CSCI 1800 Cybersecurity and International Relations

Technology & Policy Challenges

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Outline

- History of computers and networks
- Societal impact of the Internet
- Making systems secure
- Examples of cybersecurity policy formulation
- Internet governance
- Is cyber conflict possible?

History of Computers & Networks

Cyberspace Summary

- Cyberspace is the Internet, host computers, applications, stored data, networks and traffic.
- Internet is collection of independently managed subnetworks (autonomous systems or ASes).
  - Important: the Internet is privately owned/managed
- Traffic flow (i.e. routing) decided by ASes
- The Domain Name System (DNS) maps domain names into physical IP addresses (bit strings).

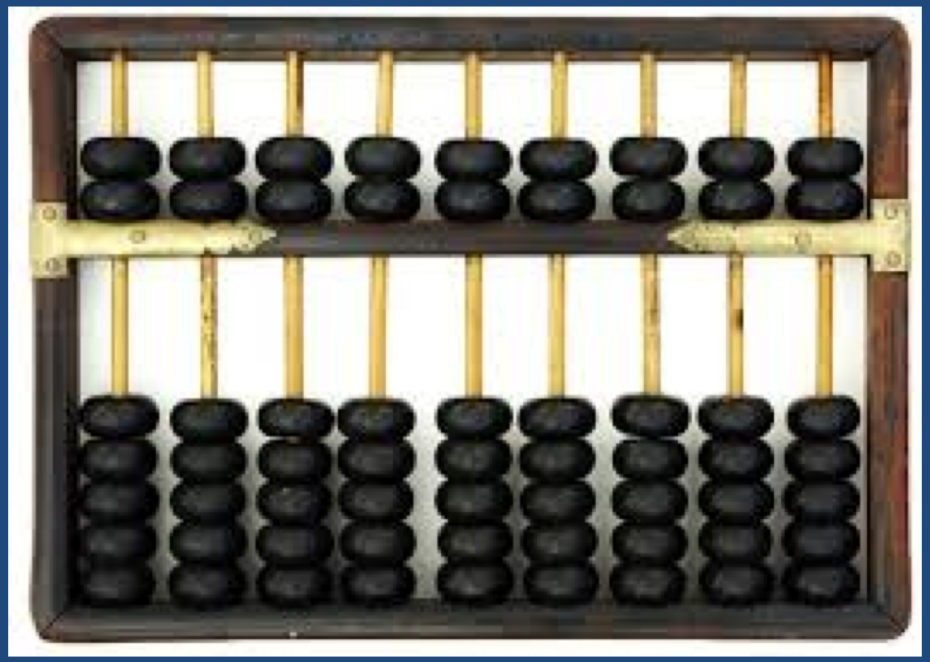
Brief History of Computers

- The first recorded use of word “computer” in 1613.
  - A computer was a person who performed computations.
- Mechanical aids to computation are very old.
  - Abacus (3,000 BC), astrolabe (150BC), slide rule (17th AD) Jacquard Loom (1801), Analytical Engine(1837), Hollerith punched card tabulator (1880s), and Zuse 3 (1941).
- First vacuum tube-based programmable computers
  - Eniac (1946), Manchester computer (1948).
- The wiki page* on computers is very good.

* See https://en.wikipedia.org/wiki/Computer

The Abacus (2,700 BC)

