

Computer Architecture (Introduction)



विद्याधनं सर्वधनं प्रधानम्

Subhasis Bhattacharjee

Department of Computer Science and Engineering,
Indian Institute of Technology, Jammu

August 23, 2023

What is Computer Architecture ?

What is a Computer?

A computer is a general purpose device that can be programmed to process information, and yield meaningful results.

It is the study of computers.

Two closely related subjects / courses are:

- Computer Architecture
 - ▶ The view of a computer as presented to software designers
- Computer Organization
 - ▶ The actual implementation of a computer in hardware.

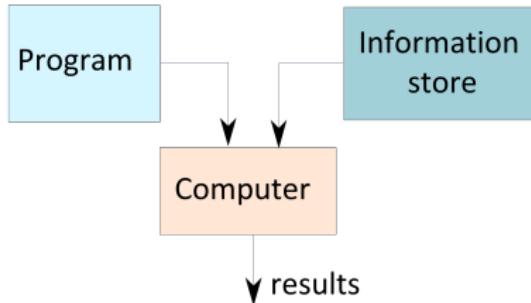
How does it work ?

- Program – List of instructions given to the computer
 - Information store – data, images, files, videos
 - Computer – Process the information store according to the instructions in the program
- Computer Program Information store results

Some examples of Computers



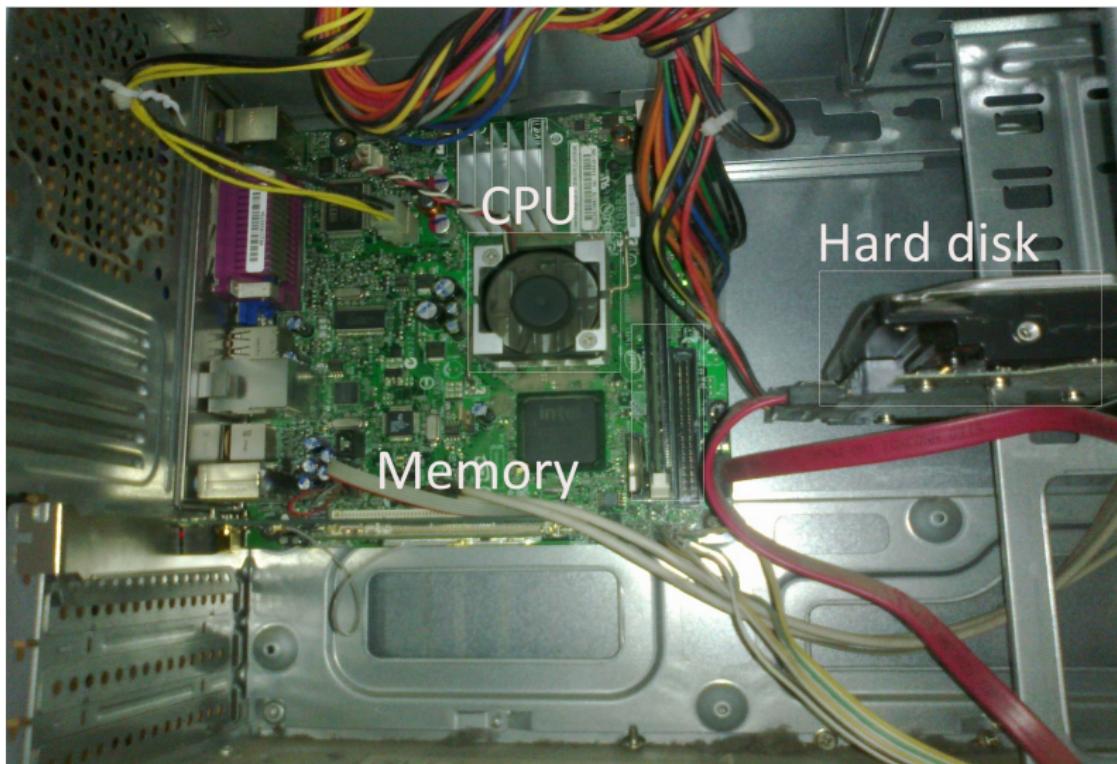
Working of a Computer?



