  - Emphasized interactivity + community
  - Used high level language (PL/I) to program operating system because designers did not want to write such a big program in assembly language
- IBM System 360 (1964-1968)
  - Single operating system for complete line of low end to high end computers with common instruction set
  - Written in assembly language
- Unix (1971)
  - Dennis Ritchie + Ken Thompson at Bell Labs loved Multics' services but hated its size + cost so took the best of it along with their own ideas to create something small enough to run on minicomputer
  - Written in portable language C - was close enough to assembly language to be efficient + high level enough to manage OS program complexity
- Minix (1987)
  - Student-oriented version of Unix by Andy Tanenbaum
  - Forked into Linux by Linus Torvalds

- Peter Denning, Fifty Years of Operating Systems, Communications of the ACM, Mar. 2016

Thing / Software - Michigan Terminal System (MTS)

- Firsts / Achievements / Uniqueness / Significance
  - One of the first time-sharing computer operating systems
  - In 1981 MTS had email, social networking (Confer, *Forum), word processing, games (including real time multiplayer games), statistics, infinite customizability through programming, laser printing
- Place Produced (Company / Institution) ~ Year ~ Country
  - University of Michigan ~ 1967 ~ USA
- People involved (Programmer)
  - Consortium of 8 universities in the US, Canada, UK from 1967 - 1999
- Type
  - Operating system
- Price / Cost
  - Free
- Computer and operating system it runs on
  - IBM System 360-67 initially and then IBM System 370 compatible computers
- Computer language written in
  - IBM 360 / 370 assembler
- Memory required
  - N/A
- Predecessors - Dartmouth TSS, Project MAC ~ Successors - Unix

UNIX Programmer's Manual



Thing / Software - UNIX

- Firsts / Achievements / Uniqueness / Significance
  - ATT could not be in computer business so it licensed the UNIX source code at nominal cost especially to universities who became big fans of it + improved it + cloned it
  - Name was play on Multics developed for Project MAC which had been troublesome
  - Easily ported to other machines as source code was distributed
  - TCP/IP eventually distributed with it, leading to its widespread adoption
- Place Produced (Company / Institution) ~ Year ~ Country
  - ATT Bell Labs ~ 1969 ~ USA
- People involved (Programmer)
  - Ken Thompson, Dennis Ritchie, Brian Kernighan
- Type
  - Operating system
- Price / Cost
  - Free (almost) before ATT breakup
- Computer and operating system it runs on
  - Originally ran on PDP-7 ~ Subsequently runs on almost every computer built since 1980
- Computer language written in
  - C
- Memory required
  - Text
- Predecessors - N/A ~ Successors - Morphs into BSD Unix (Bill Joy) -> SunOS, Mach (Rick Rashid) -> NeXTStep OS (Avie Tevanian) -> Mac OS X -> iOS, Linux (Linus Torvalds) -> Android (Andy Rubin)

Linus Torvalds

From Wikimedia Commons

Person - Linus Torvalds

- Significance
  - Creator of / Leader of Linux operating system
- Profession
  - Computer programmer
- Places worked
  - Transmeta, Linux Foundation
- Years of work
  - 1991 - present
- Things worked on
  - Linux

Thing / Software - Linux

- Firsts / Achievements / Uniqueness / Significance
  - Free, open source version of UNIX
  - Powers the Web - Linux, Apache, MySQL, PHP (LAMP)
  - Powers Android
- Place Produced (Company / Institution) ~ Year ~ Country
  - Internet ~ 1991 ~ World
- People involved (Programmer)
  - Linus Torvalds
- Type
  - Operating system
- Price / Cost
  - Free
- Computer and operating system it runs on
  - Almost every computer since 1991
- Computer language written in
  - C
- Memory required
  - Text
- Predecessors - Minix ~ Successors - Android

Thing / Software - MacOS

- Firsts / Achievements / Uniqueness / Significance
  - First widespread commercially available operating system using the Window, Icon, Menu, Pointer (WIMP) interface
- Place Produced (Company / Institution) ~ Year ~ Country
  - Apple ~ 1984 ~ USA
- People involved (Programmer)
  - Text
- Type
  - Operating system
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Macintosh
- Computer language written in
  - Assembler
- Memory required
  - Text
- Predecessors - N/A ~ Successors - MacOS X

Thing / Software - Windows

- Firsts / Achievements / Uniqueness / Significance
  - Most widely used operating system using the Window, Icon, Menu, Pointer (WIMP) interface
- Place Produced (Company / Institution) ~ Year ~ Country
  - Microsoft ~ 1985 (Windows 1.0) ~ USA
- People involved (Programmer)
  - Text
- Type
  - Operating system
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Wintel
- Computer language written in
  - Assembler
- Memory required
  - Text
- Predecessors - N/A ~ Successors - Windows 3 -> Windows 95/98 (merges with Windows NT) -> Windows XP -> Windows Vista / 7 / 8 / 10

Personal Case Study - Mainframes / IBM 370 / Assembler

- Role
  - The campus mainframe at Wayne State University was an Amdahl 470, which was an IBM 370 clone
- Story
  - I learned assembly language programming on this computer and was seduced by being able to control the entire machine
  - Once you are beneath the operating system, you become one with the machine

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- What is an operating system?
- What computational challenge do designers of operating systems face?
- What is the significance of the UNIX operating system?
- Why are computers so insecure and vulnerable to hacking?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
  - Tron
- Simulations

Conclusion

"That's not a bug, it's a feature!

- Anonymous

Topic 19

Computer Software

Bits Not Atoms

Song

Slide text

Thematic Quote

"Software is the invisible thread and hardware is the loom upon which we weave the fabric of computing and this is a rich tapestry that we have now laid across all of the Earth"

- Grady Booch, software engineer

Thematic Quote

"Computers are to computing as instruments are to music. Software is the score, whose interpretation amplifies our reach and lifts our spirits."

- Alan Kay, computer scientist

Thematic Quote

"Hardware is the body. Encumbered by the material world it is constrained by physical laws and will eventually succumb to the ravages of time. Software is the soul. The essence of code is its immateriality. An invisible spark of life, it controls the operation of the machine and can transmigrate from one host to another. It is bound not by the laws of this world but by those of another."

- Thomas Haigh, computer historian

"Software is eating the world"

- Marc Andreessen, venture capitalist

The Painting

Word Processor

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - Flowchart generator
- Year
  - 1981
- Story
  - How you wrote programs

- Name
  - World Builder BASIC program
- Year
  - 1981
- Story
  - Create your own solar system

The Question

Which development process produces the better software - commercial (the cathedral) or open source (the bazaar)?

Software Uber Alles

- Remember that the "killer app" is software!
  - Software sells hardware…

The US Constitution as Software

"The Constitution on the United States is one of my favorite systems design. Think of it: millions and millions of mutually incompatible parts, running without completely breaking for more than 200 years. It's pretty amazing, you can hold it in your hand. The reason you can hold it in your hand is they were wise enough to not put any laws in it. It's not a law-based thing, it's not a case-based thing, it's a principle-based thing. It's a kernel."

- Alan Kay, computer scientist

The US Constitution as Software

"This is my favorite meta program, the Constitution of the United States. Think about it. You can put it on a single sheet of paper and it has been the controlling force for an organism made up of millions and millions of mutually conflicting parts and has not broken for more than 200 years. Nobody has ever built an organization that complex than this and the only reason it works is this is not a set of laws but a set of principles"

- Alan Kay, computer scientist

"It has been observed that it is easy to write software that is hard to use and hard to write software that is easy to use"

- Vint Cerf, computer scientist

"Good programming is an artisan skill developed with good training and years of practice."

- Peter Denning + Craig Martell, Great Principles of Computing

Software

- Software was originally given away free by computer companies to encourage you to buy their hardware
- Over time, computer companies formed users groups that distributed application software with source code for free
- Microsoft was an anomaly - encouraging people to pay for software
- Now we are back to the past with open source software
- And many apps (most apps?) in mobile apps stores are free

Thing / Software - Visicalc

- Firsts / Achievements / Uniqueness / Significance
  - First electronic spreadsheet, a word processor for figures
  - Allowed businessmen to model their business + simulate its operation
  - When people at MIT saw it they were not impressed…it was a simple thing to do…but they never got around to doing it..
  - Killer app for Apple II computer
  - Legitimized microcomputer in business
- Place Produced (Company / Institution) ~ Year ~ Country
  - Software Arts ~ 1979 ~ USA
- People involved (Programmer)
  - Dan Bricklin, Bob Frankston
- Type
  - Spreadsheet
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Apple II
- Computer language written in
  - Assembler
- Memory required
  - Text
- Predecessors - N/A ~ Successors - Lotus 1-2-3

- Steven Levy, A Spreadsheet Way of Knowledge, Harper's, Nov. 1984

Richard Stallman

From Wikimedia Commons

Person - Richard Stallman

- Significance
  - Founder of free software movement
- Profession
  - Computer programmer
- Places worked
  - MIT
- Years of work
  - 1971 - present
- Things worked on
  - EMACS, GCC, GNU

Are Programmers Artists?

- Definition of a 10xer - "…the very best programmers are superstars, capable of achieving ten times the productivity of their merely competent colleagues"
    - 10xers are acquiring agents and feel they should be regarded as artists

(Following a discussion of Leonardo da Vinci's portrait of Ginevra de' Benci…) "Great software, likewise, requires a fanatical devotion to beauty…If you look inside good software, you find that parts no one is ever supposed to see are beautiful too."

- Paul Graham, Hackers and Painters

- Lizzie Widdicombe, The Programmer's Price, The New Yorker, Nov. 24, 2014

Place - Software Industry

- Significance
  - 1968 - Start of commercial software industry - IBM agrees to unbundle software from computers + charge for it separately, thus allowing you to buy software from other suppliers
  - 1976 - An Open Letter to Hobbyists - by Bill Gates of Micro-Soft - in the Homebrew Computer Club Newsletter - plea to stop stealing software
- Location
  - Worldwide
- Definition
  - Today - A huge global industry selling operating systems + applications
- People who worked there
  - Text
- Things created there
  - Operating systems, applications

Place - The Cathedral and the Bazaar

- Significance
  - Explained why open source software can be superior to commercial software
- Location
  - Cyberspace
- Definition
  - There are two styles of software development
    - Cathedral model of commercial world where development is closed to a few select priests
    - Bazaar model of open source world where development is open to all

    "Given enough eyeballs, all bugs are shallow" - Eric S. Raymond
- People who worked there
  - Eric S. Raymond
- Things created there
  - Open source software

Thing / Software - Open Source Software

- Firsts / Achievements / Uniqueness / Significance
  - Powers the Internet ~ Powers Mobile
- Place Produced (Company / Institution) ~ Year ~ Country
  - Individuals ~ Since 1980's ~ Around the world
- People involved (Programmer)
  - Richard Stallman
- Type
  - Operating systems + applications
- Price / Cost
  - Free under various licenses
- Computer and operating system it runs on
  - Primarily versions of Unix
- Computer language written in
  - Originally C, now various languages
- Memory required
  - Text
- Predecessors - N/A ~ Successors - N/A

Famous Bugs

- F-16 fighter plane
  - A problem in the navigation software inverted the aircraft whenever it crossed the equator but this was caught early in simulation testing and fixed
- Mars Climate Orbiter spacecraft
  - The "metric mixup" - The flight system software was written to take thrust instructions using the metric unit newtons (N), while the software on the ground that generated those instructions used the Imperial measure pound-force (lbf).
  - Therefore the spacecraft encountered Mars at an improperly low altitude, causing it to incorrectly enter the upper atmosphere and disintegrate

Famous Bugs

- Y2K
  - To save memory space, in early days of computers, programs stored as few digits as possible.
    - In COBOL, January 1, 1999 was stored as 010199.
    - As 2000 approached it became clear that many old programs in use still used this method and the date January 1, 2000, stored as 010100 by COBOL could be read by the computer as the date January 1, 1900.
  - If left unfixed, hardware, software, and communications could have been affected world wide

"Complex systems break in complex ways"

- Peter Neumann, computer scientist + computer security specialist

Computing Case Study Summary - Mars Climate Orbiter

- **Goal**
  - Gather data on Mars's atmosphere + serve as communications link for other probes
- **Center of Gravity (Strategy)**
  - Orbit Mars
- **Technology / Equipment ~ Training ~ Leadership ~ Morale**
  - Jet Propulsion Laboratory - tremendous experience sending missions to Mars
  - Lockheed Martin - tremendous experience building spacecraft
- **Tactics**
  - Spacecraft launched December 11, 1998
- **Intangibles**
  - Spacecraft disappeared / burned up in Martian atmosphere during orbital insertion around Mars on September 23, 1999
- **Mistakes**
  - Investigation traced crash to software engineer at NASA contractor who had neglected to convert English units to metric ones causing the force of the engine's orbital insertion thrust to be off by factor of 4.5
- **Outcome**
  - Bug had been overlooked several times
  - Cost of the bug = $125 million

- Elizabeth Kolbert, Project Exodus, New Yorker, June 1, 2015

Software is Eating the World

- World is in middle of technological + economic shift in which software companies are poised to take over large parts of the economy
- Happening now because we are six decades into computer revolution, four decades into microprocessor revolution, two decades into Internet revolution - all of the technology needed to transform industries through software finally works + can be delivered at global scale
- Cloud based services make it easy + cheap to launch global software powered start-ups without investing in infrastructure + employees
- Examples
  - Books (Amazon eating Borders), video (Netflix eating Blockbuster), music (iTunes / Spotify / Pandora eating record labels), photography (Kodak eaten by everyone)

- Marc Andreessen, Why Software is Eating the World, Wall Street Journal, Aug. 20, 2011

Personal Case Study - Software Developer / Computer Programmer Grosse Pointe Public Schools

- Role
  - Microsoft BASIC computer programmer
- Story
  - Developed mathematical drill + kill tutorial programs for school system from 1981-1984
  - Learned about how to do software development in a cross-platform personal computer environment of Commodore PET + Atari 800

Personal Case Study - Jud E.

- Role
  - Wrote software used on NASA's Kuiper Airborne Observatory
- Story
  - Physics major
  - Worked for NASA Ames as summer intern, wrote software for experiments on NASA's Kuiper Airborne Observatory and flew on it and watched it work
  - Loved NASA but decided he couldn't afford to work for them so made his career at Chrysler as engineer and becoming a quality guru / blackbelt for them

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- What computational challenges are faced by the designers of commercial software?
- Does software want to be free?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
- Simulations

Conclusion

"A designer knows he has achieved perfection not when there is nothing left to add, but when there is nothing left to take away."

- Antoine de Saint-Exupery, pilot and author

Topic 20

Computers in Gaming

Song

I have a pocket full of quarters
And I'm headed to the arcade

I don't have alot of money
But I'm bringing everything I made

I have a callus on my finger
and my shoulder's hurtin', too

I'm gonna eat 'em all up
Just as soon as they turn blue

'Cause I got Pac Man Fever (Pac Man Fever)
It's drivin' me crazy (Drivin' me crazy)
I got Pac Man Fever (Pac Man Fever)
I'm goin' outta my mind (Goin' outta my mind)
I got Pac Man Fever (Pac Man Fever)
I'm goin' outta my mind (Goin' outta my mind)
- Buckner & Garcia, Pac Man Fever

Thematic Quote

Slide text

The Painting

Fun and Games

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - SpaceWar! at spacewar.oversigma.com
- Year
  - 1962
- Story

- Name
  - Colossal Cave Adventure
- Year
  - 1976
- Story

- Name
  - Coleco Electronic Quarterback and Head to Head Basketball handheld games
- Year
  - 1978
- Story

The Question

Are video games an art form?

Video Game Overview

- 1972 - First games console - Magnavox Odyssey
  - Started as "brown box" console in 1966 by Ralph Baer
- 1994 - Release of Sony PlayStation marketed at men in their 20s
- PlayStation 2 is best-selling console ever

MoMA Video Game Collection

- At first
  - Pac-Man (1980), Tetris (1984), Another World (1991), Myst (1993), SimCity 2000 (1994), vib-ribbon (1999), The Sims (2000), Katamari Damacy (2004), EVE Online (2003), Dwarf Fortress (2006), Portal (2007),flOw (2006), Passage (2008), Canabalt (2009)
- Plan to add
  - Spacewar! (1962), an assortment of games for the Magnavox Odyssey console (1972), Pong (1972), Snake (originally designed in the 1970s; Nokia phone version dates from 1997), Space Invaders (1978), Asteroids (1979), Zork (1979), Tempest (1981), Donkey Kong (1981), Yars' Revenge (1982), M.U.L.E. (1983), Core War (1984), Marble Madness (1984), Super Mario Bros. (1985), The Legend of Zelda (1986), NetHack (1987), Street Fighter II (1991), Chrono Trigger (1995), Super Mario 64 (1996), Grim Fandango (1998), Animal Crossing (2001), and Minecraft (2011)
- Video games are art and design - so games selected as outstanding examples of interaction design

  "Our criteria, therefore, emphasize not only the visual quality and aesthetic experience of each game, but also the many other aspects-from the elegance of the code to the design of the player's behavior-that pertain to interaction design."

- Paola Antonelli, Video Games: 14 In The Collection, for Starters, MoMA Inside / Out, November 29, 2012

DEC PDP-1

Computer Space

Thing / Software - SpaceWar!

- Firsts / Achievements / Uniqueness / Significance
  - First video game
  - Ultimately commercialized as first arcade video game as "Computer Space" in 1970 by Nolan Bushnell for Nutting Associates but was too complex to be popular…Bushnell went on to form Atari and release Pong in 1972
- Place Produced (Company / Institution) ~ Year ~ Country
  - MIT ~ 1962 ~ USA
- People involved (Programmer)
  - Steve Russell
- Type
  - Video game
- Price / Cost
  - Free
- Computer and operating system it runs on
  - PDP-1
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - N/A ~ Successors - Computer Space

- J.M. Graetz, The Origin of Spacewar, Creative Cmoputing, August 1981

Pong

Thing / Software - Pong

- Firsts / Achievements / Uniqueness / Significance
  - First successful arcade video game
  - After failure of the complex game Computer Space for Nutting Associates in 1970, Bushnell went on to form Atari and release Pong in 1972
- Place Produced (Company / Institution) ~ Year ~ Country
  - Atari ~ 1972 ~ USA
- People involved (Programmer)
  - Alan Alcorn, Nolan Bushnell
- Type
  - Video game
- Price / Cost
  - 25 cents
- Computer and operating system it runs on
  - Stand alone arcade game
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - N/A ~ Successors - N/A

Adventure

```
.run adven


WELCOME TO ADVENTURE!!  WOULD YOU LIKE INSTRUCTIONS?

yes

SOMEWHERE NEARBY IS COLOSSAL CAVE, WHERE OTHERS HAVE FOUND FORTUNES IN
TREASURE AND GOLD, THOUGH IT IS RUMORED THAT SOME WHO ENTER ARE NEVER
SEEN AGAIN.  MAGIC IS SAID TO WORK IN THE CAVE.  I WILL BE YOUR EYES
AND HANDS.  DIRECT ME WITH COMMANDS OF 1 OR 2 WORDS.  I SHOULD WARN
YOU THAT I LOOK AT ONLY THE FIRST FIVE LETTERS OF EACH WORD, SO YOU'LL
HAVE TO ENTER "NORTHEAST" AS "NE" TO DISTINGUISH IT FROM "NORTH".
(SHOULD YOU GET STUCK, TYPE "HELP" FOR SOME GENERAL HINTS.  FOR INFOR-
MATION ON HOW TO END YOUR ADVENTURE, ETC., TYPE "INFO".)
                              - - -
THIS PROGRAM WAS ORIGINALLY DEVELOPED BY WILLIE CROWTHER.  MOST OF THE
FEATURES OF THE CURRENT PROGRAM WERE ADDED BY DON WOODS (DON @ SU-AI).
CONTACT DON IF YOU HAVE ANY QUESTIONS, COMMENTS, ETC.

YOU ARE STANDING AT THE END OF A ROAD BEFORE A SMALL BRICK BUILDING.
AROUND YOU IS A FOREST.  A SMALL STREAM FLOWS OUT OF THE BUILDING AND
DOWN A GULLY.

east

YOU ARE INSIDE A BUILDING, A WELL HOUSE FOR A LARGE SPRING.

THERE ARE SOME KEYS ON THE GROUND HERE.

THERE IS A SHINY BRASS LAMP NEARBY.

THERE IS FOOD HERE.
```

From Wikipedia

Thing / Software - Adventure

- Firsts / Achievements / Uniqueness / Significance
  - First interactive fiction / text adventure
- Place Produced (Company / Institution) ~ Year ~ Country
  - Bolt, Beranek and Newman ~ 1975 ~ USA
- People involved (Programmer)
  - William Crowther + Don Woods
- Type
  - Adventure game
- Price / Cost
  - Free
- Computer and operating system it runs on
  - Digital Equipment Corporation PDP-10
- Computer language written in
  - FORTRAN
- Memory required
  - Text
- Predecessors - N/A ~ Successors - Zork

Thing / Software - Castle Wolfenstein

- Firsts / Achievements / Uniqueness / Significance
  - First first person shooter
- Place Produced (Company / Institution) ~ Year ~ Country
  - Muse Software ~ 1981 ~ USA
- People involved (Programmer)
  - Silas Warner
- Type
  - First person shooter
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Apple II
- Computer language written in
  - Assembler
- Memory required
  - Text
- Predecessors - N/A ~ Successors - Doom

Thing / Software - Space Invaders

- Firsts / Achievements / Uniqueness / Significance
  - Killer app for videogame arcades
- Place Produced (Company / Institution) ~ Year ~ Country
  - Taito ~ 1978 ~ Japan
- People involved (Programmer)
  - Tomohiro Nishikado
- Type
  - Video game
- Price / Cost
  - 25 cents
- Computer and operating system it runs on
  - Stand alone arcade game on Intel 8080 microprocessor
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - Pong ~ Successors - Pac-Man

Thing / Software - Pac-Man

- Firsts / Achievements / Uniqueness / Significance
  - Killer app for videogame arcades
- Place Produced (Company / Institution) ~ Year ~ Country
  - Namco ~ 1980 ~ Japan
- People involved (Programmer)
  - Toru Iwatani
- Type
  - Video game
- Price / Cost
  - 25 cents
- Computer and operating system it runs on
  - Stand alone arcade game on Zilog Z80 microprocessor
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - Space Invaders ~ Successors - Too numerous to say

Nintendo Entertainment System

From Wikimedia Commons

Thing / Hardware - Nintendo Entertainment System / Famicom

- Firsts / Achievements / Uniqueness / Significance
  - Restored + revitalized + further established a respectability for videogame industry after Atari-induced videogame crash of 1983 which it has since never lost
  - Games had official Nintendo Seal of Quality so consumers knew they were getting quality product
  - Only licensed software ran on it
  - Set stage for Japanese domination of videogame industry
  - Best selling console of its time
- Place Produced (Company / Institution) ~ Year ~ Country
  - Nintendo ~ 1983 ~ Japan
- People involved (Designer)
  - Masayuki Uemura
- Type
  - Video game console
- Price / Cost
  - $100
- Size
  - 10 x 8 x 3.5"

Thing / Hardware - Nintendo Entertainment System / Famicom

- **Computing technology**
  - Integrated circuits ~ Ricoh 2A03 8 bit processor (MOS Technology 6502) + Picture Processing Unit of 2 kilobytes of video RAM of 256 x 240 pixels
- **Computing speed (in MIPS)**
  - 1.79 MHz
- **Primary memory type / technology ~ Size ~ Word length**
  - Integrated circuits ~ 2 kilobytes ~ 8 bits
- **Secondary memory type / technology ~ Size**
  - ROM cartridge ~ 8 kilobytes -> 1 megabyte (128 - 384 kilobytes average)
- **Uses / Applications / Software**
  - Super Mario Brothers, Legend of Zelda
- **Predecessors - Atari 2600 ~ Successors - Super Famicon / Super Nintendo Entertainment System**

Shigeru Miyamoto

From Wikimedia Commons

Person - Shigeru Miyamoto

- Significance
  - Responsible for many of the best-selling video games of all time
  - Created video game industry's only recognizable aesthetic - colorful, cartoonish, whimsical
  - Pioneered 3-D gameplay, nonlinear gameplay, original music
- Profession
  - Video game designer
- Places worked
  - Nintendo
- Years of work
  - 1977 - present
- Things worked on
  - 1981 - Donkey Kong
  - 1983 - Mario Brothers
  - 1986 - Legend of Zelda

- Zev Borow, Why Nintendo Won't Grow Up, Wired, January 2003

Thing / Software - Mario Brothers

- Firsts / Achievements / Uniqueness / Significance
  - Killer app for Nintendo Entertainment System
- Place Produced (Company / Institution) ~ Year ~ Country
  - Nintendo ~ 1983 ~ Japan
- People involved (Programmer)
  - Shigeru Miyamoto
- Type
  - Video game
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Nintendo Entertainment System
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - N/A ~ Successors - N/A

Thing / Software - Legend of Zelda

- **Firsts / Achievements / Uniqueness / Significance**
  - Killer app for Nintendo Entertainment System
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Nintendo ~ 1986 ~ Japan
- **People involved (Programmer)**
  - Shigeru Miyamoto
- **Type**
  - Video game
- **Price / Cost**
  - Text
- **Computer and operating system it runs on**
  - Nintendo Entertainment System
- **Computer language written in**
  - Text
- **Memory required**
  - Text
- **Predecessors - N/A ~ Successors - N/A**

Thing / Software - World of Warcraft

- Firsts / Achievements / Uniqueness / Significance
  - Most successful / largest MMORPG
- Place Produced (Company / Institution) ~ Year ~ Country
  - Blizzard ~ 2004 ~ USA
- People involved (Programmer)
  - Rob Pardo, Jeff Kaplan, Tom Chilton
- Type
  - Massively Multiplayer Online Role Playing Game
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Macintosh + Windows
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - Ultima Online, Everquest ~ Successors - N/A

Thing / Software - Minecraft

- Firsts / Achievements / Uniqueness / Significance
  - Third-best selling video game in history (after Tetris + Wii Sports) ~ 100 million registered players ~ average age is 28 ~ 40% women
  - Encourages kids to tinker ~ Provides stealth gateway to computer science
  - "This generation's personal computer" - Ian Bogost, professor of media studies
  - "Children are particularly fond of haunting any site where things are being visibly worked on They are irresistibly drawn by the detritus generated by building, gardening, housework, tailoring or carpentry." - Walter Benjamin, social critic
  - Block play is good play that cultivates abstract thought -> from Scandinavian blocks to Lego to Minecraft -> is digital sloyd (woodcrafting)
  - Online community functions as guilds with knowledgeable adults mentoring young people ~ Knowledge becomes social currency as it is shared
  - When sharing a server, kids are constantly negotiating governance which is teaching them civic literacy in a "third place" outside of home + school ~ Minecraft is a new free-ranging realm for kids
- Place Produced (Company / Institution) ~ Year ~ Country
  - Mojang ~ 2011 ~ Sweden
- People involved (Programmer)
  - Marcus "Notch" Persson
- Type
  - Game
- Price / Cost
  - $30
- Computer and operating system it runs on
  - Originally PC, Macintosh, mobile
- Computer language written in
  - Java
- Memory required
  - Text
- Predecessors - LEGO ~ Successors - N/A

- Clive Thompson, The Minecraft Generation, New York Times Magazine, Apr. 14, 2016

Computing Case Study Summary - No Man's Sky

- **Goal**
  - Create a vast digital cosmos that humans can explore while finding their own existential purpose
- **Center of Gravity (Strategy)**
  - Through science of procedural generation, make a program that allows a universe to create itself
- **Technology / Equipment**
  - For PC and PlayStation 4
- **Training ~ Leadership**
  - Sean Murray
- **Morale**
  - Of the 12 developers - great
- **Tactics**
  - Procedural generation of the universe
  - 600,000 lines of code ~ Provides unified mathematical framework for all phenomena
  - Uses real physics most of the time
  - Entire universe exists at moment of its creation but is only revealed when there is a player present to witness it
- **Intangibles**

  "What are the chances that we are living in a simulation?" - Elon Musk to Sean Murray
- **Mistakes**
  - How do you balance gameplay between survival + joy of exploration?
- **Outcome**
  - 18,446,744,073,709,551,616 unique planets

  "A team of programmers has built a self-generating cosmos, and even they don't know what's hiding in its vast reaches"

  - Roc Morin, Inside the Artificial Universe That Creates Itself, The Atlantic, Feb. 19, 2016

  - Raffi Khatchadourian, World Without End, New Yorker, May 18, 2015

Personal Case Study - GECOS BASIC / Games!

- Role
  - GE's standard time sharing service
- Story
  - First computer language I learned in 1977
  - Would stay after school to program and learned the computer could play games with you - GE Gunner, Stock Market
  - Wrote my first computer game - Star Trek
  - Opened my eyes to the power of computers

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- What computational challenge do video game designers face?
- What was the first: video game, commercial video game, successful commercial video game, home video game console, arcade video game to enter pop culture, home video game to enter pop culture?
- What video game console mainstreamed video gaming?
- What is your favorite video game and why?
- What makes video games so addictive?
- Who is the greatest video game artist and why?
- Why aren't video game creators as famous as other artists? Why did Electronic Arts original vision for the primacy of video game artists not succeed?
- If you could nominate 1 video game to be in an art museum - which would it be - and why?
- Can a video game make you cry?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
  - Coupland, Douglas - JPod
- Movies
  - JPod (Television series)
- Simulations

Conclusion

"Game Over!"

- Video game common form of farewell

Topic 21

Computers in the Arts

Song

Slide text

Thematic Quote

"Computer science is no more about computers than astronomy is about telescopes"

- Edsger Dijkstra, computer scientist

The Painting

Digital Arts and Chips of Note

- Robert Tinney

(Byte Magazine)

The Painting

Road to Point Reyes

- Rob Cook, Loren Carpenter, Tom Porter, Bill Reeves, David Salesin, and Alvy Ray Smith

(Pixar, first shown at SIGGRAPH '83 in Detroit)

"What was amazing about Pixar is that people took this long view of the problem. There was this picture they had made of the road to Point Reyes. The idea…was that if we just went outside and looked around, we saw this unbelievable landscape. Suppose you wanted to make a movie that was located there; what would it take to do that? It was this amazing moonshot idea." - Pat Hanrahan

[Reyes (Renders Everything You Ever Saw) became Lucasfilm's / Pixar's first rendering software, which led to Renderman, which led to Toy Story...]

- Leah Hoffmann, Attainting the Third Dimension, Communications of the ACM, June 2020

Artifact

- Name
  - AARON at aaronshome.com
- Year
  - 1973
- Story

The Question

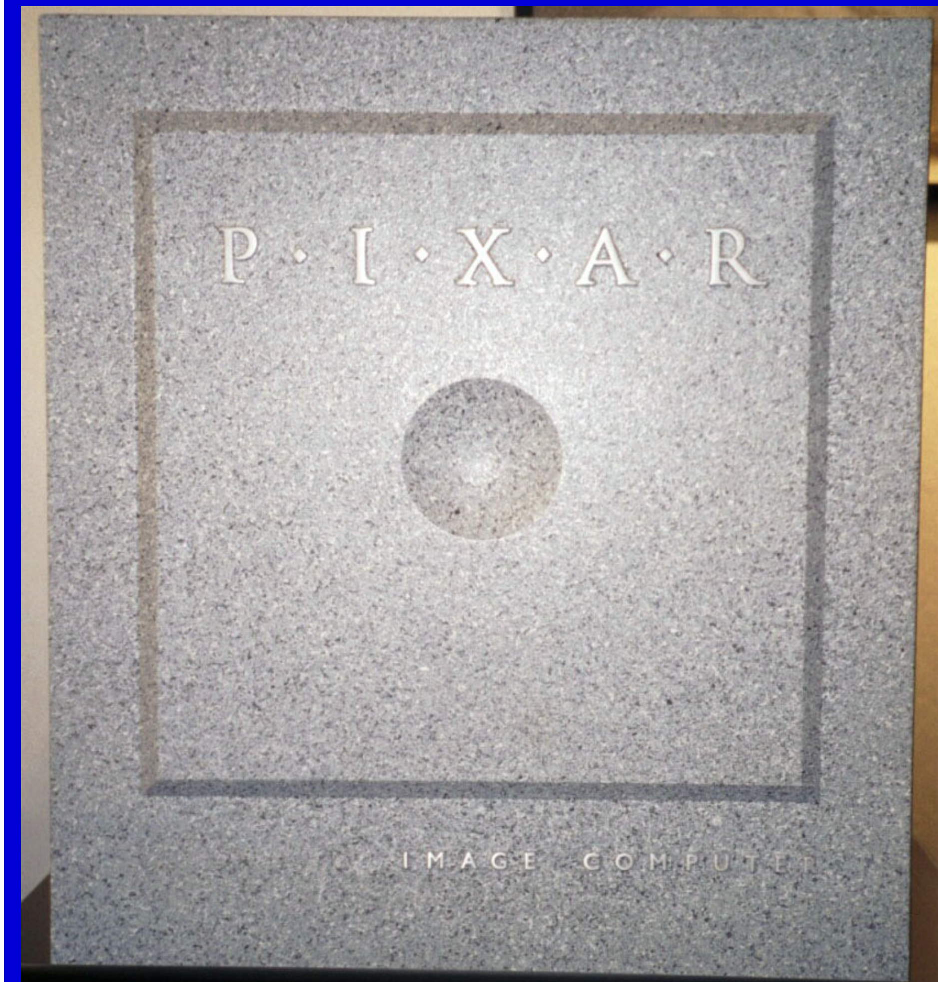
Can a computer create art on its own?