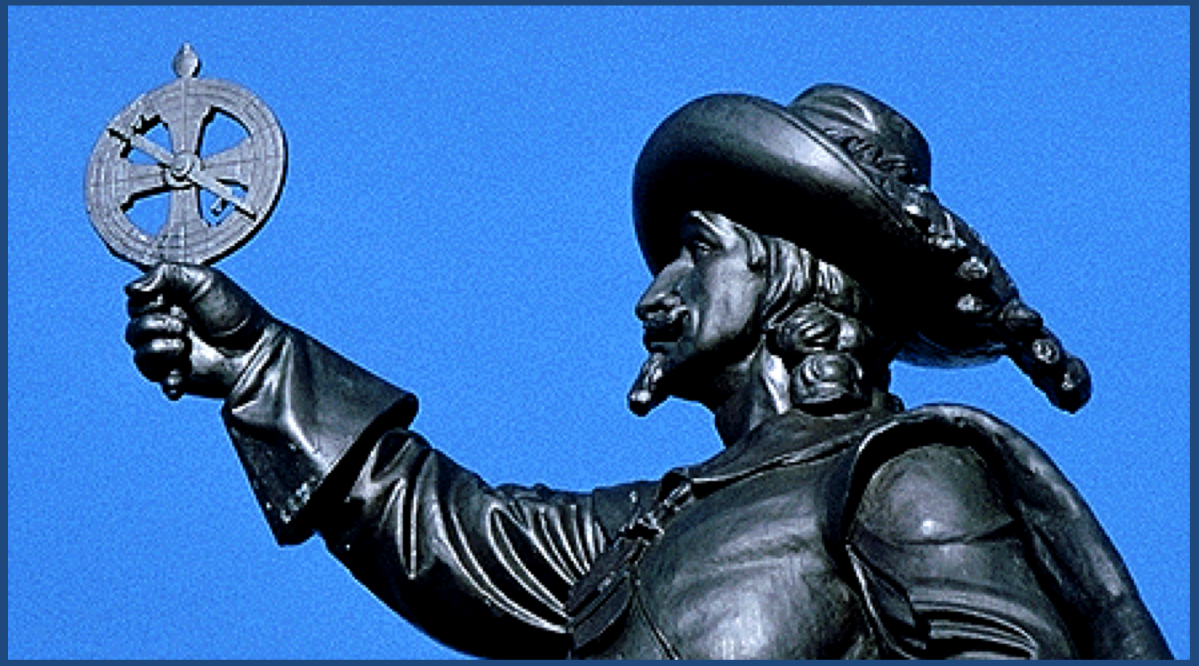
- The abacus is used for arithmetic operations



- The abacus is a model for modern computers!
- It stores data and computes with human help.

Astrolabe (8th Century BC)

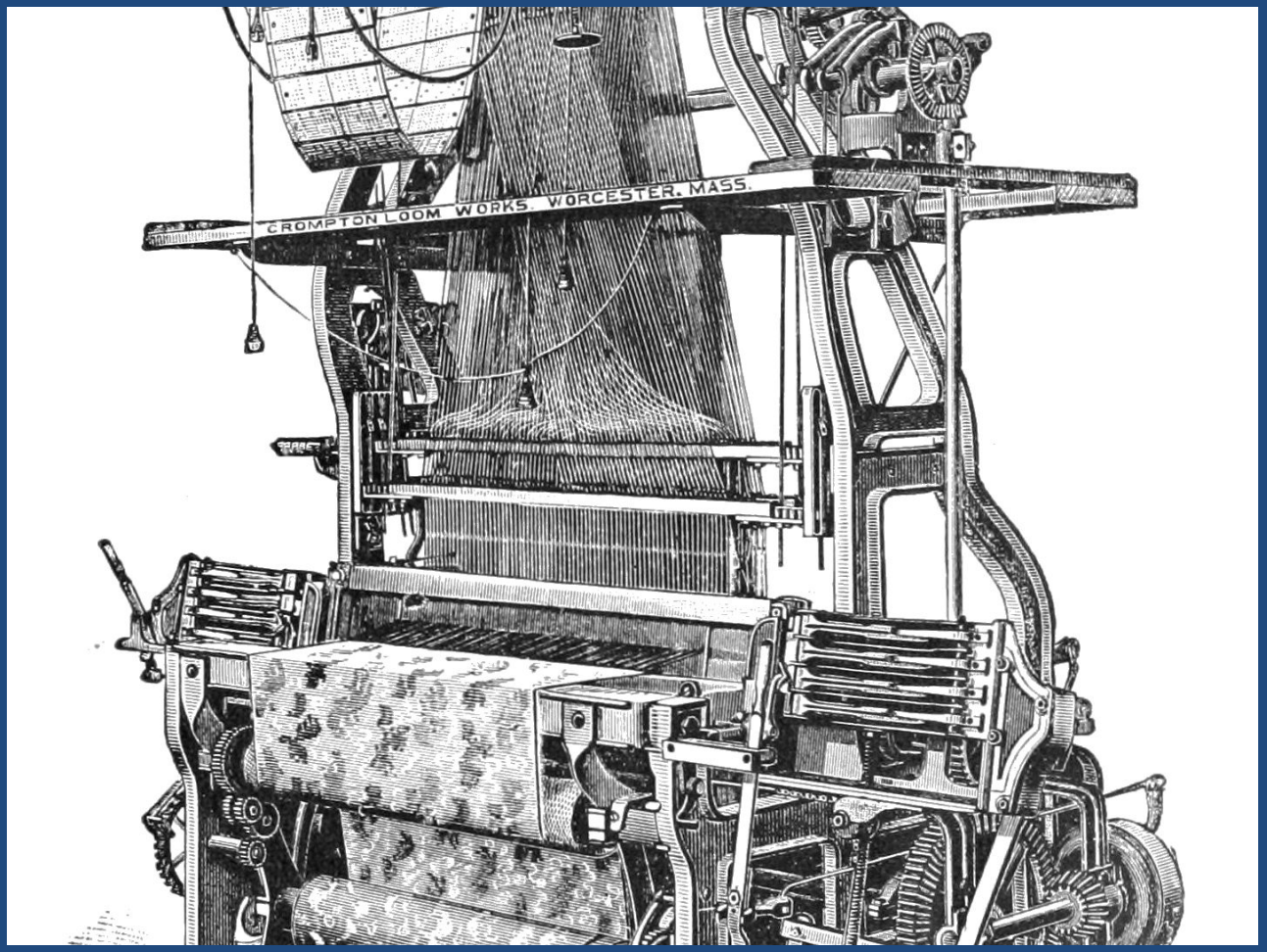
- A device for measuring angles, typically with the horizon.