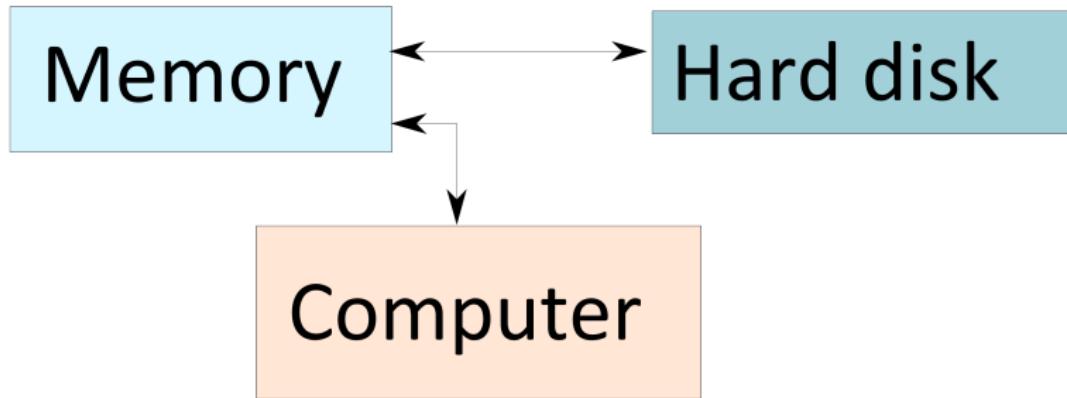
- Program – List of instructions given to the computer
 - Information store – data, images, files, videos
 - Computer – Process the information store according to the instructions in the program
- Computer Program Information store
 results

How does a computer look like?

