Today's Topics

- Basic Components of Computer System
- Basic Operations of a Computer

Basic Components of Computer System

- Central Processing Unit (CPU)
  - Arithmetic and Logic Unit (ALU)
  - Control Unit
  - (Floating Point Unit , Math Coprocessor)

-> Brain (Thinking & Control Function)

- Main Memory Unit
  - Random Access Memory (RAM)
  - Read-Only Memory (ROM)

-> Brain (Memory Function)

Basic Components of Computer System (cont'd)

- Input/Output Device
  - Punched Card, Keyboard, Mouse, Joystick, Pen Mouse, etc.
  - Display (Monitor), Printer, Plotter, etc.

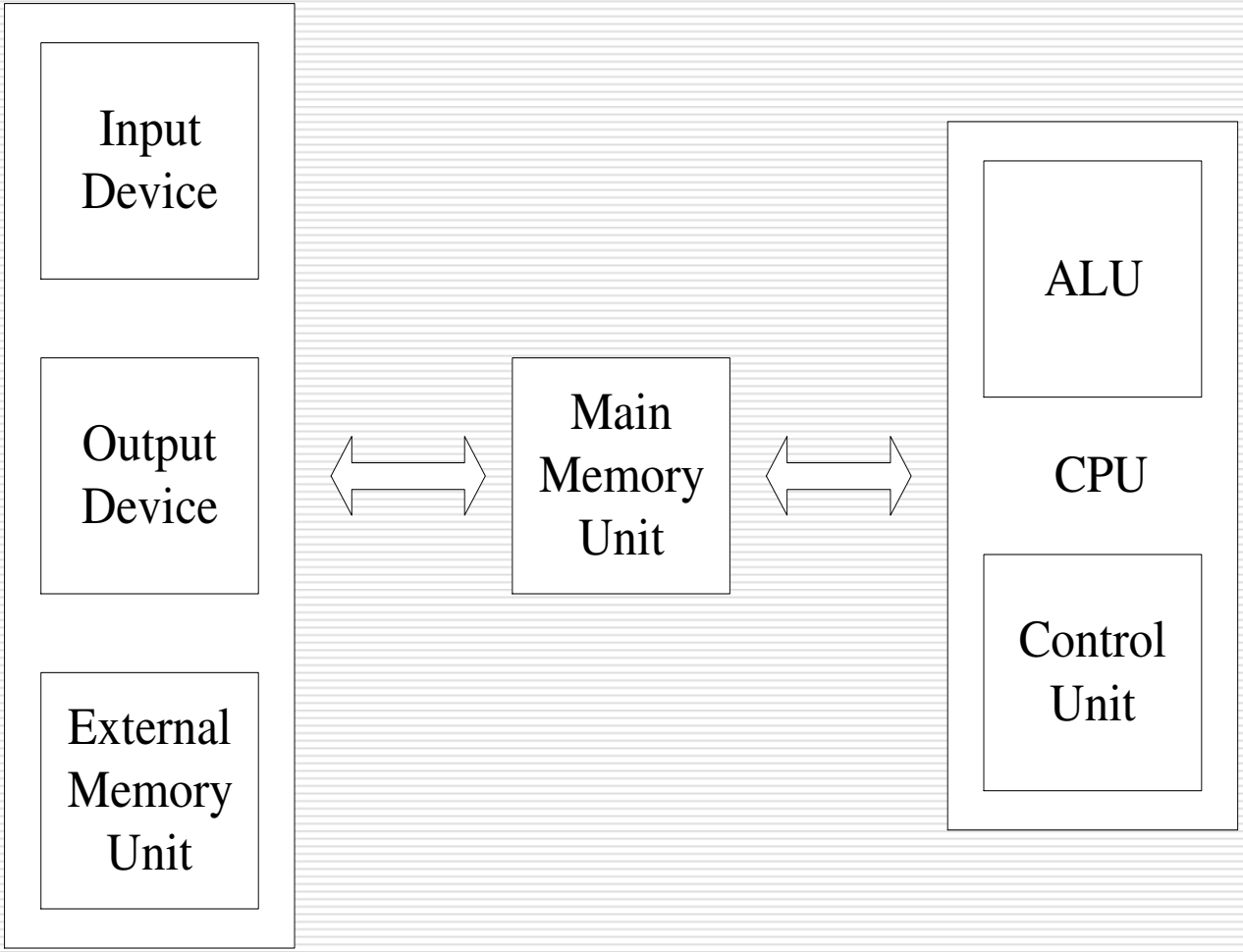
-> Eye / Ear / Touch (Input Function)

-> Hand / Mouth (Output Function)

- External Memory Unit (Auxiliary Memory, Secondary Memory)
  - Magnetic Tape, Floppy Disk, Harddisk, Optical Disk (CD-ROM), Magneto-Optical Disk (MO-Disk), USB flash drive, etc.

-> Record Books / Memos / Notes

Computer Organization

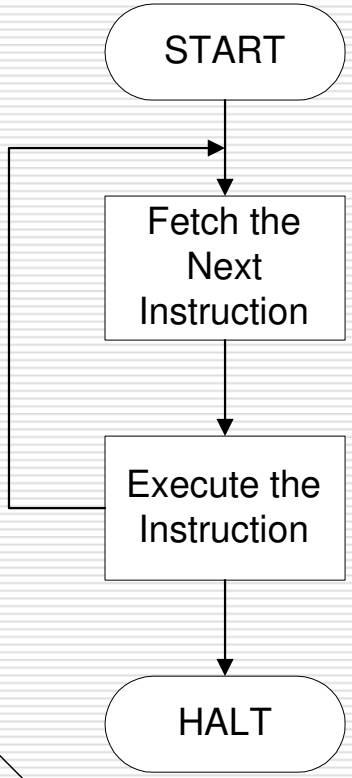


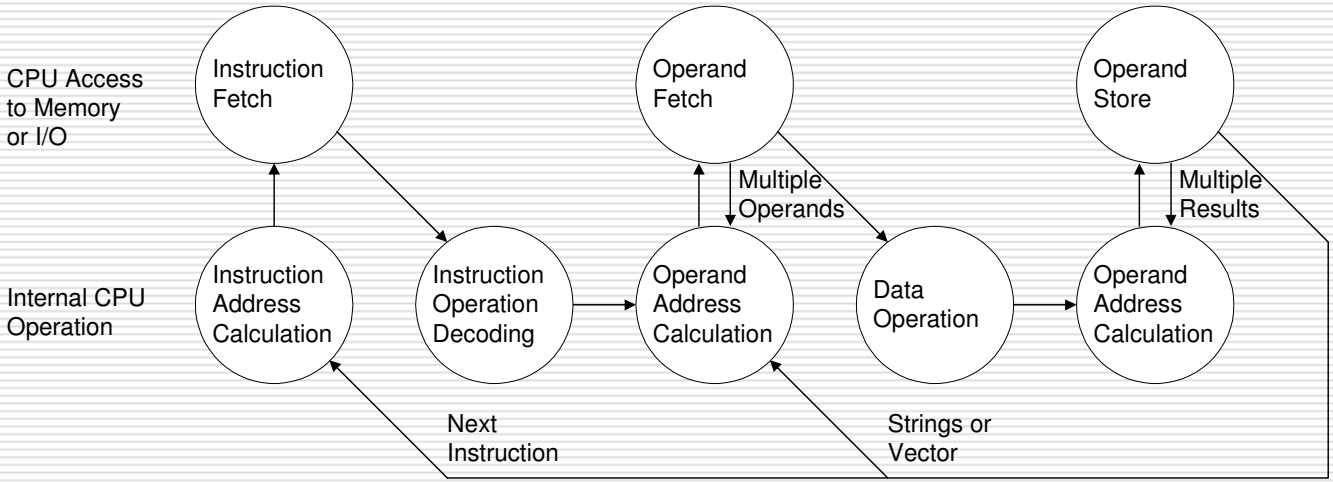
Functions of CPU

- Fetch instruction
- Interpret (decode) instruction
- Fetch data
- Process data
- Write data

