The Hardware/Software Interface
Computers and Society

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http://xkcd.com/722/
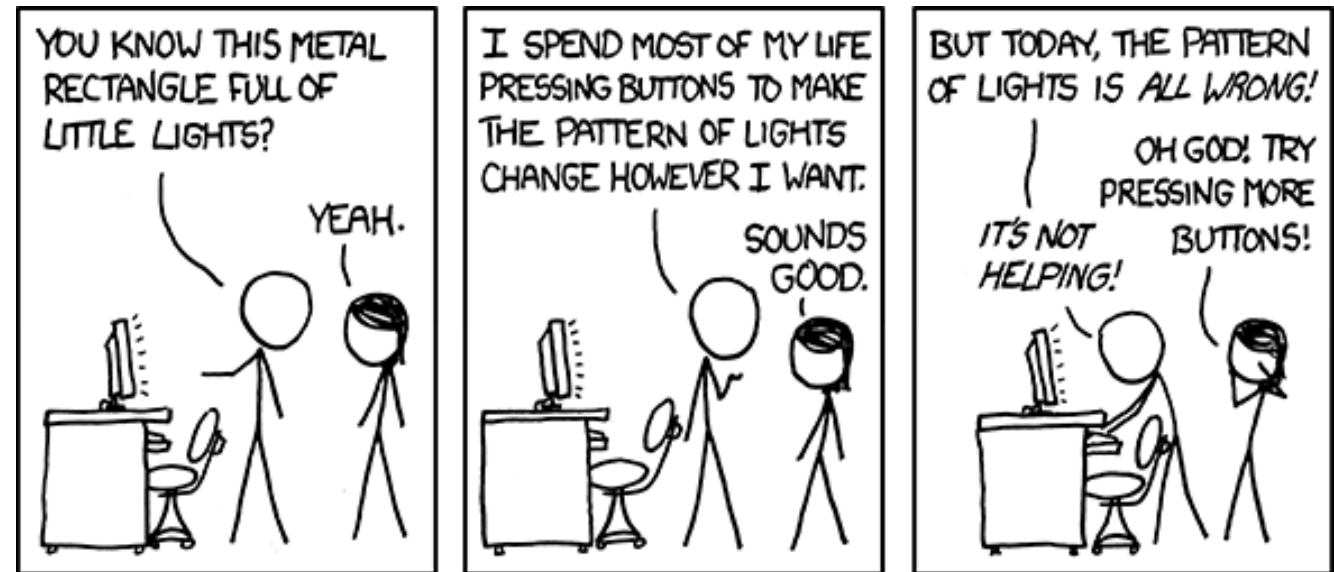
Alt text: "This is how I explain computer problems to my cat. My cat usually seems happier than me."

Relevant Course Information

❖ Lab 5 due Thursday (12/7)

❖ Course evaluations open
  ▪ See Ed post #580 for links (separate for Lecture and Section)

❖ **Final Exam:** Wed, Dec 10 12:30-2:20 (110 min)
  ▪ KNE 210 and KNE 220, depending on section
  ▪ Review Session: Friday, 12/5, 4:30-6:30 pm on CSE2 G01 & Zoom
  ▪ Section on Thursday has finals review material

Disclaimers

❖ This is a big and nuanced topic

- Could fill whole courses with this type of content
    - *e.g.*, CSE480: Computer Ethics Seminar
- Our hope is to expand your viewpoints about computers (and computing), but please think critically about the information and come to your own conclusions

❖ This lecture is a work-in-progress

- There is a lot more we wish we could cram in here
- It has a narrative that someone designed, therefore it is inevitably imbued with the values, beliefs, and experiences of the curriculum developers
- We can agree on (most) facts, but how we interpret them is a choice

Pre-Quarter Survey Quotes

❖ Note that I will be interspersing some quotes from the pre-quarter survey, where one of your prompts was:

What is your current impression of computers?

This is a fake quote!

- These will be included without attribution for privacy
- The point is not to call anyone out or to pass judgment, but to validate some of the points being made today as well as recognize that society shapes our views and values
- Some of these quotes were from a previous quarter!

Lecture Outline (1/5)

- ❖ **How We View Computers**

- ❖ A Brief History of Computers

- ❖ Who Are Computers Built For?

- ❖ The Cost of Computers

- ❖ Where Do We Go From Here?

How We View Computers

❖ Top responses: fascinating/cool, powerful, and complex

   ▪ Based on personal usage, media, and coursework

❖ Personal views vary, but many trend towards **utopian/essential, mysterious**, and **cautious**

   ▪ Easier to see the positives (that's how they're marketed), but increasingly becoming aware of negatives

   ▪ Please remember that y'all are a biased sample of society

   ▪ Also, the following quotes were from the beginning of the quarter

Pre-Quarter Survey Quotes (Utopian/Essential)

As far as I'm concerned, computers are the key to the next stage in humanity's progress, both in terms of industry and culture.

I think computers are incredibly powerful tools that have completely transformed the way we live, work, and learn. They can handle complex tasks, solve problems, and connect people around the world in ways that were unimaginable a few decades ago. My impression is based on how I've seen them evolve over the years - becoming faster, smarter, and more user-friendly - and how they've become essential in nearly every aspect of life, from education and communication to entertainment and beyond.