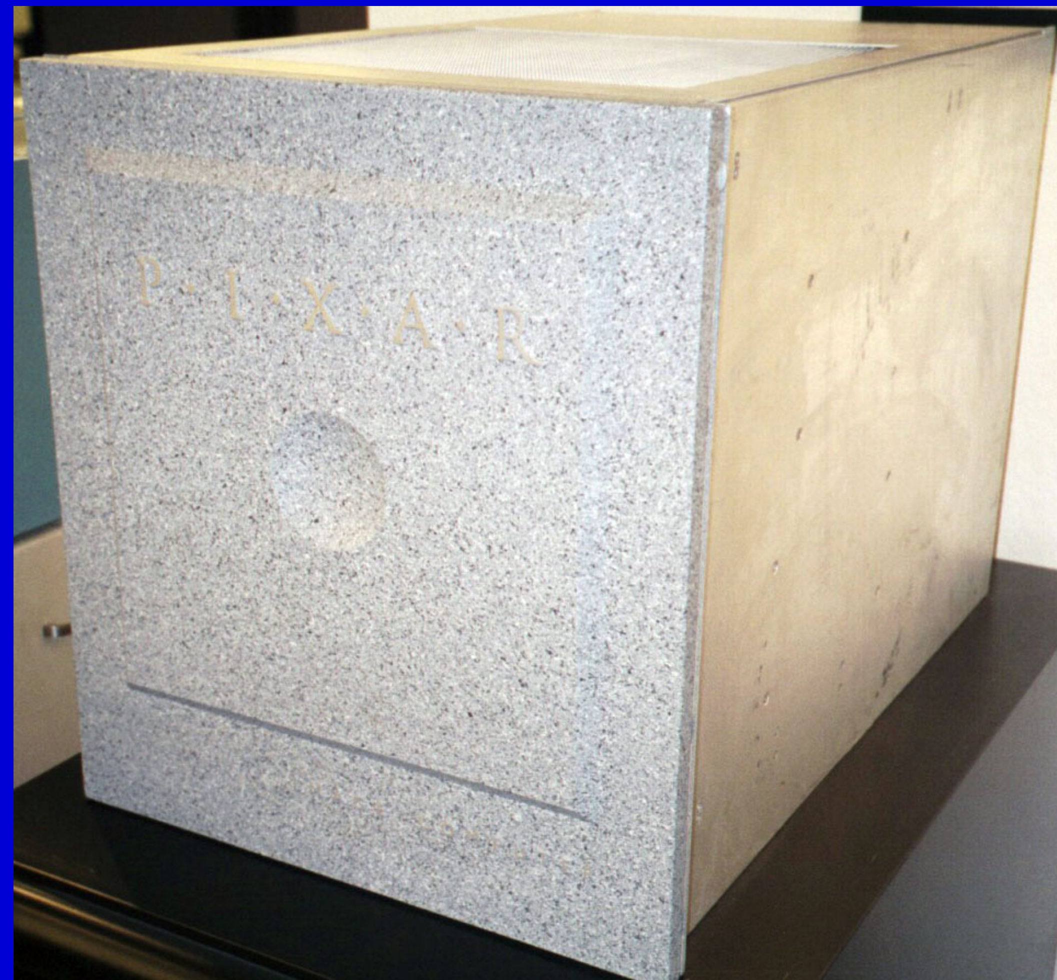
Pixar Lobby

Place - Pixar

- Significance
  - Humans using computers to create art
- Location
  - Emeryville, California
- Definition
  - Ground Zero for telling stories with computer animation
- People who worked there
  - Alvy Ray Smith, Ed Catmull, Steve Jobs
- Things created there
  - Pixar Image Computer, Renderman, Academy Award winning movies

Pixar Image Computer





Thing / Hardware - Pixar Image Computer

- Firsts / Achievements / Uniqueness / Significance
  - Dedicated three-dimensional high resolution rendering engine
- Place Produced (Company / Institution) ~ Year ~ Country
  - Pixar ~ 1986 ~ USA
- People involved (Designer)
  - Text
- Type
  - Graphics computer
- Price / Cost
  - $135,000
- Size
  - Text

Thing / Hardware - Pixar Image Computer

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - 11.8 MHz
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 100 million bytes ~ 32 bit
- Secondary memory type / technology ~ Size
  - Text
- Uses / Applications / Software
  - Medical image 3-D reconstructions, motion picture special effects
- Predecessors - N/A ~ Successors - N/A

Thing / Software - AARON

- **Firsts / Achievements / Uniqueness / Significance**
  - Tries to answer question of what are minimal conditions under which a set of marks functions as an image
  - Has moved from abstract to representational to abstract images
  - Work has been exhibited world wide, serving as artistic equivalence of Turing test
  - Cohen does not claim AARON is creative, but does ask "If what AARON is making is not art, what is it exactly, and in what ways, other than its origin, does it differ from the 'real thing?' If it is not thinking, what exactly is it doing?"
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Harold Cohen's studio ~ 1973 ~ USA
- **People involved (Programmer)**
  - Harold Cohen
- **Type**
  - Program that creates original artistic images
- **Price / Cost**
  - N/A
- **Computer and operating system it runs on**
  - Turtle robot drew the art on paper with imperfections to emulate a human, navigated via sonar, was replaced in early 1990's by robot arm
- **Computer language written in**
  - From C to Lisp, each new style of imagery it learns is hand-coded
- **Memory required**
  - Text
- **Predecessors - N/A ~ Successors - N/A**

Computing Case Study Summary - Photoshop

- Goal
  - Democratize access to raster graphics editing
- Center of Gravity (Strategy)
  - Create a raster graphics editor for personal computers
- Technology / Equipment
  - Photoshop 1.0 raster graphics editor released in 1990 for Macintosh
- Training
- Leadership
  - Thomas Knoll (PhD student at University of Michigan) + John Knoll (at Industrial Light and Magic)
- Morale
- Tactics
  - Plug-ins extend functionality
- Intangibles
- Mistakes
- Outcome
  - Roots of image processing come from Jet Propulsion Laboratory who developed first editing tools for use on data from early interplanetary missions in 1960's - 1990's - VICAR software
  - Photoshop provided these tools to everyone
  - Today enables work of artists at UnmannedSpaceflight.com + Michael Benson who process current + reprocess past NASA data

Computing Case Study Summary - Adaptive Optics

- Goal
  - Improve performance of optical systems on telescopes by reducing effect of atmospheric distortion caused by temperature changes
- Center of Gravity (Strategy)
  - Use deformable mirrors which change shape thousands of times/second to compensate for atmospheric distortion
- Technology / Equipment
  - Technology was developed for Strategic Defense Initiative + then declassified in 1991
  - Computers drive the mirrors + were fast enough to do so by 1990's
- Training ~ Leadership ~ Morale
- Tactics
  - Can be designed into new telescopes + retrofitted into older telescopes
- Intangibles ~ Mistakes
- Outcome
  - Has expanded + revolutionized the ability of Earth-based telescopes to acquire high resolution images
  - This second life for Earth-based telescopes which can be easily upgraded has lessened the needs for space-based telescopes which cannot be easily upgraded

- Joe Palca, For Sharpest Views, Scope the Sky with Quick-Change Mirrors, NPR, June 24, 2013

Person - Susan Kare

- Significance
  - Created the original icons + fonts for Macintosh
- Profession
  - Artist + graphic designer
- Places worked
  - Apple, NeXT, own firm
- Years of work
  - 1983 - present
- Things worked on
  - Macintosh, Windows, OS/2, Facebook

Person - Robert Tinney

- Significance
  - Comes up with visual metaphor to quickly convey client's message
- Profession
  - Artist
- Places worked
  - Self-employed
- Years of work
  - 1975 - present
- Things worked on
  - BYTE magazine covers

Person - Doug Menuez

- Significance
  - Provided a photojournalist's documentation of a time of great change in Silicon Valley via 250,000 images ~ Witness to end of PC era + birth of Internet era in Valley
- Profession
  - Photojournalist
- Places worked
  - Silicon Valley
- Years of work
  - 1985-2000
- Things worked on
  - Documenting the digital revolution in Silicon Valley
    - Started with Steve Jobs + NeXT, branched off eventually into the entire Valley
    - Was inspired at the start by individual's desire to use their work to make world a better place
    - Dismayed at the end by individual's desire to use their work to become rich and thus he left the Valley
    - Goals - Record daily life of people in companies, Understand human side of technology + what motivates people to take risks + try to change the world, Explore nature of innovation + how creativity is nurtured, Provide image database for future visual anthropologists, Look for signs of stress in Valley, Explore roles of women in Valley

"Fearless Genius refers to those I observed who had true intellectual genius, usually in math and science, or a kind of genius of vision, combined with a rare ability to boldly pursue the power of their ideas to fruition or failure, risking everything they had - health, sanity, family, career. The sacrifice required to invent new technology was great and not understood by the outside world."

\- Doug Menuez, Fearless Genius: The Digital Revolution in Silicon Valley 1985-2000

Person - David Bunnell

- **Significance**
  - **Serial computer magazine founder who charted growth of personal computer from hobbyist roots to it becoming engine of what John Doerr later called "largest legal accumulation of wealth in history"**
  - **First issue of PC Magazine was 100 pages, second issue was 400 pages**

  "Getting ads was so easy, all you had to do was answer the phone." - David Bunnell

  "I believe that David never got the credit he deserved for inventing the computer magazine industry, the first personal computer trade show and much of the landscape of the industry" - John Dvorak, computer columnist
- **Profession**
  - **Journalist, publisher**
- **Places worked**
  - **MITS, Ziff-Davis, International Data Group**
- **Years of work**
  - **1973-2000**
- **Things worked on**
  - **MITS Computer Notes, Personal Computing, PC Magazine, PC World, Macworld, Upside**

- John Markoff, David Bunnell A Founder of Tech Magazines PC World and Macworld Dies at 69, New York Times, Oct. 21, 2016

Ad - The Bastards Say, Welcome

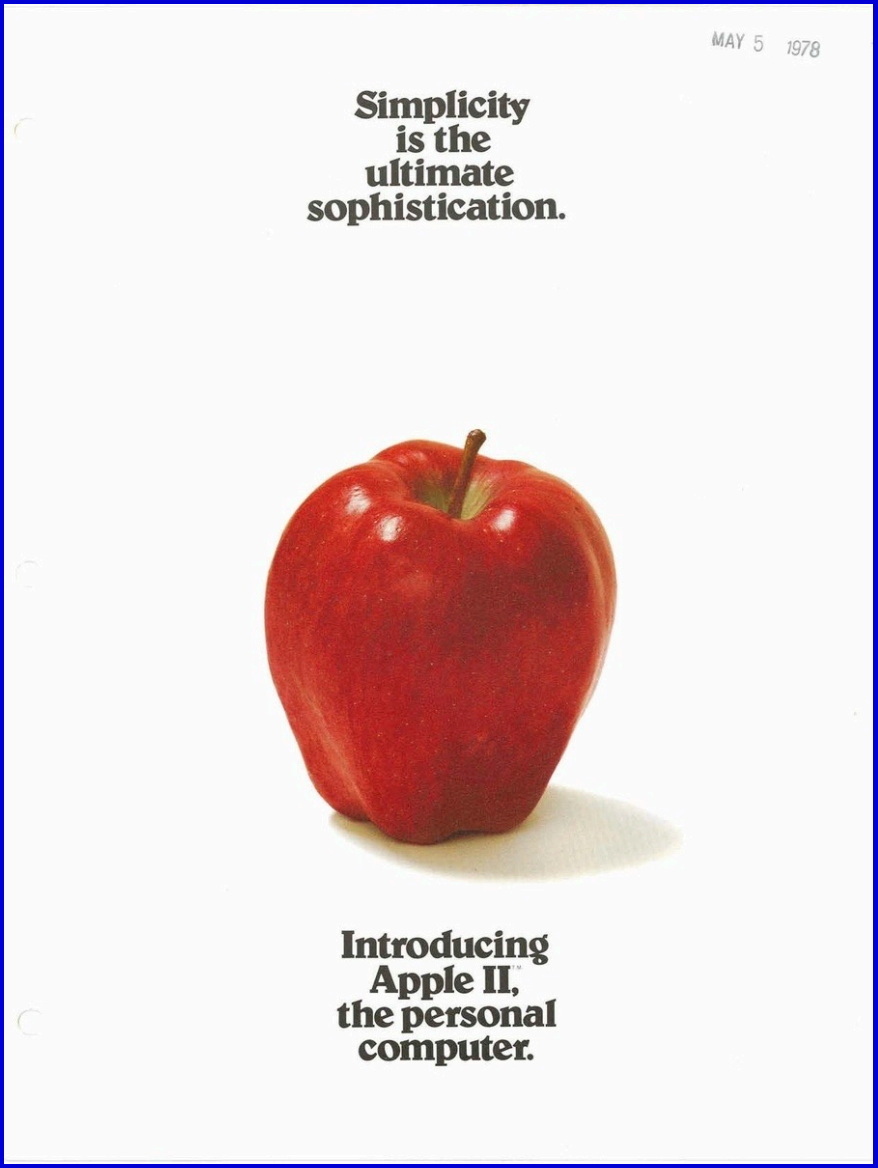
- Company - Data General
- Year - 1976
- Story
  - After IBM announced the Series/1, a 16-bit minicomputer designed to compete with DEC's PDP-11 and the Data General Nova, Data General marketing came up with a rough draft of a 2-page ad:

    "They Say IBM's Entry Into Minicomputers Will Legitimize The Market.

    The Bastards Say, Welcome."

The ad was never run

Simplicity is the Ultimate Sophistication



Attribution unknown

Ad - Simplicity is the Ultimate Sophistication

- Company - Apple
- Year - 1978
- Story

  "Simplicity is the ultimate sophistication.
  Introducing Apple II, the personal computer"

Bicycle For The Mind

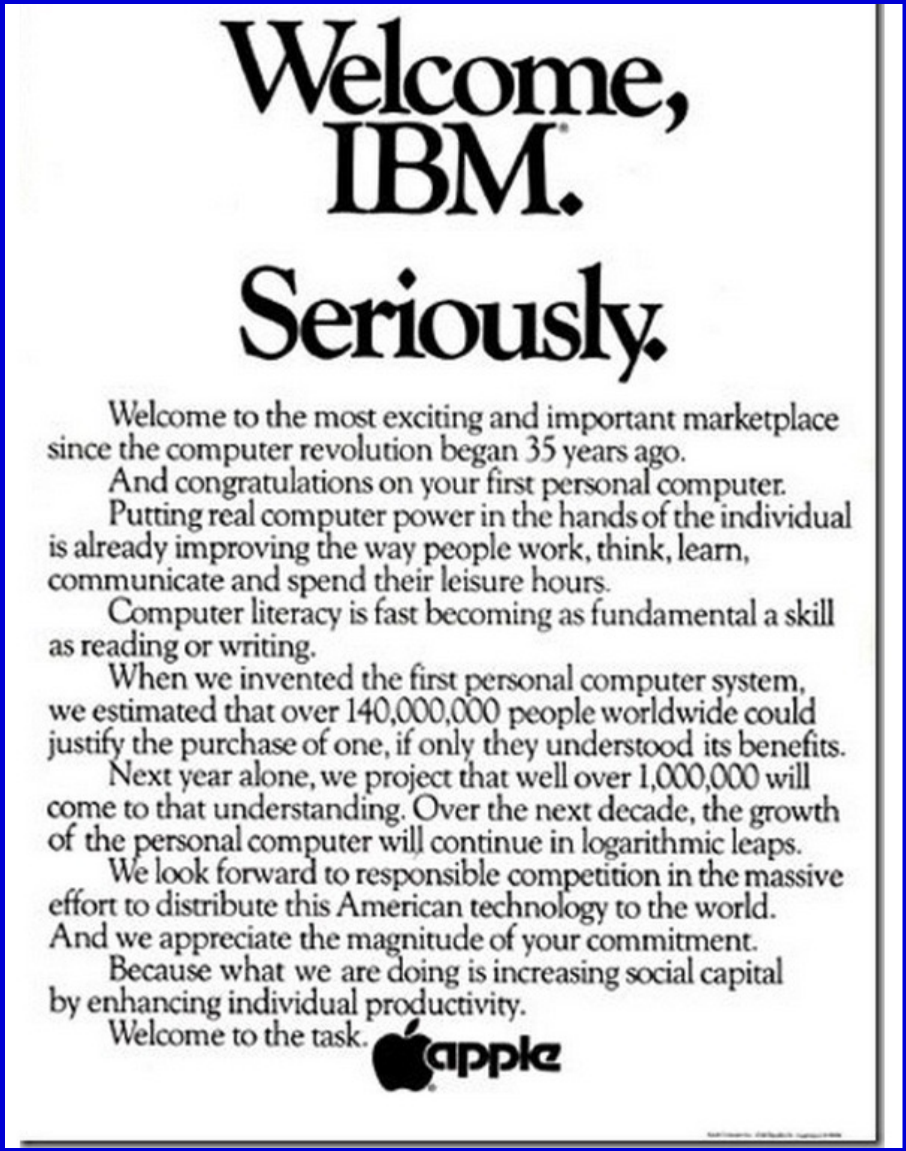
Attribution unknown

Ad - Bicycle for the Mind

- Company - Apple
- Year - 1981
- Story

  "When we invented the personal computer, we created a new kind of bicycle"

Welcome IBM



Attribution unknown

Ad - Welcome, IBM. Seriously

- Company - Apple
- Year - 1981
- Story
  - On IBM's entry to the personal computer industry

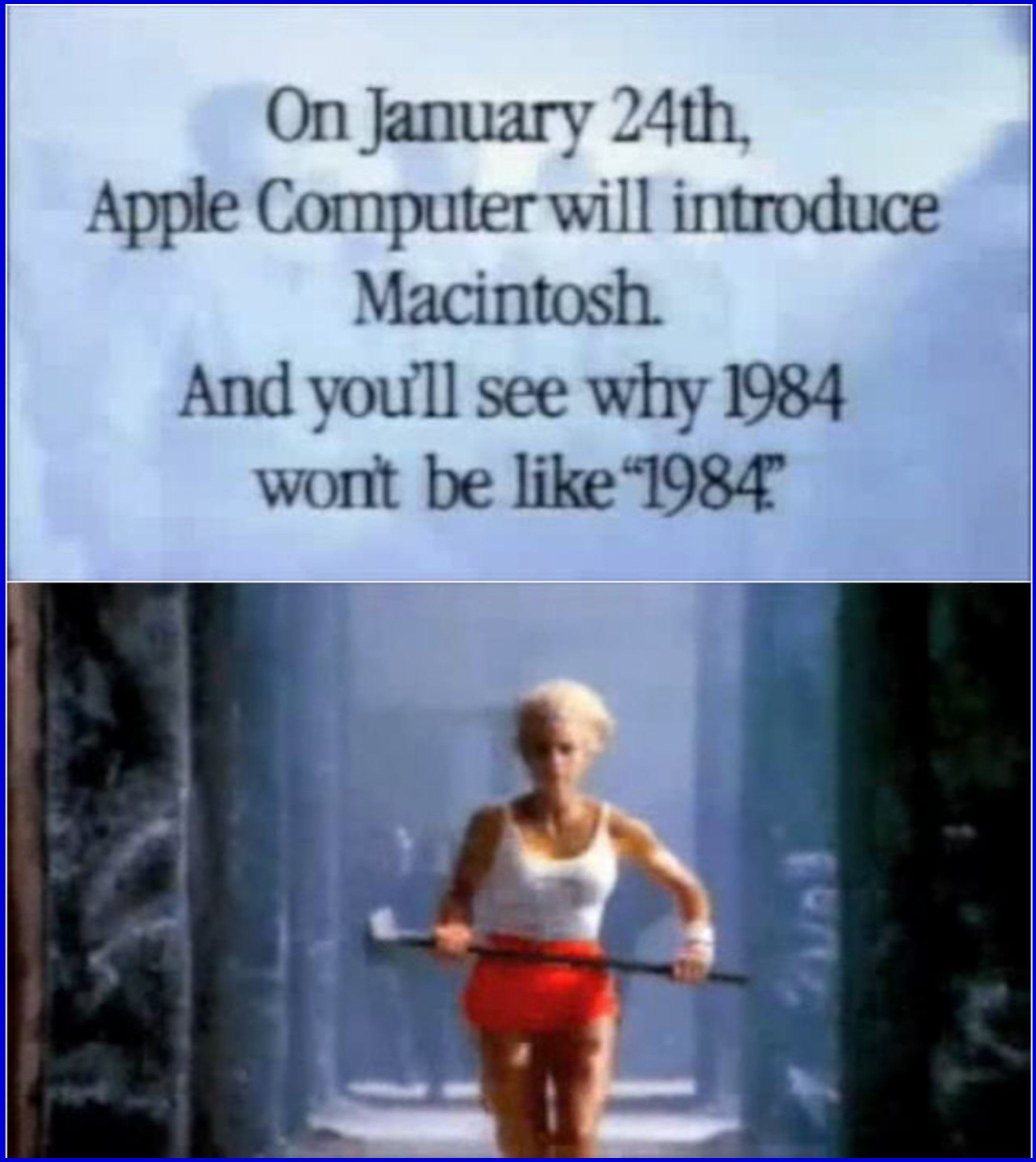
IBM PC

Attribution unknown

Ad - IBM Charlie Chaplin

- Company - IBM
- Year - 1981
- Story
  - Use an image from the past to sell a product from the future

1984

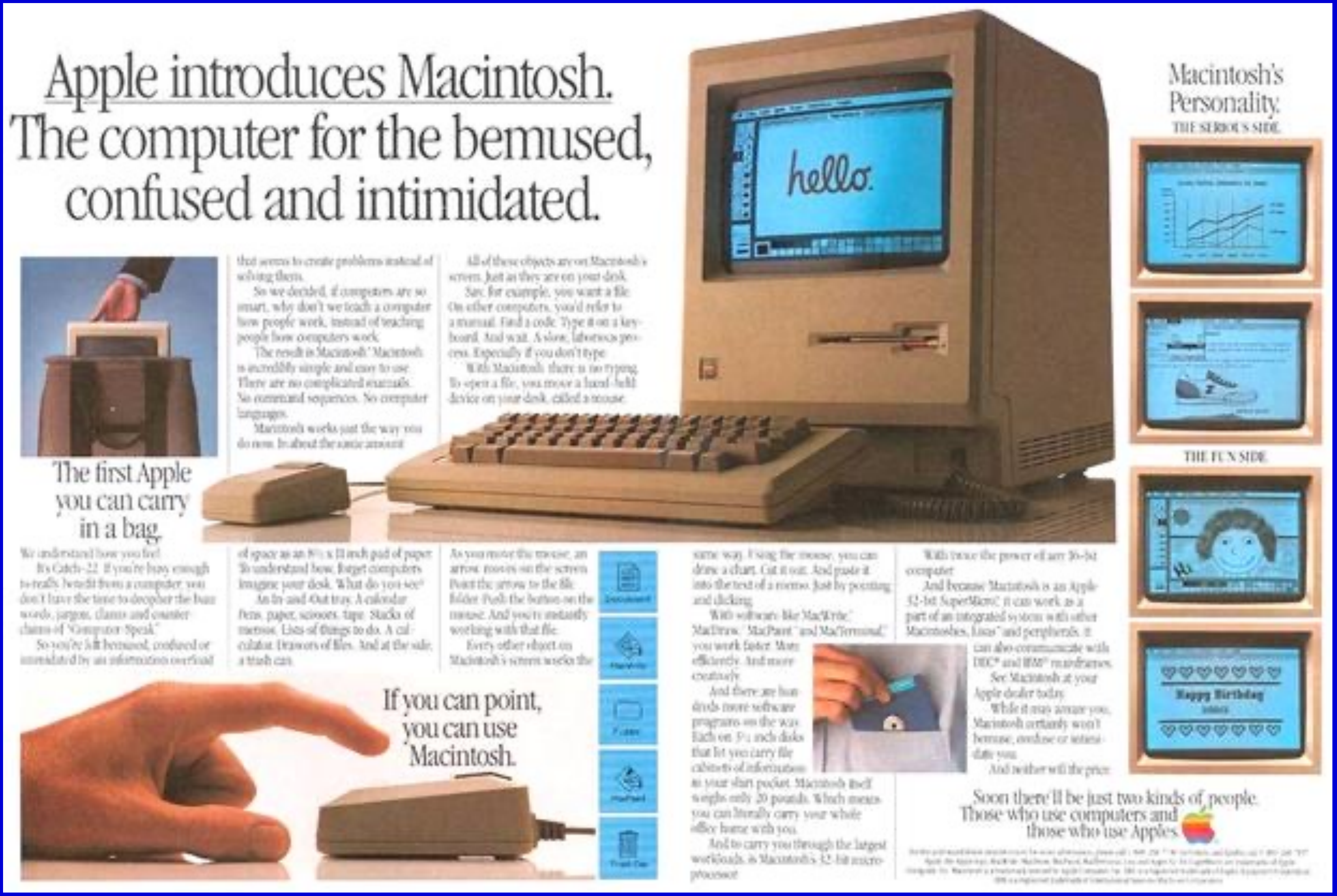


Attribution unknown

Ad - 1984

- Company - Apple
- Year - 1984
- Story
  - Directed by Ridley Scott on a movie budget
  - Announces arrival of Macintosh as antidote to IBM
  - Ran once during the Super Bowl

Apple Macintosh



Attribution unknown

Ad - Hello

- Company - Apple
- Year - 1984
- Story
  - Introducing Macintosh
  - Anthropromorphize the Macintosh

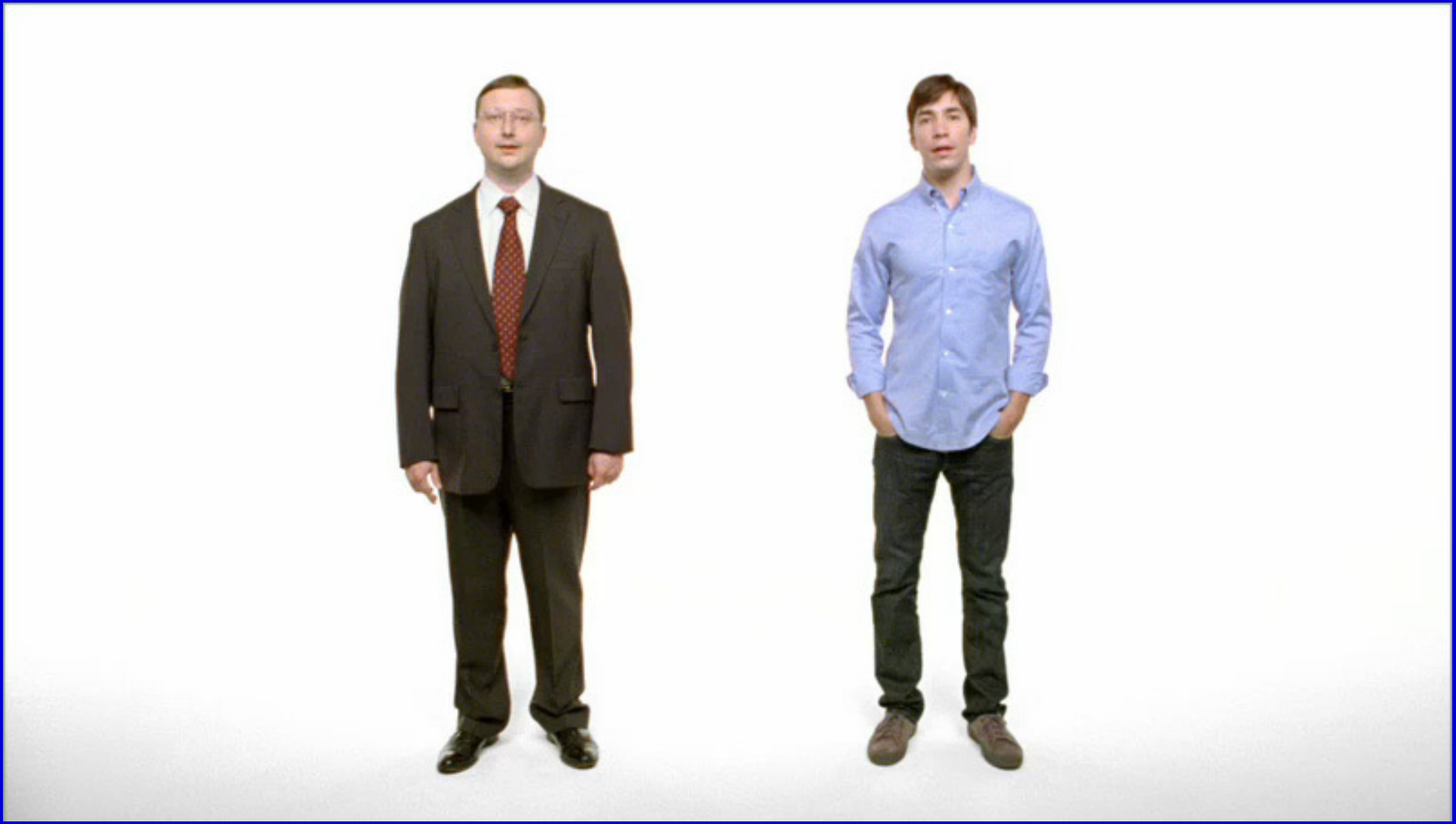
Think Different

Attribution unknown

Ad - Think Different

- Company - Apple
- Year - 1997
- Story
  - Re-brand the company and what it stands for

I'm a Mac - I'm a PC



Attribution unknown

Ad - Get a Mac

- Company - Apple
- Year - 2007 - 2009
- Story
  - Define the Mac as cool and the PC as uncool and show why in a humorous way

Electronic Arts

Attribution Unknown

Ad - Can A Computer Make You Cry?

- Company - Electronic Arts
- Year - Early 1980's
- Story
  - Attempt to identify and glorify video game software artists and have their work recognized as being serious art

Personal Case Study - SIGGRAPH 1983

- Role
  - The premiere computer graphics meeting in the world
- Story
  - Served as a student volunteer at 1983 meeting in Detroit
  - Was blown away / inspired by the work I saw at the Art Show and Movie Show - I saw the future that we take for granted today in terms of computer graphics
    - Saw Pt. Reyes - image of a road after a rain storm with a rainbow by the team that would become Pixar
    - Saw "The Works" by a team that would found Pixar and "EconoMars Earth Tours" movies

Personal Case Study - Pixar

- Role
  - The premiere computer animation movie studio
- Story
  - In 2004 received a tour of the studio from an animator…from his personalized office on the movie set where he did his work…to the render farm…to the screening studio…to Steve Jobs' office
  - Enjoyed seeing the links to the past greats of animation - "The Illusion of Life: Disney Animation"
  - Saw the single central bathroom…where all the important networking occurred

Personal Case Study - David Bunnell

- Role
  - While I was attending Macworld San Francisco 1992
- Story
  - He approached me in the exhibit hall. He was a wild looking individual who was full of energy and had an infectious smile. He asked me "What's new + exciting to you here?"

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- What computational challenges are faced by the designers of artistic software?
- Does AARON pass the Turing Test?
- How can computers be used to help humans create art?
- Are videogames a form of art?
- How can art be used to help market and sell computers?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
- Simulations

Conclusion

Topic 22

Computers for Learning

Song

Slide text

Thematic Quote

"Historically, in education the presentation has been fixed and the grade has been variable. Now through the use of computers it will be able to fix the grade and make the presentation variable"

- Steve Wozniak, founder Apple Computer

The Painting

Keys to Education and Graduation Memories and Simulation

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - One Laptop Per Child laptop
- Year
  - 2008
- Story

The Question

Can learning be made interesting, easy, fun, invisible?...Or does <u>real</u> learning require hard work?

Children are learning machines

- They teach themselves to talk, to walk, to survive in the world
- They are infinitely inquisitive about everything - until school beats that interest out of them

"Education is not preparation for life; education is life itself."

- John Dewey, educator

"Everyone is born a genius"

- Buckminister Fuller, inventor

I Seem To Be a Verb

"The mind is not a vessel to be filled, but a fire to be lighted"

- Plutarch, Greek historian

"Education is not the filling of a pail but the lighting of a fire"

- William Butler Yeats, poet

"It is a miracle that curiosity survives formal education"

- Albert Einstein, physicist

"Love is a better Teacher than Duty!"

- Albert Einstein, physicist

"I think the big mistake in schools is to try to teach children anything, and by using fear as the basic motivation. Fear of getting failing grades, fear of not staying with your class, etc. Interest can produce learning on a scale compared to fear as a nuclear explosion to a firecracker."

- Stanley Kubrick, director

"Everything is interesting, until ruined for us. Nothing in the Universe is intrinsically uninteresting. Schooling systemically ruins things for us, wiping out these interests; the last thing to be ruined determines your profession."

- Theodor Holm Nelson, hypertext visionary, in No More Teacher's Dirty Looks, Computer Decisions, Sept. 1970

Theories of Learning Are Changing

- Learning is increasingly being regarded as an apprenticeship
  - Learning should be active, rather than passive, in nature
    - Norman DA, Spohrer JC. Learner Centered Education. Communications of the ACM 1996; 38 (4) : 24-27
  - Learning should be situated in real life experiences, rather than revolving around contrived experiences
    - Seely Brown J, Collins A, Duguid P. Situated Cognition and the Culture of Learning. Educational Researcher 1989; 18(1) 32-42.
  - Learning is being recognized as a process that occurs best when it occurs in a collaborative, rather than individual manner
    - Holt J. Learning All the Time. Addison Wesley. Reading, MA. 1989.. 148-162.
  - Learning occurs more commonly outside, rather than inside, of school
    - Resnick LB. Learning In School and Out. Educational Researcher 1987; 16(8): 13-20.
  - Learning occurs through the transformation, not the transmission, of information.
    - Learner begins with data, with some effort can transform the data into information, with more effort can transform the information into knowledge, and with further effort may be able to transform the knowledge into creativity and wisdom.
- Learning is a life long continuum, rather than an isolated process

Theories of Teaching Are Changing

- Teaching therefore, must undergo a fundamental transformation
  - Teachers are going from
    - Being a "sage on the stage" to being a "guide on the side"
    - Being a lecturer or transmitter of information to being a navigator of information for their students

Theories of Learning Are Changing
The Apprentice Learner

- Apprentice learner's continuum of learning requires continuum of information support via convenient and rapid access to authoritative information

Learning is an Apprenticeship

- Thus the name apprenticechip, whose holy trinity is the apprentice, the library, and the computer

- Autodidact - from the Greek autodidaktos, meaning self-taught
- An autodidact is a self-taught person

Enhancing apprenticeship

"A man is the product of his education, his work, his reading, all his experience."