- Let us take the lid off a desktop computer

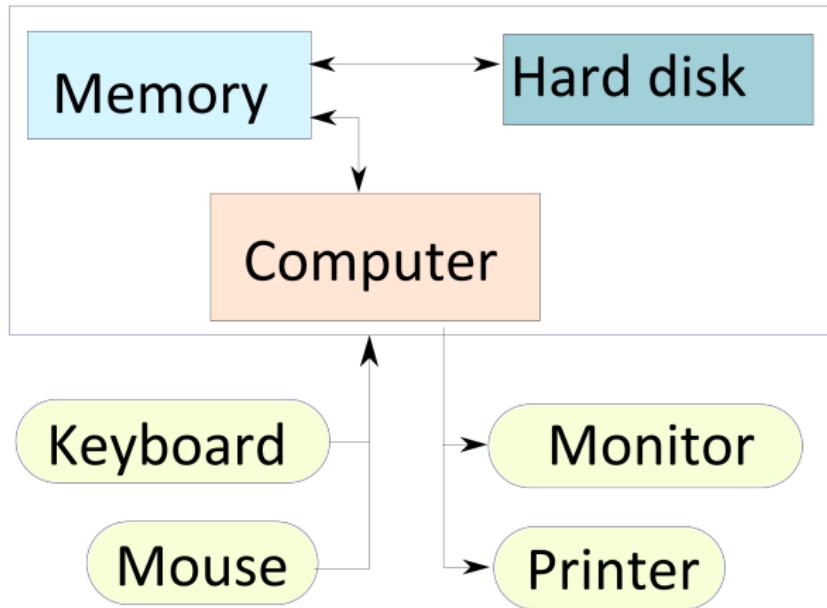


Components of a Computer System

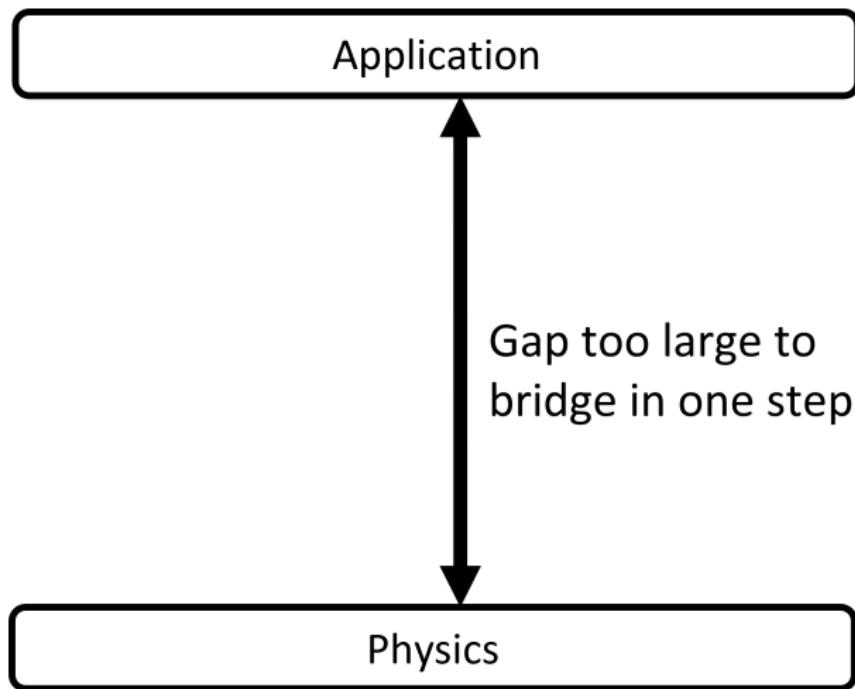


- Memory – Stores programs and data. Gets destroyed when the computer is powered off
- Hard disk – stores programs/data permanently

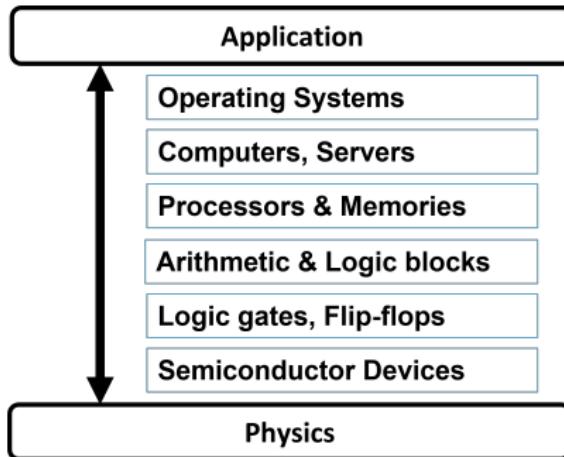
Computer System with peripheral devices



Program vs Physics ...



Where exactly is the Computer Architecture?



computer architecture - as an abstraction layer

In its broadest definition, computer architecture is the design of the abstraction layers that allow us to implement information processing applications efficiently using available manufacturing technologies.