I think that computers are the basis of all major breakthroughs from now on in human history, and will never really stop evolving. I don't know how much science fiction is realistically going to come to pass, but I have no doubt that in some ways we as a population will blow [past] anything that anyone can imagine.

Pre-Quarter Survey Quotes (Mysterious)

A lot of funny magic numbers go weewoo and suddenly there are lights on my screen. This is based on my (very obvious) lack of understanding.

I feel like my current impression of computers is that they do some crazy sh!t, and I have no clue how a lot of it happens. I've learned to code, but I still have little clue how some of the crazy things people have worked up work or how that translates to the metal slabs in my pc or phone

They're pretty magical. I remember a teacher in high school telling me about a class he took like this one where he learned about assembly, architecture, etc., and he talked about how it only made computers seem more like magic. I think I feel the same way.

Pre-Quarter Survey Quotes (Cautious)

My current impression is that they are powerful tools that can help humanity achieve their goals but it's also a double edge sword because other humans can use technologies that a majority of the population doesn't understand or know to abuse their power.

My current impression of computers is that they're essentially necessary for our survival. Despite this fact, there are plenty of negatives related to computers such as the overuse of social media, allowing predators to have greater accessibility, and climate concerns.

They're impersonal and mechanical. They've caused a lot of people to think in [an]... unfocused way rather than in a sequential, logical way. I don't like the way they've directed society at least culturally, but I think they can still accomplish a lot.

Computers as Tools

- ❖ "**We shape our buildings and afterwards our buildings shape us.**" – Winston Churchill in a 1943 speech
- ❖ "**The medium is the message**" –Marshall McLuhan
  - ▪ i.e. Our mode of communication shapes the content of our communication
  - ▪ For example, how is news different in print journalism vs. 24-hr TV news vs. TikTok?
- ❖ "**We shape our tools, and thereafter, our tools shape us.**" – John Culkin in a 1967 article about Marshall McLuhan

Lecture Outline (2/5)

❖ How We View Computers

❖ **A Brief History of Computers**

❖ Who Are Computers Built For?

❖ The Cost of Computers

❖ Where Do We Go From Here?

The First Computers

❖ **Computer**: a *person* who computes

  ▪ Doing calculations by hand quickly for aeronautics, warfare, science, etc.

The women of
Bletchley Park,
Credit: BBC

Human Computers at NACA, Credit: NASA
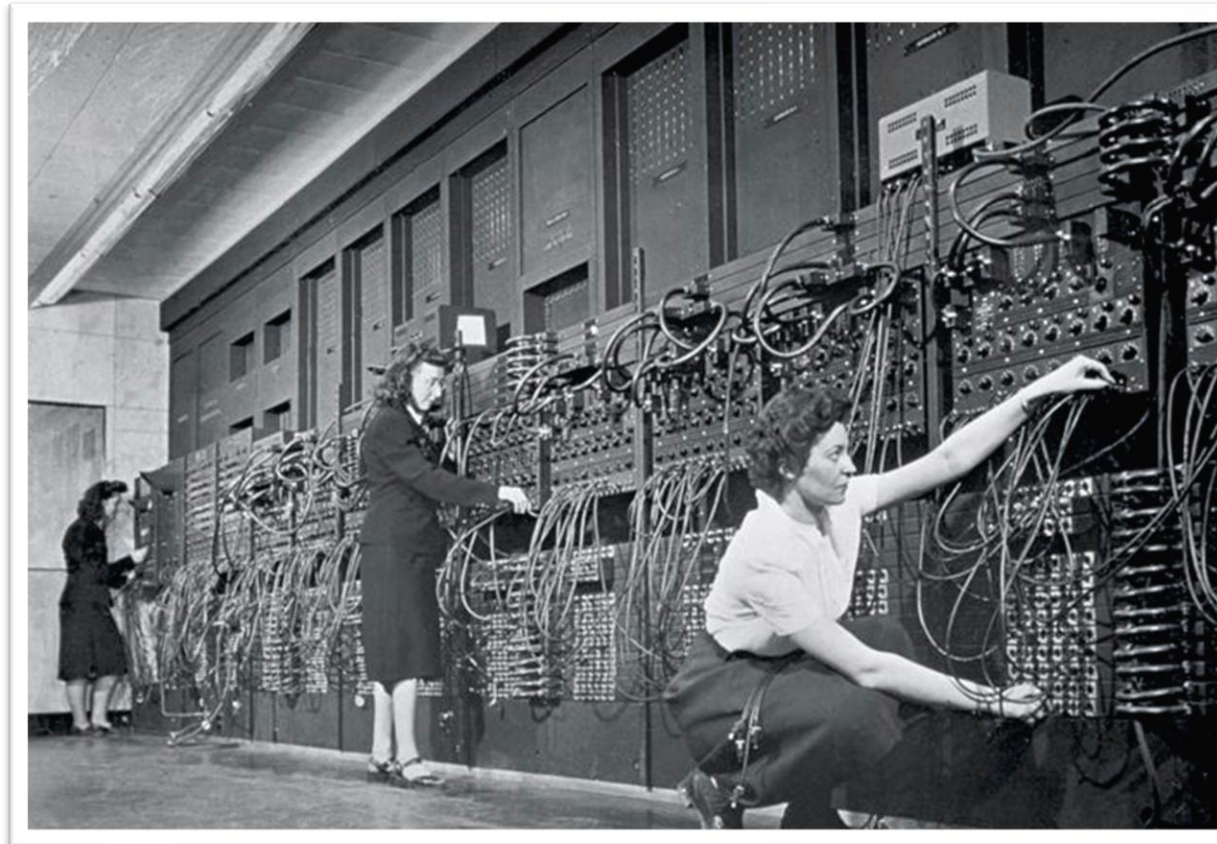
Human Computers at JPL, Credit: JPL