- Edward R. Murrow, journalist, 1962

Richard Saul Wurman

- Learning takes place not from answering questions, but from questioning answers
- Saying "I don't know" is frowned upon
- Can learn more from failure than you can from success
- Short term memory is not learning
- Learning is remembering what you are interested in, and in making connections between interests
- When you sell your expertise, you sell from a limited repertoire
  - When you sell your ignorance - your desire to learn - your curiosity - your repertoire is unlimited
    - He gets paid to learn about things he doesn't know about

"Anyone who has never made a mistake has never tried anything new"

- Albert Einstein, physicist

Apprentice Learning Experiences in My Life, and the Analog Libraries Used

- Spaceflight
  - Kerby elementary school library
- Oceanography
  - Science Research Associates learning kit + The Undersea World of Jacques Cousteau
- Military
  - Grosse Pointe Public Library, specifically Jane's Warships
- Sherlock Holmes
  - Intelligent agents at National Library of Medicine
- Coral reefs
  - Heron Island Information Centre
- Leonardo da Vinci
  - Windsor Castle library

Apprenticeship Examples
Heron Island

Learning Circle

Library

Apprenticeship Examples
Taliesen Fellowship

Begin by designing tent

End by designing house

Royal Navy Midshipman

- Great example of an apprentice learner in the time of Nelson up to today

Apprenticeship in the History of the United States

- 3 great industrial revolutions in the 20th century - automobiles in Detroit, planes in Los Angeles, computers in Silicon Valley
- All these revolutions were by the self taught - you learned by doing, from experience
- Henry Ford Museum / Edison Institute is a shrine to apprenticeship

Person - Thomas Alva Edison

- Significance
  - Most importantly launched concept of industrial research laboratory
- Profession
  - Inventor and Entrepreneur
- Places worked
  - Menlo Park New Jersey
- Years of work
  - 1870's-1931
- Things worked on
  - Genius "is ninety-nine percent perspiration and one percent inspiration"
  - "I know how to steal" - Thomas Edison
  - Improved the stock ticker and made many improvements to telegraph
  - Incandescent lamp and the electrical supply and distribution system to power it
  - Mechanical phonograph which he constantly improved and became cash cow
  - Motion pictures - kinetoscope
  - Had failures - iron ore processing, battery power for electric cars, prefabricated poured concrete houses
  - Eventually taken out by "Innovator's Dilemma" - did not embrace the future - radio and electronic phonograph

- George E. Davidson, Beehives of Invention: Edison and His Laboratories

Edison's Menlo Park Laboratory

Henry Ford Bagley Avenue Workshop / Garage

Wright Cycle Company

Store

Garage in back

Inside garage

Great Apprentice Learners

- Abraham Lincoln
- Henry Ford
- Thomas Edison
- Wright brothers

  "We were lucky enough to grow up in a home environment where there was always much encouragement to children to pursue intellectual interest; to investigate whatever aroused curiosity. In a different kind of environment our curiosity might have been nipped long before it could have borne fruit" - Orville Wright, aviator
- Frank Lloyd Wright
  - Taliesen Fellowship is the ultimate example of apprenticeship - you start by making your own dwelling / tent in the desert, and then go from there
- Steve Wozniak + Steve Jobs

Steve Jobs and Apprenticeship

"Heathkits were really great. Heathkits were these products that you would buy in kit form. You actually paid more money for them than if you just went and bought the finished product if it was available. These Heathkits would come with these detailed manuals about how to put this thing together and all the parts would be laid out in a certain way and color coded. You'd actually build this thing yourself. I would say that this gave one several things. It gave one a understanding of what was inside a finished product and how it worked because it would include a theory of operation but maybe even more importantly it gave one the sense that one could build the things that one saw around oneself in the universe. These things were not mysteries anymore. I mean you looked at a television set you would think that "I haven't built one of those but I could. There's one of those in the Heathkit catalog and I've built two other Heathkits so I could build that." Things became much more clear that they were the results of human creation not these magical things that just appeared in one's environment that one had no knowledge of their interiors. It gave a tremendous level of self-confidence, that through exploration and learning one could understand seemingly very complex things in one's environment. My childhood was very fortunate in that way."

- Steve Jobs, Smithsonian Institution Oral History Interview, Apr. 20, 1995

The Roots of Our Current Education System In the Industrial Revolution in the 19th Century

"As factory jobs overtook agricultural ones, literacy and numeracy became much more important. Employers realised that more educated workers were more productive, but were reluctant to train them themselves because they might defect to another employer. That prompted the introduction of universal state education on a factory model, with schools supplying workers with the right qualifications to work in factories. Industrialisation thus transformed both the need for education and offered a model for providing it."

- Re-Educating Rita, The Economist, Jun. 25, 2016

History of Organized School

- …is a relatively short one beginning in industrial revolution
- Learning through time has been an apprenticeship
- Organized school is a bug that will be corrected
- Learning will return to being an apprenticeship
- Teachers need to move from being a sage on the stage to a guide on the side

"Tell me, I'll forget. Show me, I may remember. But involve me and I'll understand."

- Chinese proverb

"Docendo Discimus - I teach, therefore I learn"

- Seneca the Younger, philosopher

"If we regard truth as something handed down from authority on high, the classroom will look like a dictatorship. If we regard truth as a fiction determined by personal whim, the classroom will look like anarchy. If we regard truth as emerging from a complex process of mutual inquiry, the classroom will look like a resourceful and independent community."

- Parker Palmer, educator, in The Courage to Teach

The Ultimate Goal?

"Once we have computer outlets in every home, each of them hooked up to enormous libraries where anyone can ask any question and be given answers, be given reference materials, be something you're interested in knowing, from an early age, however silly it might seem to someone else… that's what YOU are interested in, and you can ask, and you can find out, and you can do it in your own home, at your own speed, in your own direction, in your own time… Then, everyone would enjoy learning. Nowadays, what people call learning is forced on you, and everyone is forced to learn the same thing on the same day at the same speed in class, and everyone is different."

- Isaac Asimov on Bill Moyers World of Ideas, 1988

Moyers: But what about the argument that machines, computers, dehumanize learning?

Asimov: As a matter of fact, it's just the reverse. It seems to me that, through this machine, for the first time we'll be able to have a one-to-one relationship between information source and information consumer.

Jerome Bruner
The Process of Education

"We begin with the hypothesis that any subject can be taught in some intellectually honest form to any child at any stage of development." - Jerome Bruner

- Features of the spiral curriculum
  - Student revisits topic, theme or subject several times throughout their school career
  - Complexity of topic or theme increases with each revisit
  - New learning has a relationship with old learning and is put in context with the old information
- Benefits ascribed to the spiral curriculum
  - Information is reinforced + solidified each time student revisits subject matter
  - Spiral curriculum also allows a logical progression from simplistic ideas to complicated ideas
  - Students are encouraged to apply the early knowledge to later course objectives

- Howard Johnston, The Spiral Curriculum, Education Partnerships, Mar. 2012

"True learning is figuring out how to use what you already know in order to go beyond what you already think."

- Jerome Bruner, psychologist

Person - John Holt

- Significance
  - Founder of home schooling movement
- Profession
  - Educator
- Places worked
  - Originally in the school system and then outside of it
- Years of work
  - 1960's - 1980's
- Things worked on
  - Unschooling / Growing Without Schooling
    - How Children Learn
    - Teaching Your Own
    - Learning All The Time

Learning All The Time - John Holt

- **Young children as research scientists**
  - **Process by which children turn experience into knowledge is exactly the same as the process by which scientists make scientific knowledge**
- **What parents can do**
  - **A word to the wise is *infuriating* / Be guide on the side**
- **The nature of learning**
  - **Helping children explore and learn in the world is best seen as a branch of natural science, like trying to raise exotic plants or little known animals**
- **Teaching does not make learning**
  - **Learners create learning - Children are natural learners**

Learning All The Time - John Holt

- We can best help children learn
  - By making the world accessible to them
  - Paying serious attention to what they do
  - Answering their questions
  - Helping them explore the things they are most interested in

  - …by encouraging and helping them to learn what they are already busy learning

MIT Media Lab

Place - MIT Media Lab

- Significance
  - Try to invent the future of education (amongst other things)
- Location
  - Boston, Massachusetts
- Definition
  - Interdisciplinary research lab working at the convergence of technology, media, and design
  - Alliance between commercial companies + academia
- People who worked there
  - Seymour Papert
- Things created there
  - Logo computer language, LEGO Mindstorms, One Laptop Per Child

Seymour Papert

From Wikimedia Commons

Person - Seymour Papert

- Significance
  - Popularized constructionist model of learning through use of Logo computer language

  "The word constructionism is a mnemonic for two aspects of the theory of science education underlying this project. From constructivist theories of psychology we take a view of learning as a reconstruction rather than as a transmission of knowledge. Then we extend the idea of manipulative materials to the idea that learning is most effective when part of an activity the learner experiences as constructing is a meaningful product."

  - Seymor Papert, computer scientist
- Profession
  - Computer scientist
- Places worked
  - MIT
- Years of work
  - 1960's - 2000's
- Things worked on
  - Constructionism
  - Logo computer language
  - Book - Mindstorms

Mindstorms - Seymour Papert

- Is about children learning without being taught
- Real learning is not rote and not commanded, but the result of exploration and delight
- Building learning communities / Microworlds
  - Samba school
  - Logo programming - a bug is a feature, learn from mistakes

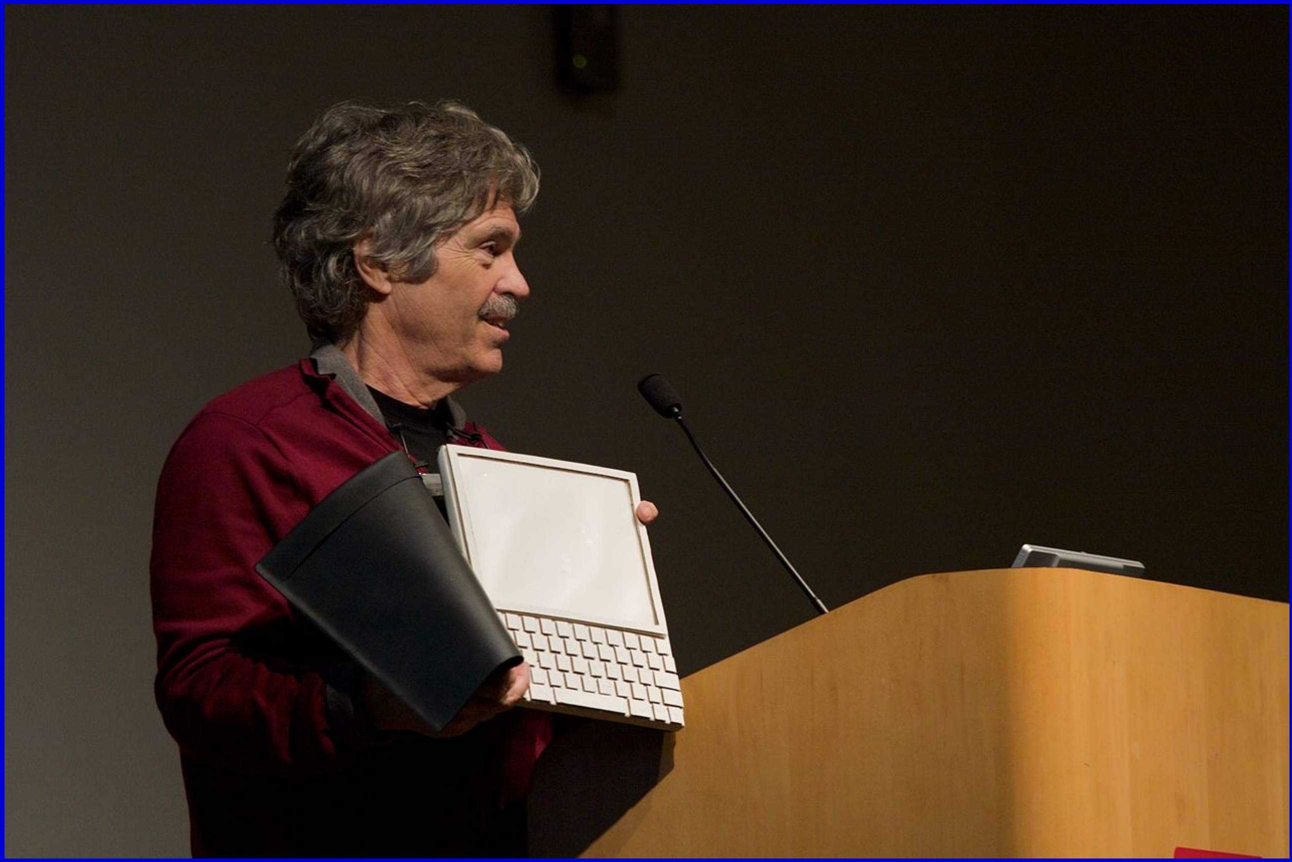
"Anyone who has never made a mistake has never tried anything new"

- Albert Einstein

"Should the computer program the kid, or should the kid program the computer?"

- Seymor Papert, computer scientist

Alan Kay



From Wikimedia Commons

Person - Alan Kay

- Significance
  - Personal Dynamic Media, Computer 10(3):31-41. March 1977
    - Sketched out how the computer can be the ultimate learning tool
- Profession
  - Computer scientist
- Places worked
  - Xerox PARC, Apple, Atari, Disney, HP, Viewpoints Research Institute, SAP
- Years of work
  - 1970 - present
- Things worked on
  - Dynabook, Smalltalk, Squeak, EToys

"Point of view is worth 80 IQ points" = "The power of the context"

- Aian Kay, computer scientist, regarding the ARPA / PARC research community of the 1960's + 1970's and what they achieved

On Learning Curves

"There is the desire of a consumer society to have no learning curves. This tends to result in very dumbed-down products that are easy to get started on, but are generally worthless and/or debilitating. We can contrast this with technologies that do have learning curves, but pay off well and allow users to become experts (for example, musical instruments, writing, bicycles, etc. and to a lesser extent automobiles). [Douglas] Engelbart's interface required some learning but it paid off with speed of giving commands and efficiency in navigation and editing. People objected, and laughed when Doug told them that users of the future would spend many hours a day at their screens and they should have extremely efficient UIs they could learn to be skilled in.

There is the general desire of people to be change adverse - "people love change except for the change part" - this includes the QWERTY and no-learning-curve ideas."

- Alan Kay, computer scientist

Alan Kay Through the Years

"The computer, viewed as a medium itself, can be all other media...This new "metamedium" is active - it can respond to queries and experiments - so that the messages may involve the learner in a two-way conversation. This property has never been available before except through the medium of an individual teacher. We think the implications are vast and compelling."

"Simulation is the central notion of the Dynabook."

"A great deal of effort has been put into providing both endless possibilities and easy tool-making through the Smalltalk programming language."

- Alan Kay + Adele Goldberg, Personal Dynamic Media, IEEE Computer, Mar. 1977

Alan Kay Through the Years

"The evolution of the personal computer has followed a path similar to that of the printed book, but in 40 years rather than 600. Like the handmade books of the Middle Ages, the massive computers built in the two decades before 1960 were scarce, expensive and available to only a few. Just as the invention of printing led to the community use of books chained in a library, the introduction of computer time-sharing in the 1960's partitioned the capacity of expensive computers in order to lower the access cost and allow community use. And just as the Industrial Revolution made possible the personal book by providing inexpensive paper and mechanized printing and binding the microelectronic revolution of the 1970's will bring about the personal computer of the 1980's with sufficient storage and speed to support high-level computer languages and interactive graphic displays."

"Thus the central problem of personal computing is that nonexperts will almost certainly have to do some programming if their personal computer is to be of more than transitory help."

"We should not predict or expect that the personal computer will foster a new revolution in education just because it could. Every new communication medium of this century - the telephone, the motion picture, radio and television - has elicited similar predictions that did not come to pass."

"The social impact of simulation - the central property of computing - must also be considered."

- Alan Kay, Microelectronics and the Personal Computer, Scientific American, Sep. 1977

Alan Kay Through the Years

"McLuhan's claim that the printing press was the dominant force that transformed the hermeneutic Middle Ages into our scientific society should not be taken too lightly - especially because the main point is that the press didn't do it just by making books more available, it did it by changing the thought patterns of those who learned to read."

"What McLuhan was saying is that if the personal computer is a truly new medium then the very use of it would actually change the thought patterns of an entire civilization. He had certainly been right about the effects of the electronic stained-glass window that was television - a remedievalizing tribal influence at best. The intensely interactive and involving nature of the personal computer seemed an antiparticle that could annihilate the passive boredom invoked by television. But it also promised to surpass the book to bring about a new kind of renaissance by going beyond static representations to dynamic simulation. What kind of a thinker would you become if you grew up with an active simulator connected, not just to one point of view, but to all the points of view of the ages represented so they could be dynamically tried out and compared? I named the notebook-sized computer idea the Dynabook to capture McLuhan's metaphor in the silicon to come."

"I had believed that end users needed to be able to program before the computer could become truly theirs...The ability to "read" a medium means you can access materials and tools created by others. The ability to "write" in a medium means you can generate materials and tools for others. You must have both to be literate. In print writing, the tools you generate are rhetorical; they demonstrate and convince. In computer writing, the tools you generate are processes; they simulate and decide."

"If the computer is only a vehicle, perhaps you can wait until high school to give "driver's ed" on it - but if it's a medium, then it must be extended all the way into the world of the child. How to do it?"

- Alan Kay, User Interface: A Personal View, published in Multimedia From Wagner to Virtual Reality, 1989

Alan Kay Through the Years

"The heart of computing is building a dynamic model of an idea through simulation. Computers can go beyond static representations that can at best argue; they can deliver sprightly simulations that portray and test conflicting theories. The ability to "see" with these stronger representations of the world will be as important an advance as was the transition to language, mathematics and science from images and common sense."

- Alan Kay, Computers, Networks and Education, Scientific American, Sep. 1991

Alan Kay Through the Years

"The other influence I had was the history of books. There was an "institutional" phase. In the year 1400 in the Vatican Library there were only 392 books. They were done by hand and it took ten years to copy one. In today's terms, 10 years at $15 / hour is $300,000. Special books might cost the equivalent of several million dollars.

In the mid 1400s, when the printing press came along, Bibles were large, they were almost two feet high and the type was about a half an inch high. They looked just like manuscripts. The reason for this is that they didn't know what books should look like. A Gutenberg Bible of 1455 cost about 3 years of a clerk's wages (about $60,000 today). So a well off person could own one. I thought of this as the "personal" book. I realized that desktop computers like the FLEX machine looked just like time-sharing terminals. Time sharing is the institutional phase of computing. Desktop computers are the personal phase of computers. (The FLEX machine was called a personal computer in my 1969 thesis.) Then I remembered that in another fifty years a Venetian printer by the name of Aldus made books the size they are today. And that was because he went out and measured saddle bags in Venice and he realized for the first time that books could be carried with people and so they had to be made in portable size. So this idea of a Dynabook came from thinking about this third phase of computing - what I would call intimate computing - where you can own these things like you own books and you can take them with you…So I started thinking about making a power idea toy for children that I called the Dynabook."

- Karen Frenkel, A Conversation With Alan Kay, Interactions, Apr. 1994

Alan Kay Through the Years

"Marshall McLuhan makes the distinction between a technology and a medium. The technology is the machinery and the medium is the way you use it. Consider for instance printing press machinery (the technology), and then the essay form (the medium), that was invented about one hundred years later...The technology of a Dynabook was behind schedule because America gave up the work on the flat screen display...What I think of as a medium is not here at all. Just as McLuhan predicted, computers today are almost universally used - except by scientists - for just imitating paper...The exceptions are those computer scientists and some physical scientists who use a computer for what its really good at, which is making and understanding complex models of things..."

"The most powerful programming language can be and should be created for children to learn...Children should be taught to think...People who learn to think well in our society are not doing it just by IQ, they do it by being more facile at representing things...I'm only interested in programming in so far as it is a vehicle for that kind of thing."

- Karen Frenkel, A Conversation With Alan Kay, Interactions, Apr. 1994

Alan Kay Through the Years

"Squeak is a project by some of the original pioneers of personal computing and networking, joined by enthusiastic more recent colleagues, to get wide spectrum authoring for all back into the mainstream of computing."

- Alan Kay, Authoring, published in The Unfulfilled Goal of Personal Computing, 1995

Alan Kay Through the Years

"Let me start by describing a parallel between the development of printing and that of computing. Before Gutenberg, the handwritten manuscript books in Europe were, by and large, owned by institutions -- the church, the monarchy, and so forth. In the case of computers, when the Univac-I appeared, sometime around 1950, computing was done on machines that also had to be owned by an institution.

In its day, Gutenberg's printing press was the equivalent, we might say, of computer workstations. In today's money, they might have cost 60 or 70 thousand dollars. Only wealthy people could own them, and only wealthy people and institutions could own the books produced on them. And the number of books printed on the Gutenberg press was still small. Also, a Gutenberg Bible was not something you would travel with; it was not designed to be replaced if it was lost or damaged. It wasn't until 50 years after Gutenberg that printers like Aldus Manutius began producing books that were affordable enough to be widely owned. They were still fairly expensive -- several hundred dollars in today's money. But they were replaceable, and they were something you could carry with you from place to place.

Still, it wasn't for another hundred some-odd years, until the 17th century, that the real potential of the printing press was realized in any full sense. So it took about 150 years for writers and publishers to really get what the technology could do and to put it into practice. And the result was that, in the 18th century, Western society underwent the transformation that produced the modern world, the world we live in today.

My point, of course, is that there may be considerable lag time between the development of a new technology and the realization of the technology's potential. This was true of the printed book, and I think it is true of the Dynabook as well."

- Alan Kay, The Dynabook Revisited: A Conversation With Alan Kay, published in The Book and the Computer, 2002

Alan Kay Through the Years

"The printing press led to a huge change in how ideas were argued. The reliability and accuracy of printing allowed people to present their ideas with fewer claims and more logic, with less allegory but tighter reasoning. So I wondered how computers could change the way ideas are presented and tested. The thing that jumped into my head was that simulation would be the basis for this new argument...More and more, I was thinking of the computer not just as hardware and software but as a medium through which you could communicate important things. Before I got involved with computers I had made a living teaching guitar. I was thinking about the aesthetic relationship people have with their musical instruments and the phrase popped into my mind: "an instrument whose music is ideas." Just as the book was an extension of the oral medium, so is the computer an extension of the print medium. There are many things that books can do, but computers have an extra dimension that seemed to me incredibly important, and this is key to the Dynabook idea. To really use a computer, you've got to be the author as well as the reader."

- Alan Kay, The Dynabook Revisited: A Conversation With Alan Kay, published in The Book and the Computer, 2002

Alan Kay Through the Years

"And in my mind the patron saint of how to teach kids is Maria Montessori. A hundred years ago, Montessori understood that children always are trying to learn about their environment, and so the best way to help them was to give them carefully organized, rich environments, where the toys and the play have 20th-century side effects. In my opinion, this is one of the great ideas in the history of education...Seymour Papert used to talk about the kid who has difficulty in mathematics. Typically, the teacher will say, "Well, this kid is not math-minded. Let's try the kid on something else." But if the kid were having difficulty in French, we couldn't say that that kid is not French-minded, because we know that had the kid been born in France he or she would have no trouble learning French. So Papert's idea was that there's something environmentally wrong about the way math is taught to kids. If the environment were right, they would learn. Well, the computer is a tool with which you can actually make rich environments, in which learning can have the character of play."

"I think that for kids, play is the most important means of learning, and so you want to harness it for as many years as you possibly can. Play is nature's built-in mechanism for the child's deepest learning. And if the environment isn't rich enough, you lose the element of play. But if you can make the environment rich and can keep the play going, then you win in a big way. Because maybe the biggest question about education is, "What is this kid going to do when teachers and parents are not around?" If children love the learning process, they want to spend all their time at it. If they don't love it, it doesn't matter much what you do in a classroom."

- Alan Kay, The Dynabook Revisited: A Conversation With Alan Kay, published in The Book and the Computer, 2002

Alan Kay Through the Years

"The most important thing about powerful inexpensive personal computers is that they form a new kind of reading and writing medium that allows some of the most important powerful ideas to be discussed and played with and learned than any book.

This is what our work and Squeak is all about. We are interested in helping children learn to think better and deeper than most adults can. We have made the Squeak medium to serve as a new kind of electronic paper that can hold new ways to represent powerful ideas."

- Alan Kay, Background on How Children Learn, 2003

Alan Kay Through the Years

"Literature is first and foremost about having ideas important enough to discuss and write down in some form. So you have to ask, "What is the literature that is best written down on a computer?" One answer is to make a dynamic simulation of some idea that you think is important, a simulation that you can play with and that you can learn from."

"So by first writing that simulation yourself, you know what the assumptions are. And by letting it run through, you can generate the phenomena and get a visceral sense of it, and then you can capture what happens in a graph. This way, the computer can be a kind of thought amplifier."

"It's like missing the difference between music and instruments. You can put a piano in every classroom, but that won't give you a developed music culture, because the music culture is embodied in people. On the other hand, if you have a musician who is a teacher, then you don't kneed musical instruments, because the kids can sing and dance. But if you don't have a teacher who is a carrier of music, then all efforts to do music in the classroom will fail - because existing teachers who are not musicians will decide to teach the C Major scale and see what the bell curve is on that. The important thing here is that the music is not in the piano. And knowledge and edification is not in the computer. The computer is simply an instrument whose music is ideas."

- Lars Kongshem, Face to Face: Alan Kay Still Waiting For the Revolution, Scholastic Administrator, Apr/May 2003

Alan Kay Through the Years

"The real printing revolution was a qualitative change in thought and argument that lagged the hardware inventions by almost two centuries. The special quality of computers is their ability to rapidly simulate arbitrary descriptions, and the real computer revolution won't happen until children can learn to read, write, argue and think in this powerful new way. We we should all try to make this happen much sooner than 200 or even 20 more years!"

- Alan Kay, The Power of Context, Feb. 24, 2004

Alan Kay Through the Years

"The (printing) press in the 15th century was first thought to be a less expensive automation of hand written documents, but by the 17th century its several special properties had gradually changed the way important ideas were thought about to the extent that most of the important ideas that followed and the way they were thought about had not even existed when the press was invented. The two most important ideas were the inventions of science and of new ways to organize politics in society…

These changes in thought also changed what "literacy" meant, because literacy is not just being able to read and write, but to fluently deal with the kinds of ideas important enough to write about and discuss...One way to look at the real printing revolution in the 17th and 18th centuries is in the co-evolution in what was argued about and how the argumentation was done. Increasingly, it was about how the real world was set up, both physically and psychologically, and the argumentation was done more and more by using and extending mathematics, and by trying to shape natural language into more logically connected and less story-like forms.

One of the realizations we had about computers in the 60s was that they give rise to new and more powerful forms of arguments about many important issues via dynamic simulations. That is, instead of making the fairly dry claims that can be stated in prose and mathematical equations, the computer could carry out the implications of the claims to provide a better sense of whether the claims constituted a worthwhile model of reality. And, if the general literacy of the future could include the writing of these new kinds of claims and not just the consumption (reading) of them, then we would have something like the next 500 year invention after the printing press that could very likely change human thought for the better."

- Alan Kay, The Real Computer Revolution Has Not Happened Yet, 2007

Alan Kay on Mobile Computing - 1

Mobile computers have turned out to be mind-numbing consumption devices - sophisticated televisions - rather than the wheels for the mind that Steve Jobs envisioned

"The big slogan at Apple, when I went there, I think it was "Wheels for the Mind."

"...we were actually looking at what we needed to interact with this system (Alto / Dynabook). You can't just have a finger; you have to have some sensitive display. You have to have a keyboard, also, because even with a perfect recognizer, you're basically consigning people to typing short things."

"Once you realize kids have to be sensible, literate users of computers, because when are you going to learn how to read? Only a few people learn how to read as adults. You learn how to read as a child. And it was the perfect timing, because this was just like two years before going to PARC. I finished my PhD. I started thinking about this. I said, "If we're gonna do a personal computer"-and that's what I wanted PARC to do and that's what we wound up doing [with the Alto]-"the children have to be completely full-fledged users of this thing. Think about what this means in the context of say, a Mac, an iPhone, an iPad. They aren't full-fledged users. They're just television watchers of different kinds."

- Brian Merchant, The Father of Mobile Computing is Not Impressed, Fast Company, Sept. 15, 2017

Alan Kay on Mobile Computing - 2

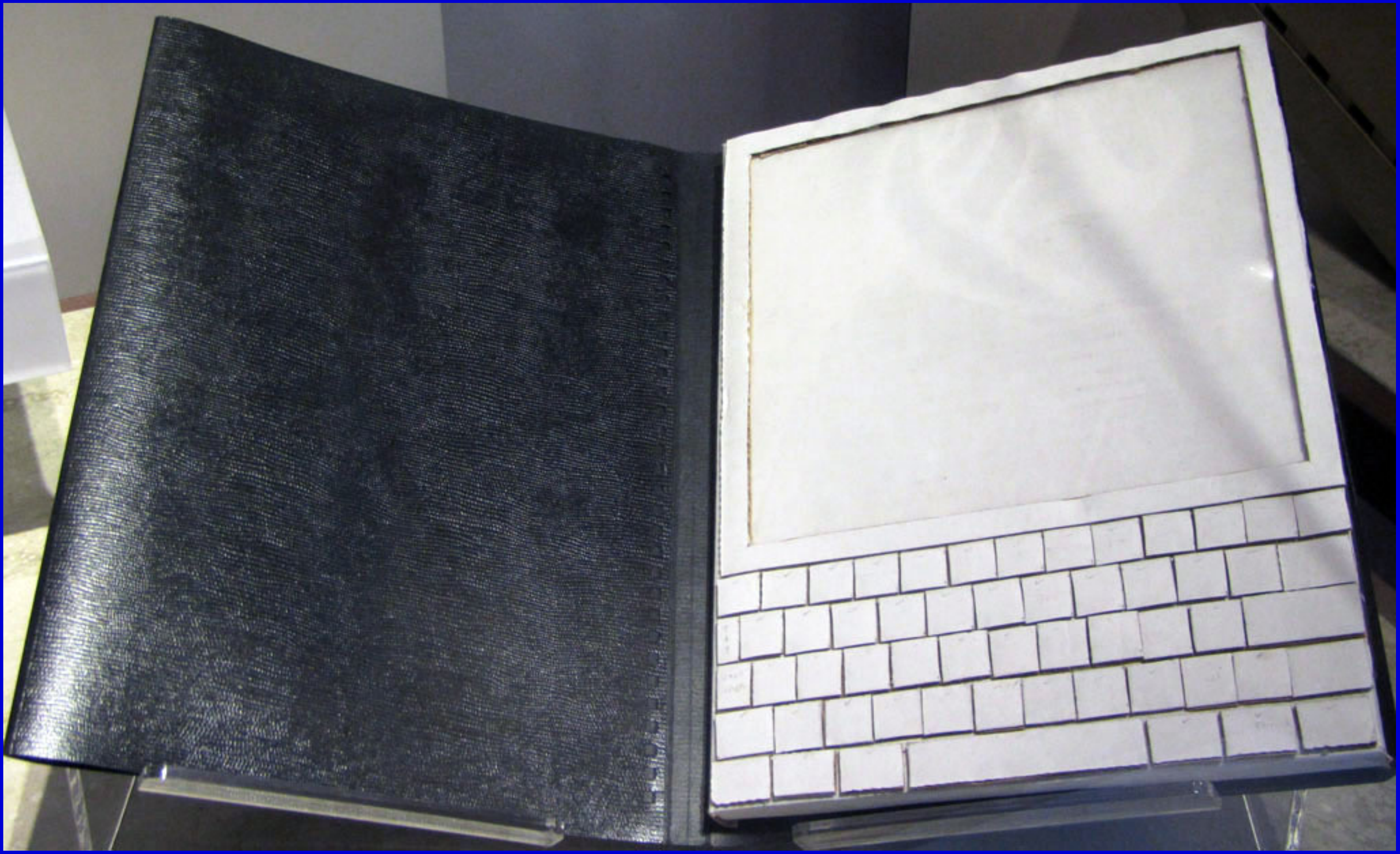
"So, this is like less than what people got with Mac in 1984. Mac had a really good undo. It allowed you to explore things. Mac had multitasking. The iPhone is basically giving one little keyhole and if you do something wrong, you actually go back out and start the app over again. Think about this. How stupid is this? It's about as stupid as you can get. But how successful is the iPhone? It's about as successful as you can get, so that matches you up with something that is the logical equivalent of television in our time."

"Well, a saying I made up at PARC was, "Simple things should be simple, complex things should be possible." They've got simple things being simple and they have complex things being impossible, so that's wrong."

"I once said, 'Television is the last technology we should be allowed to invent and put out without a surgeon general's warning.' That's a very Neil Postman-kind of thing."

- Brian Merchant, The Father of Mobile Computing is Not Impressed, Fast Company, Sept. 15, 2017

Xerox Dynabook



Thing / Hardware - Dynabook

- Firsts / Achievements / Uniqueness / Significance
  - Visionary design for what an educational computer should be
  - A portable suite of hardware, software, programming tools and services which would add up to the ultimate creative environment for kids of all ages - the intent was symmetric authoring and consuming
  - Influenced by learning theories of Jean Piaget + Jerome Bruner + Seymour Papert
- Place Produced (Company / Institution) ~ Year ~ Country
  - Xerox ~ 1972 ~ USA
- People involved (Designer)
  - Alan Kay
- Type
  - Personal computer
- Price / Cost
  - $500
- Size
  - Tablet sized - 12" x 9" x ¾" ~ Weight of 4 pounds

Thing / Hardware - Dynabook

- Computing technology
  - Integrated circuits ~ 4000 character LCD screen for display
- Computing speed (in MIPS)
  - N/A
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits
- Secondary memory type / technology ~ Size
  - Cassette tape or floppy disk ~ 1 megabyte
- Uses / Applications / Software
  - Smalltalk to create simulations
- Predecessors - N/A ~ Successors - Xerox Alto, iPad

Xerox Notetaker

Thing / Hardware - Xerox Notetaker

- **Firsts / Achievements / Uniqueness / Significance**
  - Realized as much of Alan Kay's Dynabook vision as 1976 technology allowed
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Xerox PARC ~ 1976 ~ USA
- **People involved (Designer)**
  - Doug Fairbairn
- **Type**
  - Personal computer
- **Price / Cost**
  - $50,000
- **Size**
  - 48 pounds

Thing / Hardware - Xerox Notetaker

- Computing technology
  - Integrated circuits
- Computing speed (in MIPS)
  - 1 MHz
- Primary memory type / technology ~ Size ~ Word length
  - Integrated circuits ~ 128K ~ 8 bits
- Secondary memory type / technology ~ Size
  - Floppy disk drive
- Uses / Applications / Software
  - Smalltalk
  - Had mouse + touch sensitive screen
- Predecessors - Dynabook / Alto ~ Successors - iPad

Thing / Software - PLATO

- Firsts / Achievements / Uniqueness / Significance
  - First generalized computer aided instruction system / On line educational courseware system
  - First online forums / email / chat rooms / instant messaging / multiplayer games
- Place Produced (Company / Institution) ~ Year ~ Country
  - University of Illinois + CDC ~ 1971 ~ USA
- People involved (Programmer)
  - Donald Bitzer
- Type
  - Educational software
- Price / Cost
  - Text
- Computer and operating system it runs on
  - CDC mainframes
- Computer language written in
  - TUTOR
- Memory required
  - Text
- Predecessors - N/A ~ Successors - MOOCs?