Instruction Cycle

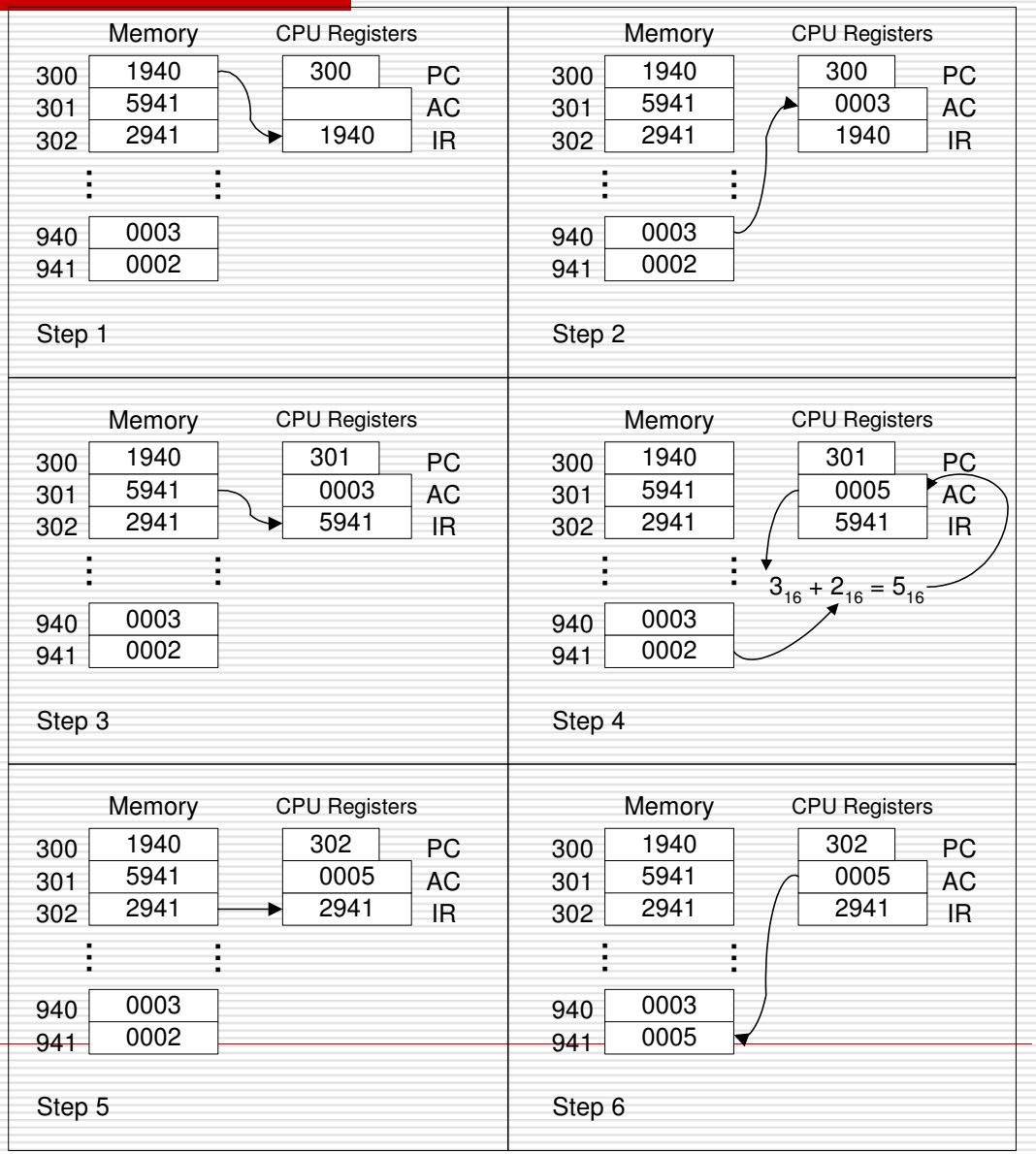
1. Fetch cycle
2. Execute cycle





Example of program execution

- Add data in 940 and 941, then store in 941.
- Can be written as b = a + b; in C



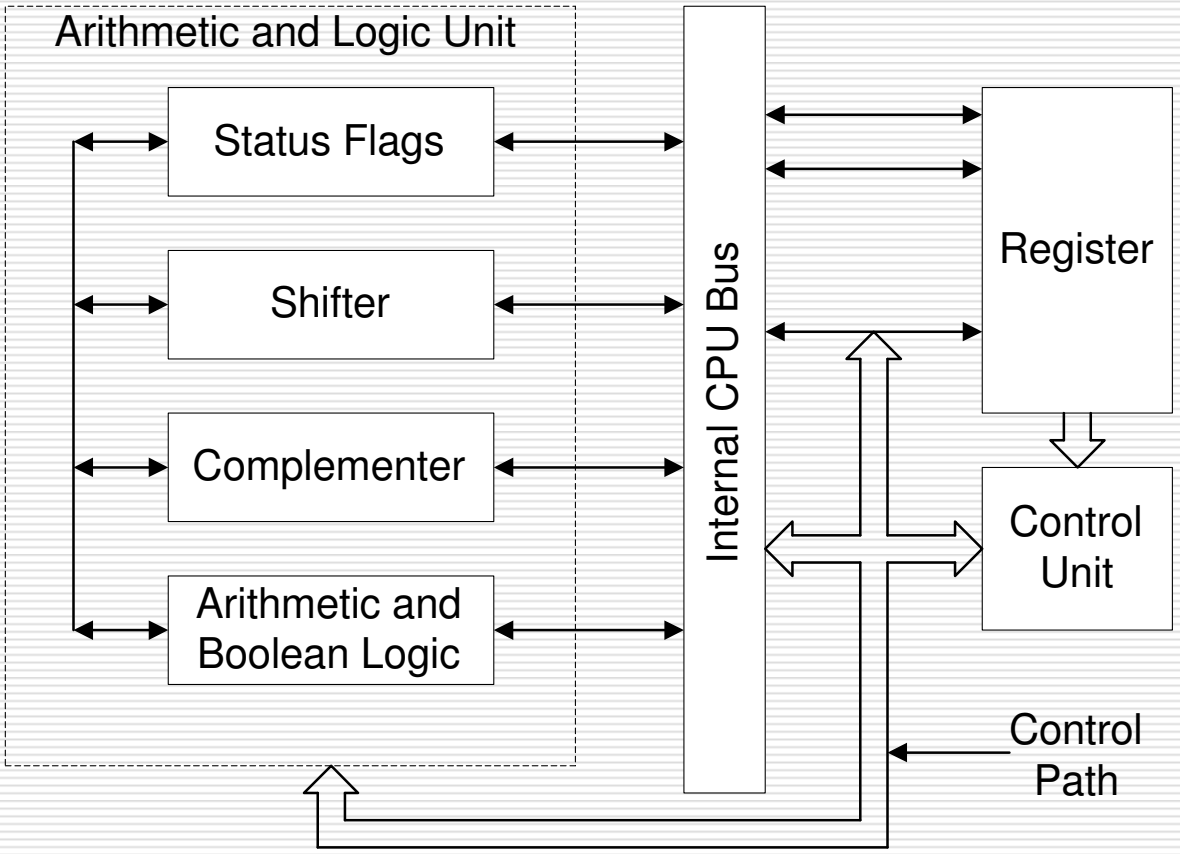
CPU

- Arithmetic Logic Unit
- Control Unit
  - Instruction Set : load, store, add, mult, branch, jump, etc.
  - Upward Compatibility
  - Method :