ENIAC

- ❖ 1st programmable, electronic, general-purpose digital computer built at UPenn in 1945
  - ▪ Automated ballistics calculations for the US military

Historical Programming (1940's)

❖ Manual plugboard wiring to connect arithmetic machines:

Jean Jennings (left), Marlyn Wescoff (center), and Ruth Lichterman program ENIAC at the University of Pennsylvania, circa 1946.
Photo: Corbis http://fortune.com/2014/09/18/walter-isaacson-the-women-of-eniac/

Historical Programming (1940's-1970's)

❖ Programming via punch cards

■ Idea taken from automated looms and data processing

By Stephencdickson - Own work, CC BY-SA 4.0,
https://commons.wikimedia.org/w/index.php?curid=79746138
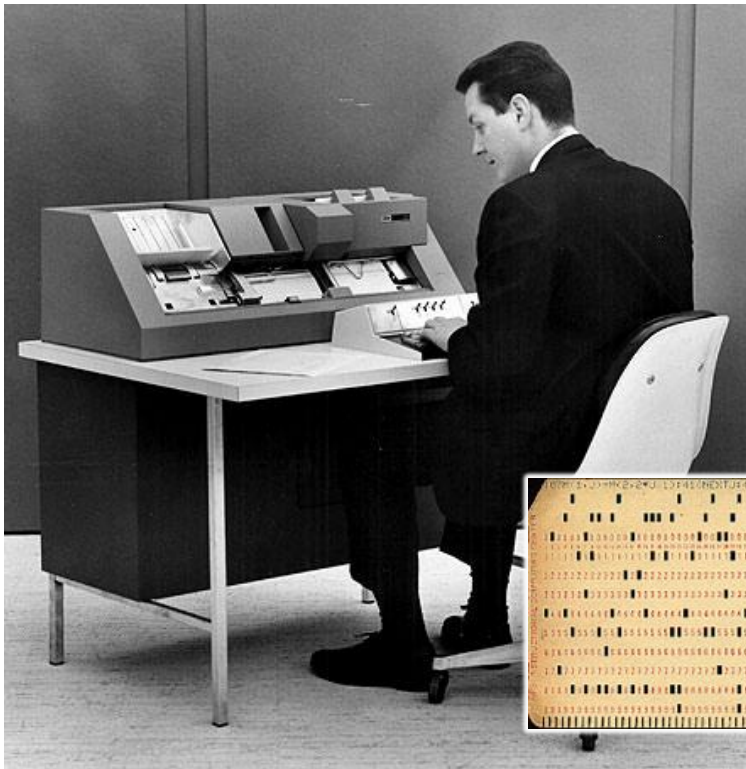
Historical Programming (1940's-1970's)

❖ Human computer operators manage program queue

■ Precursor to operating systems!

Historical Programming (1970's)

❖ Magnetic tape replaced punch cards, operating systems could run more than one program

▪ Programming by typing into a machine now:

https://s-media-cache-ak0.pinimg.com/564x/91/37/23/91372375e2e6517f8af128aab655e3b4.jpg

Computing History and Women

❖ Early computers and then later computer operators were mostly white cisgender women!

- Allowed to do the "boring, repetitive" work

- Less common, but also available to some women of color:

Source: https://netforward.net/what-hidden-figures%E2%80%8B-can-teach-us-about-the-importance-of-diversity-in-tech/
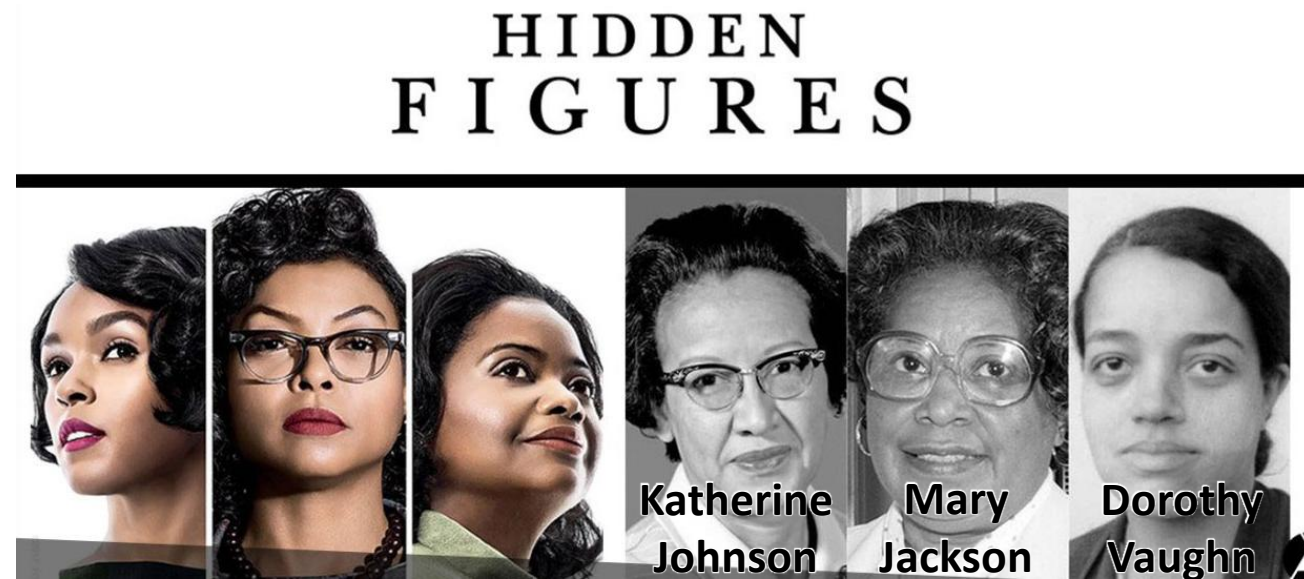
High Paying Jobs for Women

The Computer Girls

BY LOIS MANDEL

A trainee gets $8,000 a year
...a girl "senior systems analyst" gets $20,000—and up!
Maybe it's time to investigate....

Ann Richardson, IBM systems engineer, designs a bridge via computer. Above (left) she checks her facts with fellow systems engineer, Marvin V. Fuchs. Right, she feeds facts into the computer. Below, Ann demonstrates on a viewing screen how her facts designed the bridge, and makes changes with a "light pen."

Twenty years ago, a girl could be a secretary, a school teacher . . . maybe a librarian, a social worker or a nurse. If she was really ambitious, she could go into the professions and compete with men . . . usually working harder and longer to earn less pay for the same job.

Now have come the big, dazzling computers—and a whole new kind of work for women: programming. Telling the miracle machines what to do and how to do it. Anything from predicting the weather to sending out billing notices from the local department store.

And if it doesn't sound like woman's work—well, it just is.

("I had this idea I'd be standing at a big machine and pressing buttons all day long," says a girl who programs for a Los Angeles bank. I couldn't have been further off the track. I figure out how the computer can solve a problem, and then instruct the machine to do it."

"It's just like planning a dinner," explains Dr. Grace Hopper, now a staff scientist in systems programming for Univac. (She helped develop the first electronic digital computer, the Eniac, in 1946.) "You have to plan ahead and schedule everything so it's ready when you need it. Programming requires patience and the ability to handle detail. Women are 'naturals' at computer programming."

What she's talking about is *aptitude*—the one most important quality a girl needs to become a programmer. She also needs a keen, logical mind. And if that zeroes out the old Billie Burke-Gracie Allen image of femininity, it's about time, because this is the age of the Computer Girls. There are twenty thousand of them in the United

The Computer Boys Take Over

❖ Over time, programming transformed!

- From boring, repetitive work into a creative, intellectual pursuit
- From "low-status, largely feminized labor" to coveted by those in power

❖ Through the ages:

- Human computers – largely female
- ENIAC – hardware designed by men, programmed by women
- Punch cards – programs designed by men, computers operated by women
- Contemporary programming – boys encouraged, girls discouraged
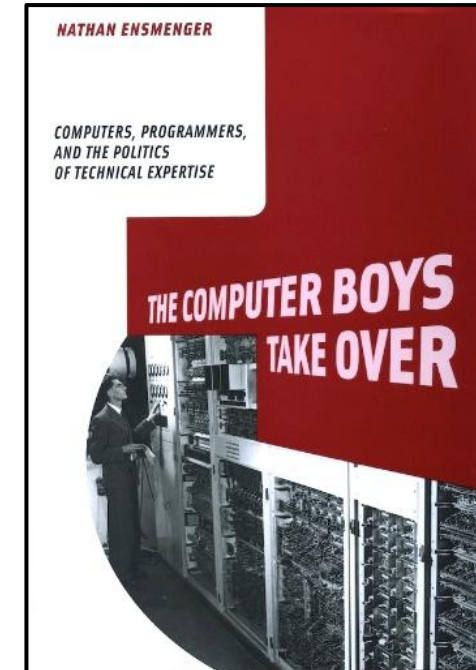
Innovation Funded by Violence

- ❖ ARPANet was the first long-distance networked group of computers [1]

- ❖ Funded by (D)ARPA, the research arm of the Pentagon

- ❖ Once again, breakthrough computing research was funded by the military!