Arithmetic Machines

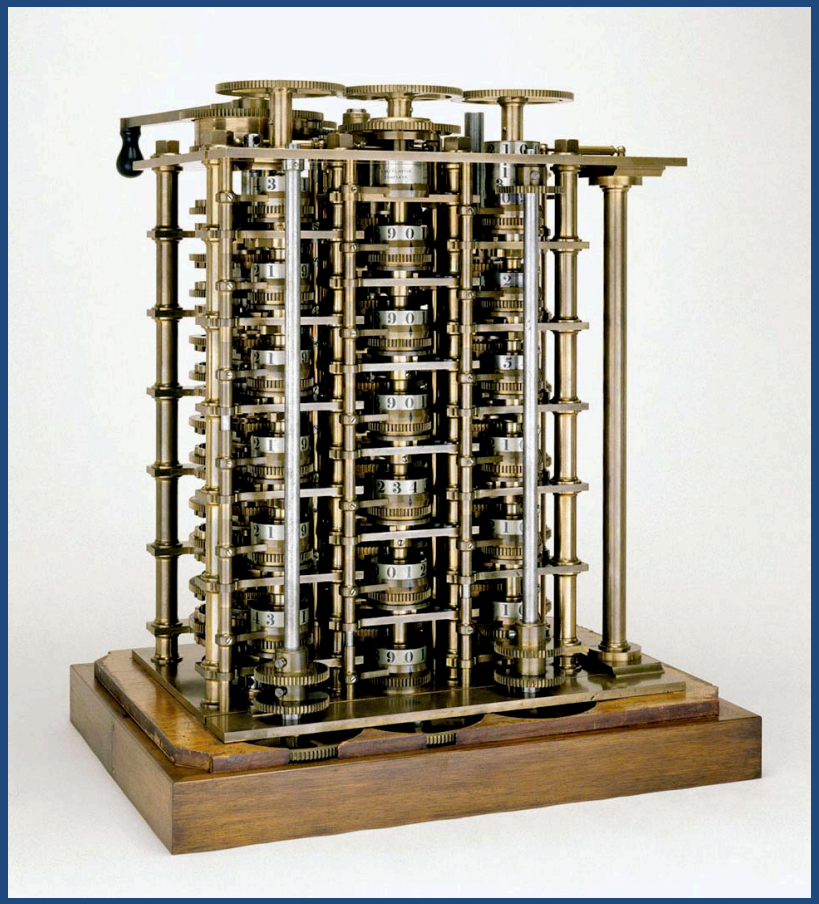
- Machines to add & subtract in decimal system designed by
  - Shickard (~1623)
  - Pascal (1640s)

Jacquard Loom (1746)