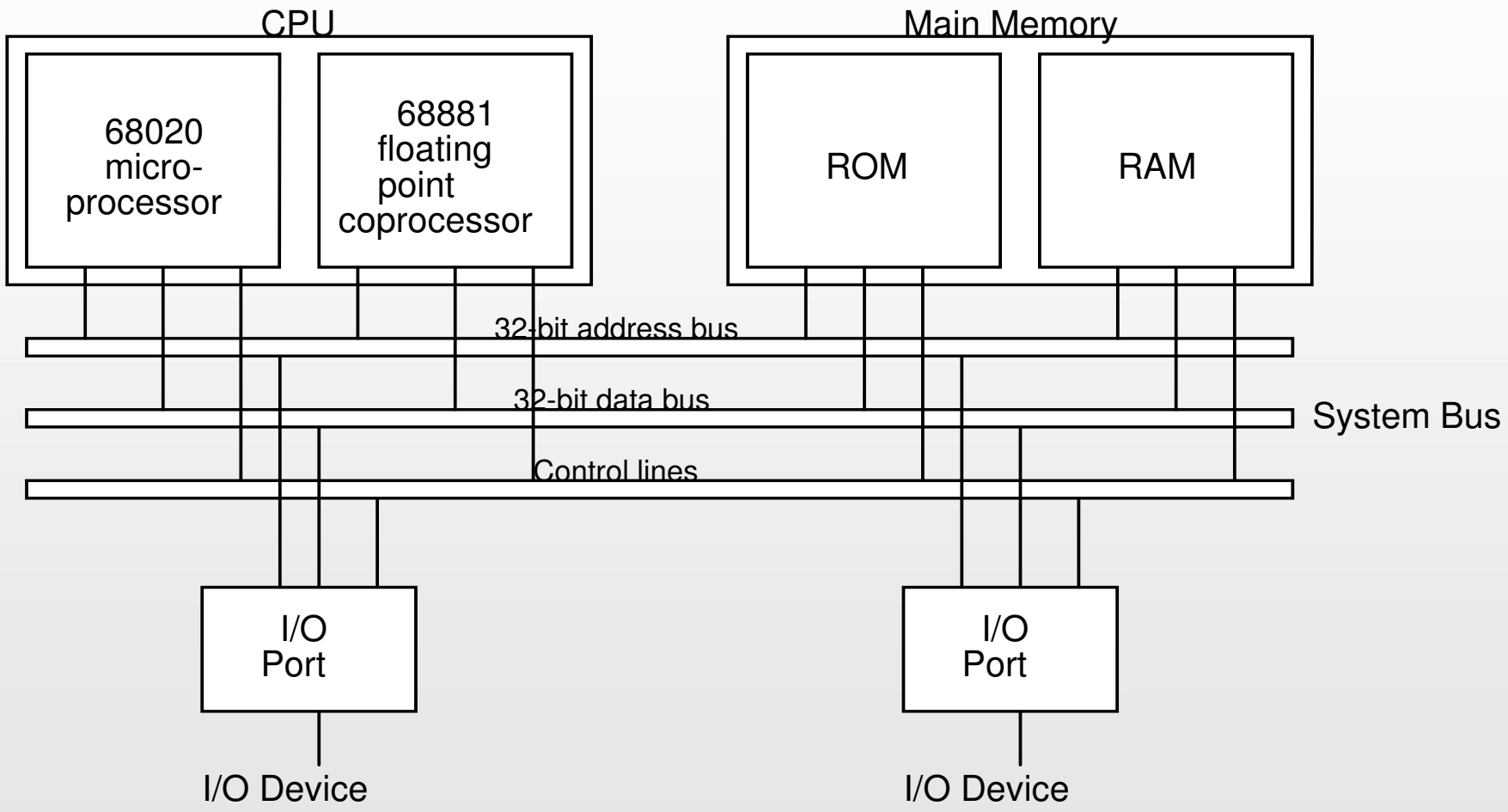
    1. Hardwired

    2. Microprogram (Nanoprogram, Picoprogram)
  - Firmware (cf. Hardware <-> Software)

CPU's common structure



Microprocessor and buses



CISC & RISC

- CISC : Complex Instruction Set Computing Processor

  Exp. Intel 80x86, Pentium, Motorola 680x0, AMD 586

- RISC : Reduced Instruction Set Computing Processor

  Exp. Sun SPARC, DEC Alpha, Power PC, Intel i960

CISC

- Merit : A lot of instruction sets : programmer's convenience
- Demerit : Long instruction -> Relatively Low Execution Speed, Complicated Circuit, High Cost

RISC

- Motivation :
  - There are not a lot of machine language users, only system programmer and compiler developer.
  - Others use high-level language.
  - There are not a lot of true *frequently-used* instructions.
  - High execution speed is most favorable.

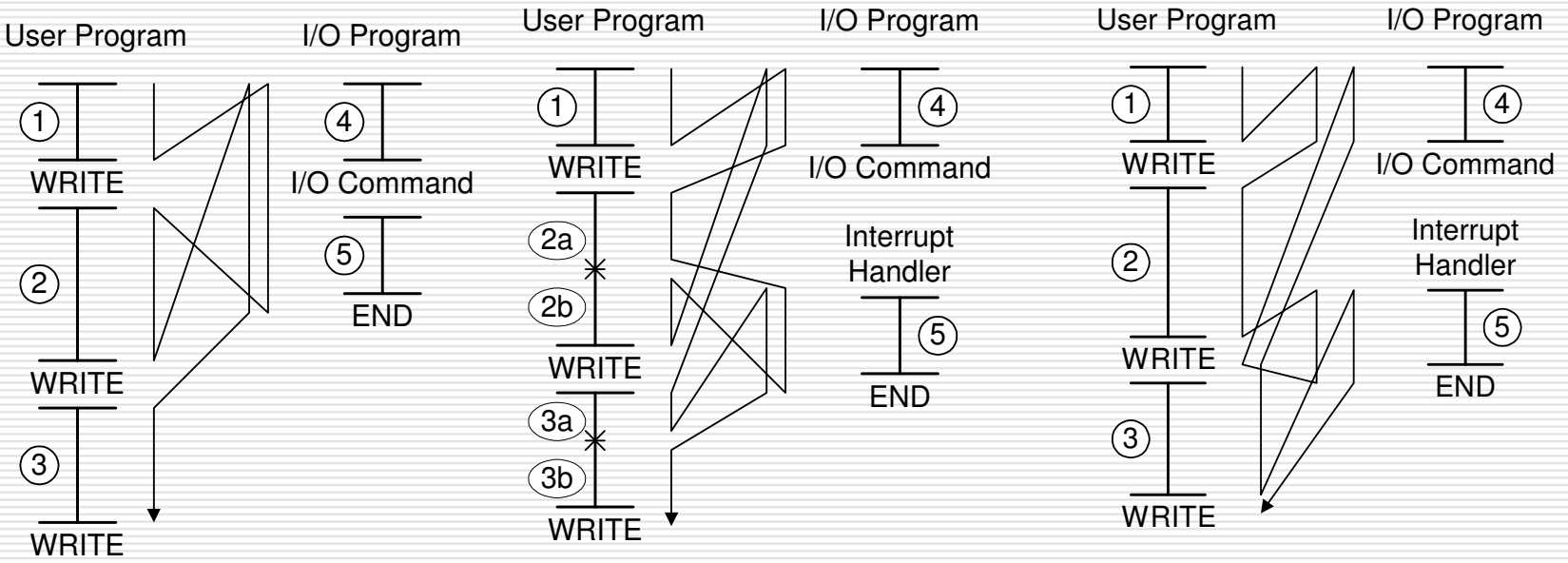
RISC

- Merit :
  - The smaller the number of instruction set, the shorter the decoding time, result in shorter instruction execution time and simpler circuit.
  - The execution time of *Non-Frequently-used* instruction is long, but it will be rarely executed, so it has a little effect on program execution time.
  - Shorter Program Execution Time

Interrupt

- an **interrupt** is a mechanism by which other modules (I/O,memory) may interrupt the normal processing of the CPU. -> Improving processing efficiency
- Classes:
  - Program error e.g., illegal instructions, divide by 0, overflow
  - Timer <- OS's regular functions
  - I/O <- I/O devices
  - Hardware failure

Interrupt (cont'd)