  - ▪ Alan Turing was funded by British Intelligence to break Nazi codes

Source: Heart et al., ARPANET Completion Report, 1978. Scanned by Larry Press
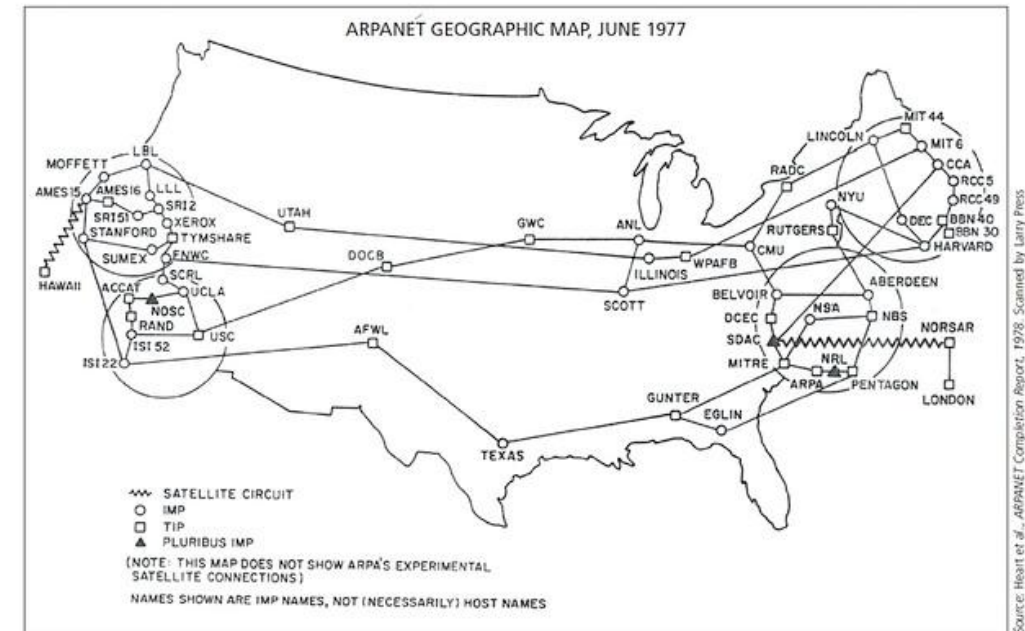
"The goal was to exploit new computer technologies to **meet the needs of military command and control against nuclear threats, achieve survivable control of US nuclear forces***, and improve military tactical and management decision making"*
-Stephen J. Lukasik (DARPA Director 1970-1975) [2]

Historical Legacy of Computers

❖ Computers **augment** the abilities of humans

 ▪ Makes the labor of boring, repetitive work more widely available

 ▪ Highly valued, but generally *exclusively* available

❖ Computers **automate** the boring, repetitive work

 ▪ Culturally, we are conditioned to believe that all of this work *should* be automated

 ▪ Consistently eliminates the jobs of marginalized folks

  • *e.g.,* ENIAC's calculation speed could displace 2,400 human computers

❖ Both narratives are simultaneously true, even today!

 ▪ Underlying goal is **efficiency of labor** (for profit)

Quick Discussion

❖ What jobs have you heard about that might be in imminent danger of automation?

  ▪ Who stereotypically holds these jobs?

❖ What are some of the consequences if there are no more "low skill" (*i.e.*, boring, repetitive) jobs for humans?

Lecture Outline (3/5)

❖ How We View Computers

❖ A Brief History of Computers

❖ **Who Are Computers Built For?**

❖ The Cost of Computers

❖ Where Do We Go From Here?

Who Are Computers Built For?

❖ New computers come with *de facto* requirements:
  ▪ $$$ – generally quite expensive
  ▪ Consistent access to electricity
  ▪ Access to the internet
  ▪ A trained user

❖ Most useful to those with social power and privilege!
  ▪ Have the means to afford new technology
  ▪ Have access to learning opportunities and education

Computer Marketing

❖ First digital computers took up whole rooms
- Housed at prestigious/exclusive universities, accessible to math and engineering students

Computer Marketing

❖ First digital computers took up whole rooms

❖ With advent of personal computing, marketed to those with leisure time and money

https://www.techrepublic.com/pictures/retro-computer-ads-from-the-early-1980s/4/

Computer Marketing

❖ First digital computers took up whole rooms

❖ With advent of personal computing, marketed to those with leisure time and money

