CSC 411

Computer Organization (Spring 2022)
Lecture 3: Basics and Computer Abstractions

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Quick notes

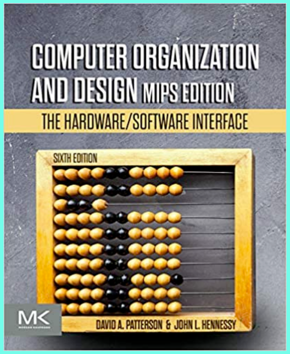
- From previous lecture
  - number systems (binary, decimal, hexadecimal, and others)
    - conversions from decimal to any
    - conversions from any to decimal
  - bitwise operators (C/C++ programming)
    - &, |, ^, <<, >>
- Required reading
  - chapter 1 (P&H)

Disclaimer

The following slides are adapted from:

Computer Organization and Design (Patterson and Hennessy)

The Hardware/Software Interface



The computer revolution

- Progress in computer technology
  - underpinned by domain-specific accelerators
- Novel applications:
  - computers in automobiles
  - cell phones
  - human genome project
  - World Wide Web
  - search engines
- Computers are pervasive

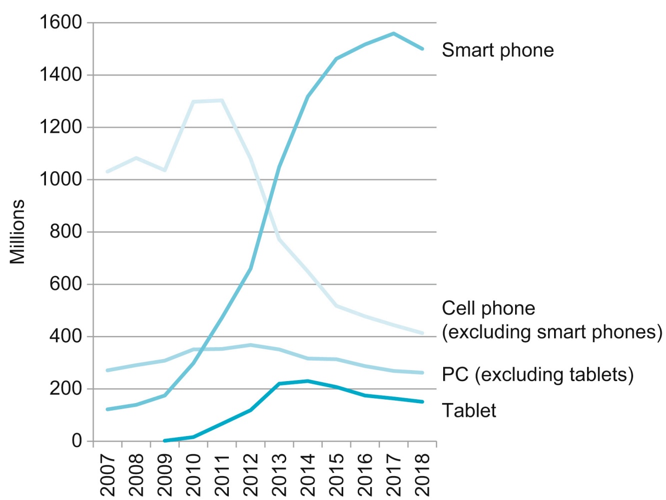
Classes of computers

- Personal computers (PC)
  - general purpose, variety of software
  - subject to cost/performance tradeoff
- Server computers
  - network based
  - high capacity, performance, reliability
  - range from small servers to building sized

Classes of computers

- Supercomputers
  - type of server
  - high-end scientific and engineering calculations
  - highest capability but represent a small fraction of the overall computer market
- Embedded computers
  - hidden as components of systems
  - stringent power/performance/cost constraints

The post PC era

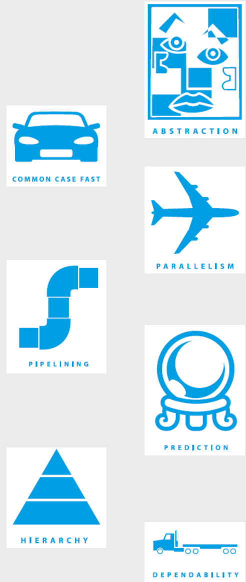


The post PC era

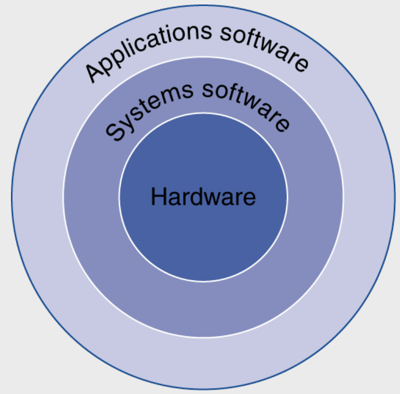
- Personal Mobile Device (PMD)
  - battery operated
  - connects to the Internet
  - hundreds of dollars
  - smart phones, tablets, electronic glasses
- Cloud computing
  - Warehouse Scale Computers (WSC)
  - Software as a Service (SaaS)
  - portion of software run on a PMD and a portion run in the Cloud
  - Amazon and Google