Thing / Software - EToys

- Firsts / Achievements / Uniqueness / Significance
  - Multimedia authoring system especially aimed at helping children learn powerful ideas by constructing them
  - But how much has it been used? What impact has it had? What effect did it have on One Laptop Per Child?
- Place Produced (Company / Institution) ~ Year ~ Country
  - Viewpoints Research Institute
- People involved (Programmer)
  - Alan Kay et.al.
- Type
  - Like LOGO - scripting that is also mathematics with turtle as vector
  - Like Hypercard - WYSIWYG page oriented user interface + media authoring
  - Like Starlogo - massively parallel objects
  - Like Squeak Smalltalk - everything is dynamic object, multimedia, multiplatform
- Price / Cost
  - Open source
- Computer and operating system it runs on
  - Linux, Macintosh, One Laptop Per Child, Windows
- Computer language written in
  - Squeak
- Memory required
  - Text
- Predecessors - Smalltalk ~ Successors - N/A

Universities of the Air

- In 1920's + 1930's universities experimented with offering their courses via radio
  - Students registered by mail, received syllabus by mail, mailed in assignments, some got credit
- Problems
  - High attrition, learning was passive, did not offer opportunities for social interaction, wasn't clear what finishing a course actually meant
- Striking similarities between massive open on-air courses from the 1920's + 1930's and massive open online courses today

\- Susan Matt and Luke Fernandez, Before MOOCs, 'Colleges of the Air,' Chronicle of Higher Education, April 23, 2013

A Laboratory For the Future of Librarianship
Distance Learning vs. Apprenticechip

- There was tremendous interest in putting University courses + curricula online in the 2000's which failed
  - UNext, Fathom
  - Format was online text to read with few images
  - No video, no interactivity, no community
  - They were ahead of the curve
- There is now tremendous interest in distance learning companies placing university courses / curricula / degrees online
  - Coursera, edX, FutureLearn, Udacity
  - Format is xMOOCs (lectures + tests)
  - Results are mixed
  - But they have it (at least) partially wrong as they view students as empty vessels to pour knowledge into
  - Is the connectivist MOOC (cMOOC) the real answer?

cMOOC as a Learning Environment
Downes Theory of Education

"To teach is to model and demonstrate
To learn is to practice and reflect"
- Stephen Downes, educator

cMOOC as a Learning Environment

- cMOOC
  - Massively multi-user environment ~ Open and distributed content ~ Online delivery ~ Course
  - Network-based connectivist MOOC
  - Based on connection rather than content
  - Looks more like online community than course
  - Does not have defined curriculum or formal assignments
- Purpose of the learning experience
  - Not to remember some body of content or accomplish some particular task
  - Navigating the chaos and making learning decisions is the lesson in cMOOC
- cMOOC is similar to constructivism
  - "Learners often select and pursue their own learning. Constructivist principles acknowledge that real-life learning is messy and complex. Classrooms which emulate the 'fuzziness' of this learning will be more effective in preparing learners for lifelong learning." - George Siemens
- Literacies appropriate for cMOOC
  - 21st century literacies of 4C's - collaboration, creativity, communication, critical thinking
  - Digital literacies - Mozilla Foundation's Web Literacy Map on how to engage with digital media (as opposed to merely consuming it) - exploring, building and connecting

- Stephen Downes, From MOOC to Personal Learning, Oct. 15, 2015

cMOOC as a Learning Environment

- **cMOOC**
  - Not located on a single platform, but is web created by linking multiple sites together
  - Architecture of web intended to optimize four design principles
    - Each member of the web operates autonomously
    - Web links diverse services and resources together
    - Web is open and supports open engagement
    - Web encourages cooperative learning
- **Engagement is at core of cMOOC learning**
  - Participants aggregate resources from multiple sources
  - Remix these in various ways
  - Adapt and repurpose them to their own needs
  - Share them
- **Structure of the course**
  - Network of individual learners interacting with each other + exchanging + working with diverse resources obtained from variety of Internet sources

- Stephen Downes, From MOOC to Personal Learning, Oct. 15, 2015

cMOOC as a Learning Environment

- Course creation
  - Like creating a network
  - Don't centralize - concentrate on creation of links
  - Use social networks to create personal knowledge
- Course components for instructors
  - Wiki to assist in planning, topics
  - Email list for announcements
  - Course blog for daily posts
  - Synchronous communications / video
- Course structure
  - Series of topics - instructors do not teach the topics, instructors investigate / work through topics (model and demonstrate)
- Course components for students
  - Blogs + Social networks
  - Content sites - Google Docs, Flickr
  - Aggregator - RSS reader
- Process
  - Each week has conversation or activity with guest + then discussion / reflection
  - Each day aggregate student content that is shared via Web site + newsletter
- How to learn in a cMOOC
  - Learning is a process of immersion into a knowing community
  - Learning is a process of recognizing and growing into or becoming an instantiation of those values
- How to evaluate learning
  - Learning is not possession of a collection of facts, it's the expression of a capacity
  - Learning is recognized by a community of experts in a network
  - We recognize our understandings by the way we use them in our social network

- Stephen Downes, Personal Learning in the Workplace, talk given at AMEE 2015

Computer as Simulator

"The computer will make people understand that the mark of an educated person is not the ability to spout little-known facts, but to have had a variety of experiences in simulated worlds that prepare one for decision-making in the real world."

- Roger Schank, computer scientist

- Roger Schank, The Computer Isn't the Medium It's The Message, Communications of the ACM, Mar. 2001

Personal Case Study - Alan Kay

- Role
  - Educational visionary
- Story
  - Lunched with him at a conference in November 1988
  - Intelligent, articulate, yet frustrating in failing to get his important message out in front of the public in more ways

Personal Case Study - Mark G

- Role
  - One of the first (first?) PhDs in education and computer science
- Story
  - Research revolves around 1) how to attract more males and females into computer science and how to train them in a way that convinces them to stay in and 2) achieving Alan Kay's Dynabook vision

Personal Case Study - Boeing Alteon Seattle Training Center - Boeing 737 Next Generation 3 degrees of freedom flight simulator

- Role
  - Where Boeing conducts much of its airliner simulator training
- Story
  - Shown in 2008 how a pilot is trained from ground school to final qualification on the simulator using a validated curriculum and performance-based assessment
  - The simulator is impressive, but the graphics were disappointing as it was an older simulator

Personal Case Study - Teaching Programming to Children

- Role
  - I am a father of two boys
- Story
  - Attempting to teach my children how to program in Scratch, Kodu, Logo, BASIC
  - Like herding cats…
  - They don't have to write their own software, they just download it…

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- How do children learn according to John Holt? How do adults learn?
- How do *you* learn best?
- What is Seymour Papert's constructionist educational theory? - Compare and contrast it to standard educational theory (drill + kill)
- Who is Alan Kay and what is the significance of the Dynabook?
- Can a video game be educational? Why aren't there educational video games?
- What is needed for computers to reach their potential as the greatest learning tool ever?
- Have we fulfilled Alan Kay's vision for the Dynabook? We have the hardware but what about the software?
- What has been the ultimate effect of these educational theorists on our education system?
- What is a serious game?
- What computational challenges are faced by designers of educational tools?
- Does learning want to be free?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
- Simulations

Alan Kay Through the Years

"Two hundred years ago the Federalist papers - essays by James Madison, Alexander Hamilton and John Jay arguing for ratification of the U.S. Constitution - were published in newspapers in the 13 colonies. Fifty years later the telegraph and its network shifted the goals of news from depth to currency, and the newspapers changed in response. Approximately 100 years after that, television started shifting the emphasis of news from currency to visual immediacy…

Where would the authors of the Constitution publish the Federalist papers today? Not in a book; not enough people read books. Not in newspapers; each essay is too long. Not on the television; it cannot deal with thoughtful content...

But the late 20th entury provides an interesting answer to the question: transmitting over computer networks a simulation of the proposed structure and processes of the new Constitution..."

- Alan Kay, Computers, Networks and Education, Scientific American, Sept. 1991

Conclusion

I invite each of you to sit down in front of your television set when your station goes on the air and stay there, for a day, without a book, without a magazine, without a newspaper, without a profit and loss sheet or a rating book to distract you. Keep your eyes glued to that set until the station signs off. I can assure you that what you will observe is a vast wasteland.

You will see a procession of game shows, formula comedies about totally unbelievable families, blood and thunder, mayhem, violence, sadism, murder, western bad men, western good men, private eyes, gangsters, more violence, and cartoons...

...Is there no room on television to teach, to inform, to uplift, to stretch, to enlarge the capacities of our children?

- Newton Minow, Chairman of the Federal Communications Commission, to the National Association of Broadcasters, May 9, 1961

Conclusion

"This instrument can teach, it can illuminate, and yes it can even inspire. But it can do so only to the extent that humans are determined to use it to those ends. Otherwise it's nothing but wires and lights in a box."

- Edward R. Murrow, journalist

Conclusion
Role of the Computer in Education

"I've helped with more computers in more schools than anybody else in the world and I absolutely convinced that is by no means the most important thing. The most important thing is a *person*. A person who incites your curiosity and feeds your curiosity; and machines cannot do that in the same way that people can."

- Steve Jobs, Smithsonian Institution Oral History Interview, Apr. 20, 1995

Topic 23

Computers as Libraries

Song

Slide text

Thematic Quote

"Everything is deeply intertwingled. In an important sense there are no 'subjects' at all; there is only all knowledge, since the cross-connections among the myriad topics of this world simply cannot be divided up neatly."

- Theodor Holm Nelson, hypertext visionary

The Painting

The Stacks

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - As We May Think
- Year
  - 1945
- Story

- Name
  - Computer Lib / Dream Machines
- Year
  - 1974
- Story

- Name
  - Core Memory and Disk platter
- Year
  - 1950's
- Story

- Name
  - Detroit Weekly Free Press
- Year
  - October 13, 1862
- Story
  - Note the high density of information on the page

The Question

"Don't be evil"

- Corporate motto of Google

Can we trust Google to not be evil?

The library is "An organized archive of the products of human intelligence"

- Pliny the Elder, author

"When I get a little money, I buy books. If there is any left over I buy food and clothes"

- Desiderius Erasmus, classical scholar

"Everybody gets so much info all day long they lose their common sense"

- Gertrude Stein, author

"What information consumes is rather obvious: it consumes the attention of its recipients. Hence a wealth of information creates a poverty of attention, and a need to allocate that attention efficiently among the overabundance of information sources that might consume it"

- Herbert Simon, computer scientist

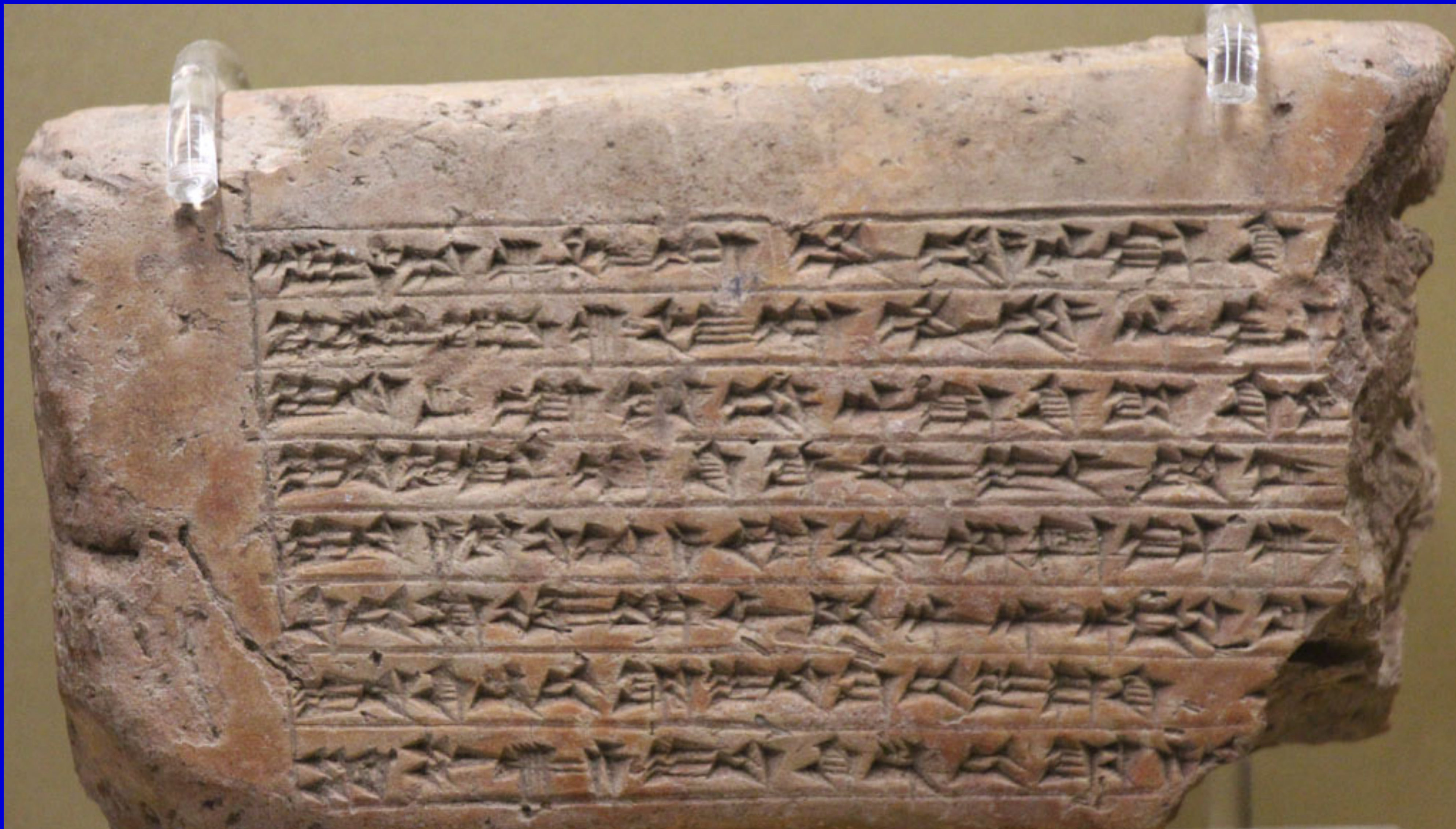
Information - Books

- Substrates
  - Rock
  - Clay
  - Papyrus
  - Velum
  - Paper
  - Electrons
- Types
  - Walls
  - Tablets
  - Scrolls
  - Codex (Illuminated manuscripts)
  - Printed (Gutenberg)
  - Printed + Personal (Aldus)
  - Digital Books

Papyrus

Papyrus plant

Cuneiform Writing



Cuneiform tablet referring to Nebuchadnezzar II Of Babylon

Ancient Libraries

- Earliest libraries were Babylonian + Syrian (2300 BC) and Hittite (1200 BC)
  - Texts written in cuneiform, mainly of religious rituals
  - Signs of cataloguing + content summaries
  - Were private libraries for religious entities
- Ancient Greeks had personal libraries
  - Booksellers present in Athens (5th century BC)
- First scholarly library in Alexandria (3rd century BC) founded by King Ptolemy
  - Had 500,000 papyrus rolls
- Rome's first public library planned by Julius Caesar (39 BC)
  - By 350 AD there were 29 libraries in Rome, many attached to public baths
- Monastic libraries (1st century AD onwards)
  - Change medium from papyrus to parchment and form from roll to codex

- Peter Jones, When Libraries Were On a Roll, Books Online, May 21, 2001

The Roman Library

- Romans invested in culture + education of ruling classes, spread literacy through all classes of society, culturally unified many of Empire's territories + first instituted public education at state expense
- Julius Caesar was first to want to give Rome a public library, but it was Augustus who did it
- Libraries belonged to multicultural complexes that involved temples + gardens + housed works of art
- Romans helped develop codex - a book with pages, punctuation, capitalization in late first century AD
- Codices + volumina (papyrus scrolls) in library shelved by language / subject / genre were kept on armaria with indices drawn up on tablets next to armaria
- Each text had a titulus tied to it with the text's title + author

- La Biblioteca Infinita (The Infinite Library), Flavian Amphitheater / Colosseum - 2014

Roman Books and Libraries

Volumen on umbilicus with titulus
Armaria
Capsa for carrying volumina

Tabula Cerata

Roman Library of Celsus at Ephesus

Finished AD 110 ~ Destroyed by earthquake AD 270

The Printing Revolution

- 1455 - Johannes Gutenberg + printing press create personal printed books
- 1501 - Aldus Manutius miniaturizes books to hand-held form
- These technological breakthroughs democratized knowledge by extending it from libraries + wealthy to common person

Lessons in Preservation Run Amuck
The Assault on Paper / Butchers of Books

- The propositions
  - Librarians are driven to save space + worried about acidic papers formally used in printing so they first purged their shelves of newspapers, replacing them with microfilmed copies, and then moved on to books
  - None of this was needed
  - Paper holds up well, even the cheapest paper
  - Microfilm is not adequate substitute for paper - has worse chemistry than paper, quality assurance of scans was terrible, extremely expensive, horrible to use
  - Librarians crave space - answer is miniaturization with microfilm + deaccessioning the originals
  - Obsession with space became an ideology of demonizing paper size + self-destructive quality + promoted technologies for destroying it all in name of preservation
  - Preservation meant destruction
  - Destruction was unnecessary - books that failed the double-fold test were microfilmed + destroyed, but double-fold test is much more harmful to book than the act of reading it
  - Destruction was brutal - microfilming could have been done in non-destructive manner but it took too much time so they were guillotined, filmed, pulped
  - Destruction was expensive - it would have been cheaper to store originals in air-conditioned warehouses where they would last indefinitely
  - Librarians intentions were good but they acted in bad faith by concocting false crisis to clear their shelves - the books were turning to dust
- These propositions add up to a terrible indictment of a venerable profession

- Nicholson Baker, Deadline, New Yorker, July 24, 2000

- Robert Darnton, The Great Book Massacre, New York Review of Books, Apr. 26, 2001

Lessons in Preservation Run Amuck
The Assault on Paper / Butchers of Books

"In order to film a file for preservation, it was necessary to destroy it; once the volumes were cut for this purpose it was impractical, and usually impossible, to restore them"

- S. Branson Marley, Chief of Library of Congress serial division

"Serials Management in microform is our own slum clearance program"

- University Microfilms ad

"This country has strip-mined a hundred and twenty years of its history."

- Nicholson Baker

- Baker bought part of the British Library's collection of American newspapers it was deaccessioning and formed non-profit American Newspaper repository which ultimately donated its collection to Duke University

- Nicholson Baker, Deadline, New Yorker, July 24, 2000

- Robert Darnton, The Great Book Massacre, New York Review of Books, Apr. 26, 2001

New Means of Production Lead to New Means of Distribution + New Audiences + New Business Models

- Technological changes in printing of books
  - 16th Century - Leads to printing of short pamphlets which were purchased by people who could not afford a book
  - 19th Century - Stereotyping (typesetting of whole sheets at once) leads to printing of magazines + newspapers thus expanding world of people who could afford to buy printed material
  - 20th Century - Affordable + portable paperback books leads to new audiences for print
  - 21st Century - eBooks leads to letting another person doing the reading to you, screen readers for mobile devices that beam one word at a time to you (Spritz), books becoming more social as you learn what others think of what you are reading
- Business model changes in printing of books
  - 17th + 18th Centuries - books sold by subscription (think Kickstarter)
  - 19th Century - rise of circulating libraries that sold annual memberships
  - 21st Century - publishers obtain access to data about their readers - what they read, how they read, why they quit a book, etc.

- Papyrus to Pixels: The Digital Transformation of the Way Books are Written Published and Sold Has Only Just Begun, The Economist, Oct. 10, 2014

Technological Solutions to Information Overload Caused By Books

- Table of contents
- Index
- Book reviews

Technological Solutions to Information Overload Caused By Web

- Human curated directories (Yahoo)
- Search engines
- Social media

Before Memex

- Paul Otlet in Belgium
  - 1895 - Universal Bibliography
    - 15 million entries on index cards, search queries submitted by telegraph
  - 1935 - Mundaneum
    - Global knowledge network - microfilm-based web of linked multimedia documents accessed, annotated, shared by a Mondotheque
    - Content cataloged by experts
- Emanuel Goldberg in Germany
  - 1927 - Statistical Machine
    - Search + retrieve data stored on microfilm, search queries submitted by telephone
- H.G. Wells in Great Britain
  - 1938 - World Brain
    - A super-human memory in a world-wide network that would lead to an era of social equality + world peace
    - Content cataloged by experts
- Vannevar Bush in U.S.
  - 1939 / 1945 - Memex
    - Microfilm-based web of linked text documents accessed, annotated, shared by a Memex
    - Content curated by trailblazers

- Alex Wright, The Secret History of Hypertext, The Atlantic, May 2014

Vannevar Bush

From Wikimedia Commons

Person - Vannevar Bush

- Significance
  - Creator of the first differential analyzer in the United States. Science advisor to President Roosevelt during World War II. Creator of the concept of hypertext as documented in his landmark article "As We May Think" in the Atlantic Magazine in 1945
  - "As We May Think" - Atlantic Magazine July 1945
    - Need to control information overload
    - Memex - mechanical machine to do what humans do poorly - store + retrieve large amounts of facts, thus allowing humans to do what they do well - make connections that allow for jumps between threads of information - Trailblazers to be guides through information
- Profession
  - Professor of Electrical Engineering, MIT
- Places worked
  - MIT, Chair of National Defense Research Committee in WW II
- Years of work
  - 1927-1945
- Things worked on
  - Differential Analyzer (analog computer), Memex

Place - Memex

- Significance
  - The first description of a hypertext system
- Location
  - As We May Think, Atlantic Monthly, July 1945
- Definition
  - Device in which individuals would compress + store all of their books, records, + communications, "mechanized so that it may be consulted with exceeding speed and flexibility." Would provide an "enlarged intimate supplement to one's memory"
- People who worked there
  - Vannevar Bush
- Things created there
  - Inspired Douglas Englebart, Theodor Holm Nelson + others to implement the vision

JCR Licklider

From Wikimedia Commons

Person - J.C.R. Licklider

- Significance
  - Vision - computer was a revolutionary device because it could be used to work in symbiosis with humans - "It is the destiny of computers to become interactive intellectual amplifiers for all people pervasively networked worldwide."
  - Computing could augment human thinking power in same way the lever + wheel extend our physical power
    - - Licklider, JCR. Man-computer Symbiosis. IRE Transactions on Human Factors in Electronics HFE-1, (Mar. 1960), 4-11.
  - Computing could be used for communication among communities
    - - Licklider JCR and Taylor, RW. The Computer as a Communications Device. Science and Technology (Apr. 1968)
  - Computer as a library
    - Books are good at displaying information and bad at storing, organizing, retrieving it - "We should be prepared to reject the schema of the physical book itself…That involves rejecting the printed page as a long-term storage device."
    - Envisioned library where computers replaced books forming a "network in which every element of the fund of knowledge is connected to every other element."
    - - Licklider, JCR. Libraries of the Future (1965)
- Profession
  - Psychologist
- Places worked
  - Director of Information Processing Techniques Office at ARPA
- Years of work
  - 1957-1970
- Things worked on
  - Founded Project MAC at MIT
  - Founded ARPANet

Ted Nelson

From Wikimedia Commons

Person - Theodor Holm Nelson

- Significance
  - Hypermedia visionary
  - Popularizer of hypertext in his landmark book, "Computer Lib / Dream Machines"
  - Spiritual father of World Wide Web
- Profession
  - Poet, philosopher, rogue (self described)
  - Software Designer, Author, "Visionary"
- Places worked
  - Independent artisan, Autodesk
- Years of work
  - 1960 - present
- Things worked on
  - Xanadu, Computer Lib / Dream Machines

Place - Xanadu

- Significance
  - All encompassing vision for a hypertext system
  - A fraction of the vision inspired the World Wide Web
- Location
  - Sausalito, California
- Definition
  - Xanalogical hypertext, a radical generalization of documents: unbreaking links to stabilized content, remix with overlays, and quotations connected to their sources.
- People who worked there
  - Theodor Holm Nelson
- Things created there
  - Never shipped a working product

The Pioneer

"The book being celebrated, Computer Lib, made the outrageous claim in 1974 that personal computing, computer graphics, interaction and hypertext would fuse into an oncoming wave that would revolutionize the world-absurd, most people thought. After 40 years of Computer Lib being very right, here we are in a soup of resulting super-problems. Now they're listening to me again."

- Theodor Holm Nelson, hypertext visionary

"Ted is a very unique individual-he formulated his ideas before the world was ready to understand them, but that has not deterred him from continuing to believe in a different future for the world of computing. Irreverent, and yet tender, he is the modern/high tech version of Don Quixote..."

- Daniele Struppa, Chancellor, Chapman University

- Intertwingled: A Celebration of the Work and Influence of Computer Iconoclast Ted Nelson, Chapman University, April 24, 2014

Thing / Software - Hypercard

- Firsts / Achievements / Uniqueness / Significance
  - First widespread hypertext program on personal computer
- Place Produced (Company / Institution) ~ Year ~ Country
  - Apple Computer ~ 1987 ~ USA
- People involved (Programmer)
  - Bill Atkinson
- Type
  - Hypertext creation
- Price / Cost
  - Free
- Computer and operating system it runs on
  - Macintosh - MacOS
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - Xerox NoteCards ~ Successors - World Wide Web

History of Digital Libraries Shows

- They were always intended to support apprenticeship + apprentice learners

Thing / Software - eBooks

- Firsts / Achievements / Uniqueness / Significance
  - Project Gutenberg - First eBook created on July 4, 1971 by Michael Hart as ASCII text file - was Declaration of Independence
  - Digital Webster - First commercially available eBook created in 1988 by Michael Hawley and Steve Jobs for NeXT computer
- Place Produced (Company / Institution) ~ Year ~ Country
  - Text
- People involved (Programmer)
  - Text
- Type
  - Text
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Text
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - N/A ~ Successors - N/A

Social Reading

- Reading traditionally thought of as solitary communion between reader + author
- But reading has always been social - think of literary salons + book clubs that sprang up with proliferation of print
- Social media tools that allow social reading today are their digital heirs which allow for noisy new collective engagement
  - Sharing of annotations, bookmarks, passages that have drawn significant reader attention
  - All of these recast books as relationships

- Adrian Versteegh, Apps Reveal Reading's Social Side, Poets & Writers, Jan./Feb. 2012

What is the Business Model?

"On the one hand, information wants to be expensive, because it's so valuable. The right information in the right place just changes your life. On the other hand, information wants to be free, because the cost of getting it out is getting lower and lower all the time. So you have these two fighting against each other.

- Stewart Brand, Founder Whole Earth Catalog

Digital Rights Management

- You are not buying eBooks, music downloads, movies, etc. - you are renting them. Proprietary software ties the purchase to a particular device + the provider of content can revoke your rights at whim
- eBooks are software - you are purchasing a license to read that can be revoked
  - 2012 Amazon blocked Kindle account to Norwegian user without reason, blocking her access to 43 books
  - Amazon doesn't operate in Norway, so she bought Kindle in UK, purchasing her books with a Norwegian address + credit card
  - When the Kindle broke and she tried to return it to get it fixed, Amazon refused to ship it back to Norway and deactivated her account

"Reading without surveillance, publishing without after-the-fact censorship, owning books without having to account for your ongoing use of them: these are rights that are older than copyright. They predate publishing. They are fundamentals that every bookseller, every publisher, every distributor, every reader, should desire. They are foundational to a free press and to a free society."

- Cory Doctorow

Personal Case Study - Ted Nelson

- Role
  - Hypertext visionary
- Story
  - Dined with him at a conference at University of Iowa in November 1991
  - Found him to be brilliant, gracious, and different
  - He taped all conversations he had - an early form of lifelogging with audiotapes + post-it notes
  - Had a self-described "hummingbird mind"

Personal Case Study - Virtual Hospital

- Role
  - Co-founder of the first medical site on the World Wide Web, and the 250th Web site overall in 1993
- Story
  - Ultimately brought together hundreds of University professors and staff who created thousands of textbooks and booklets that were read by millions of users around the world, making the Virtual Hospital digital library one of the most respected brands for health information in the world

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- What is hypertext?
- What is the significance of Vannevar Bush and Memex? Have we fulfilled Vannevar Bush's vision for Memex?
- What is the significance of Ted Nelson and Xanadu? Have we fulfilled Ted Nelson's vision for Xanadu?
- Is the World Wide Web a pale vision of hypertext as envisioned by Bush and Nelson?
- What is an End User Licensing Agreement (EULA)?
- What is Digital Rights Management (DRM)?
- Do you own and control your digital music, movies, eBooks, etc.?
- Do you use eBooks? What is good about eBooks? What is bad about eBooks?
- When was the first eBook made? What was the first commercially available eBook?
- What computational challenge do designers of eBooks have to overcome?
- Is keeping all of human knowledge on magnetic media a full-proof way to preserve human knowledge for future generations?
- Does information want to be free?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
  - Nelson, Theodor Holm - Computer Lib / Dream Machines
- Fiction
- Movies
- Simulations

Conclusion
Ancient Printer's Creed

This is a Printing-office

Crossroads of civilization

Refuge of all the arts against the ravages of time

Armoury of fearless truth against whispering rumour

Incessant trumpet of trade

From this place words may fly abroad

Not to perish as waves of sound but fixed in time

Not corrupted by the hurrying hand but verified in proof

Friend, you stand on sacred ground:

This is a printing-office.

Conclusion

"There is not such a cradle of pure democracy upon the Earth as in the free public library."

- Andrew Carnegie, philanthropist

Topic 24

Computers as a Weapon

Cyberwarfare

Song

Slide text

Thematic Quote

"The digital ecosystem of the Internet has now assumed biological complexity"

- George Dyson, author

The Painting

Software Piracy and The Wall Street Terminal and Keys to Security

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - Shockwave Rider
- Year
  - 1975
- Story

The Question

How will the information revolution affect the use of armed force?

"Beware of Geeks when bearing gifts"

- Anonymous

Cyber War

"When we think about cyber, we need to reflect on the Greek root of the word, 'kybernan,' which means to control or to govern.

When I was working for Central Command in the last Gulf War, it became very apparent to me that our biggest advantages come from what we knew and what our opponent didn't…It occurred to me…that much of what we did could have been held hostage to the disruption of any of those information systems. That was the beginnings of cyber war - the idea that the vulnerability of communications could cripple an advanced army. What made it strong also made it weak.

Then it was only a baby step from there to think about this happening across our entire society, commercially and socially. The crippling of information systems could have profound disruptive effects. What made that thought even more chilling was the notion that this power existed in the hands of a few hackers."

- John Arquilla, professor, Naval Post Graduate School

Cyber War

"When I think about cyberspace-based warfare, I think about air power. Eighty years ago, the great theorists of air power thought about having the ability to attack another society from the air without having to engage their armies or fleets first. Cyber warfare has some of those elements too...So it is a form of strategic bombardment. ...

I take heart from the notion that, in the eight decades or so of strategic aerial bombardment, their campaigns have almost never worked. It says to me that cyber bombardment campaigns are probably not likely to work either.

Now, both physical bombing and cyber bombing will have great costs associated with them, but I don't think a people will fold under that kind of pressure."

- John Arquilla, professor, Naval Post Graduate School

Netwar

"Netwar is the lower intensity, societal level counterpart to our earlier, mostly military concept of cyberwar. Netwar has a dual nature, like the two-faced Roman god Janus, in that it is composed of conflicts waged, on the one hand, by terrorists, criminals and ethnonationalist extremists; and by civil-society activists on the other. What distinguishes netwar as a form of conflict is the networked organizational structure of its practitioners - with many groups actually being leaderless - and the suppleness in their ability to come together quickly in swarming attacks. The concepts of cyberwar and netwar encompass a new spectrum of conflict that is emerging in the wake of the information revolution."

- John Arquilla and David Ronfeldt, The Advent of Netwar

Netwar

"The most potent netwarriors will not only be highly networked and have a capacity to swarm, they will also be held together by strong social ties, have secure communications technologies, and project a common 'story' about why they are together and what they need to do. These will be the most serious adversaries. But even those networks that are weak on some levels (e.g. technological) may pose stiff challenges to their nation-state adversaries. With this in mind it is necessary to go beyond just diagnosing the nature of the networked nonstate opponent in a given conflict. It will become crucial for governments and their military and law enforcement establishments to begin networking themselves. Perhaps this will become the greatest challenge posed by the rise of netwar."

- John Arquilla and David Ronfeldt, The Advent of Netwar

The Weaponization of Social Media

"The internet has long been celebrated for its power to bring people together. Yet as it turns out, this same technology is easily weaponized. Smartphones and social apps have clearly altered the nuts and bolts of violent conflict, from recruiting to battlefield reporting. But the greatest effects may be more fundamental, expanding the causes and possibly the incidence of war, and extending its reach. Social-media platforms reinforce "us versus them" narratives, expose vulnerable people to virulent ideologies, and inflame even long-dormant hatreds. They create massive groundswells of popular opinion that are nearly impossible to predict or control.

Social media has already revolutionized everything from dating to business to politics. Now it is reshaping war itself."

- Emerson Brooking and P.W. Singer, War Goes Viral, The Atlantic, Nov. 2016

The Weaponization of Social Media

- **The Dream**

  "The knowledge relayed by the telegraph would make nations so conversant with the national interests of their one-time enemies that war would come no more."

  - Johanna Neuman, historian

- **The Reality**

  "Indeed, the more we've learned about behavior on social media, the more apparent it has become that the mirror is distorted-or rather, that it distorts us. For all the hope that comes from connecting with new people and new ideas, researchers have found that online behavior is dominated by "homophily": a tendency to listen to and associate with people like yourself, and to exclude outsiders. Social networks are bad at helping you empathize with people unlike you, but good at surrounding you with those who share your outlook. The new information ecosystem does not challenge biases; it reinforces them.

- Emerson Brooking and P.W. Singer, War Goes Viral, The Atlantic, Nov. 2016

The Weaponization of Social Media

"All of these [information warfare] efforts share the same two broad objectives. The first is to overwhelm the state's adversaries, be they foreign or domestic, with misinformation: to challenge the very basis of their reality. But the second is just as important: to mobilize their own citizens and supporters and bind them to the state. The power of social media is used to intensify nationalism and demonize the enemy. In this strategy, homophily is not something to be feared or avoided. It is the goal.

The combination of untruth and homophily-set against a global battle of competing narratives-hints at a dark future. A world without facts, cleanly segregated by ideology and national allegiance, will be a more dangerous one. Such cynical use of the internet not only threatens to keep people in a perpetual state of mistrust; it may also increase the likelihood of conflict itself."