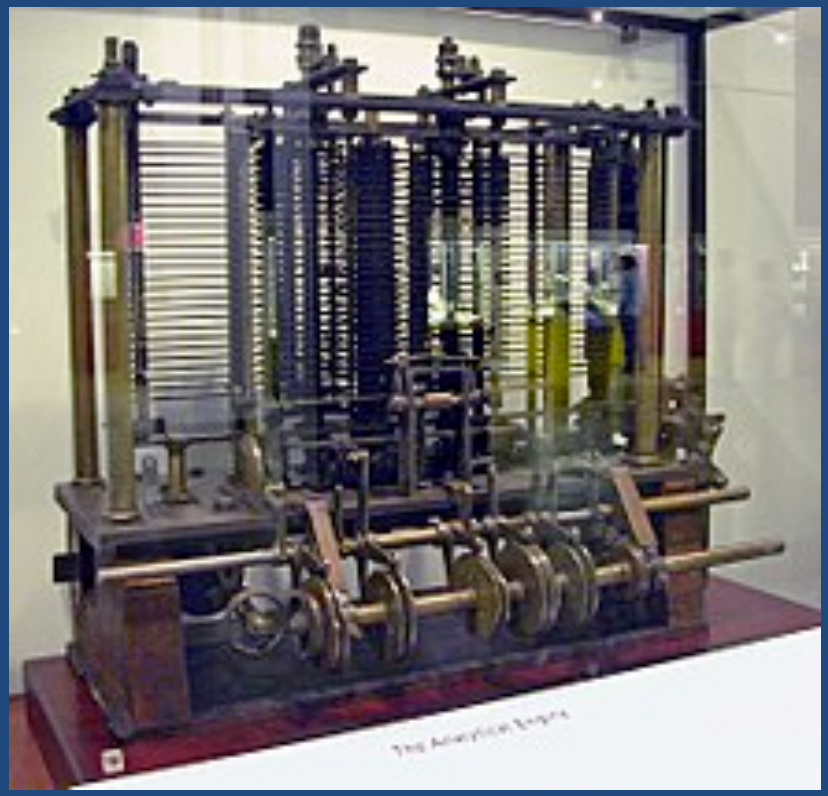
- The Jacquard Loom was one of the first programmable devices

Difference Engine (1822)



- Designed by Babbage to compute polynomials

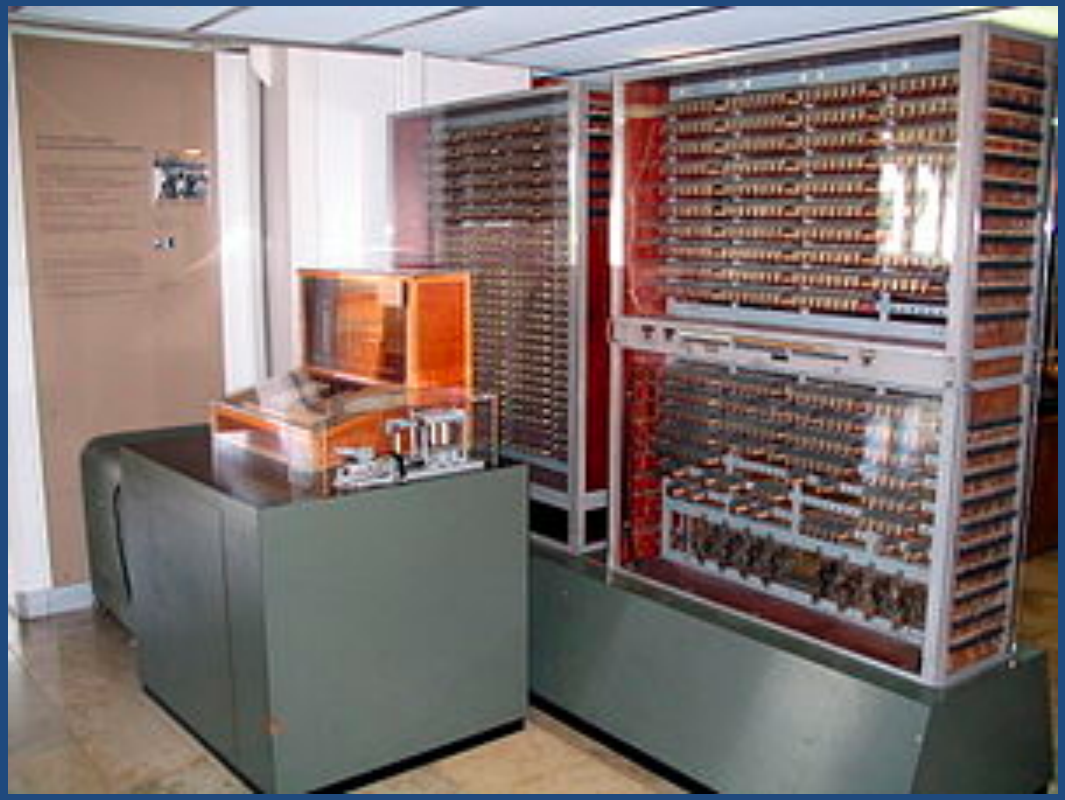
Analytical Engine (1835)



- (Part of) Babbage's general-purpose computer
- Had both "store" and "mill"!