Seven great ideas

- Use **abstraction** to simplify design
- Make the **common case fast**
- Performance via **parallelism**
- Performance via **pipelining**
- Performance via **prediction**
- **Hierarchy** of memories
- **Dependability** via redundancy



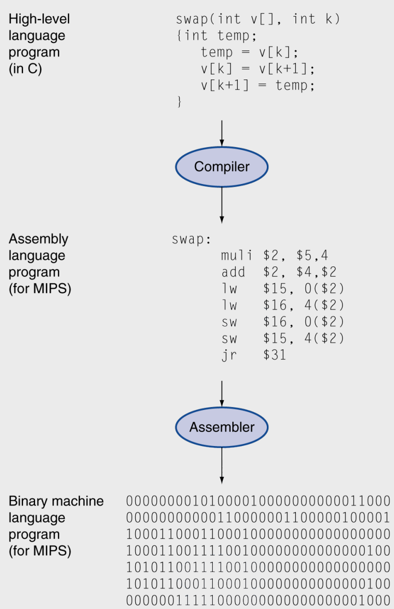
Below your program



- Application software
  - written in high-level language
- System software
  - compiler: translates HLL code to machine code
  - operating system: service code
    - handling input/output
    - managing memory and storage
    - scheduling tasks & sharing resources
- Hardware
  - processor, memory, I/O controllers

Levels of program code

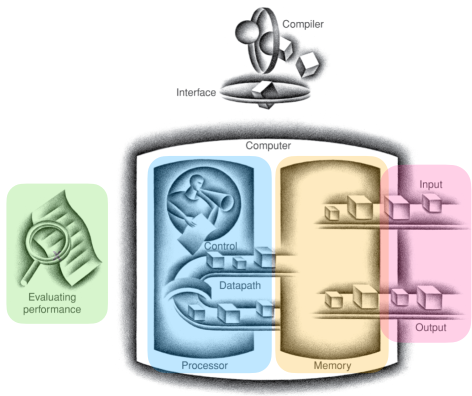
- High-level language
  - level of abstraction closer to problem domain
  - provides for productivity and portability
- Assembly language
  - textual representation of instructions
- Hardware representation
  - binary digits (bits)
  - encoded instructions and data

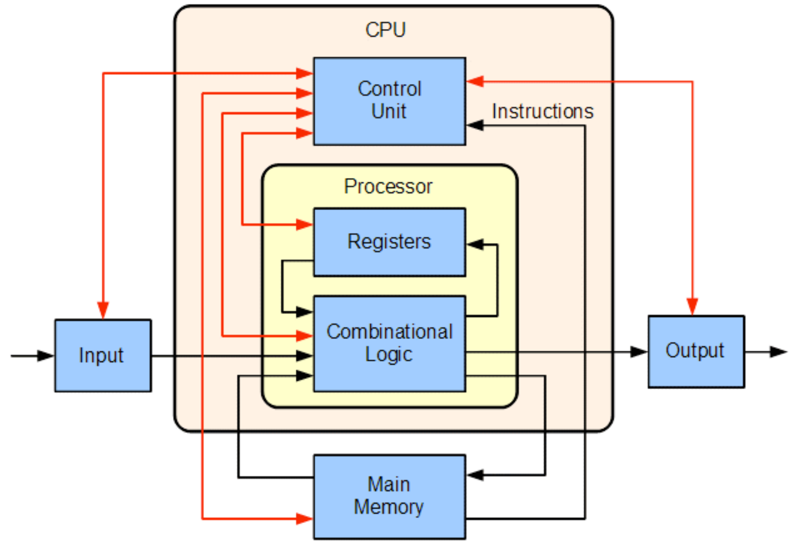



```
$ gcc hello.c -o prog
$ gcc -S hello.c -o prog
$ hexdump prog
$ xxd prog
```