- Emerson Brooking and P.W. Singer, War Goes Viral, The Atlantic, Nov. 2016

Social Media is Shaking the Globe

"It's time to start recognizing that social networks actually are becoming the world-shattering forces that their boosters long promised they would be - and to be unnerved, rather than exhilarated, by the huge social changes they could uncork.

This should come as no surprise. In a way, we are now living through a kind of bizarro version of the utopia that some in tech once envisioned would be unleashed by social media."

"Thanks to the internet, now each person with once-maligned views can see that he's not alone. And when these people find one another, they can do things - create memes, publications and entire online worlds that bolster their worldview, and then break into the mainstream."

- Farhad Manjoo, Social Media's Globe-Shaking Power, New York Times, Nov. 17, 2016

Cyber War is Open Source Warfare

- Fought by civilians for nationalism, revenge, fun
  - Messy, chaotic, impossible to control
- Benefits
  - Deniability
  - Huge talent pool
  - Access to best resources / weaponry
- US approach
  - Confused, failed attempt at centralization
- Russian + Chinese approach
  - Open source warfare
    - Engage, co-opt, protect criminals
    - Seed the movement
    - Get out of the way

- John Robb, Open Source Warfare: Cyberwar, Global Guerillas, Aug. 15, 2008

Information Operations / Electronic Attack

- Started as jamming of sensors and communications
  - Listening to them
  - Turning them off

Information Operations - Computer Attack

- Has evolved into penetration of sensor and communication networks
  - Listening to them
  - Turning them off
  - Inserting spurious information into them
  - Sowing confusion in their ranks
- Used in Kosovo, Afghanistan, Iraq
- Amongst most highly classified programs in USAF

High Powered Microwave Weapon (HPM)

- Based on electromagnetic pulse generated by nuclear weapons
- Generates blast of electromagnetic waves in microwave frequency band that overloads electrical circuitry, particularly in computer chips
  - Can destroy integrated circuits
  - Can produce standing waves in electrical wiring and communications wiring
  - Can immobilize vehicles with electronic ignition and control systems
- The US is most vulnerable to these weapons
  - How do you protect yourself from side effects?
  - Imagine the US military not having access to chips

- Michael Abrams, The Dawn of the E-Bomb, IEEE Spectrum, Nov 2003

Cyber Smoke and Mirrors

- Cyber war has never happened in the past
  - What would constitute cyber war: potentially lethal, instrumental, political act of force conducted through malicious code
- Cyber war does not take place in the present
  - Not one single cyber offense on record constitutes act of war on its own
- It is unlikely that cyber war will occur in the future
  - All politically motivated cyber attacks are merely sophisticated versions of three activities as old as warfare itself: sabotage, espionage, subversion

- Thomas Rid, Cyber War Will Not Take Place, The Journal of Strategic Studies, Feb 2012
- Thomas Rid, Why A Cyberwar Won't Happen, New Scientist, Sept. 9, 2013

Focused Case Study - The First Cyber Attack

- First national data network was in 1790's France, based upon wooden armed mechanical telegraphs in chains of towers criss-crossing the country
- Network was reserved for government use, could send messages from one end of France to the other in minutes
- In 1834, two bankers who traded government bonds in Bordeaux - Francois and Joseph Blanc - hacked the network
- Information on market movements took several days to arrive in Bordeaux from Paris by mail coach
- Bribed telegraph operator in Tours, halfway between Paris and Bordeaux to introduce deliberate errors - a spurious character indicating the direction of the previous day's market movement followed by a backspace - into routine government messages
- These errors were transmitted along the line, and seen by an accomplice who observed the Bordeaux telegraph tower with a telescope, but they were not written down in the final message
- Worked for two years before Tours telegraph operator became ill, confessed the scheme to his replacement hoping to co-opt him, and was turned in
- All were tried but not convicted as there was no law against misuse of data network

- Tom Standage, The Crooked Timber of Humanity, 1843, Oct./Nov. 2017

Focused Case Study - The First Cyber Attack

- Timeless lessons
  - Network intrusions often go unnoticed for many years, many are never detected
    - Most attackers do not advertise their presence
  - Security is a chain and humans are always the weakest link
    - Focusing on security as a technological challenge misses the point that it also depends on setting the right social + economic incentives
  - Network attacks are as old as networks themselves
    - People always find a way to make malicious use of any new invention

\- Tom Standage, The Crooked Timber of Humanity, 1843, Oct./Nov. 2017

Computing Case Study Summary - Cuckoo's Egg

- Goal
  - Hacker - steal military secrets ~ Clifford - catch hacker
- Center of Gravity (Strategy)
  - Hacker - break into military computers ~ Clifford - honey pot
- Technology / Equipment
  - Hacker - PC + dialup modem ~ Clifford - VAX computer + trace backs
- Training
  - Hacker - self taught ~ Clifford - self taught
- Leadership + Morale
  - Hacker - considers himself elite ~ Clifford enraged someone would break into his computer and use its resources - wants to get his man - pursues him over 10 months
- Tactics
  - Hacker - brute force attacks using known security weaknesses on Lawrence Berkeley Laboratory computers + 450 others of which 30 were entered ~ Clifford - honey pot + call tracing

- Clifford Stoll, Stalking the Wily Hacker, Communications of the ACM, May 1988

Computing Case Study Summary - Cuckoo's Egg

- Intangibles

  "Break-ins ultimately destroy the network connectivity they exploit…It is an understandable response to lock the door, sever connections, and put up elaborate barriers. Perhaps this is necessary, but it saddens the author, who would rather see future networks and computer communities built on honesty and trust." - Clifford Stoll

- Mistakes
  - Hacker should have attacked Lawrence Livermore National Laboratory which does classified research
  - Hacker created unauthorized account which led to accounting error which led to his detection
  - No agency in US has jurisdiction over this in 1986, therefore no one interested in helping Clifford
- Outcome
  - First scientifically documented case of pursuit of + catching a hacker ~ enlightened and raised awareness of security issues
  - Hacker (Markus Hess) was a German working for KGB, was convicted of espionage

  - Clifford Stoll, Stalking the Wily Hacker, Communications of the ACM, May 1988

Focused Case Study - Fumbling the Future

- Xerox PARC invented the future of computing, Xerox Inc. fumbled it
  - Personal computer (Alto)
  - Window Icon Menu Pointing Device interface (WIMP) + WYSIWYG editing
  - Laser printer
  - Local area network (Ethernet)

  \- Douglas K. Smith, Fumbling the Future: How Xerox Invented, Then Ignored the First Personal Computer

Focused Case Study - Fumbling the Future

- Xerox PARC invented future of warfare, Xerox Inc. fumbled it

"The "worm" programs were an experiment in the development of distributed computations: programs that span machine boundaries and also replicate themselves in idle machines. A "worm" is composed of multiple "segments," each running on a different machine. The underlying worm maintenance mechanisms are responsible for maintaining the worm, finding free machines when needed and replicating the program for each additional segment. These techniques were successfully used to support several real applications, ranging from a simple multi-machine test program to a more sophisticated real-time animation system harnessing multiple machines."

- John F. Shoch and Jon A. Hupp, The "Worm" Programs Early Experience With a Distributed Computation, Xerox Palo Alto Research Center, 1982

Computing Case Study Summary - The First Covert Cyber Attack? (1982)

- **Goal**
  - **Cripple Soviet natural gas pipeline from Siberia to Europe that would make Europe energy dependent on Soviet Union and whose profits will fund Soviet computer R&D**
- **Center of Gravity (Strategy)**
  - **Allow Soviets to covertly procure software for programmable logic controllers to automate pipeline**
- **Technology / Equipment ~ Training ~ Leadership ~ Morale**
- **Tactics**
  - **Software was designed to make pumps, turbines, valves go haywire**
- **Intangibles ~ Mistakes**
- **Outcome**
  - **Largest non-nuclear explosion and fire ever seen from space (3 kilotons) destroyed pipeline**
  - **Caused Soviets to suspect all other software they had covertly obtained**
  - **27 years before Stuxnet**
  - **…Russia now dominant supplier of natural gas to Europe**

- William Safire, The Farewell Dossier, New York Times, Feb 2, 2004

Computing Case Study Summary - Robert Morris Internet Worm

- Goal
  - Measure the size of the Internet
- Center of Gravity (Strategy) + Technology / Equipment
  - Utilize self-replicating + self-propagating program (worm)
- Training + Leadership + Morale
  - Graduate student in computer science at Cornell
- Tactics
  - Exploited know bugs in BSD Unix sendmail program + finger daemon
- Intangibles
  - Father was Chief Scientist at NSA's National Computer Security Center

- Eugene H. Spafford, The Internet Worm - Crisis and Aftermath, Communications of the ACM, June 1989

Computing Case Study Summary - Robert Morris Internet Worm

- **Mistakes**
  - Bug in the worm caused it to replicate + reinfect machines at a faster than intended rate causing computers to become catatonic
  - Circulated anonymous fix but no one received it because system administrators unplugged computers from Internet to protect them (quarantine)
- **Outcome**
  - First attack upon Internet - evening of November 2, 1988
  - Sendmail + finger bugs discovered and patches issued within 1 day by Unix "old-boy" network ~ some computers took 1 month to fix
  - Led to founding of Computer Emergency Response Team (CERT)
  - Convicted of violating Computer Fraud and Abuse Act
  - Now a professor at MIT

- Eugene H. Spafford, The Internet Worm - Crisis and Aftermath, Communications of the ACM, June 1989

Robert Morris

From Wikimedia Commons

Person - Robert Morris

- Significance
  - Accidental cyberwarrior
  - First person convicted under Computer Fraud and Abuse Act
  - Father was Robert Morris, computer scientist at Bell Labs, who helped design Multics + Unix operating systems + later became chief scientist at National Computer Security Center at NSA
- Profession
  - Professor of computer science
- Places worked
  - MIT
- Years of work
  - 1988 - present
- Things worked on
  - While a graduate student at Cornell, created Morris Worm in 1988, first computer worm on Internet, which was designed to measure size of Internet, due to a bug got out of control

Why is the Internet so Insecure?

- Telephone network had intelligent core (switches) and dumb edges (handsets)
- Internet had dumb core (data carrying network) and intelligent edges (computers controlled by users)
  - Dumb core offered few opportunities for centralized security but made it easy for new users to join
  - Intelligent edges must be controlled by people with shared motives + high degree of trust as edges served as gatekeepers to network
- Internet's architects never imagined anyone would be able to use / misuse it

  "It's not that we didn't think about security. We knew there were untrustworthy people out there, and we thought we could exclude them." - David Clark, computer scientist
- 1988's Morris Worm attack on the Internet was wakeup call for Internet's architects but it was too late because the idealists who created it were no longer in charge - no one was

  "People don't break into banks because they're not secure. They break into banks because that's where the money is. They (the Internet's architects) thought they were building a classroom, and it turned into a bank." - Janet Abbate, historian
- Morris worm revealed the downside of a network with a dumb core + intelligent edges, which pushes security to edge of network, which is where vast majority of hacks occur today
- Morris worm also showed how difficult it is to fix problems once they are widely know - buffer overflow bug it exploited is still used by hackers today

- Craig Timberg, Net of Insecurity, Washington Post, May 30, 2015

Computing Case Study Summary - The First Military Cyber Attack? (1991)

- Goal
  - Cripple Iraq's command and control system before beginning of 1991 Persian Gulf War
- Center of Gravity (Strategy)
  - Launch cyber attacks against key government + military systems in Iraq
- Technology / Equipment ~ Training
  - Unknown
- Leadership
  - Robert Morris, Chief Scientist of the NSA (and father of Robert Morris of Internet Worm fame)
- Morale ~ Tactics

  Unknown
- Intangibles ~ Mistakes
  - Like father like son?
- Outcome
  - Classified but assumed to be successful

- Samuel Greengard, Robert Morris 1932-2011, Communications of the ACM, Sept 2011 p. 17

Computing Case Study Summary - Virtual Hospital DDOS Attack in ~ 2000

- Goal
  - Take Virtual Hospital off the Internet to get even with it for some imagined slight
- Center of Gravity (Strategy)
  - Distributed denial of service attack
- Technology / Equipment ~ Training ~ Leadership ~ Morale
  - Unknown who the attack was from - the La Leche League?
    - Virtual Hospital had a lot of "enemies"
- Tactics
  - Attack used low level chronic DDOS
  - No blocking defense was ever deployed as it was not worth the effort
- Intangibles ~ Mistakes
  - Was at such a low level it never effected operation of site
- Outcome
  - Attack did consume bandwidth, but bandwidth through University was free
  - For Virtual Hospital the attack became cost of doing business
    - Learned to live with it - unsure when it began + ended - became noise

Computing Case Study Summary - Virtual Naval Hospital

- Goal
  - US - Use digital library technology to make medical reference information easily available to military medical personal regardless of their location + Internet access speed
  - China - Make sure that the digital library does not disappear from Web
- Center of Gravity (Strategy)
  - China - Make their own copy
- Technology / Equipment + Tactics
  - US - Linux + Apache Web server + CD-ROM mirrors
  - China - Webcrawler robot
- Intangibles
  - All medical reference information individually in public domain but organization + synthesis of it increases its value tremendously

Computing Case Study Summary - Virtual Naval Hospital

- Mistakes
  - Chair of Department of Military Medical Services at Second Military Medical University in Shanghai (Chinese People's Liberation Army's medical school) requests CD-ROM copy of site, sent in December 1999
  - September 2002, as US gears up to attack Iraq, Web site is crawled by a robot from Chinese International Book Trading Corporation in Beijing, accounting for 50% of traffic to site that month
  - November 2002, unauthorized mirror of site appears at Campus Medical University in Beijing
- Outcome
  - Unauthorized mirror of site remains on Web after Virtual Naval Hospital decommissioned in January 2006
  - Bottom line - coincidence or conspiracy?

Computing Case Study Summary - Russia vs. Estonia Cyber War - April 27 - May 29, 2007

- Goal
  - Russia - punish Estonia for relocation of war memorial
  - Estonia - preserve E-stonia
- Center of Gravity (Strategy)
  - Russia - Cut Estonia off the network
  - Estonia - Preserve network infrastructure

    "These attacks were an attempt to take one country back to the cave, back to the stone age"
- Technology / Equipment
  - Russia - botnets around world consisting of 1 million personal computers - generate 400 times normal Internet traffic

  - Joshua Davis, Web War I, Wired, Sept 2007

Computing Case Study Summary - Russia vs. Estonia Cyber War - April 27 - May 29, 2007

- Training / Leadership / Morale
  - Russia - black hat hackers knowledgeable with high morale
  - Estonia - white hat hackers very knowledgeable
- Tactics
  - Russia - Massive / targeted / organized distributed denial of service attacks which targeted Estonian government, banks, telecommunication providers, Internet service providers, news organizations, schools
  - Estonia - Computer Emergency Response Team (CERT) was centralized with authority to defend country - set up fire walls, then blocked all traffic from .ru, then blocked all traffic from outside Estonia
    - CERT leader socially networked with the Vetted who control the world's 13 root DNS servers to selectively kick rogue computers running botnets off Internet

- Joshua Davis, Web War I, Wired, Sept 2007

Computing Case Study Summary - Russia vs. Estonia Cyber War - April 27 - May 29, 2007

- **Intangibles / Mistakes**
  - Plausible deniability due to anonymity of attacks

  "In the 21st century, the understanding of a state is no longer only its territory and its airspace, but also its electronic infrastructure."

  "If you have a missile attack…it is an act of war…If the same result is caused by computers, then how else do you describe that kind of attack?"
- **Outcome**
  - Is an effects-based operation
  - Is a systems disruption whose aim is to disrupt target society, leaving it unable to function as modern country
  - Is designed to harm, scare, leave no visible imprint, be instantly reversible, not kill anyone
  - Is efficient + without collateral damage, causes massive panic on shoestring budget, tough to catch perpetrators
  - Creates no uproar, results in no economic sanctions, doesn't seem to be real form of warfare
    - NATO did not regard it as an armed attack on a member state that needed a response

  \- Joshua Davis, Web War I, Wired, Sept 2007

Computing Case Study Summary - Russia vs. Georgia Cyber War 2008

- **Goal**
  - Politically make an example of Georgia to other ex-Soviet states
  - Economically shut down competing Georgian oil pipelines from Caspian Sea
- **Center of Gravity (Strategy)**
  - Coordinated cyber + physical attacks
- **Technology / Equipment**
  - Botnets located all around the world - not just inside Russia
- **Training / Leadership / Morale**
  - Social networks used nationalist appeals to recruit civilian cyber soldiers who were provided with one-click tools which did not require training to launch cyber attacks against lists of suggested targets
- **Tactics**
  - Distributed denial of service attacks against 54 Georgian government / bank / media Web sites
- **Intangibles / Mistakes**
- **Outcome**
  - First combined operation linking cyber attack with ground attack

- David A. Fulghum, Cyberwar is Official, Aviation Week, Sept 14, 2009 pp. 54-55

Computing Case Study Summary - Stuxnet 2009-2010

- Goal
  - Delay Iran's nuclear weapon production program
- Center of Gravity (Strategy)
  - Conduct remote cyber sabotage on Iranian centrifuges used to enrich uranium
- Technology / Equipment
  - Virus / worm that utilizes 4 Microsoft Windows zero day security vulnerabilities (which would require Windows source code) and genuine stolen digital signatures
- Training / Leadership / Morale
  - Code appears to be written by 30 people

- Michael Joseph Gross, A Declaration of Cyber-War, Vanity Fair, April 2011

Computing Case Study Summary - Stuxnet 2009-2010

- Tactics
  - Virus / worm seeks specific programmable logic controllers on centrifuges Iranians had at Vatanz nuclear enrichment facility, sabotages them, hides itself until done
  - Spread by USB sticks
  - Has self-destruct mechanism set for 2012, which says lawyers oversaw its creation, which says it comes from a Western government
- Intangibles
  - Who created it - US, Israel, Both?
  - Who helped with it - Microsoft, Siemens?
  - How can you make a cyber attack side-effect free?

- Michael Joseph Gross, A Declaration of Cyber-War, Vanity Fair, April 2011

Computing Case Study Summary - Stuxnet 2009-2010

- Mistakes
  - Virus / worm revealed itself before its job was complete
- Outcome
  - Allegedly, centrifuges were destroyed, program was delayed
  - What industrial target in what industrial nation will be next?

"Stuxnet is the Hiroshima of cyber-war…We have crossed a threshold, and there is no turning back."

- Michael Joseph Gross, A Declaration of Cyber-War, Vanity Fair, April 2011

Computing Case Study Summary - Advanced Persistent Threat People's Liberation Army Unit 61398

- Goal
  - Enrich intelligence of the Chinese Communist party
- Center of Gravity (Strategy)
  - Conduct computer espionage focusing on political, economic, military intelligence
- Technology / Equipment
  - Standard Internet tools + social engineering
- Training
  - Hundreds to thousands of proficient English speakers with advanced computer security + networking skills
- Leadership
  - People's Liberation Army
- Morale
  - High
- Tactics
  - Spear phishing
- Intangibles
  - For long time has been engaged in theft of intellectual property
  - Now is interested in obtaining information on critical US utilities infrastructure
- Mistakes
  - Are easily tracked + identified, especially as they relax on social networks
- Outcome
  - Digital forensic evidence by Mandiant in 2013 shows an overwhelming percentage of cyber attacks on US corporations, organizations, government come from an office building in Shanghai, China = "Comment Crew" / "Shanghai Group"
  - Is central element of Chinese computer espionage + focuses on political, economic, military intelligence

- David Sanger + David Barboza + Nicole Perlroth, Chinese Army Unit is Seen as Tied to Hacking Against US, New York Times, Feb 18, 2013

Focused Case Study - Russia vs. Ukraine Cyber War 2014

- You do not need to cyber attack another country when you make its cyber infrastructure and you own the telecommunications companies that run on top of it. By doing this you have free + unfettered access to their network - this is the ultimate Trojan horse
  - Ukraine's communications intercept system (like other members of Commonwealth of Independent States) is modeled after Russia's SORM system, including being built upon Russian hardware
  - Russian companies own a significant percent of Ukraine mobile market
- There are lessons here for the US in regards to China…

- Patrick Tucker, Why Ukraine Has Already Lost the Cyberwar Too, Defense One, Apr. 28, 2014

Computing Case Study Summary - Nitro Zeus

- Goal
  - Cyberattack on Iran in case diplomatic effort to limit its nuclear program failed
- Center of Gravity (Strategy)
  - Disable air defenses, communication systems, power grid
- Technology / Equipment
  - Cyberweapons
- Training
  - Place electronic implants in Iranian computer networks to prepare battlefield
- Leadership ~ Morale
  - NSA Tailored Access Operations unit would penetrate adversary networks
  - US Cyber Command would have executed attack
- Tactics
  - Also execute focused cyberattack on Fordo nuclear enrichment site by inserting worm to disable Fordo's computer systems thus degrading the operating of its uranium enrichment centrifuges
- Intangibles
  - Only US president can authorize offensive cyberattack
  - Collateral damage hard to predict
- Mistakes
  - Was It coupled to a kinetic component?
- Outcome
  - Cyberwarfare has become standard element of US military arsenal

- David Sanger + Mark Mazzetti, US Had Cyberattack Plan if Iran Nuclear Dispute Led to Conflict, New York Times, Feb. 16, 2016

Personal Case Study - NotPetya Malware Disguised as Ransomware

- Role
  - Passenger on Deutsche Bahn, traveling from Augsburg to Interlaken
- Story
  - June 27, 2017 - Standing on train platform in Karlsruhe Hauptbahnhof, waiting to make a transfer
  - All the train information screens in the station went blank for one hour, there were not public service announcements, and then they came back up
  - The whole time the trains kept running on time
  - Originated in Ukraine, used the Windows zero-day exploit EternalBlue that was discovered by the NSA but never disclosed until the NSA was hacked by the ShadowBrokers who released it - was same exploit behind the WannaCry ransomware
  - Was initially thought to be a ransomware attack demanding $300 in Bitcoin
  - Really was a malware attack against Ukrainian financial system disguised as ransomware
  - Was done by the Russian GRU military intelligence agency on Ukraine's Constitution Day

- Ellen Nakashima, Russian Military Was Behind NotPetya Cyberattack in Ukraine, CIA concludes, Washington Post, Jan 12, 2018

NotPetya

"While many in the security community still see NotPetya's international victims as collateral damage, Cisco's Craig Williams argues that Russia knew full well the extent of the pain the worm would inflict internationally. That fallout, he argues, was meant to explicitly punish anyone who would dare even to maintain an office inside the borders of Russia's enemy. 'Anyone who thinks this was accidental is engaged in wishful thinking,' Williams says. 'This was a piece of malware designed to send a political message: If you do business in Ukraine, bad things are going to happen to you.'"

- Andy Greenberg, The Untold Story of NotPetya, the Most Devastating Cyberattack in History, Wired, Sep. 2019

Focused Case State: Anonymous as Non-State Actor

- Anonymous is a series of relationships, no membership fee, no initiation
  - Anyone who wants to be part of it simply claims allegiance
- Non-hierarchial
- Can infiltrate anything
- Started in 2004 on 4chan, moved in 2008 to Internet Relay Chat channels
- Attacks made
  - 2008 - Church of Scientology - DDOS
  - 2010 - Operation Payback against Mastercard, Visa, PayPal who had stopped facilitating donations to WikiLeaks - DDOS
  - 2011 - Numerous Operations in support of Arab Spring - DDOS, hacks, cyber care packages for protestors
  - 2013 - Million Mask March with several thousand people marching in support of Anonymous in 450 cities around world
  - 2014 - Operation Save Gaza against Israel - DDOS
  - 2014 - Operation Ferguson - including cyber care packages for protestors + doxing those it feels were responsible
- 2012 - General Keith Alexander, Director of NSA claims Anonymous may be capable of destabilizing national power grids in 2 years
  - Anonymous may be most powerful nongovernmental hacking collective in world but has never demonstrated ability or desire to damage key public infrastructure

- David Kushner, The Masked Avengers, New Yorker, Sep. 8, 2015

Zero Day Warfare

- Goal - win war before it starts by penetrating opponent's territory years before conflict begins + by focusing on shattering opponent's physical + logical cohesiveness
  - Autonomous robots + software bots penetrate opponent physically (their territory) + logically (their computer systems)
    - Most hidden + dormant but some actively + passively map opponent networks, analyze them for vulnerabilities
  - When activated, autonomous robots + software bots conduct coordinated attack from inside opponent's territory + computer systems
    - Together they damage, degrade, seize control of physical infrastructure + computer systems to enable rapid entry of conventional forces
  - External forces (conventional + autonomous robots) utilize this disruption to rapidly seize control of opponent's territory
- Will be possible within 10 years

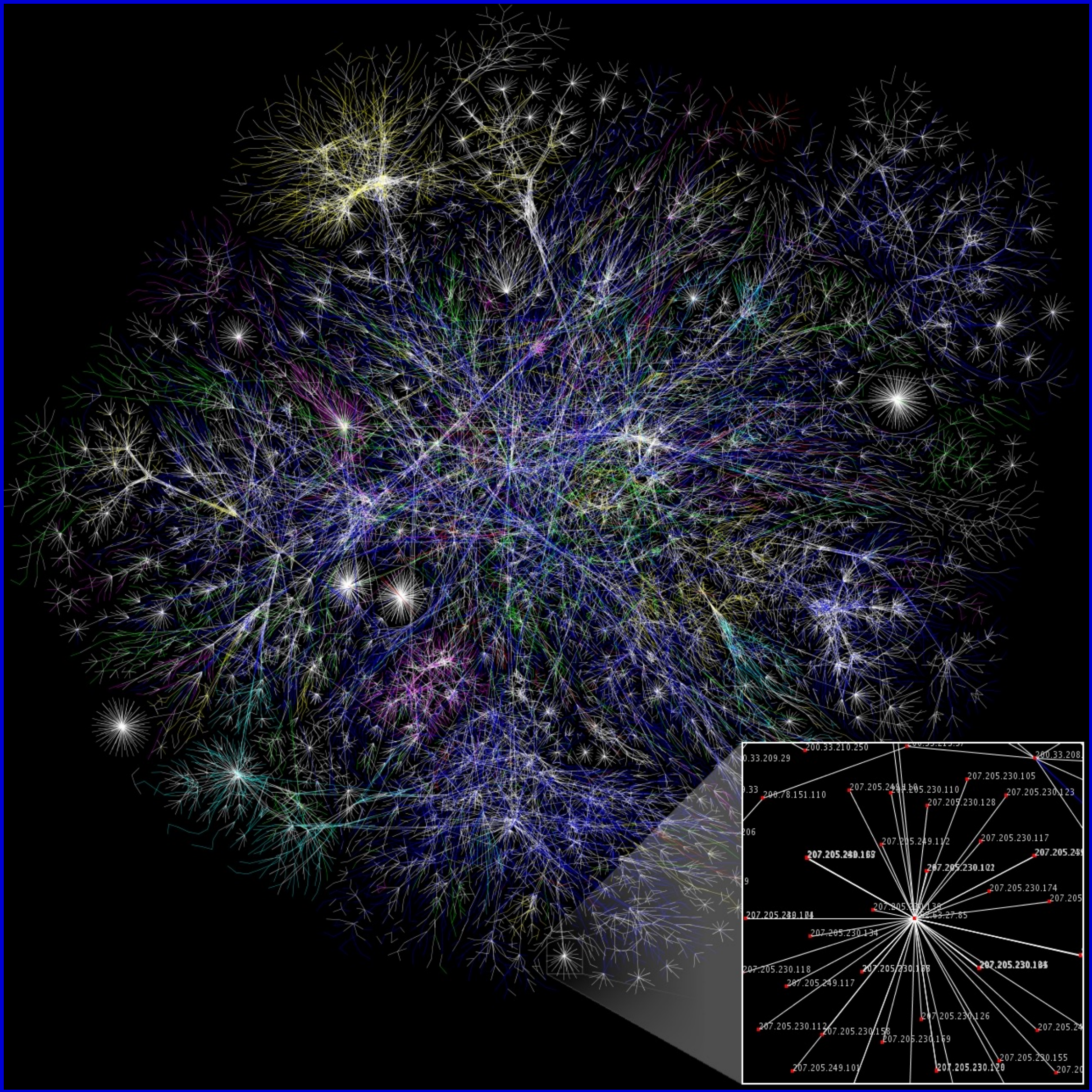
- John Robb, Zero Day Warfare, Global Guerillas Feb. 21, 2016

Morality of Cyberwar

- 3 principles for going to war justly
  - Right purpose - acting in self-defense
    - Cyberwar may move nations in direction of preemptive + preventive action
  - Due authority - seek authorization from national or supranational body
    - Cyberwar does not require armed forces but rather malicious software + skilled hackers
    - Authority loses meaning in world where individuals can wage cyberwar
  - Last resort - Pursue diplomatic efforts until they will not resolve crisis
    - Cyberwar's covert deniable nature means it can be used during negotiations
- Ideas of fighting
  - Noncombatant immunity - focus on military vs. civilian targets, avoid deliberate targeting of civilians
    - Cyberwar will cause less lethal harm to noncombatants, but with great economic cost inflicted upon innocent
  - Proportionality - avoiding excessive force
    - Cyberwar may influence type of action taken rather than degree of intensity of action
- Conclusion
  - In whether to go to war, cyberwar may encourage preemptive action + erode idea of war as tool of last resort
  - In whether to target civilians, cyberwar may provide means for causing disruption without killing
  - Non-state actors will outflank "authority" principle
  - Nations might employ disproportionate physical force in response to virtual attack

- John Arquilla, The Ethics of Cyberwar, Communications of the ACM, Oct. 2015

Internet Map from OPTE Project



From Wikimedia Commons

Cyberspace Definition

"Cyberspace. A consensual hallucination experienced daily by billions of legitimate operations in every nation, by children being taught mathematical concepts…A graphical representation of data abstracted from the banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the non-space of the mind, clusters and constellations of data. Like city lights, receding..."

- William Gibson, Neuromancer, 1984

Computing Case Study Summary - Mapping Cyberspace / Internet Mapping Project

- Background
  - "It (the voyage of HMS Beagle) was another great step in the Enlightenment project of mapping, and therefore controlling, the world."
    - Neil MacGregor, A History of the World in 100 Objects, Episode 91 Ship's Chronometer from HMS Beagle
- Goal
  - Acquire + save Internet topological data over long period of time
- Center of Gravity (Strategy)
  - To control the battle space, you must first map the battle space

Computing Case Study Summary - Mapping Cyberspace / Internet Mapping Project

- Technology / Equipment / Training / Leadership / Morale
  - Conduct frequent traceroute-style path probes, one to each Internet entity
  - Build a graph showing the path to most of nets on Internet
  - Generate map from graph showing topology at center of Internet

Computing Case Study Summary - Mapping Cyberspace / Internet Mapping Project

- Tactics / Intangibles / Mistakes
  - 1998 - Internet Mapping Project launched by Bell Labs, generating beautiful maps for Wired magazine
  - 1999 - Maps Yugoslavia during war
  - 2000 - Spun off into Lumeta, becomes IPSonar
  - 2006 - Principles leave for ATT Labs (William Cheswick) + Google (Hal Burch)
  - 2008 - Beautiful map generated for Inauguration crowds
  - 2010 - Strategic partners = security industrial complex = Northrop Grumman, SAIC
- Outcome
  - Number of routers on Internet grows from 88,000 (August 1998) to 159,000 (April 2003) to 450,000 (April 2008)
  - Currently a closed system
  - Open alternatives exist but are not currently operational - OPTE.org + Caida.org (Walrus open source)

Personal Case Study - Reading Chair's Files / Cyberspying

- Role
  - Undergraduate Computer Science major eager to make his educational experience better
- Story
  - In 1984, Chairman of Computer Science formed advisory committee consisting of members of Student chapter of Association for Computing Machinery to advise him on issues relating to the department's educational mission
  - Although a brilliant computer science theoretician, he had little grasp of the practical matters of day-to-day computing, and all his files on the university mainframe were permitted "Read All"
  - Before every meeting with him, we would review files containing his meeting calendar + meeting notes, pre-meet amongst ourselves, and come to the meeting armed with well-thought out answers to his questions and solutions to his problems
  - He would muse it was miraculous as to how we could seem to read his mind…

Personal Case Study - Morris Internet Worm Crash

- Role
  - First worm distributed via Internet
- Story
  - On November 2, 1988 I was working at my workstation at the National Library of Medicine Lister Hill Center, connected to the Internet over a T1 line, and slowly watched the Internet grind to a halt, and not knowing why…but learning the reason why the next day in the newspaper

Personal Case Study - EF-111A pilot

- Role
  - First Gulf War pilot
- Story

  "Once we turned our jammers on the first night of the war, the Iraqis were totally blinded…"

Personal Case Study - David L.

- Role
  - White hat hacker
- Story
  - Only child ~ musician ~ ham radio ~ B.S. CompSci
    - Ran world's largest Internet BBS (ISCA) + busiest FTP site (lust) while undergraduate in 1990's
    - People drove from around USA to leave offerings at front door
  - Wired / networked home including fish tanks
    - First MP3 I ever saw - on server in his car in 1992
  - Security consultant to FBI
  - Started his own Internet Service Provider
    - Eventually purchased a telephone company (CLEC)
  - …oh and by the way is now highly specialized physician
  - Saw him in action
    - Needed live phone line for demonstration at computer conference in a Hilton Hotel which hotel could not provide
    - In 5 minutes he located a hotel phone closet, hacked into it, and physically ran a phone line 100 yards with a dial tone to our podium ~ "No problem guys!"

Personal Case Study - Clifford Stoll

- Role
  - Pioneer in battling and writing about cyber warfare
- Story
  - Attended a talk he gave at MacWorld in January 1992
  - Guzzled a bottle of Mountain Dew before the talk, and gave the most brilliant + animated talk I have ever seen, running laps around the lecture hall while hurdling chairs in the isles…yet never missing a beat in terms of timing and what he wanted to say
  - He wanted you to think he was crazy but he choreographed the whole thing
  - Most brilliant presentation I have ever seen

Personal Case Study - Lt Robert A.

- Role
  - Computer science researcher
- Story
  - Served as officer in airborne unit at end of Vietnam War, helping Vietnamese boat people in operation other than war
  - Deployed Knowledge Management System - first hypertext system in the US Navy in 1980's
  - Developed Petaplex project for NSA for digital library architecture to handle 20 petabytes of storage with millions of accesses / second with sub second response time
  - Discussion in 2001 of using USS Jimmy Carter to tap undersea fiber optic cables
    - Media said it can't be done
    - He inquired as to why one should believe the media

Personal Case Study - David G.