❖ Eventually trickled down to general population via
K-12 schools

- Only those that could afford them or close enough to tech to be donated
- Also needed staff who could use/teach them
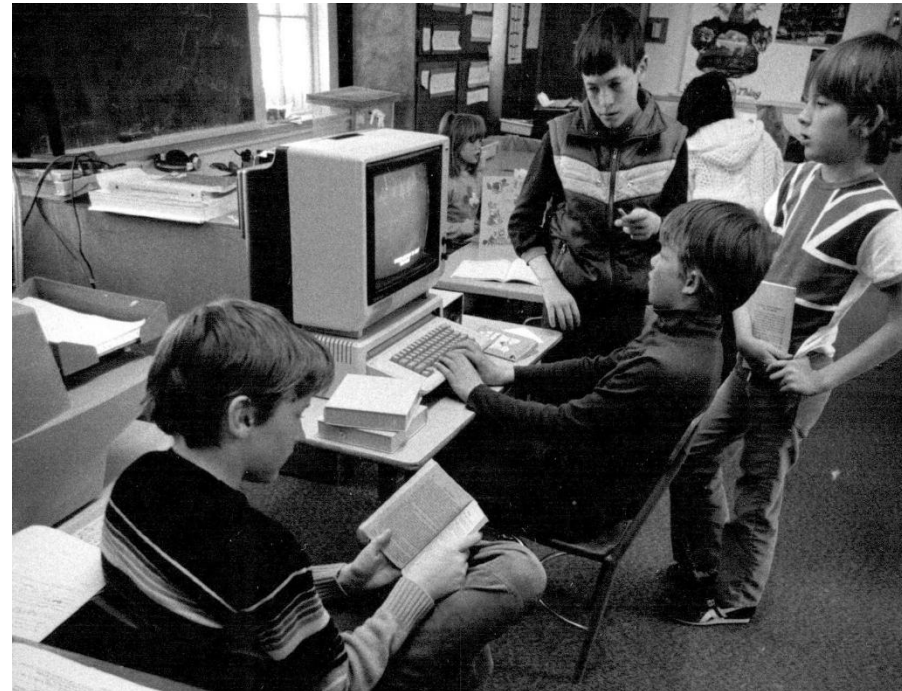
Computer Marketing

❖ First digital computers took up whole rooms

❖ With advent of personal computing, marketed to those with leisure time and money

❖ Eventually trickled down to general population via K-12 schools

❖ **Smartphones now advertised as productivity tool and social status symbol**
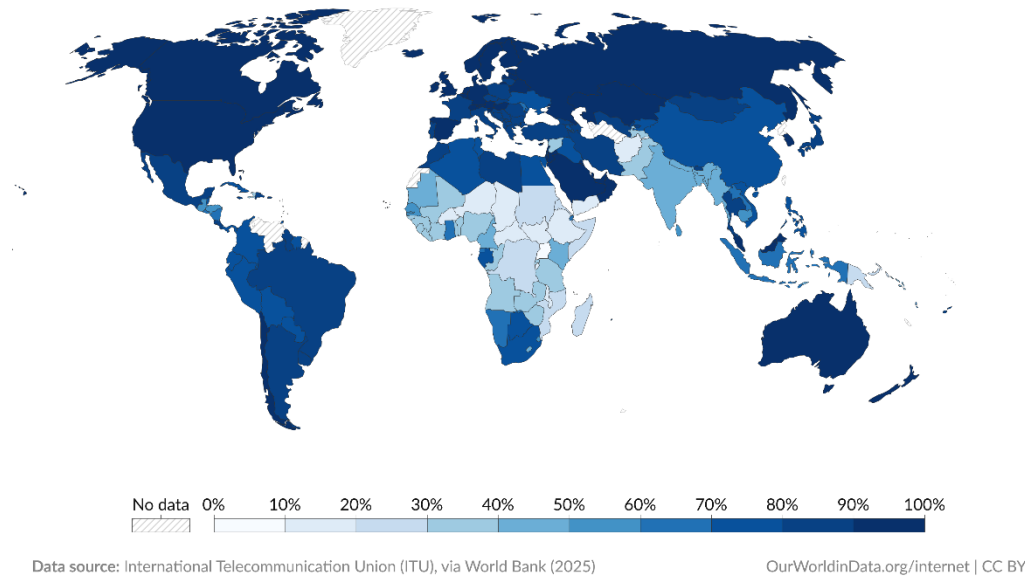
Not Everyone Has Internet Access

❖ Who designs computers & tech for them?

Share of the population using the Internet, 2023
Share of the population who used the Internet[1] in the last three months.

No data 0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Data source: International Telecommunication Union (ITU), via World Bank (2025)
OurWorldinData.org/internet | CC BY

1. Internet user An internet user is defined by the International Telecommunication Union as anyone who has accessed the internet from any location in the last three months.
This can be from any type of device, including a computer, mobile phone, personal digital assistant, games machine, digital TV, and other technological devices.

World Population Density
Residents per km², 2020   Data: EC JRC & CIESIN
Design: D A Smith CASA, UCL
☑ Map Labels ☐ Interactive Stats
20-99 400-1k 2k-3.5k 5.5k-7.5k 10k-12k 16k-22k 30k-50k 100k-200k
100-399 1k-2k 3.5k-5.5k 7.5k-10k 12k-16k 22k-30k 50k-100k 200k+

