1

A Brief History of Computing

1

2

Computing systems

- Let's take a tour of modern computing systems
- A computing system consists of two major parts: the **hardware** and the **software**
- Some hardware elements of a computer:
  - Screen, keyboard, mouse
  - Central processing unit (CPU), main memory
  - Hard drives and other storage units
- Types of software:
  - Applications software, like office productivity programs, video games, web browsers
  - Systems software, like operating systems, database systems

2

3

Computing systems

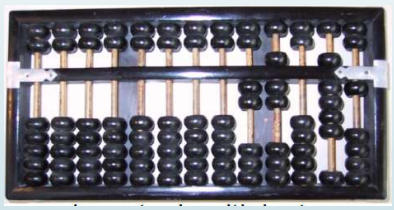
- Can hardware exist without software?
  - Sure, but is it useful? ➔ It depends
    - General Purpose CPUs [Intel x86, core i5, i7, etc.] Not really
    - Specialized hardware [FPGAs, ASICs with functionality built into hardware] – Yes. Although functionality was developed with software based tools
- Can software exist without hardware?
  - In a literal sense, no – hardware is needed to execute software
  - But, the underlying problem-solving techniques employed by the programmer to create the software do exist separately from the hardware and software
- One more part to a computer system: data
  - The software needs some kind of data to process: numbers, text, images, sound, video

3

4

A quick history of computing

- We think of computers as modern inventions
- Computing devices
  - go back thousands of years
  - have many of the same basic features of digital computers
- **Abacus** – an early device to record numeric values and do basic arithmetic (16th century B.C.)



- https://www.youtube.com/watch?v=GF6nCmcQ5es
- What does an abacus have to do with laptops, smartphones and tablet computers???

4

5

A quick history of computing

Modern computers borrow four important concepts from the abacus:

1. Storage
2. Data Representation
3. Calculation
4. User Interface

5

6

A quick history of computing

- 1. Storage
  - An abacus stores numbers, which are the most fundamental type of data in modern computing.
  - In a modern computer, all data – text, images, audio, video – is represented using binary numbers (1s and 0s)
- 2. Data Representation
  - The abacus represents numbers using beads on spindles.
  - Modern computers employ a variety of techniques for representing data on storage media:
    - Magnetic
    - Optical
    - Electrical

6

7

A quick history of computing

- 3. Calculation
  - By moving beads on abacus spindles, user can perform addition, subtraction, multiplication, and division
  - Modern computers contain powerful central processing units that perform calculations at astonishing speeds
- 4. User Interface
  - The beads and spindles on the abacus
  - Modern computers provide a wide variety of input and output devices for the user

7

8

A quick history of computing

- In the 17th century people began tinkering with physical devices that could do computations and calculations
- Blaise Pascal
  - the French mathematician and philosopher
  - one of a few to design and build a physical calculator
- Calculator could only do addition and subtraction
  - Input is given using dials
  - Output is read on small windows above each dial

8

9

Programmable devices

- Pascal's calculator and other similar devices of that time were not programmable
- One of the first programmable devices in history was a loom
- Joseph Marie Jacquard's loom (1804) could be programmed by feeding in a set of punched cards
- This is not all that different from quitting a program that's running on your computer and starting another one!

- https://www.youtube.com/watch?v=MQzpLLhN0fY

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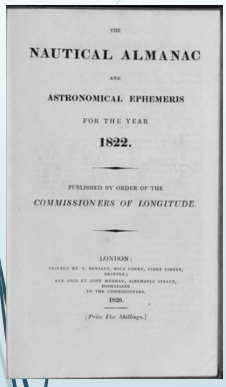
Rise of Analytical Engine



- Summer of 1821 – Mathematician Charles Babbage and astronomer John Herschel were working on creating a book of mathematical tables.
- Almanac contains tables denoting positions of the Moons, planets and stars – which are used by navigators to determine location at the sea.
- Manual work caused a number of errors.
- Babbage showed his frustration with the large number of errors by exclaiming, "I wish to God these calculations had been executed by steam!"
- What made Babbage think steam engines could help him solve mathematical problems?