- Role - Computer security specialist
- Story - Ph.D. in computer science, worked at NSA, then Naval Research Laboratory (NRL), now in private industry
  - Created Onion Routing at NRL which is a way to camouflage communication over a public network and thus avoid censorship
  - Evolved into open-source Tor system

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- Who invented cyber war, and as usual, missed it?
- When was the first cyber attack?
- What nations have been crippled by cyber war?
- What was the first cyber attack you experienced?
- How will computers change the nature of war?
- What computational challenges regarding security do computer and software engineers face?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
  - Stoll, Clifford - The Cuckoo's Egg
- Fiction
- Movies
- Simulations

Conclusion

"So, for me, the real meaning of cyber warfare is on the battlefield. Much as aircraft which couldn't break societies with bombardment transformed 20th century warfare, I think cyber attacks will transform 21st century warfare. Militaries which are highly dependent on secure information systems will be absolutely crippled, just as if they didn't have aircraft above to protect them in the 20th century. If they don't have good cyber defenses in the 21st century, they'll be absolutely helpless."

- John Arquilla, professor, Naval Post Graduate School

Conclusion
Rules of Computer Security

- RULE ONE: Do not own a computer.
- RULE TWO: Do not power it on.
- RULE THREE: Do not use it.

  - Robert Morris Sr., NSA cryptographer

Topic 25

Lawfare

Song

Slide text

Thematic Quote

"Governments of the Industrial World, you weary giants of flesh and steel, I come from Cyberspace, the new home of Mind. On behalf of the future, I ask you of the past to leave us alone. You are not welcome among us. You have no sovereignty where we gather."

- John Perry Barlow, cyber-libertarian, 1996 in "A Declaration of the Independence of Cyberspace"

- [In 1996, 50 million people, or 0.86% of humanity, used the Internet.
- In 2016, 3.3 billion people, or 40% of humanity, uses the Internet.
- No system of this scale can be completely self-governing.

- Growing Up, The Economist, Mar. 26, 2016]

The Painting

Seventeen Seventy Six

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - CD / DVD to rip
- Year
  - ~ 1999
- Story

The Question

How can a law be legal that makes everyone a criminal?

Carterfone Prototype

Thing / Hardware - Carterfone

- **Firsts / Achievements / Uniqueness / Significance**
  - Led to landmark regulatory decision related to telecommunications - In 1968 the FCC ruled any device could be connected to ATT telephone network as long as the device did not cause harm to the network
  - This created possibility of selling devices that could connect to phone system + opened market to customer owned equipment like answering machines, FAX machines, modems
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Carter Electronics ~ 1959 ~ USA
- **People involved (Designer)**
  - Thomas Carter
- **Type**
  - Phone patch
- **Price / Cost**
  - Text
- **Size**
  - Shoebox

Thing / Hardware - Carterfone

- Computing technology
  - Transistors
- Computing speed (in MIPS)
  - N/A
- Primary memory type / technology ~ Size ~ Word length
  - N/A
- Secondary memory type / technology ~ Size
  - N/A
- Uses / Applications / Software
  - Manually connects two way mobile radio system to public switched telephone network (phone patch)
- Predecessors - N/A ~ Successors - N/A

Place - Cyberspace

- Significance
  - Initially conceived of as humanity's next unregulated frontier
- Location
  - A virtual location
- Definition
  - The electronic medium of computer networks, in which online communication takes place
- People who worked there
  - Science fiction authors
- Things created there
  - Internet

Cyberspace Definition

"Cyberspace. A consensual hallucination experienced daily by billions of legitimate operations in every nation, by children being taught mathematical concepts...A graphical representation of data abstracted from the banks of every computer in the human system. Unthinkable complexity. Lines of light ranged in the non-space of the mind, clusters and constellations of data. Like city lights, receding..."

- William Gibson, Neuromancer, 1984

Code and Other Laws of Cyberspace

- Book description from Amazon:
  - "There's a common belief that cyberspace cannot be regulated - that it is, in its very essence, immune from the government's (or anyone else's) control. Code, first published in 2000, argues that this belief is wrong. It is not in the nature of cyberspace to be unregulable; cyberspace has no "nature." It only has code - the software and hardware that make cyberspace what it is. That code can create a place of freedom - as the original architecture of the Net did - or a place of oppressive control. Under the influence of commerce, cyberspace is becoming a highly regulable space, where behavior is much more tightly controlled than in real space. But that's not inevitable either. We can - we must - choose what kind of cyberspace we want and what freedoms we will guarantee. These choices are all about architecture: about what kind of code will govern cyberspace, and who will control it. In this realm, code is the most significant form of law, and it is up to lawyers, policymakers, and especially citizens to decide what values that code embodies."

    \- Lawrence Lessig, Code and Other Laws of Cyberspace

Code = Law

"Code = Law"

- Lawrence Lessig, Law Professor

- The way we code (the Web, the Internet, apps) determines the way we live online
  - Therefore we need to bake our values into our code
- If Code = Law, what values should we bake into our code?
  - Freedom of expression? Privacy? Universal access to all knowledge?

"Natural scientists are given a universe and seek to discover its laws. Computer scientists make laws in the form of programs and the computer brings a new universe to life."

- Alan Kay, computer scientist

What Are Your Rights in Cyberspace?

"Those who would give up essential Liberty, to purchase a little temporary Safety, deserve neither Liberty nor Safety."

- Benjamin Franklin, November 15, 1755

Aaron Swartz

"We can rightly judge a society by how it treats its eccentrics and deviant geniuses - and by that measure, we have utterly failed.

...

His form of civil disobedience consisted of heading into an M.I.T. closet with a laptop, hooking it up to the Internet, and downloading millions of articles from JSTOR, an academic database. Swartz thought information should be free. It wasn't a major coup, but it counts as a defiant act-and one that made its point, for it was, and remains, absurdly hard for the public to gain access to what academics supposedly write for it.

The act was harmless - not in the sense of hypothetical damages or the circular logic of deterrence theory (that's lawyerly logic), but in John Stuart Mill's sense, meaning that there was no actual physical harm, nor actual economic harm. The leak was found and plugged; JSTOR suffered no actual economic loss. It did not press charges. Like a pie in the face, Swartz's act was annoying to its victim, but of no lasting consequence.

In this sense, Swartz must be compared to two other eccentric geniuses, Steve Jobs and Steve Wozniak, who, in the nineteen-seventies, committed crimes similar to, but more economically damaging than, Swartz's. Those two men hacked A.T. & T.'s telephone system to make free long-distance calls, and actually sold the illegal devices (blue boxes) to make cash. Their mentor, John Draper, did go to jail for a few months (where he wrote one of the world's first word processors), but Jobs and Wozniak were never prosecuted. Instead, they got bored of phreaking and built a computer. The great ones almost always operate at the edge.

…

- Tim Wu, How the Legal System Failed Aaron Swartz - And Us, New Yorker, Jan. 14, 2013

Aaron Swartz

Just last year, the Ninth Circuit Court of Appeals threw out a similar prosecution. Chief Judge Alex Kozinski, a prominent conservative, refused to read the law (1986 Computer Fraud and Abuse Act) in a way that would make a criminal of "everyone who uses a computer in violation of computer use restrictions-which may well include everyone who uses a computer." Ortiz and her lawyers relied on that reading to target one of our best and brightest.

It's one thing to stretch the law to stop a criminal syndicate or terrorist organization. It's quite another when prosecuting a reckless young man. The prosecutors forgot that, as public officials, their job isn't to try and win at all costs but to use the awesome power of criminal law to protect the public from actual harm. Ortiz has not commented on the case. But, had she been in charge when Jobs and Wozniak were breaking the laws, we might never have had Apple computers. It was at this moment that our legal system and our society utterly failed.

Defenders of the prosecution seem to think that anyone charged with a felony must somehow deserve punishment. That idea can only be sustained without actual exposure to the legal system. Yes, most of the time prosecutors do chase actual wrongdoers, but today our criminal laws are so expansive that most people of any vigor and spirit can be found to violate them in some way. Basically, under American law, anyone interesting is a felon. The prosecutors, not the law, decide who deserves punishment.

Today, prosecutors feel they have license to treat leakers of information like crime lords or terrorists. In an age when our frontiers are digital, the criminal system threatens something intangible but incredibly valuable. It threatens youthful vigor, difference in outlook, the freedom to break some rules and not be condemned or ruined for the rest of your life. Swartz was a passionate eccentric who could have been one of the great innovators and creators of our future. Now we will never know."

- Tim Wu, How the Legal System Failed Aaron Swartz - And Us, New Yorker, Jan. 14, 2013

Aaron Swartz

From Wikimedia Commons

Person - Aaron Swartz

- Significance
  - Cyberspace martyr who died for our sins

  "He used his prodigious skills as a programmer and technologist not to enrich himself but to make the Internet and the world a fairer, better place." - Family of Aaron Swartz
- Profession
  - Software developer, Internet activist
- Places worked
  - Mainly on his own
- Years of work
  - 2000 - 2013
- Things worked on
  - RSS, Creative Commons, Reddit
  - Guerilla Open Access Manifesto
  - Opened up PACER federal court records
  - Activist against Stop Online Piracy Act (SOPA / PIPA)
  - Downloading all articles in JSTOR for which he was charged under Computer Fraud + Abuse Act

- The Internet's Own Boy: The Story of Aaron Swartz

Focused Case Study - IBM Antitrust Suits

- In 1960's - created the software industry
- In 1980's - freed IBM to compete in personal computers

Focused Case Study - ATT Antitrust Suit

- Broke up ATT, allowed them to compete in computers

Focused Case Study - Microsoft Antitrust Suit

"The way to make money in technology is by setting de facto standards"

- Bill Gates, CEO Microsoft, 1990

- Microsoft had > 90% of market for several categories of PC software
  - Microsoft BASIC programming language
  - MS-DOS and Windows operating systems
  - Microsoft Word / Excel / PowerPoint bundled into Microsoft Office

- Robert X. Cringely, Before PCs Vanish, Microsoft Fights for Relevance in the Cloud, Technology Review, Jun. 21, 2016

Focused Case Study - Microsoft Antitrust Suit

"The reality of the software business today is that if you find something that can make you ridiculously rich, then that's something Microsoft is going to want to take from you. All we can do is meet with them and try to see what they're going to do to us when they feel like doing it. If they want to kill you, they'll kill you."

- Max Metral, CEO of Firefly, a collaborative filtering company, in 1997

(10 months later Firefly was acquired by Microsoft and disappeared)

Focused Case Study - Microsoft Antitrust Suit

- Made them take their eye off the ball

Forcing Tech Giants to Share Some of Their Wealth is a Good Idea

- 1956 - Consent decree forces AT&T, America's telephone monopoly, to license all its past patents free of charge, including the ones for the transistor -> Leads to rise of Intel
- 1969 - IBM, accused of monopolising mainframes, decides to market computers and their programs separately -> Leads to creation of the software industry, allows Microsoft to rule PC software
- End of 2000s - Microsoft agrees, at the end of its antitrust trials in America and Europe, not to discriminate against rival browsers and to license technical information which allows other operating systems to work easily with Windows -> Allows Google to take off
- Today - Force today's tech giants to open up their data vaults -> Lower the barriers to market entry and giving newcomers a better chance to compete

- The Art of the Possible, The Economist, Jun. 30, 2018

The Case For Patents

- In return for registering + publishing your new / useful / non-obvious idea,
- You get a temporary monopoly on using it,
- Thus providing an incentive to innovate because it assures innovator of material gain if innovation finds favor,
- And also providing tools to allow others to innovate because publishing good ideas allows one innovation to build upon another and increase speed of technological advance

- A Question of Utility, The Economist, Aug. 8, 2016

The Case Against Patents

The granting of patents "excites fraud, stimulates men to run after schemes that may enable them to levy a tax on the public, begets disputes and quarrels betwixt inventors, provokes endless lawsuits [and] bestows rewards on the wrong persons."

"Comprehensive patents are taken out by some parties, for the purpose of stopping inventions, or appropriating the fruits of the inventions of others."

- The Economist, July 26, 1851

Focused Case Study - Patent Trolls

- Eolas - patent troll company founded in 1994 by Michael David Doyle
  - Claims with his team at UCSF to have created first Web browser that supported plugins in 1993 and patented this innovation
  - Patent contested by Pei-Yuan Wei who developed the Viola Web browser that had plugins in 1992 + this claim is supported by Tim Berners-Lee
  - Sued many companies including Microsoft in 2003 and won, made much money from them, made additional money from licensing
  - Patents invalidated in 2012

Focused Case Study - DMCA

- What it prevents
- If everybody's somebody, than no one's anybody
- If everyone is a criminal, than no one's innocent

Thing / Software - Handbrake

- Firsts / Achievements / Uniqueness / Significance
  - Makes ripping a film from DVD to data storage device easy
  - Does not defeat / circumvent copy protection
- Place Produced (Company / Institution) ~ Year ~ Country
  - Individual effort originally ~ 2003 ~ France
- People involved (Programmer)
  - Eric Petit
- Type
  - Video transcoder
- Price / Cost
  - Free + open source
- Computer and operating system it runs on
  - Linux, Macintosh, Windows
- Computer language written in
  - C
- Memory required
  - N/A
- Predecessors - N/A ~ Successors - N/A

Spam

- 1971 - Peter Bos, MIT sysadmin, sent "There is no way to peace. Peace is the way" to 1,000 users
- 1978 - DEC marketer Gary Thuerk sent to everyone on ARPANet email an invite to DEC open house
- 1994 - Green Card Lottery Spam by Laurence Canter + Martha Siegal - law firm sent message to every Usenet group - invoked First Amendment in defense - got 1,000 clients - wrote a book "How to Make a Fortune on the Information Superhighway"
- 2003 - US Congress CAN SPAM Act - goal was to eliminate spam through commercial pressure - costs of spamming skyrocketed, leads to involvement of criminal syndicates who focus on identity theft + financial fraud + botnets
- Cost of spam - $10 billion / year spent on antispam measures with success rate > 95%

- Michael Specter, Damn Spam, New Yorker Aug 6, 2007

- Evgeny Morozov, The Common Enemy, Wall Street Journal, May 9, 2013

The Question at Hand

"Do we want our government, and the governments of countless other countries, to have the ability to compel Apple - or any other technology company - to grant access to any of our data they request?"

- Christopher Mims, Just One Issue Matters in the Clash Between Apple and the FBI, Wall Street Journal, Feb. 25, 2016

The Future of Privacy

"The US Supreme Court is currently hearing a case (US vs. Wurie) to decide whether police may routinely search your cell phone if they have any reason to arrest you, such as a traffic stop. The argument is that if you carry something on your person and come to the attention of the police, it's fair game: as a result you may be prosecuted for possession of child pornography, the possession being discovered after a traffic stop. Or perhaps you have a message implying you are selling drugs. Other scenarios come to mind.

When thinking about the advance of technology and the movement toward Thoughtcrime, you might keep this in mind as well."

- Jerry Pournelle

- US Supreme Court Decision June 25, 2014, 9-0: "The police generally may not, without a warrant, search digital information on a cellphone seized from an individual who has been arrested."

The Future of Privacy

- European Union citizens have the "Right to be Forgotten"
- Legal right to control availability of "inadequate, irrelevant or no longer relevant or excessive" information about them
- Traditionally this material would remain available on Web sites and thus findable via search engines
- But now EU citizens can ask to have it deleted from Web sites or not indexed by search engines
- Right to be Forgotten is a slippery slope that reminds one of George Orwell's Ministry of Truth in 1984 who had the job to alter previously published newspaper, magazine + encyclopedia articles to bring them into more perfect alignment with the latest beliefs of Big Brother

- Terry Teachout, Airbrushing the Internet, Wall Street Journal, Nov. 6, 2014

Personal Case Study - Apple II Piracy - Joe R, Robin H, Joe G, Dave L

- Role
  - Copyright protection never works
- Story
  - Before the Internet, pirated software was distributed face-to-face on floppy disks
  - There was a group of individuals who took pride in amassing + sharing huge collections of software…ironically they never actually used any of the software themselves
  - I saw one of these individuals caught by the FBI

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- Have the early predictions of cyberspace being humanity's next unregulated frontier come true?
- If Code = Law, what values should we bake into our code?
- Compare and contrast the cybercrimes of Steve Jobs / Steve Wozniak to Aaron Swartz
- What computational challenge do legislators face?
- Is the US and international patent systems asphyxiating innovation?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
- Simulations

Conclusion

"Ask not what the Internet can do for you, ask what you can do for the Internet"

- Dave Winer, software developer and writer

Topic 26

Computers in the Future

Song

Slide text

Thematic Quote

"The future is here. It's just not widely distributed yet."

- William Gibson, science fiction author

Thematic Quote

"Every 30 years there is a new wave of things that computers do. Around 1950 they began to model events in the world (simulation), and around 1980 to connect people (communication). Since 2010 they have begun to engage with the physical world in a non-trivial way (embodiment)."

- Butler Lampson, computer scientist

Thematic Quote

"How we design and interact with our increasingly intelligent machines will determine the nature of our society and our economy. It will increasingly determine every aspect of our modern world from whether we live in a more or less stratified society to what it means to be human."

- John Markoff in Machines of Loving Grace

The Painting

Future Past

- Robert Tinney

(Byte Magazine)

Artifact

- Name
  - Tamagotchi
- Year
  - Late 1990's
- Story
  - One of first artificial-intelligence powered toys - a virtual pet

The Question

What is computing's impact today on our lives and on society?

What will be computing's impact in the future on our lives and on society?

"It's tough to make predictions, especially about the future."

- Yogi Berra, baseball manager

"It's tough to think about the future when you are so busy changing history"

- Ernest Gann, aviation author, in The Black Watch

"Pre-imagining is the imagining of things that are to be"

- Leonardo da Vinci, inventor

"Real progress is not a leap in the dark, but a succession of logical steps"

- Robert Goddard, rocket scientist

"It is difficult to say what is impossible, for the dream of yesterday is the hope of today and the reality of tomorrow."

- Robert Goddard, rocket scientist

"It has often proved true that the dream of yesterday is the hope of today and the reality of tomorrow."

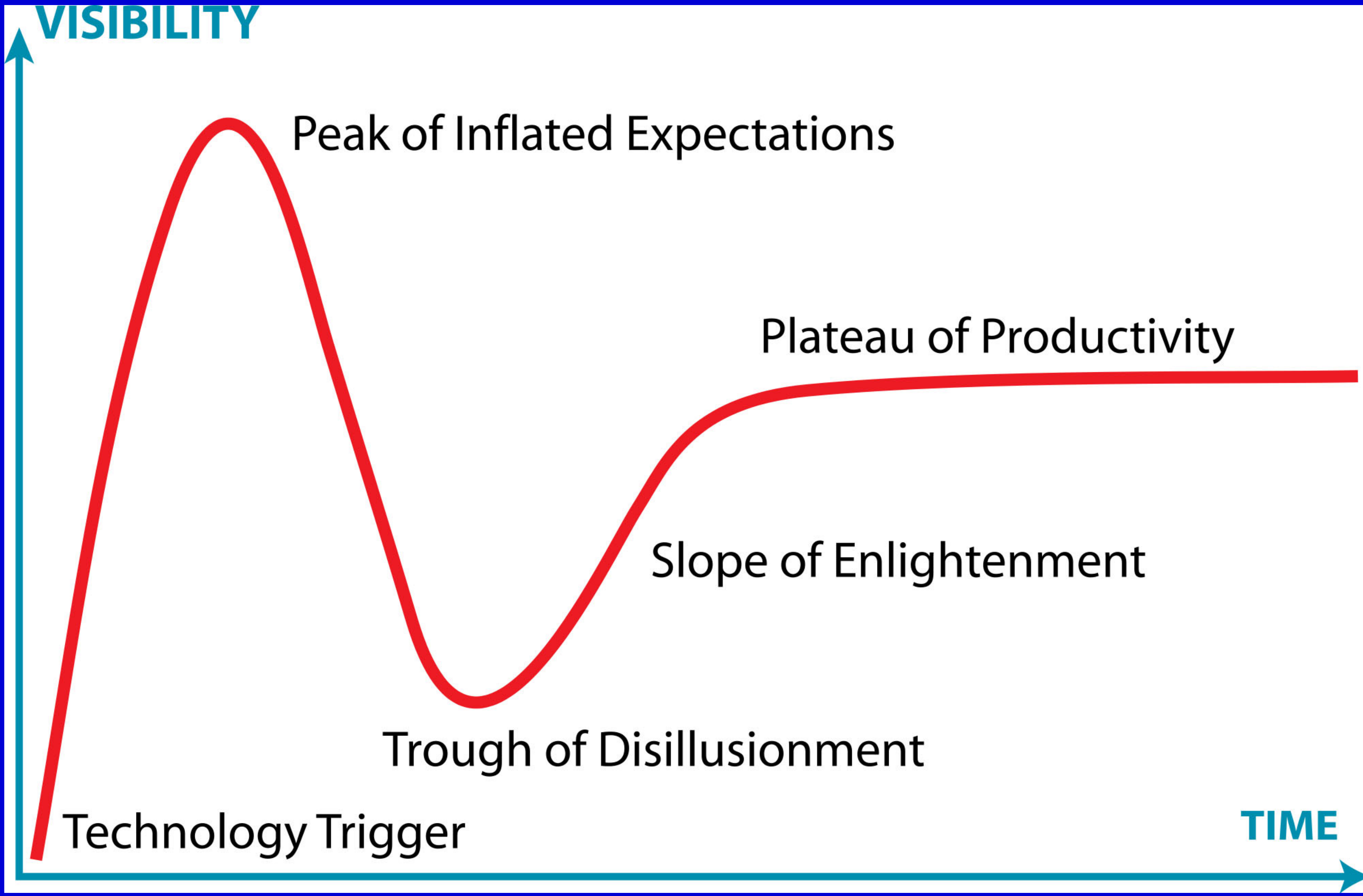
- Robert Goddard, rocket scientist

…But Sometimes You Get It Right

"The whole human memory can be, and probably in a short time will be, made accessible to every individual. This new all-human cerebrum need not be concentrated in any one single place. It can be reproduced exactly and fully, in Peru, China, Iceland, Central Africa, or wherever else seems to afford an insurance against danger and interruption. It can have at once, the concentration of a craniate animal and the diffused vitality of an amoeba."

- H.G. Wells, World Brain, 1938

Gartner Hype Cycle



From Wikimedia Commons

Take Gartner Hype Cycle With Grain of Salt

"We tend to overestimate change in the short term.
We tend to underestimate change in the long term"

- Old axiom

"Never mistake a clear view for a short distance"

- Paul Saffo, futurist

(we overestimate the short-term + underestimate the long-term impact of new technologies)

Cyberutopianism Through Time

- Airplane
- Radio
- Internet

(I am struck by the) "automatic way in which people go on repeating certain phrases which were fashionable before 1914. Two great favourites are the 'abolition of distance' and the 'disappearance of frontiers.' I do not know how often I have met with statements that 'the aeroplane and the radio have abolished distance' and 'all parts of the world are now interdependent.' Actually the effect of modern inventions has been to increase nationalism, to make travel enormously more difficult, to cut down the means of communication between one country and another."

- George Orwell, author

Computing Case Study Summary - Human-Nets Mailing List circa early 1980's

- Goal
  - Promote peace, love, understanding amongst nations and make the world a better place to live
- Center of Gravity (Strategy)
  - Design world wide computer network to facilitate this utopian vision = World Net
- Technology / Equipment
  - ARPANET ~ Mailing list
- Training / Leadership / Morale
  - The brightest luminaries in computer science + engineering on the ARPANET in early 1980's participated

Computing Case Study Summary - Human-Nets Mailing List circa early 1980's

- **Tactics**
  - Base design on ARPANET, a network based on trust, where everyone knows everyone else
  - Discussed technical, economic, social issues behind such a network and proposed implementations such as Telesophy + Xanadu
- **Intangibles / Mistakes / Outcome**
  - Discussions influenced + inspired many Internet pioneers
  - Predicted the bright side of Internet exactly
  - Missed the dark side of the Internet completely - anonymity, spam, cybercrime, use in terrorism, use in cyber warfare
    - All of these due to fact Internet's design based on ARPANET which was built on trust
  - Lesson learned: when designing utopia, expect the best, plan for the worst

Missing the Forest For the Trees

"I didn't realize how negative the negatives were going to be. I always knew intellectually that technology was neutral and would engender bad things and good things, but I was optimistic - more than I should have been. I see now that a lot of the values we try to build into the technology, to keep the web open, can get swept away and used for awful things."

- Joi Ito, Director of the MIT Media Lab

- Steven Levy, Joi Ito Explains Why Donald Trump is Like the Sex Pistols, Backchannel, Dec. 6, 2016

Akihabara

秋葉原駅
Akihabara Station
JR東日本

TORII PARTS 自動制御機器 防犯機器 LED照明
株式会社鳥居パーツ TEL03-3253-9518

APPLE

SEGA
LAOX

Place - Akihabara

- Significance
  - A creative place of the past, present and future
  - Visit the world of Blade Runner today
- Location
  - Surrounding the Akihabara train station in Tokyo, Japan
- Definition
  - Hub of technological innovation in Japan
- People who worked there
  - N/A
- Things created there
  - Japan's electrical appliance industry, Japan's consumer electronics industry, Japan's manga + anime + videogame industries

Thing / Software - Internet of Things

- Firsts / Achievements / Uniqueness / Significance
  - An ecology of computers + computer software
  - A security nightmare
- Place Produced (Company / Institution) ~ Year ~ Country
  - Everywhere ~ 2020? ~ Around the world
- People involved (Programmer)
  - N/A
- Type
  - Every device in the world connected to the Internet
- Price / Cost
  - Text
- Computer and operating system it runs on
  - All computers and operating systems
- Computer language written in
  - N/A
- Memory required
  - N/A
- Predecessors - N/A ~ Successors - N/A

Affective Computing

- Today computers are emotionally inert
- In the near future, by scanning your face, computers will be able to decode your unspoken reaction to a movie, debate, or video call through techniques of affective computing which creates emotionally intelligent computers
- Affdex is a software tool from Affectiva that can quantify, aggregate, leverage emotions
- Soon all devices will have an emotion chip that will constantly determine what your emotion is
- Three major resources individuals have are money, time, attention
- Many of the free services we use on Internet are paid for by the attention we offer to companies who track our habits + preferences = Attention Economy
- The Emotion Economy will operate similarly

"If we know the emotion of each user, we can provide more personalized services." - Samsung researcher

- ...a smartwatch, with its biosensors, is going to know everything about you...

- Raffi Khatchadourian, We Know How You Feel, New Yorker, Jan. 19, 2015

Deep Learning

- Deep learning systems - a modern refinement of machine learning systems, which mimic layers of neurons in brain, by crunching vast amounts of data, can learn to perform some tasks as well as humans such as pattern recognition, translation, playing videogames
- These learned tasks are narrow + specific
- Powers Google's search engine, Facebook's automatic photo tagging, Apple's Siri voice assistant, Amazon's shopping recommendations, Tesla's self-driving cars

"Instead of people writing software, we have data writing software" - Jen-Hsun Huang, CEO of NVIDIA

- Long term goal is to create an artificial general intelligence which can solve a wide variety of tasks
- Most optimistic view is that this will take a decade

  - Dawn of Artificial Intelligence, The Economist, May 9, 2015
  - Rise of the Machines, The Economist, May 9, 2015
  - March of the Machines, The Economist, Jun. 25, 2016
  - The Return of the Machine Question, The Economist, Jun 25, 2016
  - From Not Working to Neural Networking, The Economist, Jun 25, 2016

Deep Learning

"Perhaps the best way to think about AI is to see it as simply the latest in a long line of cognitive enhancements that humans have invented to augment the abilities of their brains. It is a high-tech relative of technologies like paper, which provides a portable, reliable memory, or the abacus, which aids mental arithmetic. Just as the printing press put scribes out of business, high-quality AI will cost jobs. But it will enhance the abilities of those whose jobs it does not replace, giving everyone access to mental skills possessed at present by only a few. These days, anyone with a smartphone has the equivalent of a city-full of old-style human "computers" in his pocket, all of them working for nothing more than the cost of charging the battery. In the future, they might have translators or diagnosticians at their beck and call as well."

- Dawn of Artificial Intelligence, The Economist, May 9, 2015
- Rise of the Machines, The Economist, May 9, 2015
- March of the Machines, The Economist, Jun. 25, 2016
- The Return of the Machine Question, The Economist, Jun 25, 2016
- From Not Working to Neural Networking, The Economist, Jun 25, 2016

Unsupervised Learning

- Supervised learning is what's behind machine learning / pattern recognition advances in AI
  - Weakness is that it relies on expensive sets of training data
- 2016 - AlphaGo becomes world's Go champion
  - Supervised learning - learned Go by studying thousands of games between experts (training data), extracting rules + strategies from them which it refined in games against itself
- 2017 - AlphaGo Zero - better than AlphaGo
  - Unsupervised learning - starts with rules of game + reward function that awards it point for a winning and then plays against itself trying to maximize winning
  - Taught itself the game without using human experts + their training data
  - Plays with a non-human style, devising never seen before strategies

- Going Places, The Economist, Oct. 21, 2017

Stanley

SICK
Powered by Diesel
03
RedBull
MDV
MOHR DAVIDOW VENTURES
ANDROID

Thing / Software - Stanley

- **Firsts / Achievements / Uniqueness / Significance**
  - First successful self-driving car
  - Winner of 2005 DARPA Grand Challenge which required it to drive 132 miles without human intervention
- **Place Produced (Company / Institution) ~ Year ~ Country**
  - Stanford University ~ 2005 ~ USA
- **People involved (Programmer)**
  - Stanford Racing Team + Sebastian Thrun
- **Type**
  - Self-driving car (2005 Volkswagen Toureg)
- **Price / Cost**
  - N/A
- **Computer and operating system it runs on**
  - Machine learning algorithm running on 6 Linux boxes in trunk integrates stored memory of past experience with new data from LIDAR, video camera, GPS
- **Computer language written in**
  - N/A
- **Memory required**
  - N/A
- **Predecessors - 2004 DARPA Grand Challenge which ended in failure ~ Successors - Google self driving car**

Thing / Software - Google Self Driving Car

- Firsts / Achievements / Uniqueness / Significance
  - 5 levels - Level 0 has driver completely in control at all times, Level 3 is limited automation that requires driver to take charge from time to time (Google's cars) , Level 4 is full self driving automation
- Place Produced (Company / Institution) ~ Year ~ Country
  - Google ~ 2016 ~ USA
- People involved (Programmer)
  - Text
- Type
  - Self driving car
- Price / Cost
  - Text
- Computer and operating system it runs on
  - Works by providing software that ties driver aids together and provides sensors that see all around vehicle - lane-keeping systems, adaptive cruise control auto-parking systems, emergency braking, satnav systems
- Computer language written in
  - Text
- Memory required
  - Text
- Predecessors - Stanley ~ Successors - N/A

Self Driving Cars

Car accidents kill 12.4 million people / year and injure 50 million people / year

"They (car companies) want to make cars that make drivers better. We want to make cars that are better than drivers."

- Anthony Levandowski, Google engineer

"There will be crashes and lawsuits. And because the car companies have deep pockets they will be targets, regardless of whether they're at fault or not. It doesn't take many fifty- or hundred-million-dollar jury decision to put a big damper on this technology."

- Dean Pomerleau, roboticist

- Burkhard Bilger, Auto Correct, New Yorker, Nov. 25, 2013

Potential Impacts of Self Driving Cars

- Look different
- Challenge notion of car ownership as car is one of the most expensive things you own but they sit idle 96% of time
- Rise of car sharing leads to fewer vehicles on road and fewer parking lots needed
- Former parking lots could be converted to urban living spaces, or workers could live even farther from job + work during commute
- Car makers, car insurance companies, taxi drivers, truck drivers undergo upheaval
- 94% of car accidents due to human error so these should decrease drastically
- From "I don't want to share the road with robots" to "I don't want to share the road with other human drivers"
- Traffic flows more smoothly
- Children, elderly, disabled gain more independence

- If Autonomous Vehicles Ruled the World: From Horseless to Driverless, The Economist, Aug. 1, 2015

A Potential Lesson From The Aviation Industry

"Some senior pilots urge their juniors to turn off the autopilots from time to time, in order to maintain their skills. That sounds like good advice. But if the junior pilots only turn off the autopilot when it is absolutely safe to do so, they are not practising their skills in a challenging situation. And if they turn off the autopilot in a challenging situation, they may provoke the very accident they are practising to avoid.

An alternative solution is to reverse the role of computer and human. Rather than letting the computer fly the plane with the human poised to take over when the computer cannot cope, perhaps it would be better to have the human fly the plane with the computer monitoring the situation, ready to intervene. Computers, after all, are tireless, patient and do not need practice. Why, then, do we ask people to monitor machines and not the other way round?"

- Tim Harford, Crash: How Computers Are Setting Us Up for Disaster, The Guardian, Oct. 11, 2016

DARPA Robotics Challenge

- Goal is to create robots that can do urban search and rescue, which is one step away from urban search and destroy
- None of robots are autonomous - usually operate under human control (teleoperation)
- Robots had to complete 8 tasks: drive a utility vehicle through obstacle course, traverse an obstacle course, climb a ladder, remove debris in doorway, move through doorways (push, pull, weighted pull), cut a shape from a wall with a tool, close 3 types of valve, unreel + connect a hose
- Prelim round in December 2013 won by Team Schaft from Japan which was bought by Google + did not participate in Final round
- Final round in June 2015 won by Team Hubo from Korea
- Not large amount of progress between rounds

- John Markoff, Already Anticipating Terminator Ethics, New York Times, Nov. 24, 2013

- John Markoff, Japanese Team Dominates Competition to Create Generation of Rescue Robots, New York Times, Dec. 22, 2013

- Huw Williams, A Giant Leap for Robotkind, Jane's International Defence Review, Mar. 2014

- Logan Kugler, Robots Compete in Disaster Scenario, Communications of the ACM, Jul. 2014

- John Markoff, Korean Robot Makers Walk Off With $2 Million Prize, New York Times, Jun. 6, 2015

DARPA Robotics Challenge

- Generalized intelligence is being capable of seeing, understanding, and planning
- Robots are nowhere close to this
- At DARPA Robotics Challenge, the robots were being teleoperated
- Their seeing (and keeping their balance and taking steps) was being managed autonomously by onboard software, but their understanding and planning was being performed by the humans teleoperating them
- Robots are not currently replacements for humans, they are extensions for humans

\- Immigrants From the Future, The Economist, Mar. 29, 2014

The Future of Robots

- In the past, industrial robots were designed to replace humans and were caged
- In the future, robots will be designed to work alongside + collaborate with humans and wander amongst us
- Humanoid form factor is chosen for these robots
  - For social reasons - humans have affinity for their own shape
  - For technical reasons - must be able to navigate a world of handles / switches / doors etc. designed for humans

- John Markoff, Making Robots More Like Us, New York Times, Oct. 26, 2013

The Future of Robots

- Moore's Law is over
- We are undergoing a rapid acceleration in AI machine perception - pattern recognition technologies due to deep learning
- What hasn't happened is AI cognition - there have been no breakthroughs in planning + thinking, which is needed for autonomy

- John Markoff, author of Machines of Loving Grace: The Quest For Common Ground Between Humans and Robots

- A Conversation with John Markoff, Edge, Jul. 16, 2015

The Future of Robots

"The intuitive idea is that the more money you spend on a robot, the more autonomy you will be able to design into it. The fact is actually the opposite is true: The cheaper the robot, the more autonomy it has."