Components

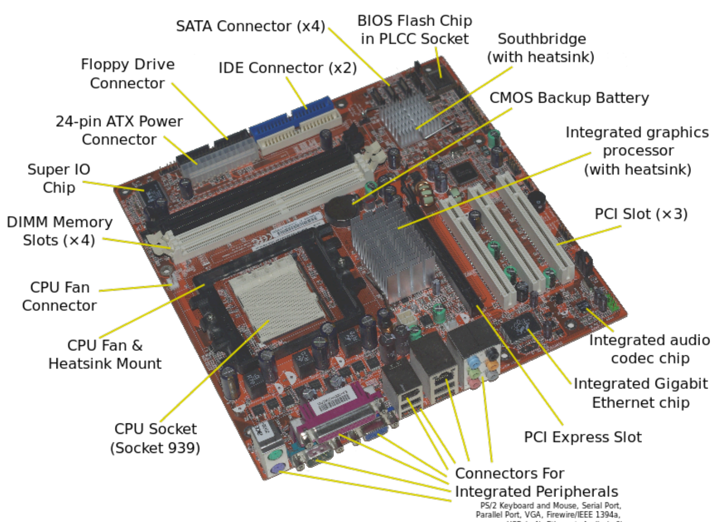
- Same components for all kinds of computers
  - desktop, server, embedded
- Input/output includes
  - user-interface devices
    - display, keyboard, mouse
  - storage devices
    - hard disk, CD/DVD, flash
  - network adapters
    - for communicating with other computers





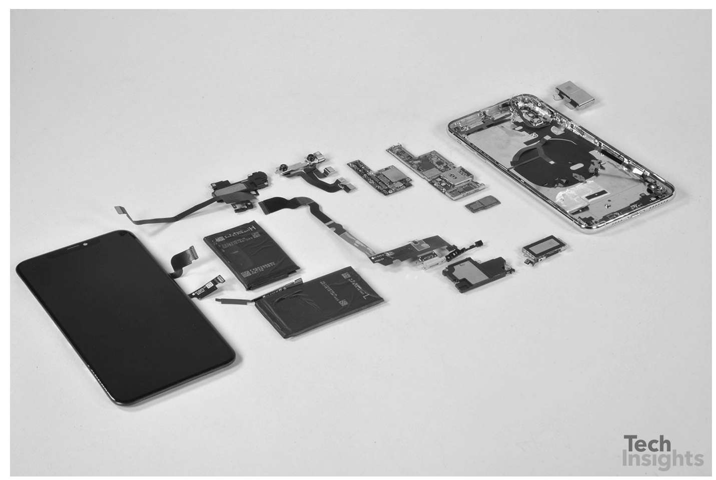
https://en.wikipedia.org/wiki/Computer_architecture

Opening the box



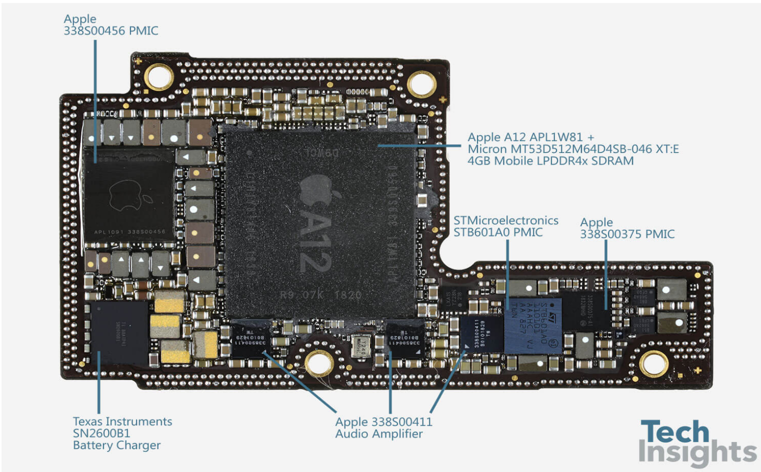
https://electricalacademia.com/computer/motherboard-components/