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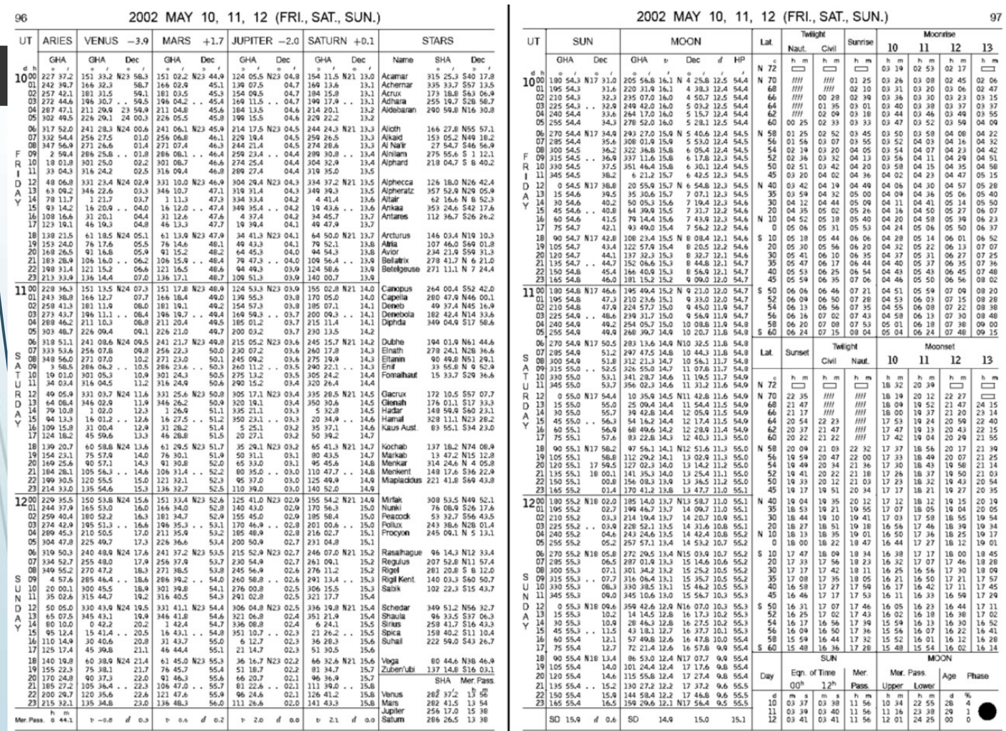

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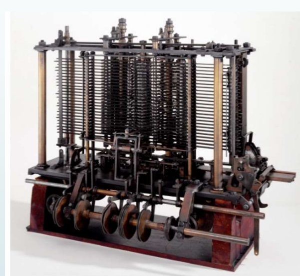
12

Programmable devices

- Charles Babbage designed the Analytical Engine, a mechanical, programmable computer in 19th Century
  - It was never built in Babbage's time due to a lack of manufacturing capabilities (ahead of his time!)
  - Design called for punched cards to be fed into the machine to program it to perform mathematical calculations
  - Output would go to a printer or punched cards
  - See for details: https://www.thoughtco.com/first-computer-charles-babbages-1221836



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13

Programmable computers

- Many others
- Now, move forward to the 20th and 21st centuries
- A modern computer has three basic requirements:

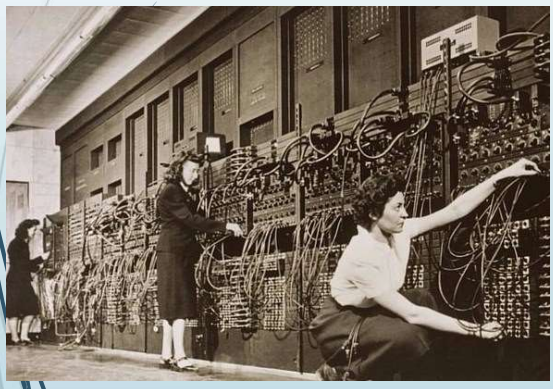
1. Must be electronic and not exclusively mechanical.
2. Must be digital, not analog
   - Uses discrete values (digits), not a continuous range of values to represent data. (i.e. digital vs mercury-based thermometer)
3. Must employ the **stored-program concept**
   - the device can be reprogrammed by changing the instructions stored in the memory of the computer