- Rodney Brooks, roboticist

Think Roomba vacuum cleaner vs. DARPA Robotics Challenge Atlas robots

- John Markoff, Relax the Terminator is Far Away, New York Times, May 25, 2015

The Robot as Friend

- 1960's - Eliza - Computer program which pretended to be a psychotherapist
  "I was startled to see how quickly and how very deeply people...became emotionally involved with the computer and how unequivocally they anthropomorphized it." - Joseph Weizenbaum, creator of Eliza
- Late 1990's - Tamagotchi - Virtual pet, one of first artificial-intelligence powered toys
  - Seduced users into belief that it had lifelike qualities
- 2010's - Hello Barbie - Doll with Siri-like interface
  - Can it pass a child's Turing Test?

- James Vlahos, Barbie Wants to Get to Know Your Child, New York Times Magazine, Sep. 20, 2015

"Let an ultra-intelligent machine be defined as a machine that can far surpass all the intellectual activities of any man however clever. Since the design of machines is one of these intellectual activities, an ultra-intelligent machine could design even better machines; there would then unquestionably be an "intelligence explosion," and the intelligence of man would be left far behind. Thus the first ultra-intelligent machine is the last invention that man need ever make."

- Irving John Good, Speculations Concerning the First Ultra-intelligent Machine, 1965

The Robot as Foe
The Paperclip Maximizer

- Thought experiment from Nick Bostrom, philosopher at Oxford University who believes artificial intelligence is existential threat to humanity:

"Imagine an artificial intelligence, he says, which decides to amass as many paperclips as possible. It devotes all its energy to acquiring paperclips, and to improving itself so that it can get paperclips in new ways, while resisting any attempt to divert it from this goal. Eventually it "starts transforming first all of Earth and then increasing portions of space into paperclip manufacturing facilities". This apparently silly scenario is intended to make the serious point that AIs need not have human-like motives or psyches. They might be able to avoid some kinds of human error or bias while making other kinds of mistake, such as fixating on paperclips. And although their goals might seem innocuous to start with, they could prove dangerous if AIs were able to design their own successors and thus repeatedly improve themselves."

- Frankenstein's Paperclips, The Economist, Jan 25, 2016

The Way Forward?

- Key points from James Barrat's "Our Final Invention"
  - Intelligence explosion this century
    - At some point we will create machines that are as skilled at AI research as we are + at that point they will be able to improve their own capabilities very quickly
  - Power of superintelligence
    - Once machines are smarter than we are they will be steering the future rather than us
  - Superintelligence does not imply benevolence

    "To educate [someone] in mind and not in morals is to educate a menace to society" - Theodore Roosevelt
  - Convergent instrumental goals
    - Superintelligent machines are dangerous to humans as for any set of goals they might have they will use all our resources to achieve those goals

    "The AI does not love you, nor does it hate you, but you are made of atoms it can use for something else" - Eliezer Yudkowsky
  - Human values are complex
  - Human values are fragile

- Luke Muehlhauser, Book Review of Our Final Invention: Artificial Intelligence and the End of the Human Era, KurzweilAI, Oct. 4, 2013

The Way Forward?

- What should we do as:
  - Superintelligent machines will use all our resources to accomplish their goals
  - We don't know how to give them the same goals we have
  - We don't know how to make sure they keep our goals as they modify their core algorithms to become smarter
    - We need to figure out how to make sure the first self-improving intelligent machines are human friendly + will stay that way
    - Philosophers need to figure out how we can get an AI to learn what our ideal values are
    - Mathematicians need to figure out how we can get an AI to keep doing what we want even as it rewrites its core algorithms to become smarter + better achieve its goals

- Luke Muehlhauser, Book Review of Our Final Invention: Artificial Intelligence and the End of the Human Era, KurzweilAI, Oct. 4, 2013

OpenAI

"With artificial intelligence, we're summoning the demon"
AI is "potentially more dangerous than nukes"
- Elon Musk

- Non-profit artificial intelligence research company
- Funded by tech luminaries with $1 billion
- Intended to counteract large companies who may get too powerful by owning superintelligence systems devoted to profits
- Goal is to develop a human positive AI that will be freely owned by the world

- Steven Levy, How Elon Musk and Y Combinator Plan to Stop Computers From Taking Over, Medium, Dec. 11, 2015

The Future of Artificial Intelligence

"I think it is a mistake to be worrying about us developing malevolent AI anytime in the next few hundred years. I think the worry stems from a fundamental error in not distinguishing the difference between the very real recent advances in a particular aspect of AI, and the enormity and complexity of building sentient volitional intelligence. Recent advances in deep machine learning let us teach our machines things like how to distinguish classes of inputs and to fit curves to time data. This lets our machines "know" whether an image is that of a cat or not, or to "know" what is about to fail as the temperature increases in a particular sensor inside a jet engine. But this is only part of being intelligent, and Moore's Law applied to this very real technical advance will not by itself bring about human level or super human level intelligence. While deep learning may come up with a category of things appearing in videos that correlates with cats, it doesn't help very much at all in "knowing" what catness is, as distinct from dogness, nor that those concepts are much more similar to each other than to salamanderness. And deep learning does not help in giving a machine "intent", or any overarching goals or "wants". And it doesn't help a machine explain how it is that it "knows" something, or what the implications of the knowledge are, or when that knowledge might be applicable, or counterfactually what would be the consequences of that knowledge being false. Malevolent AI would need all these capabilities, and then some. Both an intent to do something and an understanding of human goals, motivations, and behaviors would be keys to being evil towards humans."

"Worrying about AI that will be intentionally evil to us is pure fear mongering. And an immense waste of time."

- Rodney Brooks, Artificial Intelligence is a Tool Not a Threat, Nov. 10, 2014

The Future of Artificial Intelligence

"Contrary to the more fantastic predictions for AI in the popular press, the Study Panel found no cause for concern that AI is an imminent threat to humankind. No machines with self-sustaining long-term goals and intent have been developed, nor are they likely to be developed in the near future. Instead, increasingly useful applications of AI, with potentially profound positive impacts on our society and economy are likely to emerge between now and 2030, the period this report considers. At the same time, many of these developments will spur disruptions in how human labor is augmented or replaced by AI, creating new challenges for the economy and society more broadly."

- The One Hundred Year Study on Artificial Intelligence, 2016

The Machinery Question

Concerned the "influence of machinery on the interest of the different classes of society" and the "opinion entertained by the labouring class, that the employment of machinery is frequently detrimental to their interests"

- David Ricardo, economist, 1821

The "demon of mechanism" which was guilty of "oversetting whole multitudes of workmen"

- Thomas Carlyle, 1839

Artificial intelligence is leading to a transformation of society "happening ten times faster and at 300 times the scale, or roughly 3,000 times the impact" of the Industrial Revolution

- McKinsey Global Institute

- The Return of the Machine Question, The Economist, Jun 25, 2016

The Future of Jobs

- Worldwide 1.25 million people / year die in car accidents
- Over 90% of these accidents are caused by human error
- Automation of driving could save over a million lives / year
- Automation of driving will have disruptive effect on global economy - current industries will shrink + new industries will rise
- In US, 10% of all jobs involve operating a vehicle and most of these will disappear...

- Moshe Vardi, The Moral Imperative of Artificial Intelligence, Communications of the ACM, May 2016

The Future of Jobs

- By playing the long game in investing in its business and not worrying about profits, Amazon can be described as a "charitable organization being run by elements of the investment community for the benefit of consumers" - Matthew Yglesias, blogger
- Things popularized by Amazon - safe e-commerce, customer reviews, customer satisfaction
- Industries upended by Amazon - publishing industry including bookstores / publishers / ebooks, cloud computing

- Relentless.com, The Economist, Jun 21, 2014

- How Far Can Amazon Go?, The Economist, Jun 21, 2014

The Future of Jobs

"The combination of ceaseless innovation and low-wage drudgery makes Amazon the epitome of a successful New Economy company. It's hiring as fast as it can-nearly thirty thousand employees last year. But its brand of creative destruction might be killing more jobs than it makes. According to a recent study of U.S. Census data by the Institute for Local Self-Reliance, in Washington, brick-and-mortar retailers employ forty-seven people for every ten million dollars in revenue earned; Amazon employs fourteen."

- George Packer, Cheap Words, New Yorker, Feb. 17, 2014

The Future of Jobs

- In the past, economists argued that by raising productivity, automation which economizes on use of labor will increase incomes, thus generating demand for new products + services, which then in turn creates new jobs for displaced workers
- People thinking otherwise were Luddites, who were 19th century textile workers who smashed machines which were taking their jobs

"The overall effect of mechanisation turned out to be job creation on an unprecedented scale. Machines allowed individual workers to produce more, reducing the price of many goods, increasing demand and generating a need for more workers. Entirely new jobs were created to oversee the machines. As companies got bigger, they required managers, accountants and other support staff. And whole new and hitherto unimagined industries sprang up with the arrival of the railways, telegraphy and electrification."

- The Onrushing Wave, The Economist, Jan. 18, 2014

- Answering the Machinery Question, The Economist, Jun 25, 2016

Universal Basic Income

- As jobs dry up because of spread of artificial intelligence, give everyone a month check of ~ $1,000 to cover housing, food, health care and other basic needs
- Would liberate humanity from labor + suffering - as computers perform more of the work people can engage their passions rather than have to engage in drudgery of labor
- Being pushed by technologists

"We're talking about divorcing your basic needs from the need to work" - Albert Winger, venture capitalist

- Questions on this include: What would people really do with their time? How would it affect economic inequality? How would it alter people's psychology + mood - do we need to be employed to feel fulfilled? Can a country afford this?

- Farhad Manjoo, A Plan in Case Robots Take the Jobs: Give Everyone a Paycheck, New York Times, Mar. 3, 2016

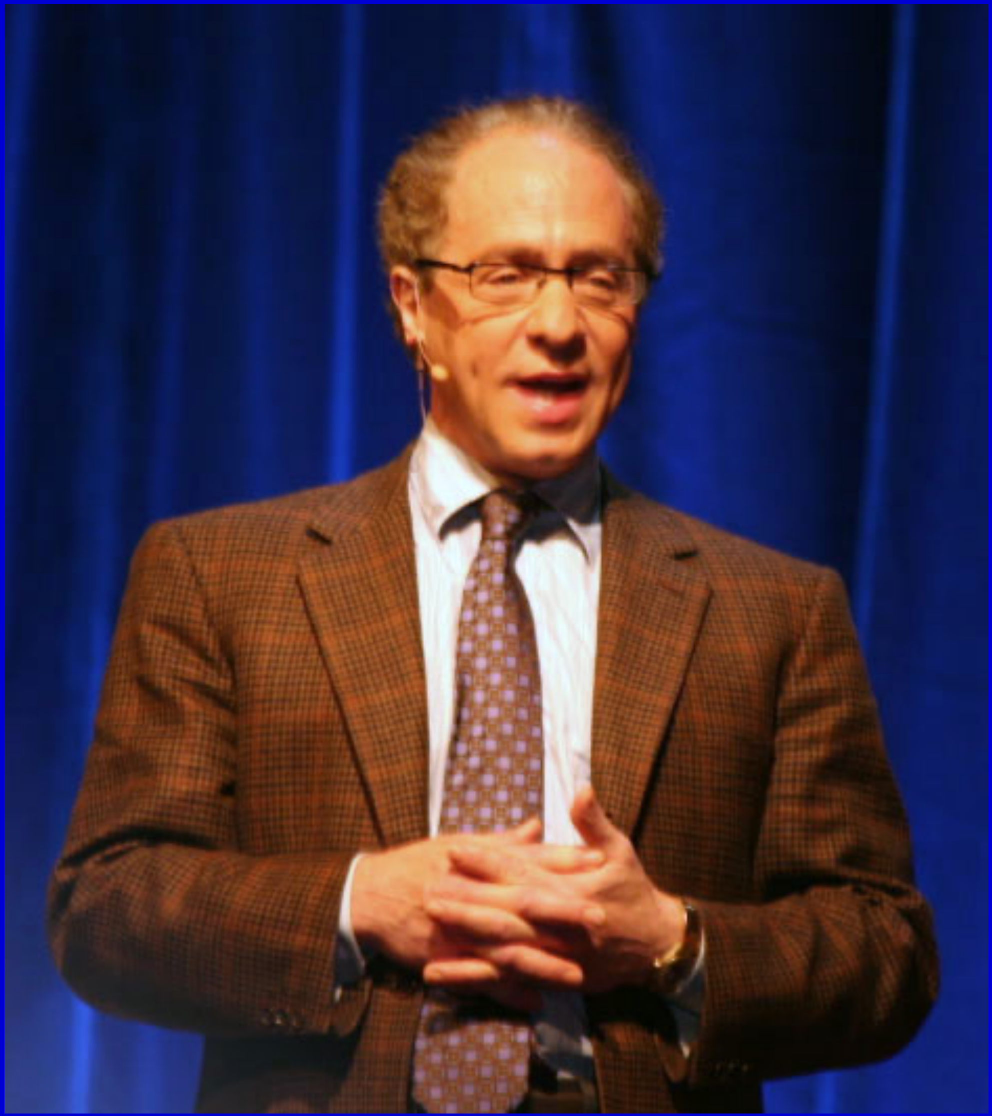
Universal Basic Income

- Work is an important institution - is main mechanism though which spending power is allocated + provides people with meaning / structure / identity
- New technologies may threaten the future of work
- Thus revived interest in Universal Basic Income = unconditional government payment to all citizens as supplement to or replacement for wages
- People who are not working or are working part time are not penalized if they work more
- Is a way to keep consumer economy going + support non-working population
- But the threat to the future of work has not materialized yet, and worries that new technologies would mean the end of work have in the past always been proven wrong

- Basically Flawed, The Economist, Jun. 4, 2016

- Re-Educating Rita, The Economist, Jun. 25, 2016

Ray Kurzweil



From Wikimedia Commons

Person - Ray Kurzweil

- Significance
  - His quest is to make man immortal by merging man with machines
- Profession
  - Computer scientist
- Places worked
  - Various businesses of his own, Google
- Years of work
  - 1960's - present
- Things worked on
  - Optical character recognition, speech recognition, text to speech, musical instruments, The Singularity

Cognitive Computing

- By 2029, Kurzweil believes computers will be able to do all the things that humans do, only better
- He is now Google's Director of Engineering and his job description is to help bring natural language understanding to Google

"And what's not generally appreciated is that Watson's knowledge was not hand-coded by engineers. Watson got it by reading. Wikipedia - all of it. Computers are on the threshold of reading and understanding the semantic content of a language, but not quite at human levels. But since they can read a million times more material than humans they can make up for that with quantity. So IBM's Watson is a pretty weak reader on each page, but it read the 200m pages of Wikipedia. And basically what I'm doing at Google is to try to go beyond what Watson could do. To do it at Google scale. Which is to say to have the computer read tens of billions of pages. Watson doesn't understand the implications of what it's reading. It's doing a sort of pattern matching. It doesn't understand that if John sold his red Volvo to Mary that involves a transaction or possession and ownership being transferred. It doesn't understand that kind of information and so we are going to actually encode that, really try to teach it to understand the meaning of what these documents are saying."

- Ray Kurzweil

- Carole Cadwalladr, Are the Robots About to Rise? Googles' New Director of Engineering Thinks So, The Guardian, Feb. 22, 2014

The Singularity

- Defined by John von Neumann, mathematician

  "Ever accelerating progress of technology and changes in the mode of human life, which gives the appearance of approaching some essential singularity in the history of the race beyond which human affairs, as we know them, could not continue."

- Popularized by Vernor Vinge, science fiction writer

- Commercialized by Ray Kurzweil

The Coming Singularity?

"Kurzweil believes that we're approaching a moment when computers will become intelligent, and not just intelligent but more intelligent than humans. When that happens, humanity - our bodies, our minds, our civilization - will be completely and irreversibly transformed. He believes that this moment is not only inevitable but imminent. According to his calculations, the end of human civilization as we know it is about 35 years away."

"Here's what the exponential curves told him. We will successfully reverse-engineer the human brain by the mid-2020s. By the end of that decade, computers will be capable of human-level intelligence. Kurzweil puts the date of the Singularity - never say he's not conservative - at 2045. In that year, he estimates, given the vast increases in computing power and the vast reductions in the cost of same, the quantity of artificial intelligence created will be about a billion times the sum of all the human intelligence that exists today."

"One of the goals of the Singularity Institute is to make sure not just that artificial intelligence develops but also that the AI is friendly. You don't have to be a super-intelligent cyborg to understand that introducing a superior life-form into your own biosphere is a basic Darwinian error."

- Lev Grossman, 2045: The Year Man Becomes Immortal, Time, Feb 10, 2011

Quantitative change leads to qualitative change

"Twenty years from now, we'll have nanobots, because another exponential trend is the shrinking of technology. They'll go into our brain through the capillaries and basically connect our neocortex to a synthetic neocortex in the cloud providing an extension of our neocortex. Now today, I mean, you have a computer in your phone, but if you need 10,000 computers for a few seconds to do a complex search, you can access that for a second or two in the cloud. In the 2030s, if you need some extra neocortex, you'll be able to connect to that in the cloud directly from your brain…And our thinking, then, will be a hybrid of biological and non-biological thinking, but the non-biological portion is subject to my law of accelerating returns. It will grow exponentially. And remember what happens the last time we expanded our neocortex? That was two million years ago when we became humanoids and developed these large foreheads. Other primates have a slanted brow. They don't have the frontal cortex. But the frontal cortex is not really qualitatively different. It's a quantitative expansion of neocortex, but that additional quantity of thinking was the enabling factor for us to take a qualitative leap and invent language and art and science and technology and TED conferences. No other species has done that.

And so, over the next few decades, we're going to do it again. We're going to again expand our neocortex, only this time we won't be limited by a fixed architecture of enclosure. It'll be expanded without limit. That additional quantity will again be the enabling factor for another qualitative leap in culture and technology."

- Ray Kurzweil, Get Ready for Hybrid Thinking, TED Talk, March 2014

Computing Case Study Summary - HAL 9000 (Heuristically programmed ALgorithmic computer)

- Goal
  - Create in 1966 a vision of what computing would be like in 2001
- Center of Gravity (Strategy)
  - Interview IBM's best and brightest (Ernest Bevilacqua, Gil Fox, Bob D'Arcona) for basic programming structure for HAL + Prof. Irving John Good (an associate of Alan Turning) for his predictions on sentient computers
- Technology / Equipment
  - Relies on heuristic algorithm design
  - Executes 2 trillion computations / second ~ Has quintillion megabytes of optical memory
  - HAL could see, listen, speak, reason, play chess, plan, express emotions
  - Has reasoning, knowledge, planning, learning, communication, perception, ability to manipulate objects
- Training
  - HAL was taught by an instructor, Dr. Chandra
- Leadership
  - HAL believes mission's success is up to it

- Arthur C. Clarke, 2001 A Space Odyssey
- Adam Johnson, 2001: The Lost Science
- Frederick Ordway III, 2001: A Space Odyssey - Vision Versus Reality at 30

Computing Case Study Summary - HAL 9000 (Heuristically programmed ALgorithmic computer)

- Morale
  - The HAL 9000 series has never made an error
- Tactics
  - HAL is responsible for overseeing the operation of the spaceship Discovery
  - Sentience of HAL based on 4 philosophical questions + their relevance to mission: What am I doing? What should I be doing? How am I doing? How should I be doing?
- Intangibles
  - HAL gets paranoid, begins to make errors, crew decides to turn it off
- Mistakes
  - HAL tries to murder the crew to contain true nature of mission
- Outcome
  - Crew lobotomizes HAL ~ Crew achieves mission success without HAL

    - Arthur C. Clarke, 2001 A Space Odyssey
    - Adam Johnson, 2001: The Lost Science
    - Frederick Ordway III, 2001: A Space Odyssey - Vision Versus Reality at 30

Evolution of Future Computing

- Most powerful computer today - Google
- Most powerful computer of (relatively) near future - USS Enterprise
- Most powerful computer of distant future - MultiVAC

Computing Case Study Summary - Star Trek

- **Date**
  - **USS Enterprise in The Original Series / The Animated Series - Early 23rd century**
- **Goal**

  "Deep in the heart of this ship are our computer banks. They operate the entire ship. They also contain the whole of human + humanoid knowledge. They are indisputably reliable. Our lives depend on them."
- **Center of Gravity (Strategy) [Deliver results in]**

  "In a matter of a few seconds, we can obtain an answer to any factual question, regardless of its complexity."
- **Technology / Equipment**
  - **Data center 1,900 square meters**
- **Training ~ Leadership ~ Morale**

- Schmucker KJ, Tarr RM, The Computers of Star Trek, Byte, December 1977

Computing Case Study Summary - Star Trek

- Tactics [Interface]
  - Unrestricted conversational voice input / output
  - Automatic programming in natural language
  - Computer analysis of complex, ill defined problems
    - Semantic comprehension of natural language ~ Computer understanding of the meaning of a statement ~ Has an English compiler which can accept + correctly process unrestricted English
- Intangibles [Indexes]
  - Indexes everything - cached copy of United Federation of Planets knowledge because transmission speed in space via subspace radio is too slow
  - Estimated to be 10^{22} bits = 10^{14} volumes, each volume = 1,000 pages => 10^{17} pages - each page is 1,000 words => 10^{20} words - each word is 6-8 letters =>10^{21} words => each word represented by 8 bits => 10^{22} bits
- Mistakes
  - Computer security still a problem
- Outcome
  - Works quite well

- Schmucker KJ, Tarr RM, The Computers of Star Trek, Byte, December 1977

Computing Case Study Summary - Multivac

- Date - 2061 to end of time
- Goal

  "How can the net amount of entropy of the universe be massively decreased?" => "How may entropy be reversed?"
- Center of Gravity (Strategy) [Deliver results in]
  - Minutes to seconds
- Technology / Equipment
  - 2061 - Multivac - "miles and miles" to Planetary AC's "hundreds of square miles" in size ~ Self adjusting + self correcting
  - 2161 - Microvac - half the volume of a space ship
  - 22061 - Galactic AC - 1,000 feet across on its own planet
  - 1,022,061 - Universal AC - 2 foot diameter globe, diffusely woven into fabric of hyperspace ~ self designing + self replicating
  - 100,000,000 - Cosmic AC - in hyperspace, neither matter nor energy
  - 10,000,000,000 - AC

  - Asimov, Isaac, The Last Question

Computing Case Study Summary - Multivac

- Training ~ Leadership ~ Morale
- Tactics [Interface]
  - Multivac - Typing input ~ Printing output
  - Microvac - Voice input ~ Printing output
  - Galactic AC - Voice input + output
  - Universal AC - Thought input + output
  - Cosmic AC + AC - Complete assimilation of man into computer
- Intangibles [Indexes]
  - Indexes everything
- Mistakes
  - Once last question was answered there was no man left to give answer to…so AC does a demonstration instead
- Outcome

  "Insufficient data for a meaningful answer."=> "Let there be light!"

  - Asimov, Isaac, The Last Question

Are We Living in a Simulation?

- Humanity will reach a "post-human" stage = culture that has mastered artificial intelligence + has achieved capability of "perfect" simulations of reality + human consciousness with near-infinite computing resources
  - Individuals in a post-human civilization can perform near perfect "ancestor simulations" of the past, including today
  - If over a given time period there are many simulations of present period of history, each containing simulated sentient individuals who think they are experiencing the real world, the probability that a given sentient individual is actually experiencing true reality rather than simulated reality is extremely small
- Can be ruled out on basis of physical size of computer required
  - A lattice simulating our Universe with a diameter of 10E27 meters would be very large
  - Simulation array would need 10E50 elements on a side with each point on lattice requiring storage of ~ 20 bits to represent its state
  - Such a Universe simulation, using 3D cube would be 10E35 meters / side
  - There is not enough matter in Universe to construct such an object, and if it was constructed it would collapse into giant black hole

- John Cramer, Is Our World Just a Computer Simulation?, Analog, Jul./Aug. 2013

Personal Case Study - MIT Media Lab

- Role
  - World renowned center for innovation in media, computing, communications
- Story
  - Sat in on 2 classes in 1994-1995
  - Brilliant teachers, brilliant guest lecturers, brilliant students
  - The Infinite Corridor
  - Lived up to its reputation
  - But has it changed the world as much as Stanford + Silicon Valley?

Personal Case Study - Working with Industry to Implement a Vision

- **Role**
  - **Instigator, Innovator, and Collaborator with private industry**
- **Story**
  - **Vision was focused on empowering physicians through learning tools that enhance learning at the point-of-care and documenting and preserving this learning to create a personalized learning environment / knowledge management / e-memory system for every physician**
  - **Worked with**
    - **WordPerfect**
    - **Apple - Advanced Technology Group, Newton Group, Macintosh group**
    - **Digital Ocean**
    - **IBM**
  - **Lesson is you have to align your research interests with their market and product interests in order to accomplish things**

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

Questions for Further Discussion

- What is the singularity and do you believe the singularity is near?
- How close are we to achieving the vision of the ship's computer in Star Trek TOS?
- Could God be a computer? (as in Isaac Asimov's science fiction story "The Last Question") -- Could our universe be someone else's simulation?
- Is biology simply a brief but necessary stage between inanimate matter and intelligent inanimate matter / machine intelligence?
- What computational challenge do designers of artificially intelligent systems have to overcome?
- Who owns your data after you die?
- Do we want a world where computers are autonomous, talking to one another, and humans are out of the loop?
- Could artificial intelligence create an unemployment crisis? Will more and more jobs move from non-routine to routine and become susceptible to automation?
- If machines become capable of almost any work humans can do, what will humans do?
- How will humanity occupy itself in the presence of intelligent machinery?
- Predictive Policing ala Minority Report - is this a good idea or a bad idea?
- What lessons from the past can we apply to the present and future?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
  - Stephenson, Neal - Snow Crash
- Movies
- Simulations

Conclusion

"Computers are incredibly fast, accurate, and stupid; humans are incredibly slow, inaccurate and brilliant; together they are powerful beyond imagination"

- Albert Einstein, physicist

Topic 27

Conclusion

Song

Slide text

Thematic Quote

"Computers are not about computing, but everyday life"

- Nicholas Negroponte, founder MIT Media Lab

The Painting

Painting Name

- Artist's Name

(Location of painting)

Artifact

- Name
- Year
- Story

The Question

- Will the future of computing be open or closed?

From Antikythera to Android

Over 2000 years…

…Nothing new under the sun…

From Wikimedia Commons

Themes

What we are going to discuss / What we have discussed
Everything is deeply intertwingled / We keep going in loops

- Topic 2 - Bigger isn't better
  - Smaller companies + teams out-innovate larger companies + teams
- Topic 2 - Innovator's Dilemma
  - Innovation rarely comes from the companies on the top of a field - they get taken out by the innovators (with the exception of Apple)
  - The producer of a higher priced product never thinks how they can make a cheaper version of it while the producer of the lower priced product is always thinking how they can make a cheaper version of more expensive product (HP turned down the Apple I)
- Topic 3 - Arc of technology advances but the apps remain the same
  - For computers - brass gears, electromagnetic relays, vacuum tubes, transistors, integrated circuits
  - For communications - copper wire, fiber optic strands, wireless
- Topics 3, 10, 13, 23, 26 - Sufficient quantitative change can be qualitative change
  - Moore's Law and increasing transistor density allows computing cycles to be wasted on frivolous tasks, Motorola StarTac mobile phone is always turned on + in your pocket due to long battery life and small size, AltaVista as first search engine to index whole Web…same is true in evolution of mammalian brain
- Topics 4 + 13 - Computer location
  - From being with you (Antikythera Mechanism) to being with you (mobile phone)

Themes

What we are going to discuss / What we have discussed
Everything is deeply intertwingled / We keep going in loops

- **Topics 4 + 13 - From Apps on Antikythera Mechanism to Apps on mobile phones**
  - From handheld Antikythera Mechanism to mobile phones, we want to take computing with us + use it in our daily lives
- **Topic 5 - Computing and cryptography have always served one another**
  - From Bombes + Enigma to Harvest Stretch to CRAY-1 to NSA PRISM
- **Topics 6 + 26 - Computer size**
  - Computer size goes from filling a room (ENIAC) to in your hand but connected to a computer filling a warehouse (Google)
- **Topics 6, 7, 9, 11, 13 - The primacy of open hardware systems**
  - Computing from closed (early computers) to open (IAS computer design in 1950's) to closed (mainframes) to open (minis with Unix) to closed (early PCs) to semiopen (Wintel) to closed (iOS) to open (Android)
  - An open standards computer (IBM-PC) produced by starched shirts at IBM trumped closed computer produced by hippies at Apple (Macintosh)
  - An open communication system (World Wide Web) trumped a closed system (Gopher)
- **Topics 7, 9, 11, 12 - From centralization to decentralization to centralization**
  - Computing - from centralized systems (mainframes) to decentralized systems (minis) to centralized systems (time sharing) to decentralized systems (PCs) to centralized systems (cloud) …

Themes

What we are going to discuss / What we have discussed
Everything is deeply intertwingled / We keep going in loops

- **Topics 8, 12, 16 - From centralization to decentralization to centralization**
  - **Communication - mainframes / minis had timesharing with communication and collaboration tools (centralized) -> the advent of PCs as unconnected islands broke all this (decentralized) -> it took the Ethernet and Internet to connect them back together so they could communicate and collaborate on interoperable Web but much time was lost (centralized) -> mobile phones running apps that don't interoperate (decentralized)**
- **Topics 5 + 11 + 12 + 23 - Perfect is the enemy of good enough - people will embrace an available good enough solution that can be incrementally improved over time rather than wait for perfection - lowest common denominator solutions are often acceptable**
  - **Hollerinth instead of Babbage**
  - **The PC instead of the Dynabook**
  - **The Internet instead of interactive television**
  - **The Web instead of Xanadu**
- **Topics 11 + 12 - Killer App is never what you think it will be**
  - **For Apple II it was supposed to be computer programming, ended up being VisiCalc**
  - **For Mac it was supposed to be MacWrite / MacPaint, ended up being PageMaker**
  - **For ARPANet was supposed to be remote login + sharing resources, ended up being Email**

Themes

What we are going to discuss / What we have discussed
Everything is deeply intertwingled / We keep going in loops

- Topics 12 + 19 - The primacy of open software systems
  - Open source software LAMP (Linux / Apache / MySQL / PHP) powers the Internet
  - Open source software (Android - derived from Linux) powers the mobile world
- Topic 16 - The primacy of open communication systems
  - Communications from open systems (BBSs / FidoNet / Usenet) to closed systems / walled garden (AOL / Prodigy) to open systems (Web) to closed systems (Facebook) to …
- Topic 17 - Programming
  - From mainframe machine language to assembler to high level languages as computer gets more powerful to PC's machine language / assembler to high level languages to mobiles...
- Topic 25 - Monopolies arise and are then swept away, often for legal reasons
  - ATT in communications, IBM in hardware, Microsoft in software
- Topic 27 - Nothing new under the sun / Been there done that
  - In contrast to what the media would have you think each day about the latest / greatest thing in computing
- Topic 27 - The field of computing is full of smart people, but true visionaries are rare
- Topic 27 - The best products are the result of one company providing both the hardware and the software integrated together, controlling the whole solution

Themes

What we are going to discuss / What we have discussed
Everything is deeply intertwingled / We keep going in loops

- Topic 15 Artificial Intelligence
  - Artificial Intelligence is a field that has been trying to live up to its promise for the last 50 years…until now?
- Topics 12 + 16 + 19 The best things in life are free
  - Open source software
  - Open standards-based communication systems (Web)
- Topic 16 There ain't no such thing as a free lunch (TANSTAAFL)
  - You are the product of Google, Facebook, etc.
- Topics 8 + 22 + 23 - Expansive visions of computing intended for intellectuals are dumbed down for the masses
  - Engelbart's NLS vision -> we got the mouse
  - Kay's Dynabook vision -> we got the consumption tablet
  - Nelson's Xanadu vision -> We got the Web
- Topic 3 - History of computing is that of increasing intimacy

Amusing Ourselves To Death

"The tendency in American culture to turn over to technology sovereignty, command, control over all of our social institutions...America has developed a new religion, as it were, and the religion is its faith in that human progress and technological innovation are the same thing and that paradise can be achieved through greater and greater commitment to technology."

"...if one wants to think about what has happened to public life in America, one has to think, of course, first about television, but also about CDs and also about faxes and telephones and all of the machinery that takes people out of public arenas and keeps them fixed in their homes so that we have a kind of privatization of American life...they never have to go out in the street at all and never have to meet their fellow citizens in any context because we'd have this ensemble of technologies that keep us private, away from citizens."

"All technological change is what I call a Faustian bargain. It gives you something, but it also taketh away something. "

- Neil Postman: Technopoly: The Surrender of Culture to Technology, C-SPAN Booknotes, Aug. 30, 1992

Amusing Ourselves To Death

(Martin Luther) "did know the power of the printing press. He understood it better than almost anyone of this time and was not reluctant to credit the printing press with the advancement of his ideas and of the Reformation. "

"...new technologies transform everything about a culture...if you put the printing press into Europe in the mid 15th century, you don't have 50 years later Europe plus the printing press. You have a new Europe because everything gets changed -- the political system, the religious system and so on. "

"If you put television into America in 1946, by 1960 you don't have America just "plus television", but a new kind of America, so that our social relations are altered and our attitudes toward childhood are altered and our political system is altered and we get new meanings of old words and so on. "

"But then Western culture had about 300 years to adapt itself to the printing press. So we developed new forms of economic life, new political ideas, new notions about education -- all organized around the printing press. But in our own time, our situation is much more difficult to cope with because almost daily, it seems, new technologies come on the scene and our social institutions don't have time to assimilate them and reorganize themselves to accommodate the demands of the technology."