Computing Devices in 1949

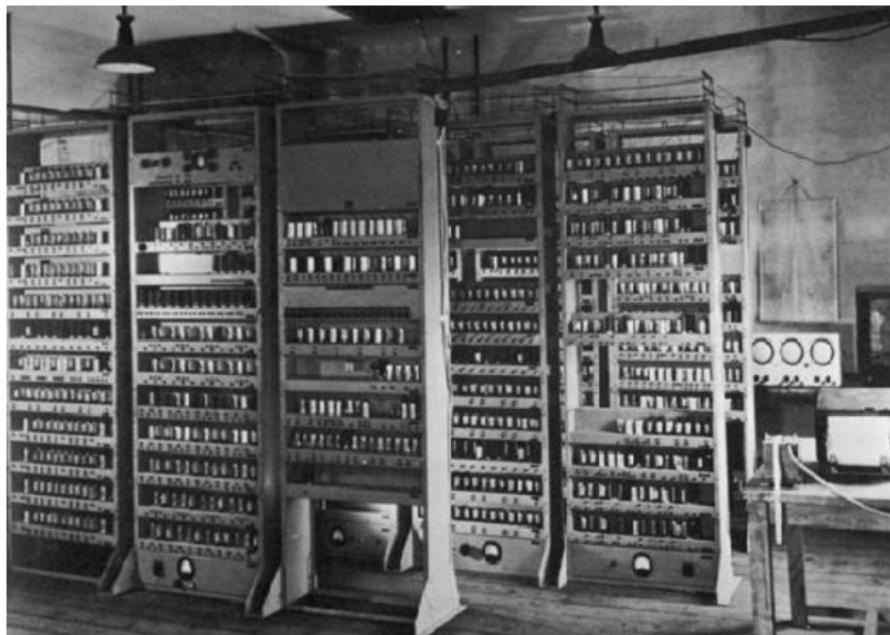
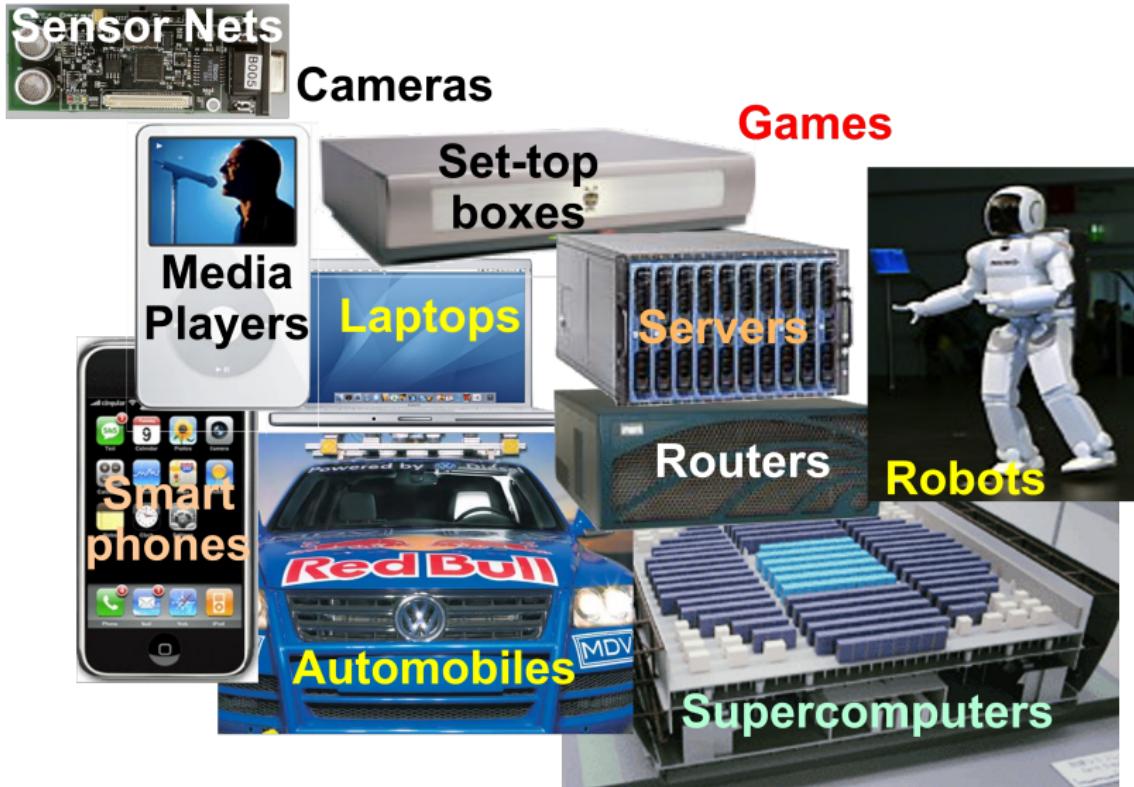
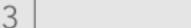