Map Guide   Analysis
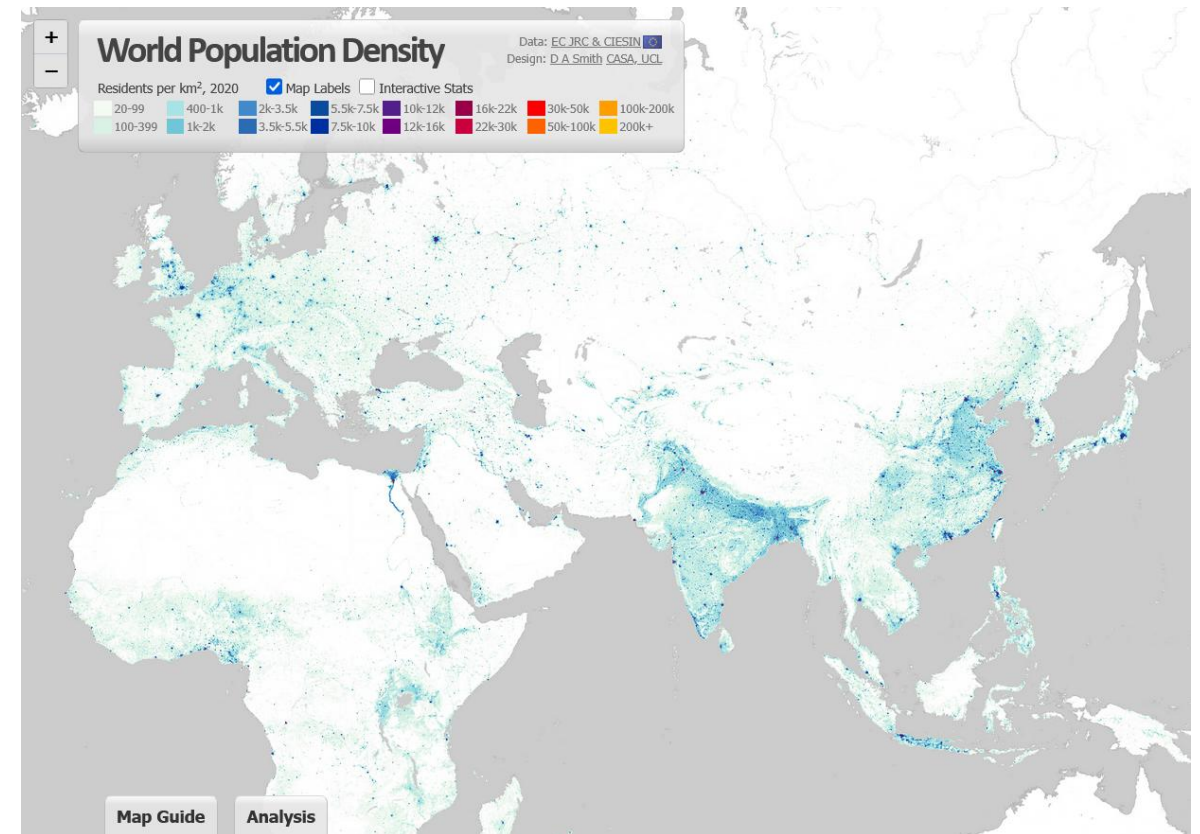
https://ourworldindata.org/internet
Accessed Dec. 2, 2025.

# Lecture Outline (4/5)

❖ How We View Computers

❖ A Brief History of Computers

❖ Who Are Computers Built For?

❖ **The Cost of Computers**

❖ Where Do We Go From Here?

Costs of Production

❖ Creating products is a process that involves labor, hazards, and waste:

■ "From a slow process of elemental development, these elements and materials go through an extraordinarily rapid period of excavation, smelting, mixing, and logistical transport – crossing thousands of kilometers in their transformation. Geological processes mark both the beginning and the end of this period, **from the mining of ore, to the deposition of material in an electronic waste dump**." – https://anatomyof.ai
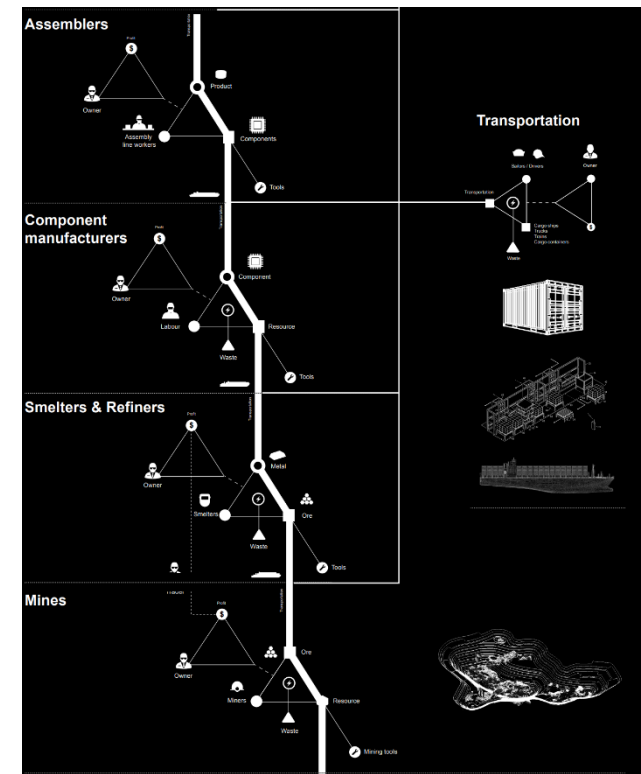
Costs of Production

❖ Material resources:
- Silicon (non-renewable)
  - Silicon dioxide purified from quartz or silica sand
  - In 2021, shortage of silicon metal caused 300% price spike – China cut production to reduce power consumption
  - Other industries that require silicon, including auto and solar, in trouble because supply being gobbled up by chip manufacturers
- Lithium (non-renewable)
  - Lithium-ion batteries have a limited lifespan
  - Classified as non-hazardous waste and often end up in landfills or incinerators
  - Could be recycled, but the cost of collecting, sorting, and shipping used batteries to a recycler often exceeds the scrap value
- Plastics