13

14

Programmable computers

- ENIAC (Electronic Numerical Integrator and Computer)
  - Built in the 1940s
  - Among the first computers to employ the stored-program concept



14

15

Programmable computers

- Again, the **stored-program concept** is the idea that programs (software) along with their data are *stored* (saved) in the memory of a computer
  - Not referring to storage on hard drives, flash drives or CDs
  - Referring to **main memory** of the computer, sometimes called the **RAM** (random access memory)
- A modern processor
  - reads the **machine instructions** *stored* as 1s and 0s in the main memory
  - executes those instructions in sequence
  - Key point: these instructions can be changed to easily reprogram the computer to do new tasks

➨ A typical processor has a thousand or more different machine instructions.

15

16

Transistors

- A variety of devices have been used to represent digits and to control the operation of computing machines
- In the 1940s:
  - Bardeen, Brattain, and Shockley invented the **transistor**, which is an electronic switch with no moving parts
- In the 1950s and 1960s:
  - Kilby, Noyce, and others used transistors to develop **integrated circuits**
  - Devised a way to manufacture thousands – later, millions and billions – of transistors on a single wafer of silicon
- A single **chip** contains:
  - an integrated circuit
  - a ceramic or plastic case
  - external pins to attach it to a **circuit board**

16

17

Transistors

Noyce and businessman Gordon Moore commercialized this technology by co-founding Intel Corporation in 1968

Manufacturing technologies improved in the 1950s and 1960s:

Engineers were able to pack many more transistors per unit area on silicon wafers

Moore's law: Moore observed that the number of components within an integrated circuit was doubling every 18 months.

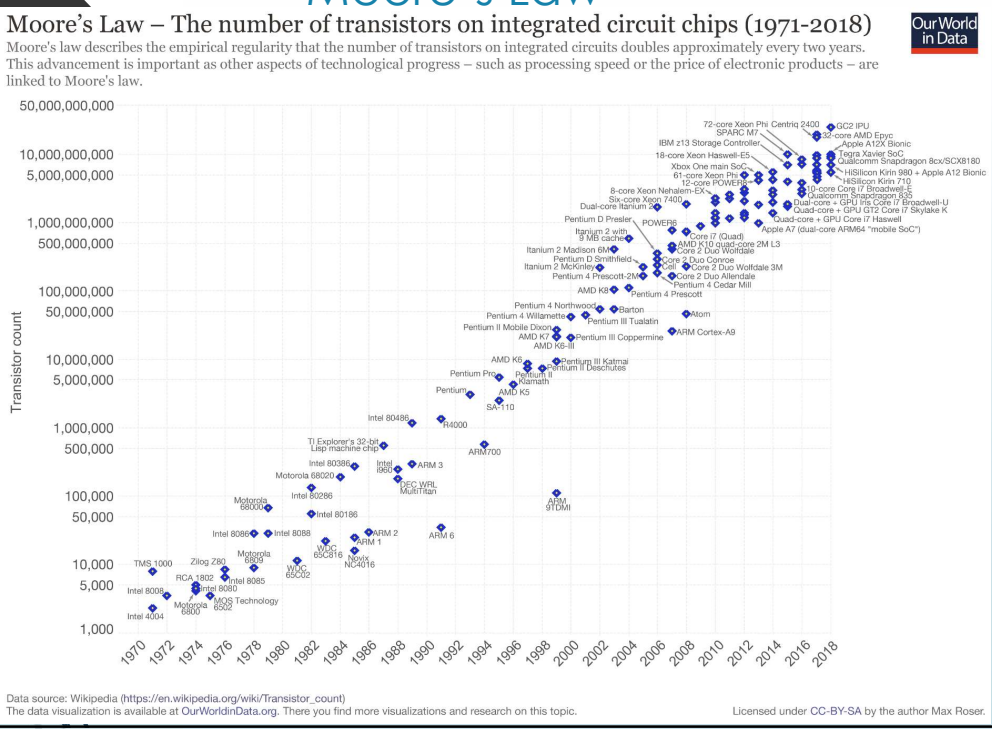
- The trend has continued pretty steadily since then.