Zuse Z3 (1941)

- Considered the world's first working programmable, fully automatic (electromechanical) computing machine.

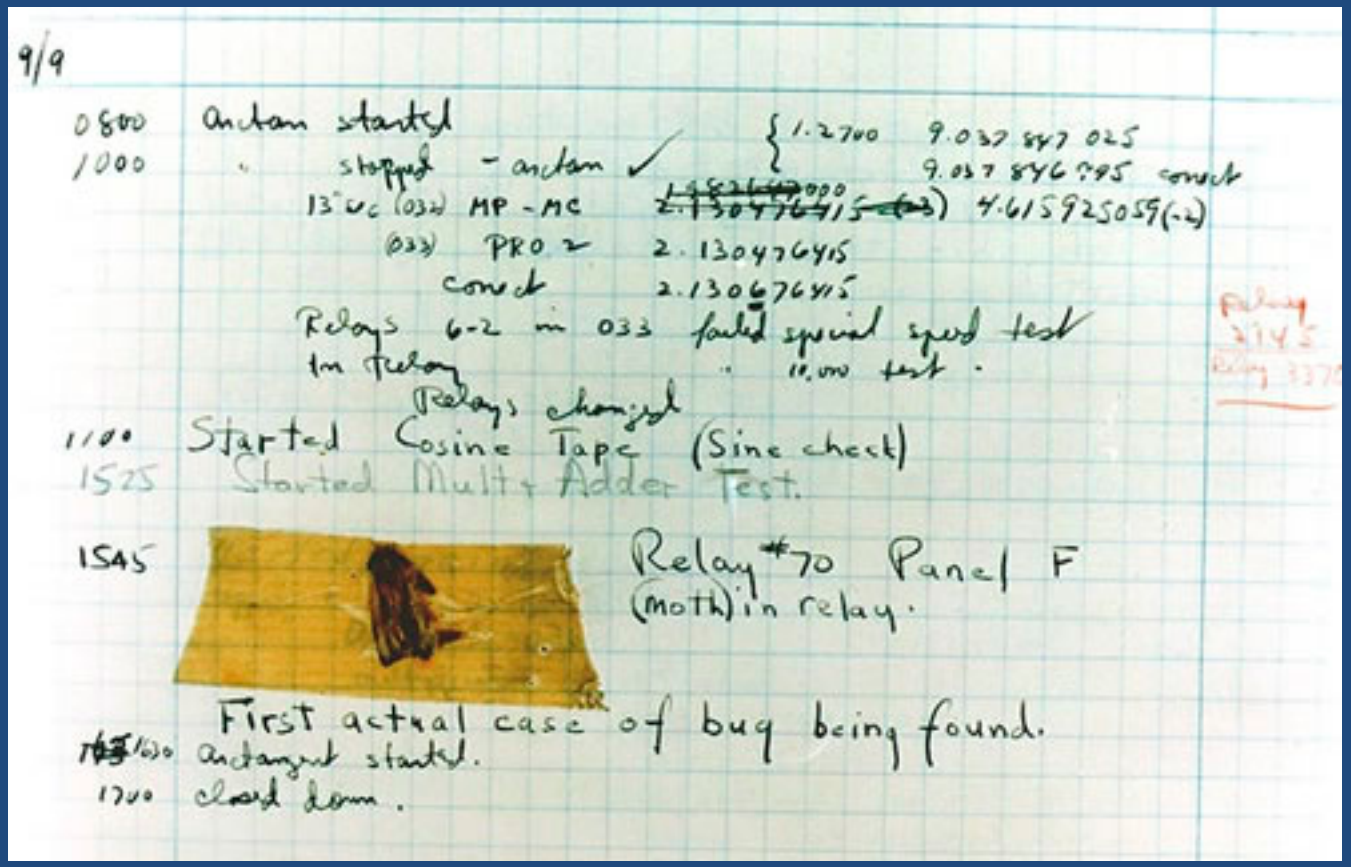


The Eniac (1946)