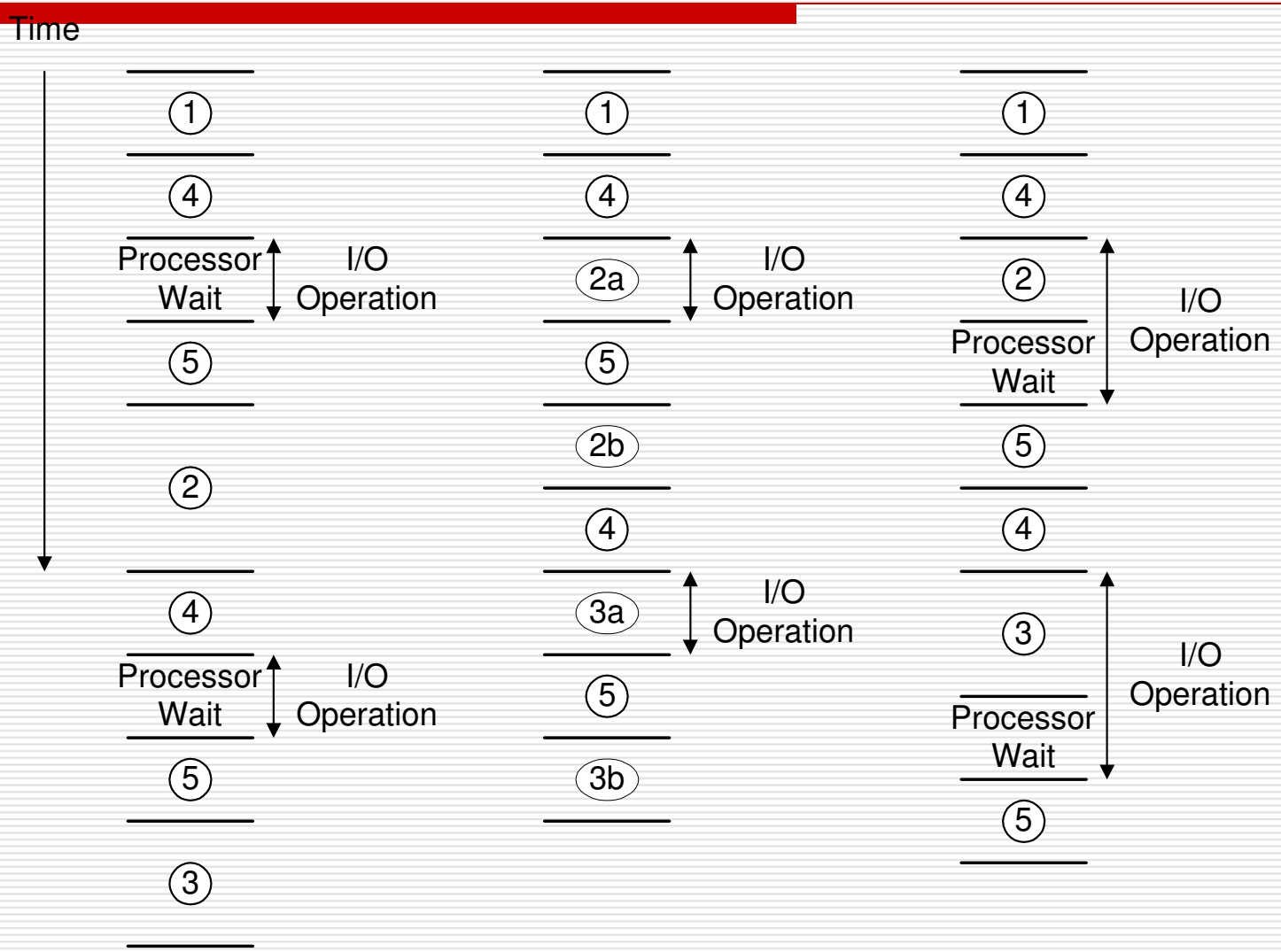


w/o interrupt

with interrupt; short I/O wait

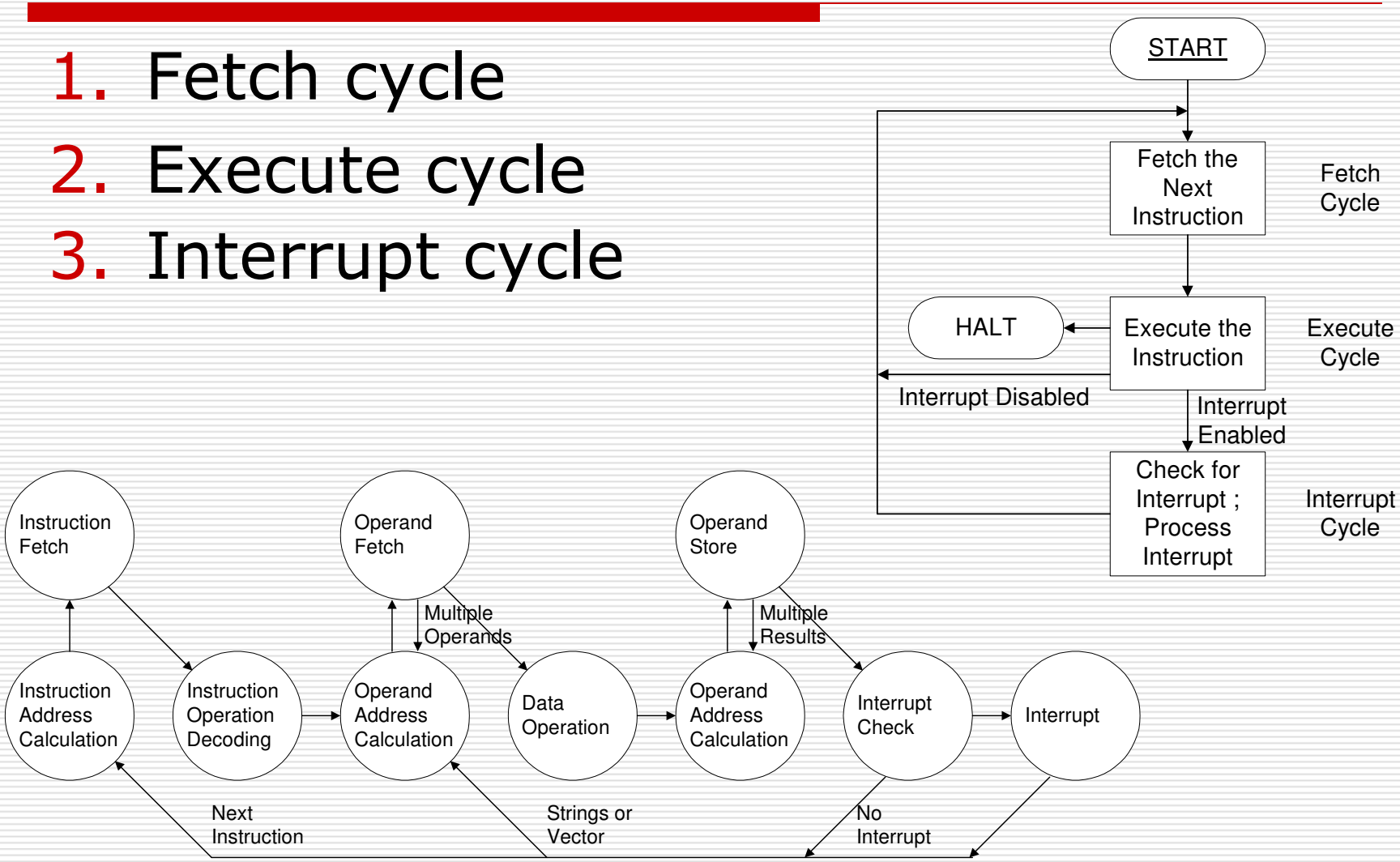
with interrupt; long I/O wait

Interrupt (cont'd)