Figure: EDSAC, University of Cambridge, UK, 1949

Computing Devices embedded - Today



Top global server vendors (in percent)

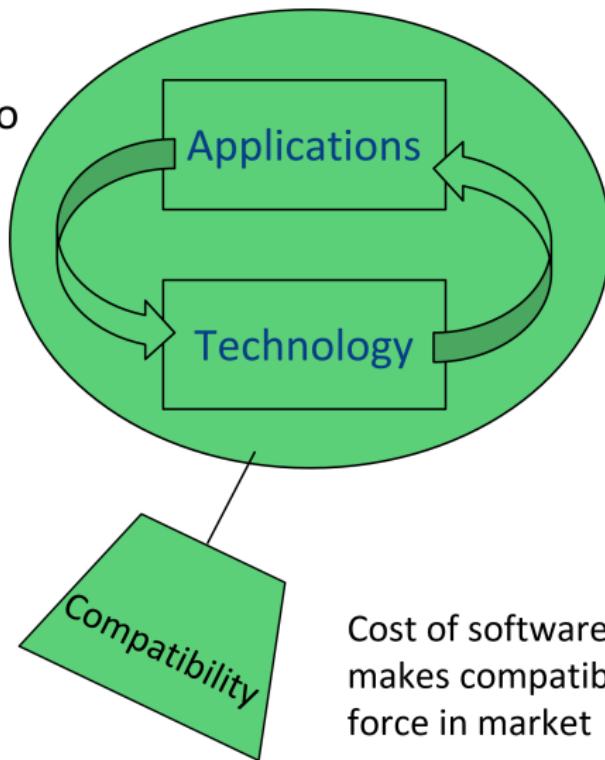
Company	2017	Market share	2018	Revenue growth [†]	Server core processor chip
Dell	17.7		18.8	52.9	Intel, AMD
HPE/New H3C Group	21.4		16.6	11.7	Intel, AMD
IBM*	6.6		7.3	57.0	IBM
Lenovo*	5.3		6.9	85.7	Intel, AMD
Inspur*	3.3		4.8	112.3	Intel, AMD
Cisco*	5.6		4.8	22.4	Intel, AMD
Huawei*	3.5		4.3	77.1	Intel, AMD, ARM Holdings
ODM direct**	22.5		24.4	55.9	Intel, AMD
Others	14.2		12.2	23.1	Intel, AMD

TSMC supplies server core processor chips for AMD, ARM Holdings and soon IBM platforms
 *IDC declares a statistical tie when there is a difference of 1% or less in the share of revenues or shipments among two or more vendors **Original design manufacturer direct includes megadata center orders by Google, Amazon, Facebook, Microsoft to manufacturing partners †As of second quarter

Source: IDC

Evolving Computer Architecture continually...

Applications suggest how to improve technology, provide revenue to fund development