- The ENIAC (1946) considered to be the first general-purpose electronic computer

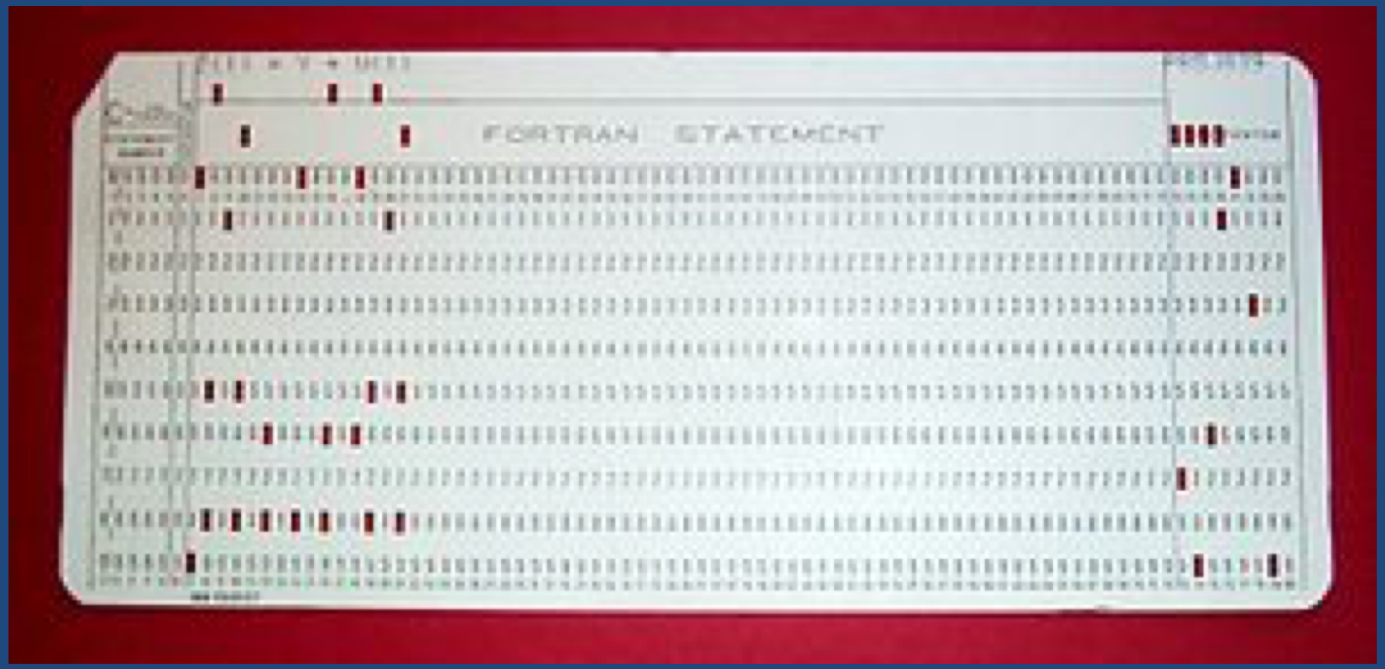
Etymology of the Computer Bug

- The actual first computer bug was a moth found trapped in an electromagnetic relay of the Harvard Mark II computer