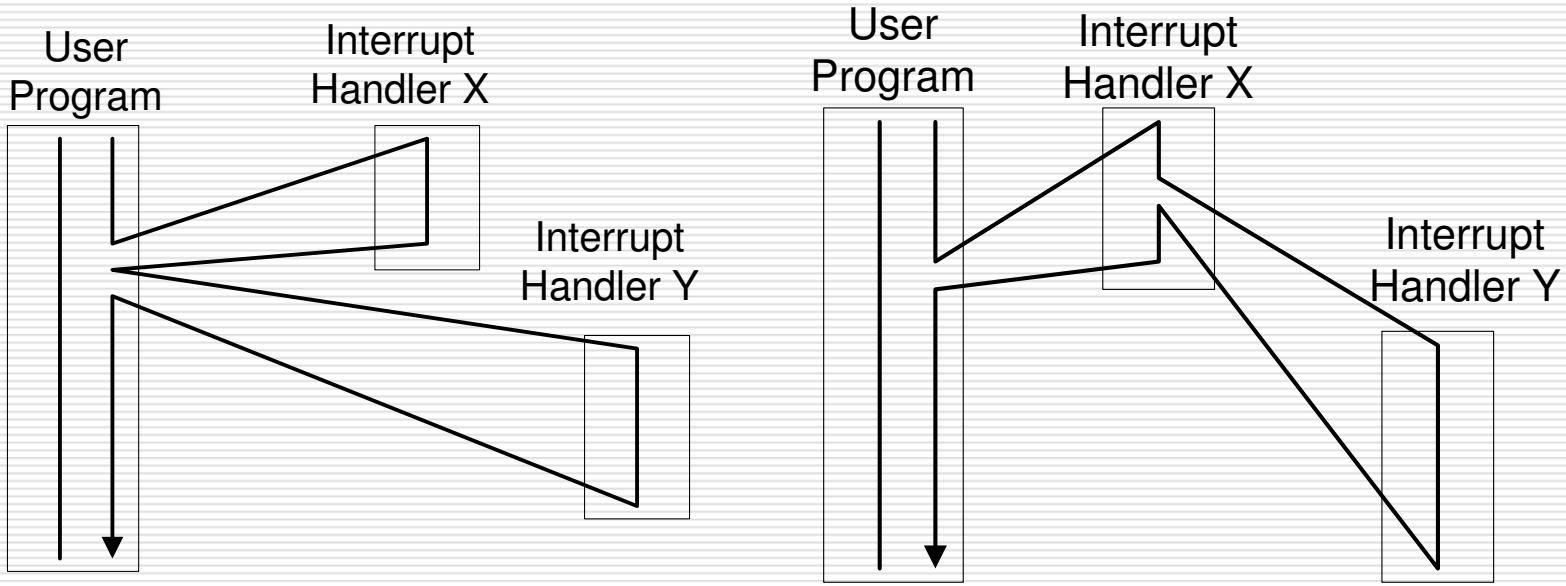
State diagram with Interrupt

1. Fetch cycle
2. Execute cycle
3. Interrupt cycle

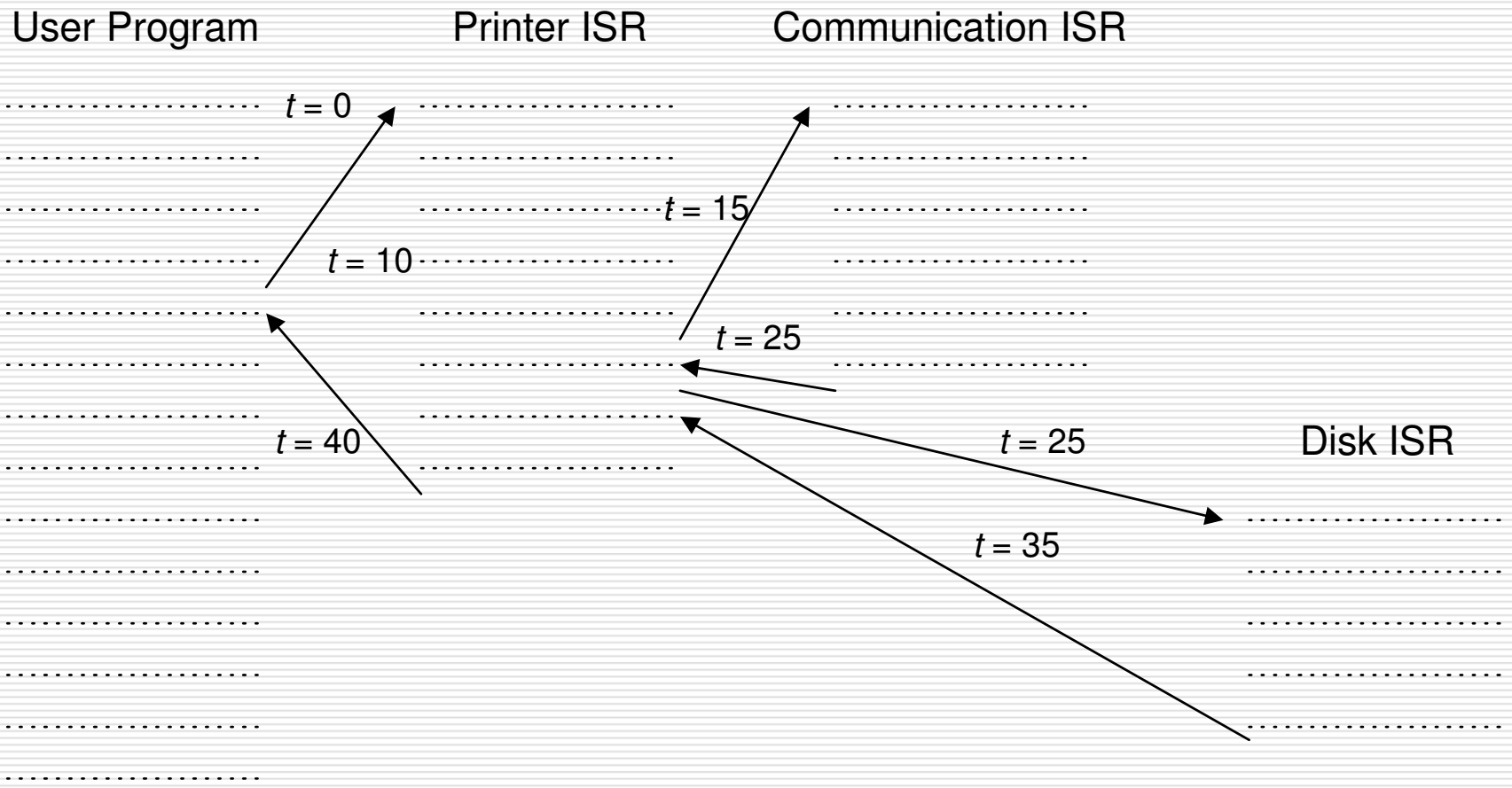


Multiple Interrupts

- Sequential interrupt processing
- Nested interrupt processing

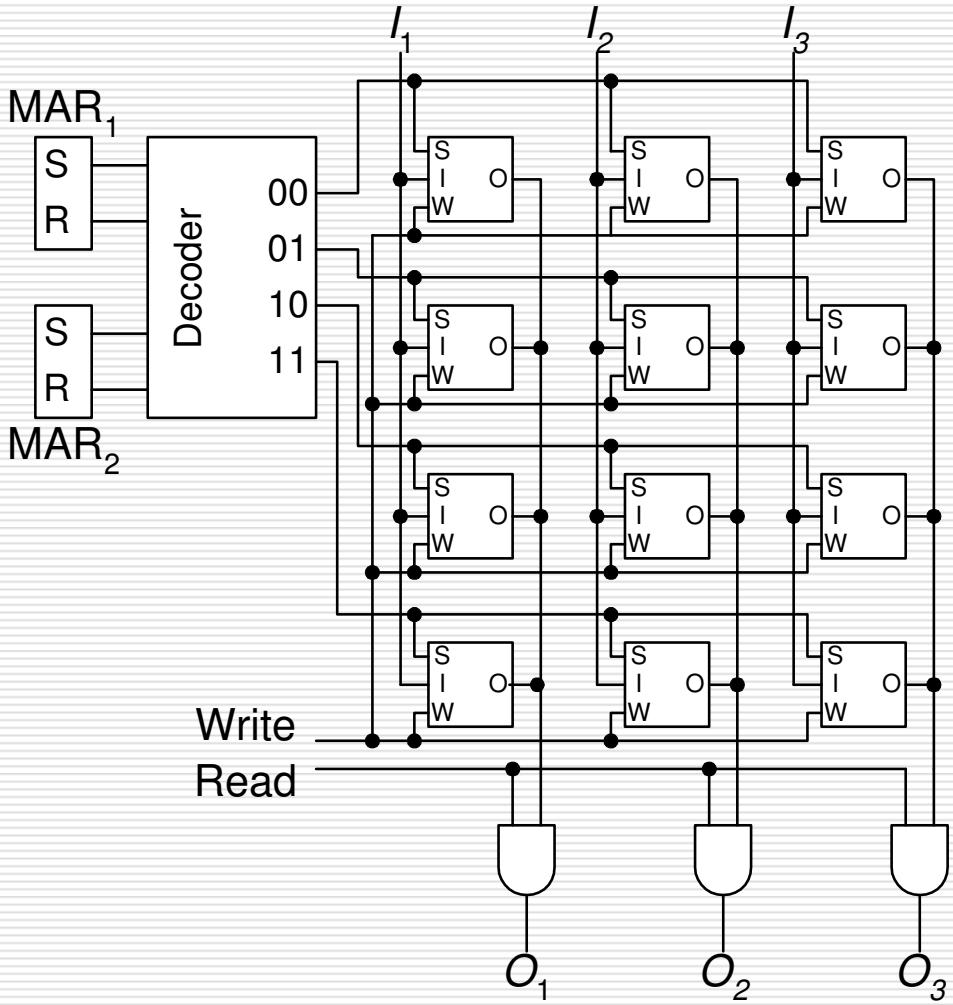


Example of nested interrupt processing



ISR = Interrupt Service Routine

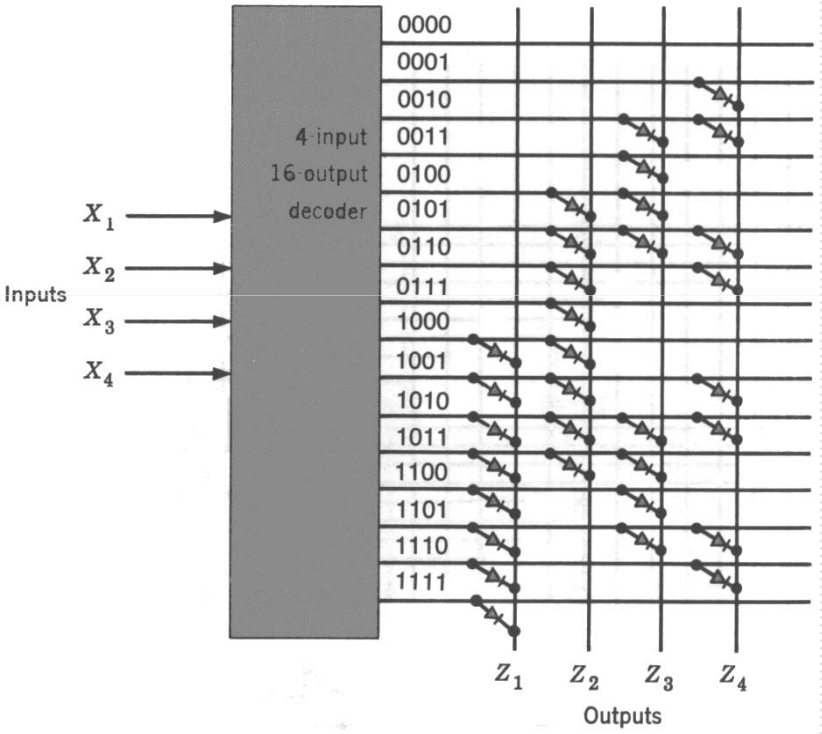
RAM structure

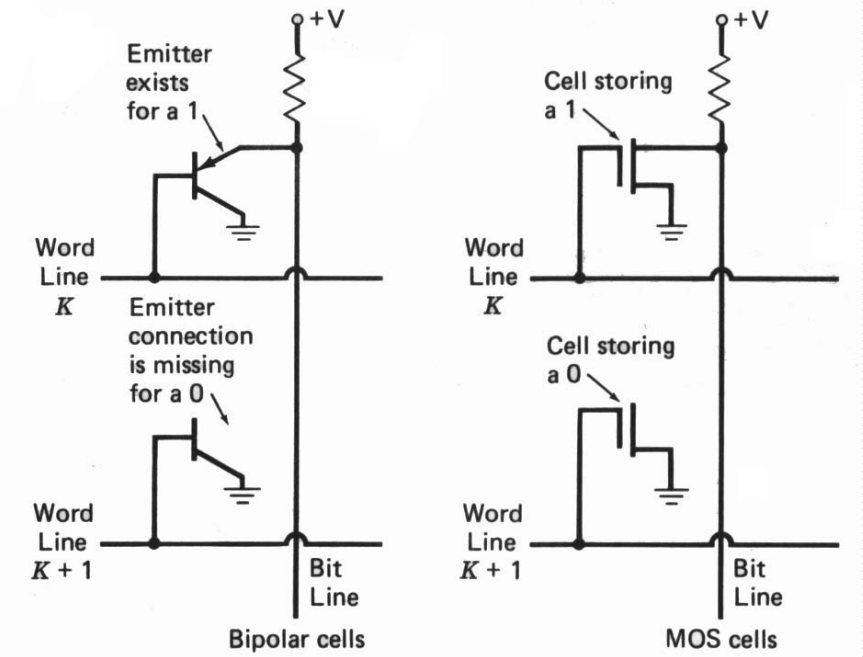


RAM types

- Static RAM (SRAM)
  - Advantages : high speed
  - Disadvantages : expansive, large
  - Application : Register, cache
- Dynamic RAM (DRAM)
  - Advantages : cheap, small, low power consumption
  - Disadvantages : refresh circuit required, low speed
  - Application : main memory