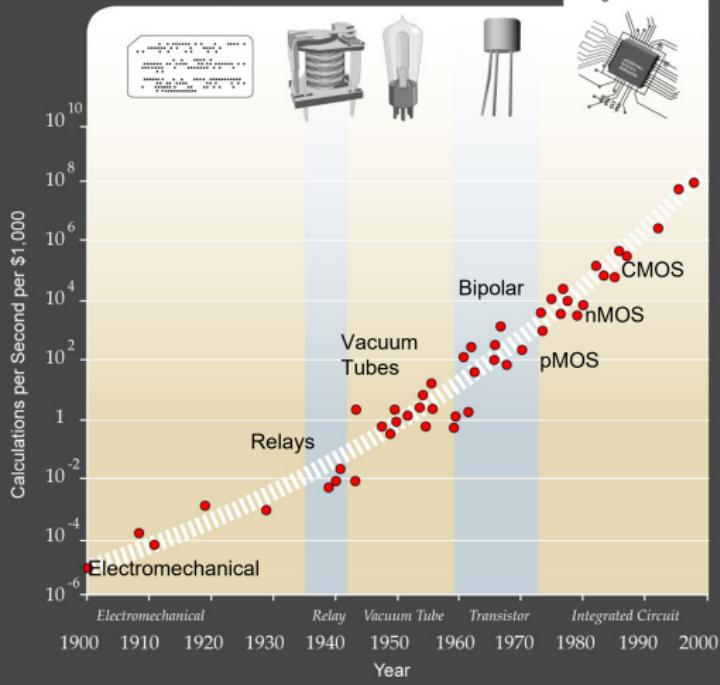


Improved technologies make new applications possible

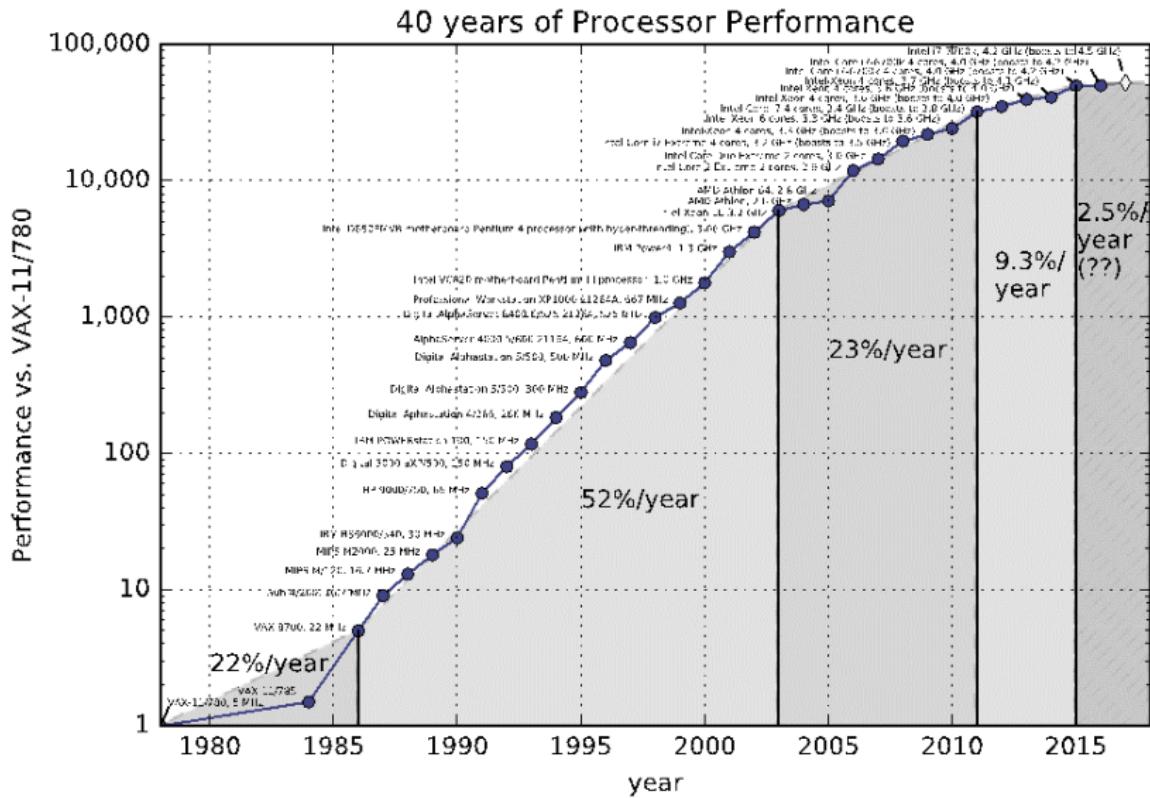
Cost of software development makes compatibility a major force in market