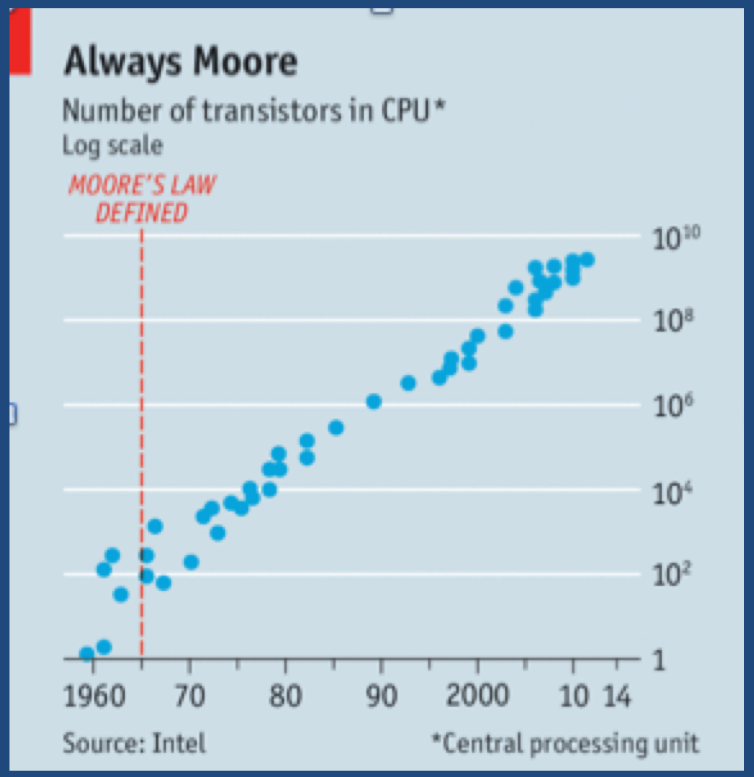
Punched Card (1700s – 20th Cent.)

- A 1970s punched card containing one line from a Fortran program



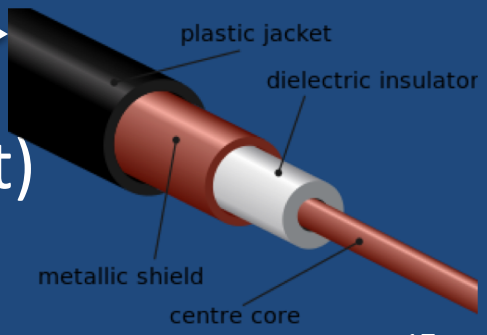
The Computer Industry

- Driven by micro miniaturization of devices.
- Transistor (a switch) became available in 1950s.
- Invention of the integrated circuit (1958/9) led to *exponential growth* of devices per unit area over time (Moore's Law).
  - *Moore's Law is now ending*
- In 1958, one transistor per chip. In 2019, $40 \cdot 10^9$ transistors/chip!



Computer Networks

- First computer networks* emerge in 1950s
- ARPANET, Internet precursor, emerged in 1969.
- Networks of many different sizes now exist.
  - Local, regional, national, international
- Multiple communication technologies are used.
  - Twisted pair, coaxial, optical fiber, radio (wireless)
- Many protocols are employed.
  - TCP/IP (Internet), Ethernet (local net)



* See https://en.wikipedia.org/wiki/Computer_network

Societal Impact of the Internet

Political Power of Social Media

- Governments limit access to information
  - Google and NYT not available in China
  - Turkey shut down Internet during its elections
- Social media – facilitates organizing & recruiting
  - Arab Spring (2010-14), ISIS emerges (~2011-12)
- Fake news is lucrative and disruptive
  - The Follower Factory (NYT, 1/27/18), Devumi sells followers
    https://www.nytimes.com/interactive/2018/01/27/technology/social-media-bots.html
  - Kompromat (**компромат)** is increasingly practiced

Critical Infrastructure at Risk

- A networked economy is more fragile
  - Computers can be hacked, networks blocked
- Critical infrastructure (CI) is now on the Internet
  - Exposes nations to damaging attacks
  - Supervisory control & data acquisition (SCADA) systems
    - They control electrical grid, plants, water delivery, etc.
    - Can experience cascading failures
- Cloud computing has become very popular.
  - More secure but clouds provide big targets.

A Chemical SCADA System

Just-in-Time (JIT) Delivery

- Greatly facilitated by the global Internet
- UK Study done by Lord Cameron in 2007*:
  - 80% of grocery sales occur in 4-5 chains.
  - Only 4-5 days of food supply on shelves.
  - UK is “nine meals away from anarchy”.
  - UK food supply is totally dependent on oil.
  - If oil supply were cut off, law and order would break down in three full days.
- Fragility of JIT systems is worrisome.
- Too many systems in modern economies are JIT.