ROM structure





ROM Applications

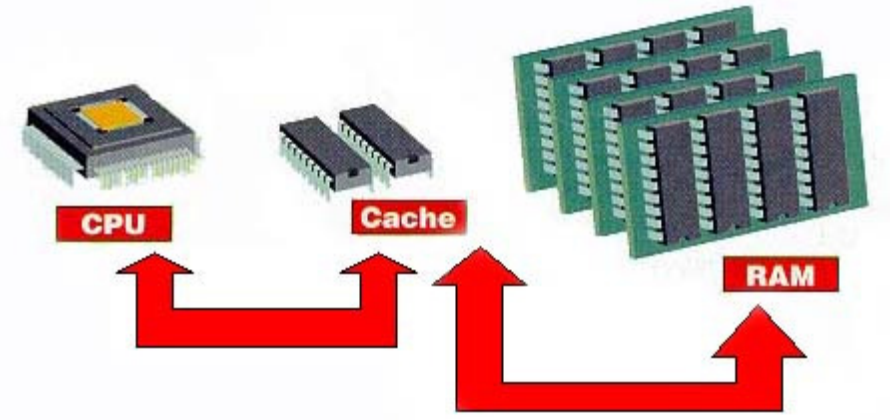
- Microprogramming
- Library subroutines, e.g., I/O functions
- System programs
- Function tables

ROM Types

- Factory-manufactured ROM
  - Disadvantages : high manufacturing cost, unprogrammable
- Programmable ROM (PROM)
- Erasable Programmable ROM (EPROM)
- Electrically Erasable Programmable ROM (EEPROM)
- Flash memory

Cache Memory

- A special buffer storage, smaller and faster than main storage, that is used to hold a copy of instructions and data in main storage that are likely to be needed next by the processor, and that have been obtained automatically from main storage.



Why's cache memory?

- Locality of Reference
  - Temporal locality: Recently accessed items tend to be accessed again in the near future.
  - Spatial locality: Accesses tend to be clustered in the address space, e.g., arrays or loops.
  - Sequential locality: Instructions tend to be accessed sequentially.
- Cache is accessed by "content". -> content addressable memory (CAM)

Semiconductor Memory Types

Memory Type	Category	Erasure	Write	Volatility
Random Access Memory (RAM)	Read/Write	Electrically	Electrically	Volatile
Read-only Memory (ROM)	Read Only	Not possible	Masks	Nonvolatile
Programmable ROM (PROM)	Read Only	Not possible	Electrically	Nonvolatile

Semiconductor Memory Types

Memory Type	Category	Erasure	Write	Volatility
Erasable PROM (EPROM)	Read-mostly memory	UV light	Electrically	Nonvolatile
Flash Memory		Electrically, block level		
Electrically Erasable PROM (EEPROM)		Electrically, byte level		

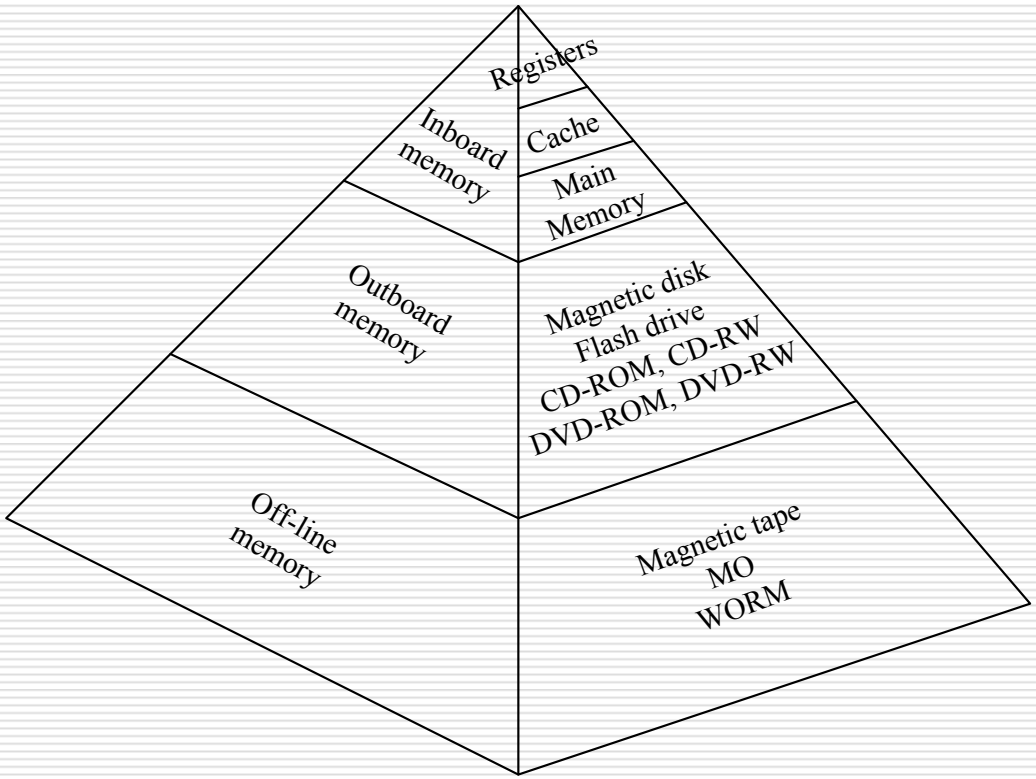
Secondary Memory

- 3.5” Floppy Disk (5.25”, 8” etc.)
- Harddisk

-> Magnetic Disk

- CD-ROM, CD-R -> Optical Disk, Write Once Read Many (WORM)
- Magneto-Optical Disk (MO Disk)
- Digital Audio Tape, 8 mm Video Tape -> Magnetic Tape
- USB flash drive