Moore's Law The Fifth Paradigm

Logarithmic Plot



Single-Thread Processor Performance



Upheaval in Computer Design

- Most of last 50 years, Moore's Law ruled
 - ▶ Technology scaling allowed continual performance/energy improvements without changing software model
- Last decade, technology scaling slowed/stopped
 - ▶ Dennard (voltage) scaling over (supply voltage fixed)
 - ▶ Moore's Law (cost/transistor) over?
 - ▶ No competitive replacement for CMOS anytime soon
 - ▶ Energy efficiency constrains everything
- No “free lunch” for software developers, must consider:
 - ▶ Parallel systems
 - ▶ Heterogeneous systems

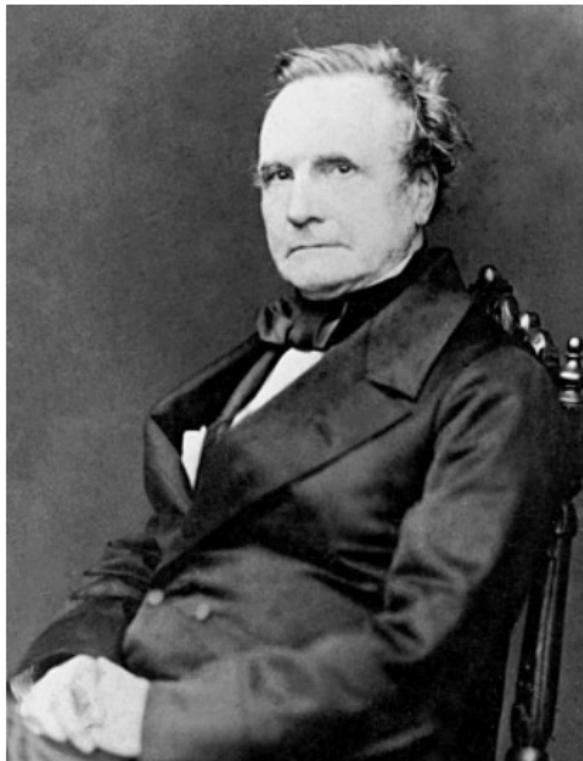
Today's Dominant Target Systems

- Mobile (smartphone/tablet)
 - ▶ >1 billion sold/year
 - ▶ Market dominated by ARM-ISA-compatible general-purpose processor in system-on-a-chip (SoC)
 - ▶ Plus sea of custom accelerators (radio, image, video, graphics, audio, motion, location, security, etc.)
- Warehouse-Scale Computers (WSCs)
 - ▶ 100,000's cores per warehouse
 - ▶ Market dominated by x86-compatible server chips
 - ▶ Dedicated apps, plus cloud hosting of virtual machines
 - ▶ Now seeing increasing use of GPUs, FPGAs, custom hardware to accelerate workloads
- Embedded computing
 - ▶ Wired/wireless network infrastructure, printers
 - ▶ Consumer TV/Music/Games/Automotive/Camera/MP3
 - ▶ Internet of Things!

Digital Computers

- Represent problem variables as numbers encoded using discrete steps
 - ▶ Discrete steps provide noise immunity
 - ▶ Write algorithms using discrete steps
- Enables accurate and deterministic calculations
 - ▶ Same inputs give same outputs exactly
- Not constrained by physically realizable functions

Charles Babbage (1791-1871)



- Lucasian Professor of Mathematics, Cambridge University, 1828-1839
- A true "polymath" with interests in many areas
- Frustrated by errors in printed tables, wanted to build machines to evaluate and print accurate tables
- Inspired by earlier work organizing human "computers" to methodically calculate tables by hand.

Ada Lovelace (1815-1852)



- Translated lectures of Luigi Menabrea who published notes of Babbage's lectures in Italy.
- Lovelace considerably embellished notes and described Analytical Engine program to calculate Bernoulli numbers that would have worked if AE was built
 - ▶ The first program!
- Imagined many uses of computers beyond calculations of tables
- Was interested in modeling the brain.