Opening the box



iPhone XS MAX (components)

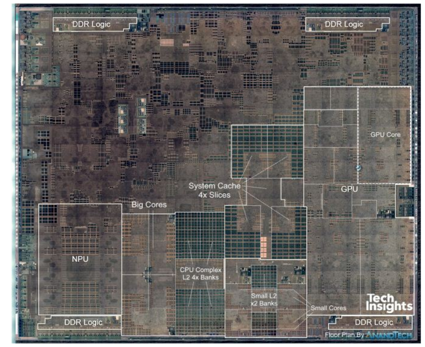
Opening the box



iPhone XS MAX (logic board)

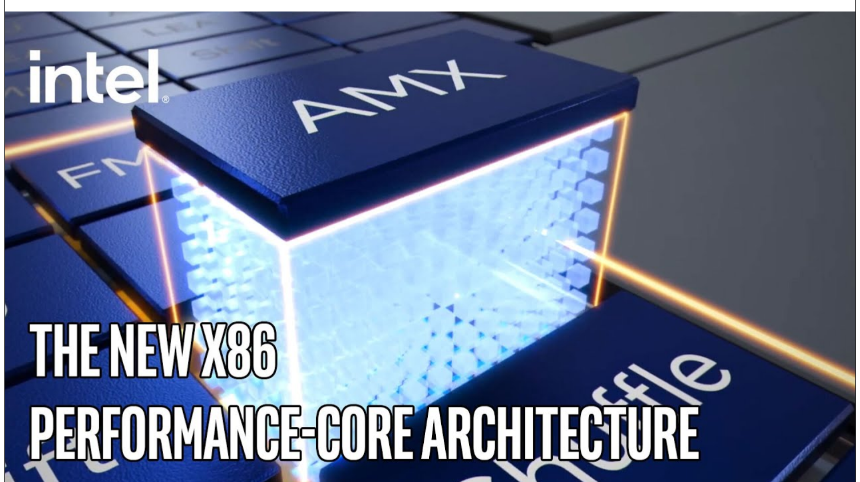
Inside the processor (CPU)

- Datapath
  - performs operations on data
- Control
  - sequences datapath, memory, ...
- Cache memory
  - small fast SRAM memory for immediate access to data



A12 processor

Intel's x86 core



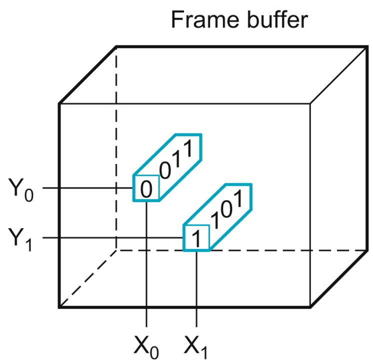
https://www.youtube.com/watch?v=ijTRvIQV7bE

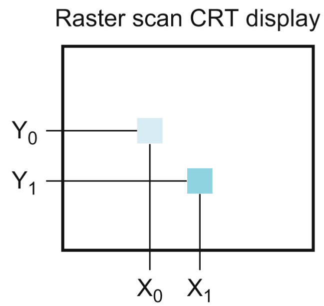
Touchscreen

- PostPC device
- Supersedes keyboard and mouse
- Resistive and Capacitive types
  - most tablets, smart phones use capacitive
  - capacitive allows multiple touches simultaneously

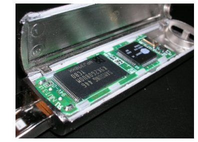
Through the looking glass

- LCD screen: picture elements (pixels)
  - mirrors content of frame buffer memory





Safe place for data



- Volatile main memory
  - loses instructions and data when power off
- Non-volatile secondary memory
  - magnetic disk
  - flash memory
  - optical disk (CDROM, DVD)