See http://www.utne.com/environment/nine-meals-away-from-anarchy-zm0z13jfzros.aspx
https://www.theguardian.com/commentisfree/2010/jan/11/nine-meals-anarchy-sustainable-system

Cloud Computing

- Third-parties provide computing & storage.
  - E.g. Google, Amazon, HP, IBM, Microsoft
  - Using replication and full-time staffs, clouds are more secure than personal computers
- They also present big targets.
  - Chip vulnerabilities impact clouds (e.g. Meltdown)
- Fortunately, operators can afford good security
  - Some can provide better security than companies

Making Systems Secure

Software Complexity = Insecurity

- Software complexity continues to grow.
  - 2007 Mac OS X 10.4 – 86 Million lines of code (LOC)
  - 2010 Windows 10 – 50 Million LOC
- Number of errors grows with software complexity
- If 1 security error/10^3 LOC ⇨ 86,000 bugs in OS X
- A software engineer can only write several 10s of lines of documented & tested lines of code per day.
- Thus, writing secure code is very challenging!

Cyber Attacks

- Attacker motivation
  - Script kiddies seek fun
  - Criminals seek profit
  - Hacktivists have a political agenda (e.g. Anonymous) – they use DDoS
  - Nation states seek information, compromising or not
  - Terrorists seek recruits and may launch attacks

Inside, Close-In, Remote Attackers

- Insider theft
  - Represents greatest risk
- Close-in attackers can
  - Communicate via WiFi
  - Sit at console
  - Listen to noise emanating from a computer
- Remote attackers can
  - Impersonate a user over the phone – social engineering
  - Probe and attack hosts via the Internet
  - Attack via a compromised website
  - Manipulate the Domain Name System
  - Launch a man-in-the-middle attack
  - Phish

Intro to Internet Governance

Government Group of Experts (GGE)

- UN convened five GGE sessions to examine existing and potential cyberspace threats and propose cooperative responsive measures.
- Representative proposed norms, e.g.
  - International law applies online as well as offline
  - States should not knowingly allow their territory to be used for internationally wrongful acts using ICTs
  - States should not engage in or support espionage for commercial advantage

Brief History of UN Involvement

- US develops Internet & runs DNS until ‘16
- Internet Engineering Task Force (IETF), premier standards body, created in US in 1986
- In 1998 Russian Federation expresses concern to UN that cyberspace technologies could be destabilizing and affect security of nations.
- World Summit on Information Society (WSIS) (2003-5) launched by UN to develop cyberspace agenda, effort to build the information society

Current System for Managing Internet

- ICANN manages domain names
  - ICANN decides which suffixes allowed (i.e. .ru or .xxx)
  - Regional Internet Registries (RIRs) issues IP addresses to Registrars & numbers to autonomous systems.
- Computer emergency response teams (CERTs) monitor health of Internet, coordinate action

- Internet technology decided by open process
  - Through the IETF and W3C
- Anyone can contribute

* How the Internet Got Its Rules, Steve Crocker, NYT 4/6/2009 See http://www.nytimes.com/2009/04/07/opinion/07crocker.html

Current System for Managing Internet

- Internet service providers (ISPs) and ASes* (private orgs.) provide service and route traffic
- ISPs connect together at exchange points (IXPs)
- Security of DNS and routing handled privately
- Individual governments legislate nationally
- Some intergovernmental coordination exists on cybercrime
- But, no organization is in charge of it all!

* AS = autonomous system

Internet Governance Today

- Internet governance not as controversial today as it was 2013.
- US Department of Commerce proposed to relinquish its control to ICANN in 2014.
- The transition occurred on October 1, 2016.
  - ICANN is now independent!

Is Cyber Conflict Possible?

Offense & Defense in Cyberspace

- US created CYBERCOM headed by 4-star general who also heads the National Security Agency

- Many other countries have “stood up” their own cyber commands.

Cyber Conflict

- Is cyber conflict possible?
  - What might be the nature of a conflict?
  - Could it lead to widespread loss of electricity?
  - Could it lead to kinetic warfare?
- Would it constitute an existential threat?
  - Bulletin of Atomic Scientists doomsday clock just moved from two minutes to 100 sec. to midnight
  - Cyber viewed as a threat multiplier

Snowden Controversy

- In 2013 Edward Snowden, a contract National Security Agency (NSA) employee began releasing* NSA secret documents.
- NYT and others urged amnesty
- Gen. Hayden & others call him traitor.
- What is your assessment of this incident?

* https://www.theguardian.com/us-news/the-nsa-files

Review

- Cyberspace presents many technical, policy and diplomatic questions.
- To address them we need to understand the
  - Technologies involved
  - Existing policies and agencies setting them
  - Determine what is at risk, and
  - Formulate new policies and get them adopted
  - Ask how to get governments to cooperate on this