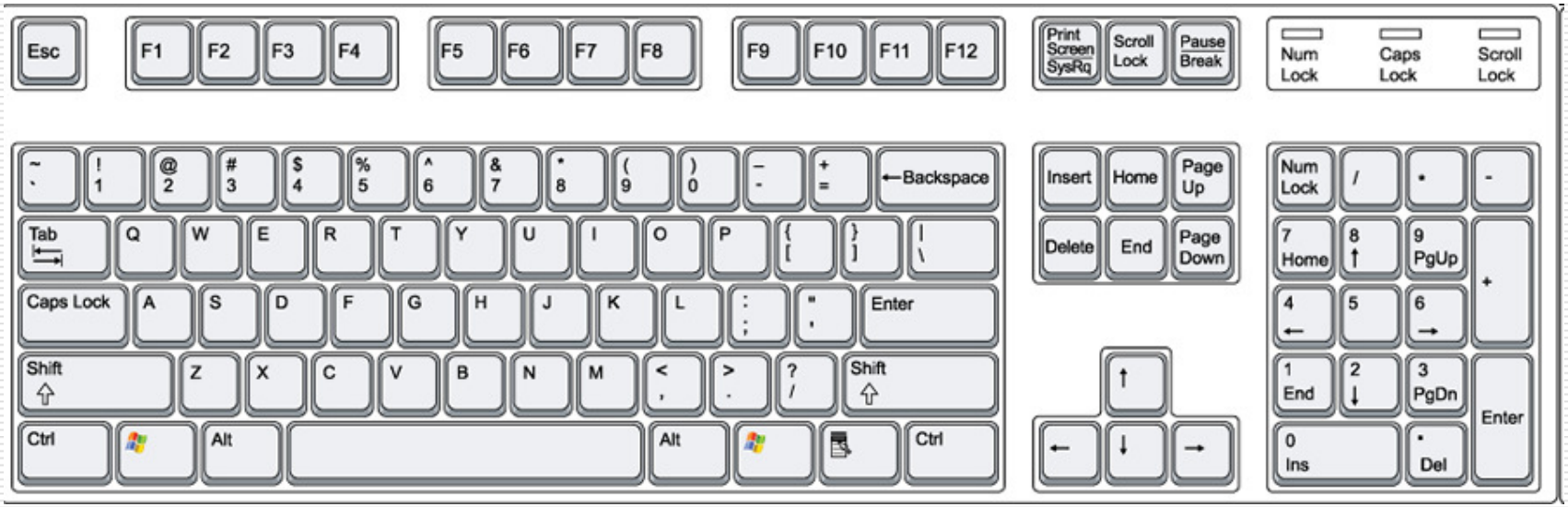
Typical Memory Hierarchy



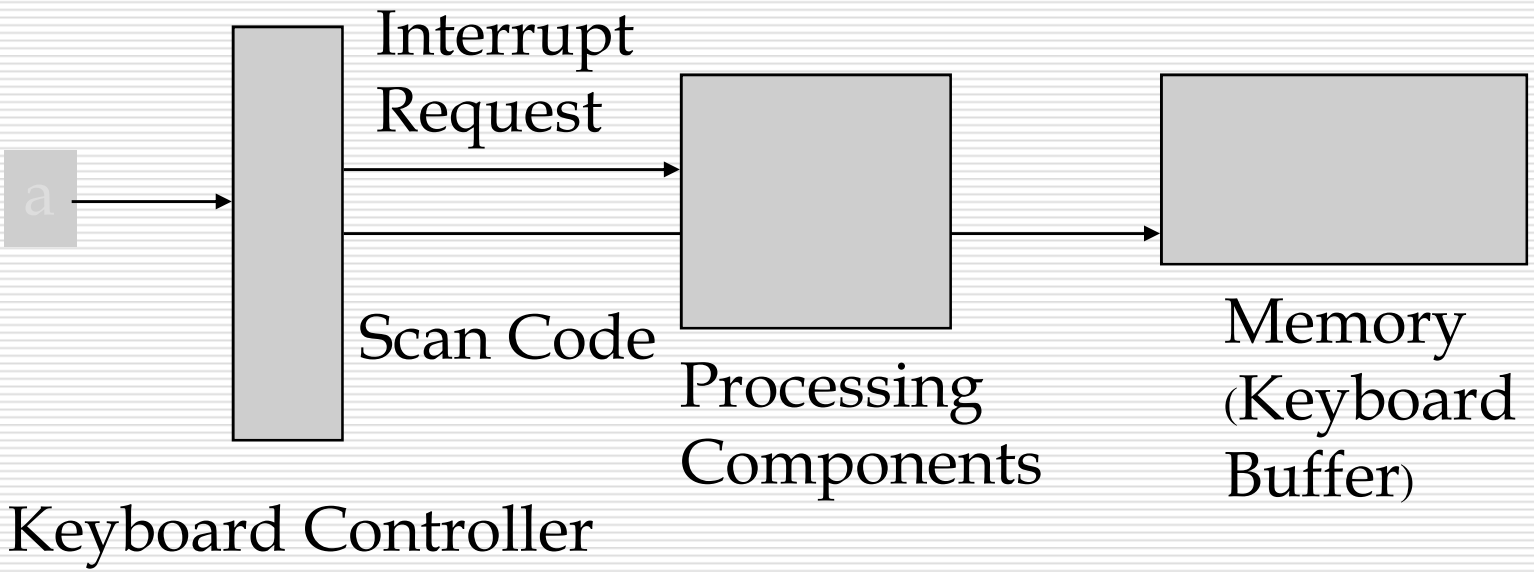
- The lower one goes,
  - The lower the cost per bit
  - The greater the capacity
  - The longer the access time
  - The lower the frequency of access of memory

Input Device

- Keyboard
  - Alphanumeric Keys (mostly QWERTY layout)
  - Numeric Keypad
  - Function Keys
  - Cursor-Movement Keys



How a computer accepts an input from a keyboard ?



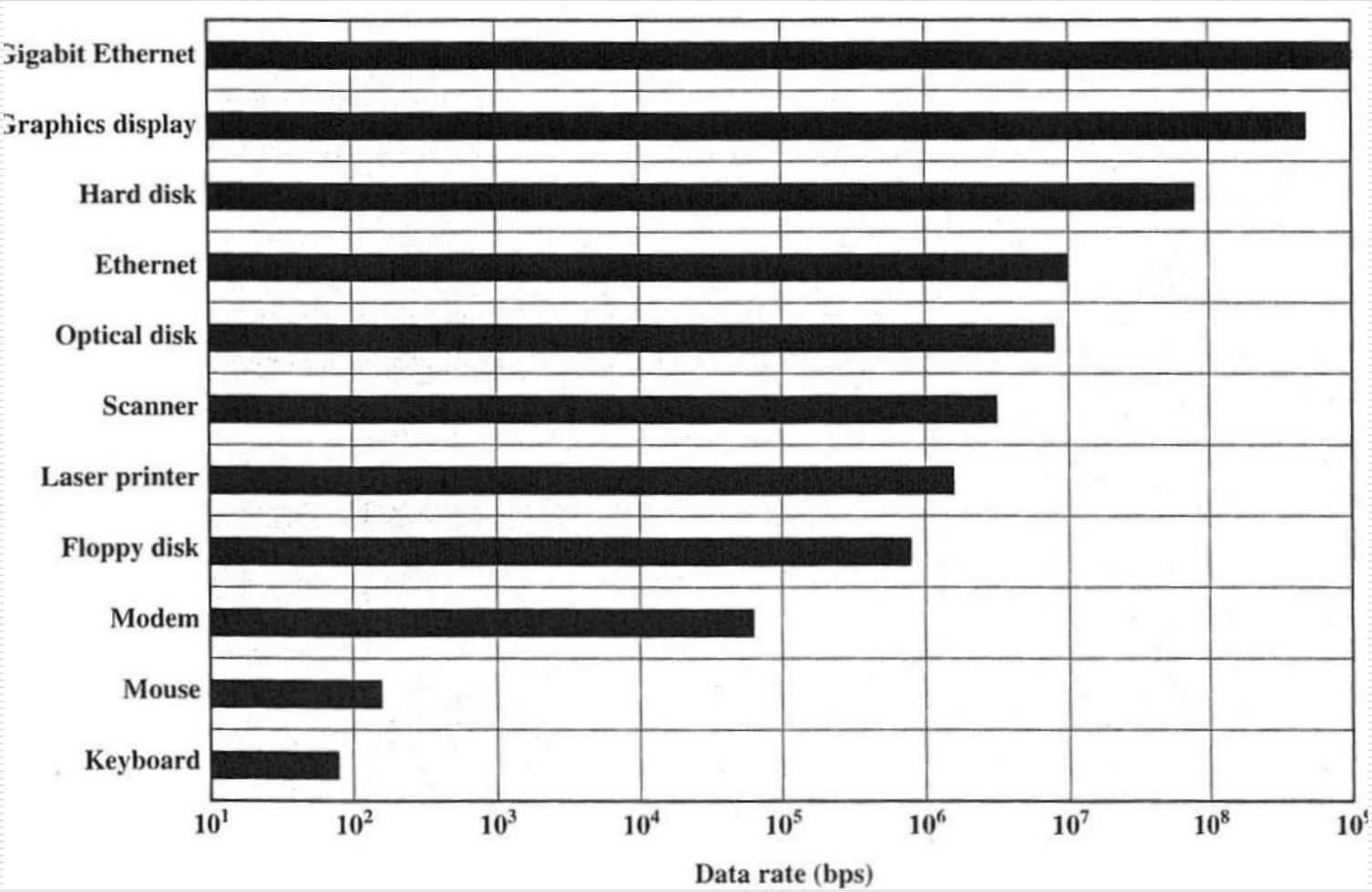
Input Device (Cont.)

- Mouse
  - Mechanical Mouse
  - Optical Mouse
  - Trackball / Touchpad
- Pens
- Touch Screens
- Bar-Code Readers
- Scanners and Optical Character Recognition (OCR)
- Digital camera

Output Device

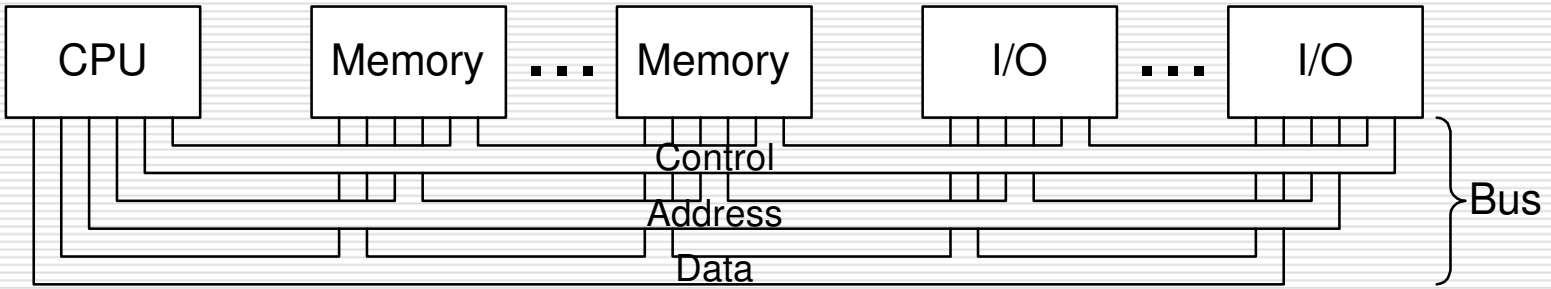
- Cathode-Ray Tube (CRT) Display Monitor
- Liquid Crystal Display (LCD)
- Printer : Laser, Dot-Matrix, Ink-Jet
- Plotter