Networks

- Communication, resource sharing, nonlocal access
- Local area network (LAN): Ethernet
- Wide area network (WAN): the Internet
- Wireless network: WiFi, Bluetooth

Technology trends

- Electronics technology continues to evolve
  - increased capacity and performance
  - reduced cost

Year	Technology used in computers	Relative performance/unit cost
1951	Vacuum tube	1
1965	Transistor	35
1975	Integrated circuit	900
1995	Very large-scale integrated circuit	2,400,000
2020	Ultra large-scale integrated circuit	500,000,000,000

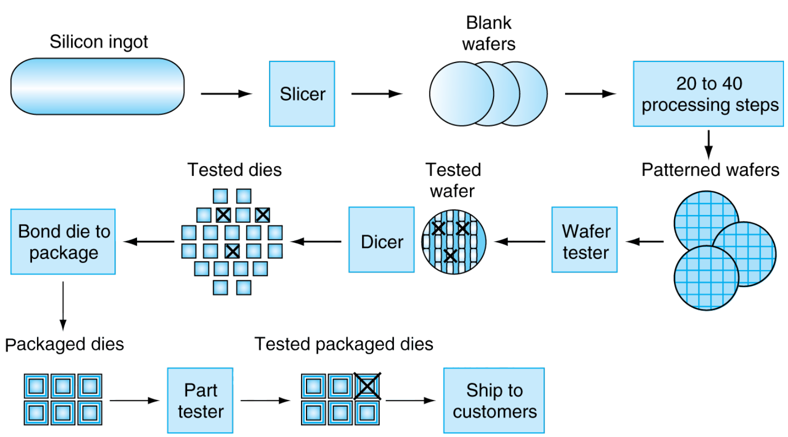
Chip Manufacturing

Semiconductor technology

- Silicon

- Add materials to transform properties
  - conductors of electricity
  - insulators
  - semiconductors (can conduct or insulate under specific conditions)

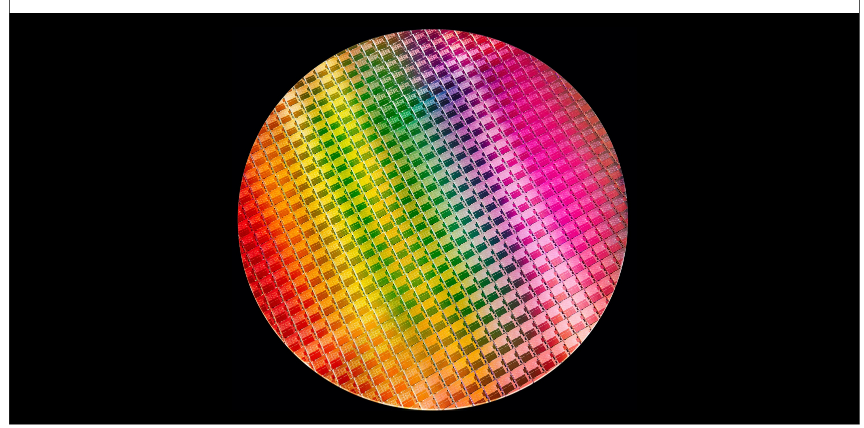
Manufacturing ICs



Yield: proportion of working dies per wafer

Intel® Core 10th Gen

- 300mm wafer, 506 chips, 10nm technology
- Each chip is 11.4 x 10.7 mm



From sand to silicon

https://www.youtube.com/watch?v=_VMYPLXnd7E

Integrated circuit cost

- Nonlinear relation to area and defect rate
  - wafer cost and area are fixed
  - defect rate determined by manufacturing process
  - die area determined by architecture and circuit design

$$\text{cost per die} = \frac{\text{cost per wafer}}{\text{dies per wafer} \times \text{yield}}$$

$$\text{dies per wafer} \approx \frac{\text{wafer area}}{\text{die area}}$$

$$\text{yield} = \frac{1}{\left(1 + (\text{defects per area} \times \text{die area}/2)\right)^n}$$