Costs of Production
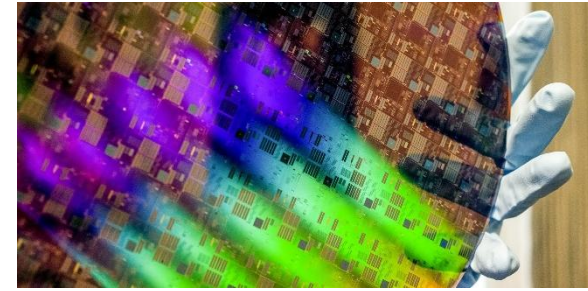
❖ Semiconductor chip manufacturing:

- Needed for computers, cell phones, "smart" appliances, automobiles, airplanes, health-care equipment, etc.

- Semiconductor factories
  - Takes 5+ years and billions of dollars to build
  - Lots of expensive machinery & chemicals to process and protect wafers (people just maintain the machines)
  - A silicon wafer takes ~3 months and ~700 steps to process
  - Use of fossil fuels and chemicals can be harmful to the health of those living in proximity to manufacturing facilities

- Global affair
  - ~75% manufactured in Asia, must be imported
  - Supply chain: raw materials, manufacturing workers, transport

Costs of Production

❖ Use and disposal:
- Strain on electrical grid during use and wasted energy while idling contribute to greenhouse gases and pollution
  - Bitcoin mining is particularly power-intensive: The amount of electricity used to mine bitcoin "has historically been more than [electricity used by] entire countries, like Ireland" [1]
- Increases in speed an energy efficiency have not blunted the waste — they have increased it! [2]
  - Computers get faster ⇒ people use computers more ⇒ carbon emissions and electronic waste surge
  - Jevon's Paradox: "efficiency increases consumption" –William Stanley Jevon (1865) [3]
- Millions of tons of electronic waste are discarded into landfills in the Global South each year
  - Heavy metals can pollute the soil and contaminate groundwater [4]

Quick Discussion

❖ There is a tension here between…

- The potential benefits of integrating computational systems into our lives
- The cost of said computerization, in terms of $, e-waste, and carbon emissions

❖ Which parts of our homes, workplaces, and lives could/should probably do *without* computerization?

Quick Polls

❖ **Answer polls on Ed as quickly as possible; no discussion needed**

■ About how frequently do you buy a new computer or smartphone?

- **A**: Once a year or more frequently
- **B**: Every 1-2 years
- **C**: Every 3-5 years
- **D**: Every 5+ years
- **E**: I don't own or don't buy

■ What is the main reason that you buy a new computer or smartphone?

- **A**: Old one broke or lost
- **B**: Old one is too slow
- **C**: Old one no longer supported
- **D**: Newer version released
- **E**: New tech released
- **F**: Not applicable

The Technology Cycle

❖ Computers and technology eventually break down and stop working, but the industry really relies on consumers buying *before* that happens
  - The entire chip industry depends on a brand new laptop/smartphone meaning something!
    - Consumers want speedups, engineers should deliver
    - Self-fulfilling, industry taught consumers to believe "faster is better"
  - **Obsolescence**: when an object, service, or practice is no longer maintained, required, or degraded even though it may still be in good working order.
    - Newer version or new tech released = "technical obsolescence"
    - Old one is too slow = "functional obsolescence"
    - Old one no longer supported = "planned obsolescence"

The Technology Cycle

- Technology and longevity:
  - Longevity is nearly impossible to design for
    - Nothing is future-proof!
    - We've seen lots of weird historical artifacts in this class
  - Tension around technological change
    - *Companies* and *developers* hate supporting the same tool over a long period of time
    - *Consumers* tend to be resistant to change and hate being "forced" to upgrade
    - Backwards-compatibility can be a decent compromise
  - "Exciting" areas see lots of change, "boring" areas neglected
    - *e.g.,* unemployment systems and ATMs still run on COBOL (1959) [1]

The Technology Cycle

- ❖ Who benefits? Who loses?
  - The consumers?
  - The developers?
  - The Earth?

- ❖ "The Consumer Technology Association notes that the average smartphone lifespan is 4.7 years. This obsolescence cycle fuels the purchase of more devices, drives up profits, and increases incentives for the use of unsustainable extraction practices."
  – https://anatomyof.ai

Lecture Outline (5/5)

❖ How We View Computers

❖ A Brief History of Computers

❖ Who Are Computers Built For?

❖ The Cost of Computers

❖ **Where Do We Go From Here?**

Where Do We Go From Here?

❖ In this class, we have examined some of how computers got to where they are today – but we get a say in where we go from here!

❖ You have unprecedented power and access as technologists – be the change that you want to see!

▪ What would you like to accomplish?

▪ Who/what will you support (explicitly or tacitly)?

❖ Remember, computers shape society and society shapes computers

▪ Be wary of what you build and how you design it!

▪ Make sure you take the messy social context into account