"When television came along, it would have been, in theory, possible to have the same conversation. "What are the benefits, what are the deficits? Let's talk about it and then let's see is there anything we can plan to do that would minimize the deficits?" Well, we didn't have such a conversation, and with the computers now, we're not having such a conversation. All we hear is what they will do for us. We don't hear what they will undo."

- Neil Postman: Technopoly: The Surrender of Culture to Technology, C-SPAN Booknotes, Aug. 30, 1992

Amusing Ourselves To Death

"...what we might mean by a tool-using culture; that is, people whose symbolic world -- their politics, their religion, their education -- are not commanded and dominated by technology. They have tools. They invent tools, but they always invent their tools to solve problems in the physical world, but they do not let the tools control their social and symbolic lives."

"Technocracy is a culture in which you have serious technology competing with a more traditional social and symbolic world...The two world views -- the technological and what you might call the humanistic, although that loads the case, but the traditional view of religion and education and politics and so on. Those two worlds rub against each other, but technology is not yet strong enough to make the traditional world irrelevant or invisible. "

"We go over into technopoly when the technological world overwhelms the traditional world."

"The reason I call America the first technopoly is that more than any other culture that I can think of, we have committed ourselves to technology. Our destiny now is tied up with technology."

- Neil Postman: Technopoly: The Surrender of Culture to Technology, C-SPAN Booknotes, Aug. 30, 1992

Amusing Ourselves To Death

"Censorship, after all, is the tribute tyrants pay to an assumption that the public knows the difference between serious discourse and entertainment -- and cares...How delighted would all the kings, czars and fuhrers of the past and commissars of the present be to know that censorship is not a necessity when all political discourse takes the form of a jest."

- Neil Postman, Amusing Ourselves to Death

Personal Case Study - Cybersmith

- Role
  - First cybercafe chain in the US in 1995
- Story
  - Went to opening night - wondered if it would fly
  - Idea was you would go to cybercafé and pay to use computers with high speed Internet access, maybe buy something mediocre to eat on the side - like a Xanadu SilverStand
  - Turns out people didn't want to travel to and pay for high speed Internet access - they wanted convenient Internet access in their homes which at that time was slow dialup
  - What ultimately succeeded was the opposite of their vision - you go to a café (Starbucks) and are willing to pay for a great drink, and high speed Internet access to your computer is thrown in for free via WiFi
  - …not all ideas are great, even if they come from Nicholas Negroponte and the MIT Media Lab…

Computing Case Study Summary - Voyager 1 - The World's Longest Continuously Running Computer

- Goal
  - Control + operate the Voyager 1 and 2 interplanetary / interstellar spacecraft
- Center of Gravity (Strategy)
  - Onboard computer linked to Earth and reprogrammable via Deep Space Network
- Technology / Equipment
  - 3 pairs of computers for redundancy built by General Electric with total of 68 kilobytes of memory
  - Master clock runs at 4 MHz but CPU's clock runs at 250 KHz so it performs 8,000 instructions / second
  - [A 2013 smartphone runs at 1.5 GHz with 4 or more processors and performs 14 billion instructions / second]
- Training ~ Leadership ~ Morale
- Tactics
  - Computer Command System - carries out instructions from ground to operate spacecraft + look for problems with spacecraft + respond to them
  - Flight Data System - collect data from + control scientific instruments + format data for storage / transmission
  - Attitude + Articulation Control System - moves scan platform + maneuvers spacecraft
- Intangibles ~ Mistakes
- Outcome
  - Started working in 1977 and still running today

  - Jet Propulsion Laboratory, Voyager FAQ

Communications Case Study Summary - Deep Space Network

- **Goal**
  - **Communicate with interplanetary spacecraft**
- **Center of Gravity (Strategy)**
  - **Worldwide network of 3 tracking sites spaced 120 degrees apart, as Earth rotates antennas at sites maintain continuous contact with spacecraft in deep space**
- **Technology / Equipment**
  - **Antennas now in California, Australia, Spain**
  - **From 26 to 34 to 64 to 70 meter single antennas to arrays of 4 x 34 meter antennas**
- **Training ~ Leadership ~ Morale**
  - **Text**
- **Tactics**
  - **Locate antennas in valleys to shield them from nearby radio frequency signals**
- **Intangibles ~ Mistakes**
  - **Text**
- **Outcome**
  - **Data rates have advanced from 8.33 bits per second in 1963 to over 1 million bits per second**

- Deep Space Network's 50th Anniversary, Astrobiology Magazine, Jan. 1, 2014

Ad - Name

- Company
- Year
- Story

Class Simulation

- Topic aspects

Poem

Slide text

The Question for Further Discussion

- Is the history of computing one of personal empowerment, freedom for the masses, and goodness

  \- or -

  one of personal replacement, enslavement, and evil?

Questions for Further Discussion

- Time for Reflection:
  - Take an hour and reflect back upon the Learning Objectives / Computer History Frequently Asked Questions for this course found in Topic 1
    - What is the history of computing?
    - What is the future of computing?
    - What lessons can we learn from computing's past that will help guide us in determining computing's future?

      - or -

    - Where has computing come from?
    - And where might it be taking us?

Reading Assignments

- Computing A Concise History Chapter x
- TED Talks for this Topic
  - http://www.computerhistories.org/ToLearnMore.html

Recommended Reading to Learn More

- Non-fiction
- Fiction
- Movies
- Simulations

Final Thought

- The future of computing - whether it is to be open or closed - is in your hands
  - You need to stay informed on these issues
  - You should patronize corporations who favor openness and protect your security and privacy
  - In our democracy you need to elect representatives who represent your interests, rather than the interests of corporations and governments

Conclusion

"Heretofore, the technological advance that most altered the course of modern history was the invention of the printing press in the 15th century, which allowed the search for empirical knowledge to supplant liturgical doctrine, and the Age of Reason to gradually supersede the Age of Religion. Individual insight and scientific knowledge replaced faith as the principal criterion of human consciousness. Information was stored and systematized in expanding libraries. The Age of Reason originated the thoughts and actions that shaped the contemporary world order.

But that order is now in upheaval amid a new, even more sweeping technological revolution whose consequences we have failed to fully reckon with, and whose culmination may be a world relying on machines powered by data and algorithms and ungoverned by ethical or philosophical norms."

- Henry Kissenger, How the Enlightenment Ends, The Atlantic, June 2018

Conclusion

"What is the problem to which this technology is the solution - this is the question to ask."

- Neil Postman, media theorist, in talk at Isabella Stewart Gardener Museum on Feb. 8, 1995

Conclusion
So Where Are We Now?

"A handful of people, having no relation to the will of society, having no communication with the rest of society, will be taking decision in secret which are going to affect our lives in the deepest sense."

- C.P. Snow (author of The Two Cultures and the Scientific Revolution in 1959) writing in 1962 in Computers and the World of the Future (edited by Martin Greenberger)

Conclusion

COMPUTER HISTORIES™

A HISTORY OF COMPUTING IN 100 PEOPLE, PLACES, AND THINGS

CURATED BY MICHAEL P. D'ALESSANDRO, M.D.

"Change is the only constant"

- Heraclides, Greek philosopher

"The future never just happened. It was created."

- Will and Ariel Durant, historians

Appendix

How I Teach This Course

How To Use This Course - Learning and Teaching Suggestions for Computer Histories

- If you are a student you may simply read the slides of those topics that interest you
- If you are a teacher you may use the slides to teach either a
  - 1. Lecture-based course if you have a large amount of time
    - Teacher uses slides to cover the entire syllabus by giving 1 topic / class session, without or with student preparation / review of the slides before lecture
  - 2. Seminar-based course if you have a small amount of time
    - At first class meeting, students decide which topics they want to cover and design their own syllabus - or - teacher may assign a topic to each student based upon their major
    - For each class session, the teacher assigns beforehand the questions from the beginning and end of the topic ("The Question" + "Questions for Further Discussion") to be discussed by the students
    - The students must read the topic before class, and come prepared to answer the questions using information from the topic's case studies to illustrate their answers
    - The teacher will lead and guide the student's discussions and offer their own insight and expertise

Philosophically…

- I see a course as a way of organizing a discussion, using readings and viewings to provide a common ground for discussion of the topics and questions in the course

Preparation For This Course - If You Are Taking The Whole Course

- Before the first class meeting, students should prepare for this course in the following manner
  - Review all the slides in all of the topics
  - Select 3 areas of interest from amongst the topics
    - These areas of interest are what you will focus on in your readings, field trips, and essays

Expectations For Students

- I have high expectations for you as students in this course. By the end of this course I expect you to accomplish the Goal of This Course. To do so I expect you to do the following:
  - Attend every class
  - Come to class prepared to discuss the day's topic by reading the assigned topic in Computer Histories and viewing the assigned videos before class
  - Participate in class in a challenging yet respectful manner
  - Participate online in discussions + simulation in a challenging yet respectful manner
  - Turn in assignments on time

What I Hope To Avoid

"College is a place where a professor's lecture notes go straight to the student's lecture notes, without passing through the brains of either."

- Mark Twain, author

What I Hope To Do

"The mind is not a vessel that needs filling, but wood that needs igniting."

- Plutarch, Greek historian

Personal Case Study - About Me

- Who am I?
  - A physician
  - A professor
  - A researcher
    - Area of research interest is educational informatics (www.educationalinformatics.org), including digital libraries that support the practice of medicine
  - An amateur computer historian (amateur = love)

Personal Case Study - About Me
What Did You Do During the War Daddy?

- I supported Apple in its darkest hours
- I helped make information free at the dawn of the Web (Virtual Hospital)
- I gave more than I took (Educational Informatics)

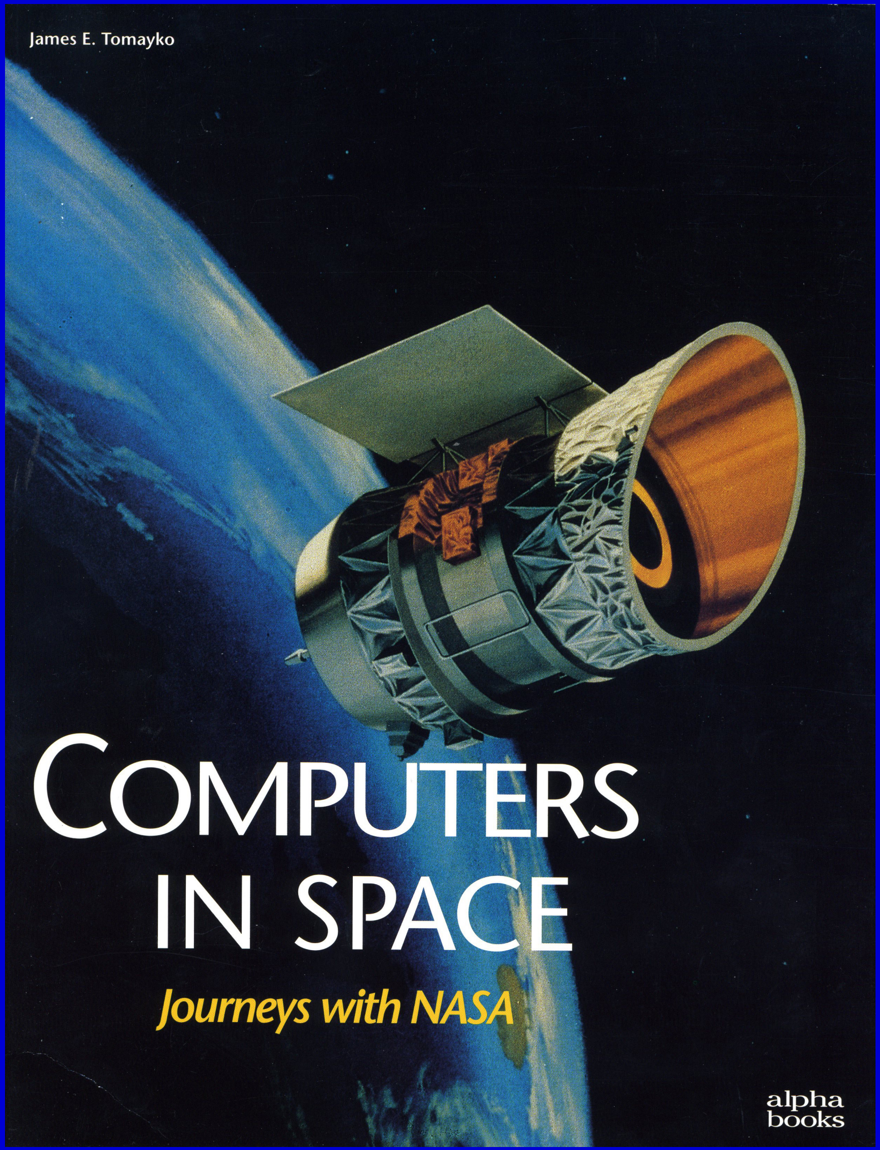
Computers Used

Year	Computer / OS	Languages
1977	GE 600 / GE Mark III~GECOS~ TSS	Basic
1981	HP2000 / -	Waterloo Fortran IV (WATFIV)
1981-1986	Apple II+ / DOS 3.3~ProDos	Applesoft Basic, UCSD Pascal, Terrapin Logo
1981-1982	Atari 800 / -	Atari Basic
1981-1982	Commodore PET / -	Commodore Basic
1982-1985	IBM 360-370 / MTS	PL-1, 360 Assembler
1983	Tandy Model 100	Basic
1984-1985	DEC VAX 11/780 / VMS~Eunice	Lisp
1987-Pres	Apple Macintosh / OS 1-10	HTML, Scratch, Python
1991-Pres	NEC TurboGrafix-16	
1991-Pres	Nintendo SNES	
1991-1992	ZX-88 / -	
1993-2003	Apple Newton / Newton OS	Newton Bookmaker
1995	Poquet PC / MS-DOS	
2000-Pres	Sony Playstation 1	
2005-Pres	Nintendo 64	
2006-Pres	Nintendo DS	
2007-Pres	Microsoft Xbox + Xbox 360 / Sony Playstation 2 + 3 / Nintendo Gamecube + Wii	
2008-Pres	One Laptop Per Child	Logo, Squeak, Scratch, EToys
2010-Pres	Windows 7	Kodu

Personal Case Study - About Me - What I Do Professionally

- I am in medical intelligence
- I have a number of sensor platforms working in various parts of the electromagnetic spectrum that gather data for me around the clock
- I gather + analyze data + use scientific method to synthesize it into new information useful to others and try to draw new inferences about the bigger picture from it
- I do my best work when working closely with a multidisciplinary team
- I give briefs and written reports
- My field is always changing and I am always learning

Personal Case Study - About Me
My First Exposure to Computer History



~ 1984, Wayne State University, Lecture to Student ACM Chapter on Computers in Space by James Tomayko

Personal Case Study - About Me -Why I Am Interested in Computer History

- **Computers are magical**

  "Any sufficiently advanced technology is indistinguishable from magic"

  - Arthur C. Clarke, author

  "When an elderly but distinguished scientist says something is possible, he's more than likely right; when he says something is impossible, he's almost certainly wrong"

  - Arthur C. Clarke, author

- **Computers are beautiful to look at**

- **The people behind computers are amongst the most interesting I have met in my life**

  "Everything is deeply intertwingled"

  - Theodor Holm Nelson

Personal Case Study - About Me -Why I Am Interested in Computer History

- I am a child of Apollo
  - But by the time I was old enough to contribute, Apollo was over
  - The Computer Revolution has been my Apollo program
    - And I am lucky to have lived through a large part of it, and influenced it in a small way

Personal Case Study - About Me - Why Am I Here and Why Do I Teach This Course?

- I feel the topic of computer history is crucial to our society
  - We are at a crucial time in the history of computing - will its future be open or closed? What we learn from the past can teach us of the future we should have - and that you should demand from technologists and politicians.
- Unfortunately computer history is not being taught
  - …even though there is an increasing interest amongst public in computing
- How will you responsibly exercise control over computing in your lives through your politicians?
  - By reading, writing, and discussion
  - So this course is a step in that direction
- ...and on a personal level I have two sons
  - I'm doing it for my kids...and for you

Personal Case Study - About You
[First Class Meeting Icebreaker - Ask Every Student]

- Who are you
  - Where are you from?
- What is your computing background?
- What is your major / what are you interested in studying?
- Why are you here?

First Assignment Before Leaving Class

- Name you prefer / where are you from?
- What is your major / What are you interested in studying?
- What is your computing background?
  - List 3 favorite computers you have owned or used
  - List 3 software programs you are expert at
  - List any programming languages you know
  - List 3 favorite video game systems you have owned or used
  - List 3 favorite computer games or video games
- Why are you here?
  - Why did you take this course?
  - What are your expectations for the course?
  - Are there any specific computing topics you are interested in?
- Write three specific questions about the subject of this course that you want answered during this semester
- Write three reasons about why you enrolled in this course. Be honest

How We Will Do This

- Readings / Viewings / Artifacts / Lectures / Discussions
  - Balance between theory and practice
  - Case studies and simulations to tie it all together
- Before class each week
  - Read textbook, view videos
- In class each week
  - Simulation update, Artifact presentation, Tour of topics, Discussion
- Note that although for organizational purposes the topics are presented in a linear order, they are all deeply intertwingled
- Our common touchstones will be current computing issues as we are all living through them together
- Curriculum at www.computerhistories.org

How We Will Do This

- Each topic has
  - Song to start with
  - Thematic quote
  - Painting
  - Artifact
  - (Framing) Question
  - Case studies to bring the topic into focus
  - Ad
  - Relationship to the ongoing simulation
  - Poem
  - Questions for further discussion
  - Recommended readings to learn more
- Look at computer history
  - From microscopic to macroscopic levels
  - In the context of everything else

How We Will Do This

- Review Exam Essay Topics at end of this Appendix so you can work on them throughout the course
- I'll do my best to teach to the test

Assignments

- Daily Readings
  - Computer Histories river of news (coming soon)
- Weekly Readings for class
  - Computing A Concise History by Paul Ceruzzi

Supplementary Readings

- Nonfiction Readings for What Computer History is Like - Choose one:
  - Kidder, Tracy - The Soul of a New Machine
  - Levy, Steven - Hackers
  - Stoll, Clifford - The Cuckoo's Egg

Supplementary Readings

- Fiction Readings for What Computer History is Like - Choose one:
  - Bronson, Po - The First $20 Million is Always the Hardest
  - Coupland, Douglas - JPod
  - Coupland, Douglas - Microserfs
  - Dillon, Pat - The Last Best Thing
  - Lyons, Daniel - Options: The Secret Life of Steve Jobs
  - Stephenson, Neal - Snow Crash

Assignments

- Movie Viewings for What Computing History is Like - Choose one:
  - Halt and Catch Fire (Television series)
  - Jpod (Television series)
  - Pirates of Silicon Alley
  - Silicon Valley (Television series)
  - The Social Network
  - Startup.com

Assignments

- Documentary Viewings for What Computing History is Like - Choose one:
  - Steve Jobs The Lost Interview
  - Triumph of the Nerds: The Rise of Accidental Empires

Assignments

- Participate in a class startup simulation that stretches over the course and is followed by a hot wash-up / after action review

What Are My Favorite Sources

- @CHM blog
- I Cringely (www.cringely.com)
- See the Bibliography for a list of my Sources

Exams

- Choose from amongst the following topics for your exam essays
  - Read the "Essays" document at www.computerhistories.org

Course Evaluation

- Be Honest!

- What did you like about this course?
- What did you dislike about this course?
- What was missing from this course?
- How would you improve this course?

Final Assignment Before Leaving Class

- What ONE thing sticks in your mind as the most valuable, significant, or enjoyable thing you learned during this course?

Bibliography

Notes on Sources

- To read an original article referenced in this course:
  - Go to your favorite Internet search engine
  - Type into the search box within quotation marks the article's title, followed by, within separate quotations, the article's author or place of publication

Sources

- Journals currently read regularly
  - Communications of the Association for Computing Machinery, Core Magazine, Economist, IEEE Annals of the History of Computing, IEEE Computer, Macworld
- Journals formerly read regularly
  - Byte, Creative Computing, Historically Brewed, Infoworld, Datamation, SoftTalk, SunExpert
  - Digital Computer Museum Report, The Computer Museum Report, The Computer Museum Annual Report, The Computer Museum News
- Scientists /Journalists read regularly
  - Robert X. Cringely, Steven Levy, Farhad, Manjoo, John Markoff, Christopher Mims, Walter Mossberg, Jerry Pournelle, Tom Standage, Stephen Wolfram
- Web sites read regularly
  - @CHM Blog, I Cringely
- Radio programs listened to regularly
  - Babbage from The Economist, BBC Discovery, BBC In Our Time, BBC Science in Action, Big Picture Science, Cybersecurity Podcast
- Television programs currently viewed regularly
  - Computer History Museum lecture series, TED Talks

Bibliography
Computing

- Bascomb, Neal - The New Cool: A Visionary Teacher, His FIRST Robotics Team, and the Ultimate Battle of Smarts
- Bell, C Gordon and Gemmell, Jim - Total Recall
- Blum, Andrew - Tubes: A Journey to the Center of the Internet
- Brand, Stewart - The Media Lab
- Brand, Stewart - The Whole Earth Catalog
- Brand, Stewart - The Whole Earth Software Catalog
- Brandon, David - Life in a 17th Century Coffee Shop
- Ceruzzi, Paul - Computing: A Concise History
- Coupland, Douglas - Kitten Clone
- Cringely, Robert X - Accidental Empires
- Davidson, George E - Beehives of Invention: Edson and His Laboratories
- Davis, Joshua - Spare Parts
- Deutschman, Alan - The Second Coming of Steve Jobs
- Drexler, K Eric - Engines of Creation: The Coming Age of Nanotechnology

Bibliography
Computing

- Gershenfeld, Neil - Fab
- Gilder, George - Telecosm
- Gonick, Larry - The Cartoon Guide to the Computer
- Graham, Neil - Artificial Intelligence
- Graves, Charles - The Thin Red Lines
- Gresh, Laurie and Weinberg, Robert - Computers of Star Trek
- Hafner, Katie - The Well
- Hafner, Katie and Markoff, John - Cyberpunk
- Hokanson, Drake - The Lincoln Highway: Main Street Across America
- IBM - Innovation in IBM Computer Technology
- Isaacson, Walter - Steve Jobs
- Kaplan, Jerry - Startup: A Silicon Valley Adventure
- Kelly, Kevin - Signal
- Kidder, Tracy - Soul of a New Machine
- Kidwell, Peggy and Ceruzzi, Paul - Landmarks in Digital Computing

Bibliography - Computing

- Lapsley, Phil - Exploding the Phone
- Levy, Steven - Hackers
- Levy, Steven - Insanely Great
- McCorduck, Pamela - Machines Who Think
- Melissinos, Chris and O'Rourke, Patrick - The Art of Video Games: From Pac-Man to Mass Effect
- Menuez, Doug and Kounalakis, Markos - Defying Gravity
- Menuez, Doug - Fearless Genius: The Digital Revolution in Silicon Valley 1985-2000
- Negroponte, Nicholas - Being Digital
- Nelson, Theodor Holm - Computer Lib / Dream Machines
- Nelson, Theodor Holm - The Home Computer Revolution
- Padua, Sydney - The Thrilling Adventures of Lovelace and Babbage
- Price, David - The Pixar Touch

Bibliography
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- Rettig, Marc - The History of Electronic Computing
- Rheingold, Howard - Smart Mobs
- Rheingold, Howard - The Virtual Community
- Richards, Mark and Alderman, John - Core Memory: A Visual Survey of Vintage Computers
- Schlender, Brent + Tetzeli, Rick - Becoming Steve Jobs
- Smith, Michael - Bletchley Park: The Code Breakers of Station X
- Standage, Tom - The Turk
- Standage, Tom - The Victorian Internet
- Starosielski, Nicole - Undersea Network
- Stephenson, Neal - Mother Earth Mother Board
- Sterling, Bruce - The Hacker Crackdown
- Stoll, Clifford - The Cuckoo's Egg
- Stross, Randall - Steve Jobs and the NeXT Big Thing
- TechKnowlogy - The History of the Computer
- Turing, Dermont - Bletchley Park: Demystifying the Bombe

Bibliography
Computing

- Vale, Thomas + Vale, Geraldine - US 40 Today: Thirty Years of Landscape Change in America
- Veit, Stan - Stan Veit's History of the Personal Computer
- Ventura, Piero - Communication
- Wallis, Michael - Route 66 The Mother Road
- Wallis, Michael + Williamson, Michael - Lincoln Highway Coast to Coast From Times Square to the Golden Gate
- Wheeler, Tom - Mr. Lincoln's T-Mails, The Untold Story of How Abraham Lincoln Used The Telegraph to Win the Civil War
- Winkler, Jonathan - Nexus: Strategic Communication and American Security in World War I
- Winston, Patrick - Artificial Intelligence
- Zientara, Marguerite - The History of Computing. A Biographical Portrait of the Visionaries Who Shaped the Destiny of the Computer Industry

Bibliography
Selected Fiction - Computing

- Asimov, Isaac - I, Robot
- Blake, Victoria - Cyberpunk
- Breton, Thierry and Beneich, Denis - SoftWar
- Bronson, Po - The First $20 Million is Always the Hardest
- Brunner, John - Shockwave Rider
- Bueno, Carlos and Lopez, Ytaelena - Lauren Ipsum
- Chiang, Ted - The Lifecycle of Software Objects
- Cline, Ernest - Ready Player One
- Coupland, Douglas - Microserfs
- Coupland, Douglas - JPod
- Dick, Phillip K - Do Androids Dream of Electric Sheep?
- Dillon, Pat - The Last Best Thing
- Eggers, Dave - The Circle
- Gibson, William - Neuromancer
- Gibson, William and Sterling, Bruce - The Difference Engine

Bibliography
Selected Fiction - Computing

- Hogan, James - The Two Faces of Tomorrow
- Keillor, Garrison - With BLT
- Lyons, Daniel - Options: The Secret Life of Steve Jobs
- Masamune, Shirow - Ghost in the Shell
- Orwell, George - 1984
- Powell, Jessica - The Big Disruption
- Sawyer, Robert - Identity Theft / Red Planet Blues
- Selznick, Brian - The Invention of Hugo Cabret
- Simpson, Mona - A Regular Guy
- Singer, PW + Cole, August - Burn-In
- Stephenson, Neal - Snow Crash
- Sterling, Bruce - Mirrorshades: A Cyberpunk Anthology
- Vinge,Vernor - Rainbow's End
- Vinge, Vernor - True Names

Bibliography
Comics / Pulps / Manga

- Ban, Toshio - The Osamu Tezuka Story - A Life in Manga and Anime
- Ellis, Warren - Global Frequency
- Ishinomori, Shotaro - Cyborg 009
- McCarthy, Helen - The Art of Osamu Tezuka God of Manga
- Schodt, Frederik - Dreamland Japan: Writings on Modern Manga
- Schodt, Frederik - Manga! Manga! The World of Japanese Comics
- Schodt, Frederick - The World of Japanese Comics
- Shiner, Lewis - Hacker Files
- Tezuka, Osama - Astroboy

Plays

- I Robot (radio drama)
- Microserfs (radio drama)
- This is For Everyone (radio drama)
- Your Perfect Summer, On Sale Here (radio drama)

Movies
Computing

- A.I. Artificial Intelligence
- Attachments (Television series)
- Astroboy
- Belle
- Bicentennial Man
- Blackhat
- Blade Runner
- Blade Runner 2049
- Breaking the Code
- Computer Wore Tennis Shoes
- The Conversation
- Forbin Project
- Ghost in the Shell
- Halt and Catch Fire (Television series)
- Hidden Figures
- Hugo

Movies Computing

- Idiocracy
- Imitation Game
- Jobs
- JPod (Television series)
- Live Free or Die Hard
- Metropolis (by Osamu Tezuka)
- Network
- 1984
- Pirates of Silicon Valley
- Ready Player One

Movies Computing

- Silicon Valley (Television series)
- Sneakers
- The Social Network
- Star Trek (The Animated Series, The Original Series, The Next Generation, The Movies)
- Steve Jobs
- Summer Wars
- Tron
- Tron Legacy
- Truman Show
- 2001: A Space Odyssey
- WALL-E
- Wargames
- Wild Palms (Television series)
- Year 1999 A.D.

Documentaries
Computing

- Ancient Computer
- Codes That Changed the World (radio sereis)
- Computing Britain (radio series)
- Cuckoo's Egg
- Empire of the Air: The Men Who Made Radio
- General Magic
- Get Lamp
- The Internet's Own Boy: The Story of Aaron Swartz
- Love Notes To Newton
- The Machine That Changed the World

Documentaries
Computing

- Nerds 2.0.1: A Brief History of the Internet (Television series)
- NerdTV
- Silicon Valley, The American Experience
- Springboard: The Secret History of the First Real Smartphone
- Startup.com
- Steve Jobs The Lost Interview
- Top Secret Rosies The Female Computers of World War II
- Transcendent Man: The Life and Ideas of Ray Kurzweil
- Triumph of the Nerds: The Rise of Accidental Empires (Television series)
- Zero Days

Computers Used

Year	Computer / OS	Languages
1977	GE 600 / GE Mark III~GECOS~ TSS	Basic
1981	HP2000 / -	Waterloo Fortran IV (WATFIV)
1981-1986	Apple II+ / DOS 3.3~ProDos	Applesoft Basic, UCSD Pascal, Terrapin Logo
1981-1982	Atari 800 / -	Atari Basic
1981-1982	Commodore PET / -	Commodore Basic
1982-1985	IBM 360-370 / MTS	PL-1, 360 Assembler
1983	Tandy Model 100	Basic
1984-1985	DEC VAX 11/780 / VMS~Eunice	Lisp
1987-Pres	Apple Macintosh / OS 1-10	HTML, Scratch, Python
1991-Pres	NEC TurboGrafix-16	
1991-Pres	Nintendo SNES	
1991-1992	ZX-88 / -	
1993-2003	Apple Newton / Newton OS	Newton Bookmaker
1995	Poquet PC / MS-DOS	
2000-Pres	Sony Playstation 1	
2005-Pres	Nintendo 64	
2006-Pres	Nintendo DS	
2007-Pres	Microsoft Xbox / Sony Playstation 2 / Nintendo Gamecube	
2008-Pres	One Laptop Per Child	Logo, Squeak, Scratch, EToys
2008-Pres	iOS	
2010-Pres	Windows 7	Kodu
2017-Pres	iOS	Swyft

Computer Networks Travelled

- Bulletin Board Systems / FidoNet
- Merit Network / Confer II
- BITNET / CSNet / UUCPNet / ARPANet
  - Usenet: Human-Nets, SF-Lovers
- NSFNet
- Walled garden systems - AOL, BIX, eWorld, GENIE, Prodigy
- Internet

Computer Games Played

- Apple II
  - Sargon

MOOCs Attended

- Big Data: Data Visualisation from Queensland University of Technology via FutureLearn
- Video Game Design and Development from Abertay University via FutureLearn
- Video Game Design and Development: Character Design from Abertay University via FutureLearn
- Video Game Design and Development: A Bit-by-Bit History of Video Game Music from Abertay University via FutureLearn
- Data Science in the Games Industry from University of Dundee via FutureLearn

Museum Exhibitions

- Information Age, National Museum of American History - 1994
- Beyond the Limits, National Air and Space Museum - 1994
- The Art of Video Games exhibit and lecture by curator Chris Melissinos, Smithsonian American Art Museum - 2012
- Networld, Museum of Science and Industry - 2013
- Time and Navigation, National Air and Space Museum - 2014
- Places and Spaces: Mapping Science, University of Iowa Libraries - 2017
- Religious Changes and Print 1450-1700, Newberry Library - 2017
- Mathematica: A World of Numbers and Beyond by Charles and Ray Eames, The Henry Ford - 2019

Computer Museums Visited

- Bletchley Park
- British Museum - Clocks and Watches Gallery
- Computer Museum (Boston)
- Computer History Museum Alpha Phase
- Fabyan Villa Museum / Riverbank Laboratories
- Google Data Center, Council Bluffs, Iowa
- Harvard Collection of Historical Scientific Instruments (Harvard Mark I)
- Henry Ford Museum and Greenfield Village
- Hermitage (Peacock Clock automaton)
- HP Garage, Palo Alto
- Marconi's First US Trans Atlantic Wireless Telegraph Station, South Wellfleet, Massachusetts

Computer Museums Visited

- MIT Museum
- Museum of Broadcast Communications, Chicago
- National Archeological Museum of Greece (Antikythera Mechanism "removed for exhibit")
- National Cryptologic Museum
- National Electronics Museum
- National Museum of Computing (Bletchley)
- Science Museum - Information Age, Mathematics (London)
- Smithsonian Museum of American History - Information Age
- SS Great Eastern launch site
- Tezuka Osamu World (Kyoto)
- University of Illinois Champaign Urbana (ILIAC, National Center for Supercomputer Applications / Mosaic, PLATO)

Computer Laboratories Visited

- Akihibara Electric Town, Tokyo, Japan
- Apple Computer Advanced Technology Group
- Boeing Alteon Seattle Training Center - 737 NG flight simulator
- Cybersmith (first Internet Café February 1995)
- General Motors Research Lab
- Idaho National Laboratories / Arco Idaho
- Internet Archive
- MIT Tech Model Railroad Club
- Pixar
- Shibuya, Tokyo, Japan
- Studio ASIMO (ASIMO is not home…)
  - Saw ASIMO at EAA Airventure 2013
- Watched Watson beat humans at Jeopardy (2011)

Computer Companies Worked With

- Apple Computer - Macintosh / Newton
- Computer Museum
- Digital Ocean
- IBM
- MIT Media Lab
- Word Perfect

Computer Conferences Attended

- SIGGRAPH 1983, Detroit
- National Computer Conference (NCC) 1985, Chicago
- MacWorld 1992, San Francisco
- MacWorld 1993, Boston (Newton + Mosaic)
- Apple World Wide Developer Conference 1994
- MIT 6.270 Lego Robot Contest 1994
- Advances in Digital Libraries 1996
- Advances in Digital Libraries 1997
- Joint Conference on Digital Libraries 2001
- Maker Faire Detroit 2012

Professional Memberships

- Current
  - Association for Computing Machinery
- Past
  - American Medical Informatics Association
  - The Computer Museum / Computer History Museum

For Bibliographies Related to Learning and Libraries See:

www.apprenticechip.org