Combating miniaturization challenges:

Intel, AMD (Advanced Micro Devices) and others now make processors that feature multiple processing **cores** that perform calculations in parallel with each other

17

Moore's Law



18

19

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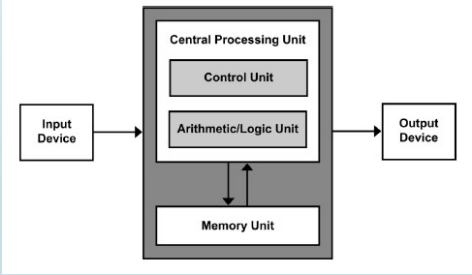
19

20

Modern computer architecture

- The stored program approach used today is implemented using **von Neumann architecture**, named after U.S. mathematician John von Neumann
- This architecture contains input devices, output devices, a processor and a memory unit



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21

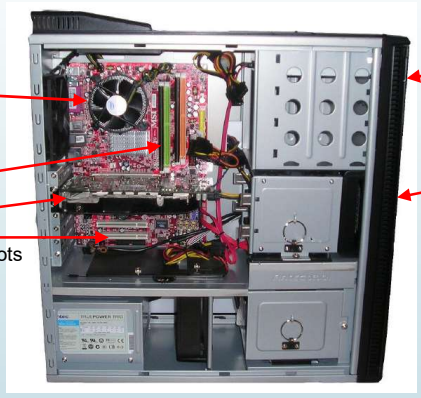
Modern computer architecture

- In modern computers (PCs), the major components in a von Neumann machine reside physically in a circuit board called the **motherboard**
  - The CPU, memory, expansion cards and other components are plugged into slots so they can be replaced
  - Hard drives, CD drives, and other storage devices are connected to the motherboard through cables
- The central processing unit is the “brain” of the machine
  - its **arithmetic/logic unit** (ALU) performs millions or billions of calculations per second
  - The **control unit** is the main organizing force of the computer and directs the operation of the ALU

21

22

Modern computer architecture



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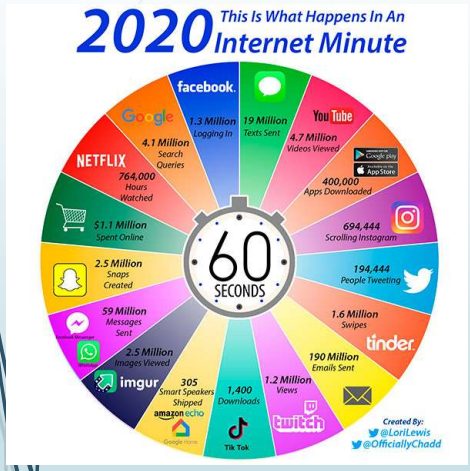
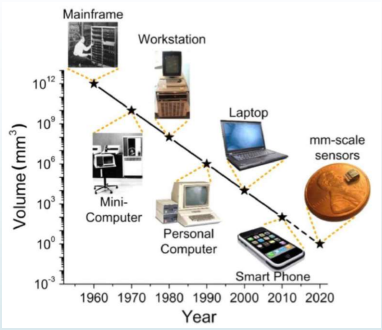
23

The information explosion in 21st century





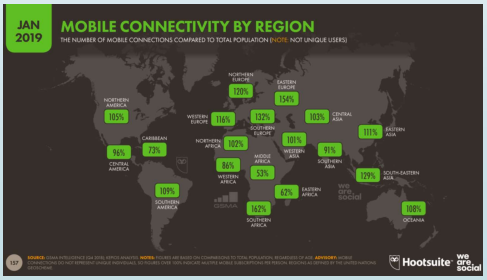


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Figure 1 source: https://www.visualcapitalist.com/what-happens-in-an-internet-minute-in-2019/

Figure 2 source: https://wearesocial.com/global-digital-report-2019

23

Introduction 24

24

24