Typical device data rates



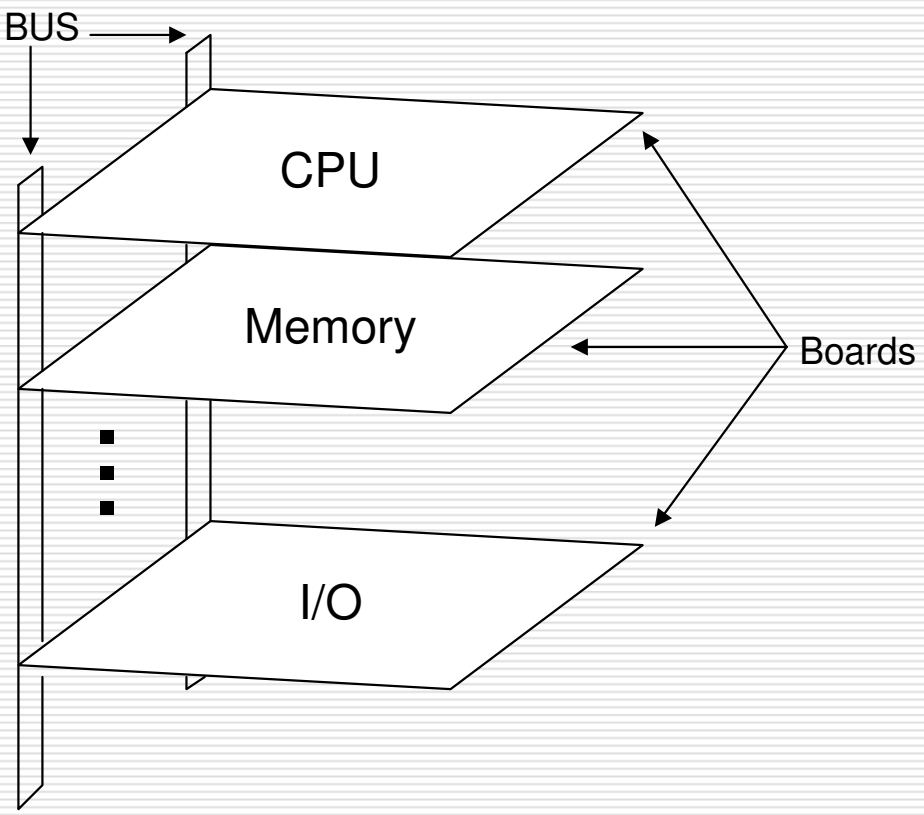
System Interconnection

- Basic System bus
  - Address bus
  - Data bus
  - Control line, e.g., Memory write/read, I/O write/read, Transfer ACK, Bus request/grant, Interrupt request/grant, clock, reset

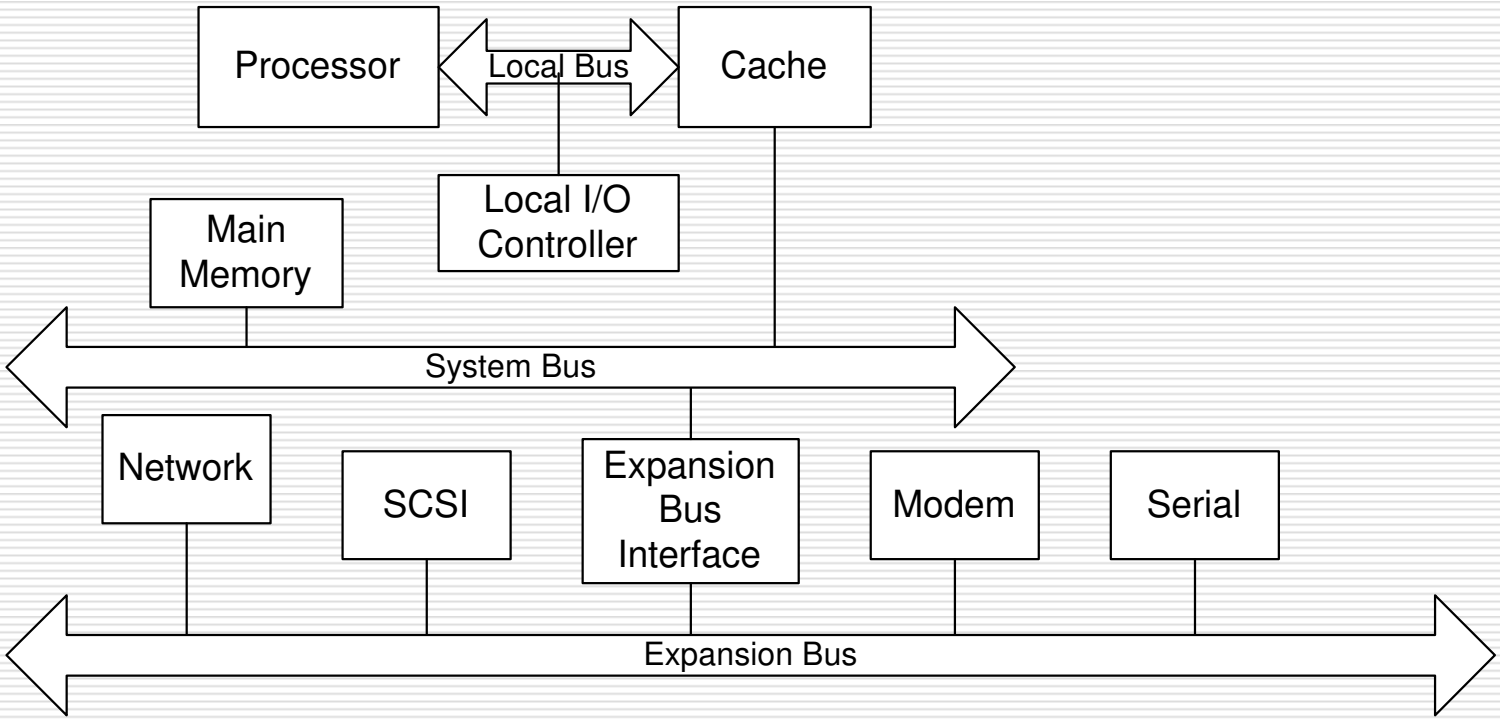


Conventional structure

- Slot structure
  - Advantages : easy to expand or change
  - Disadvantages : slow with increasing number of components, bottle neck problem

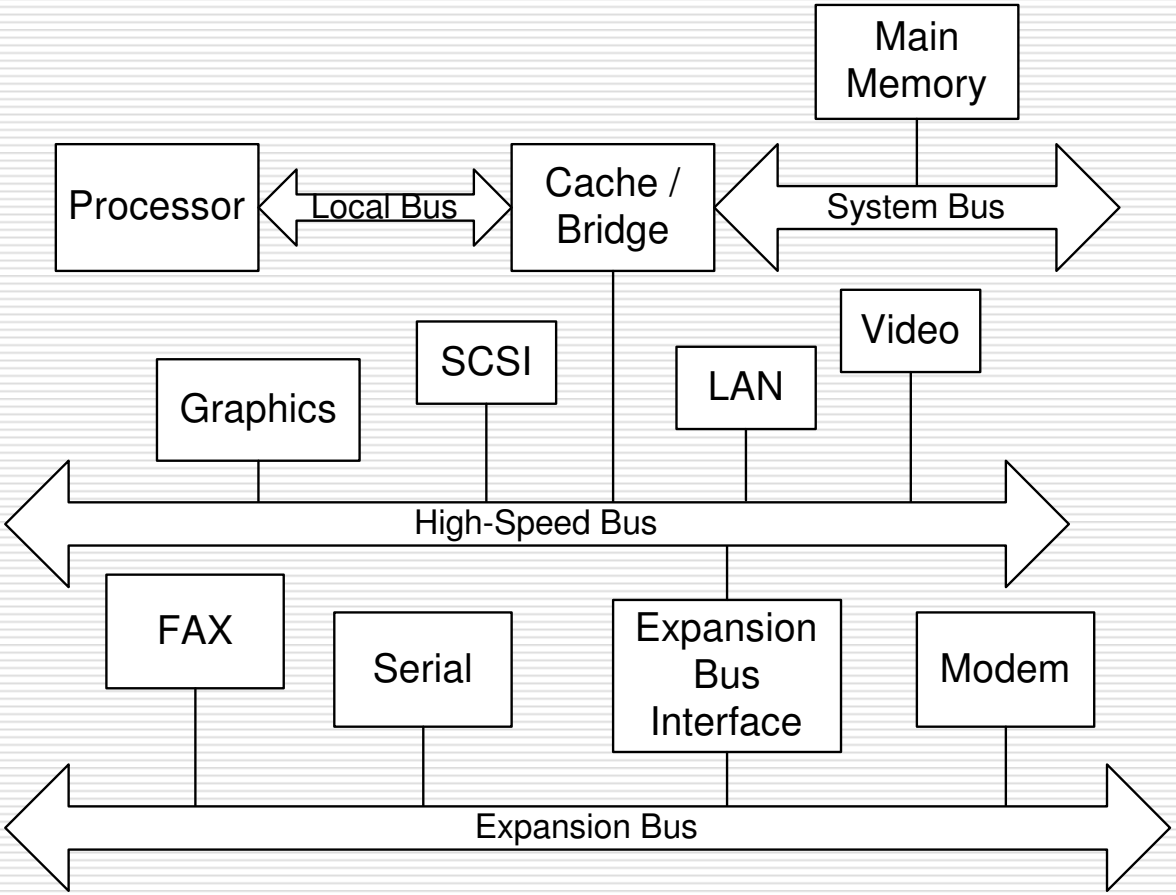


Multiple-bus System



High-speed bus system

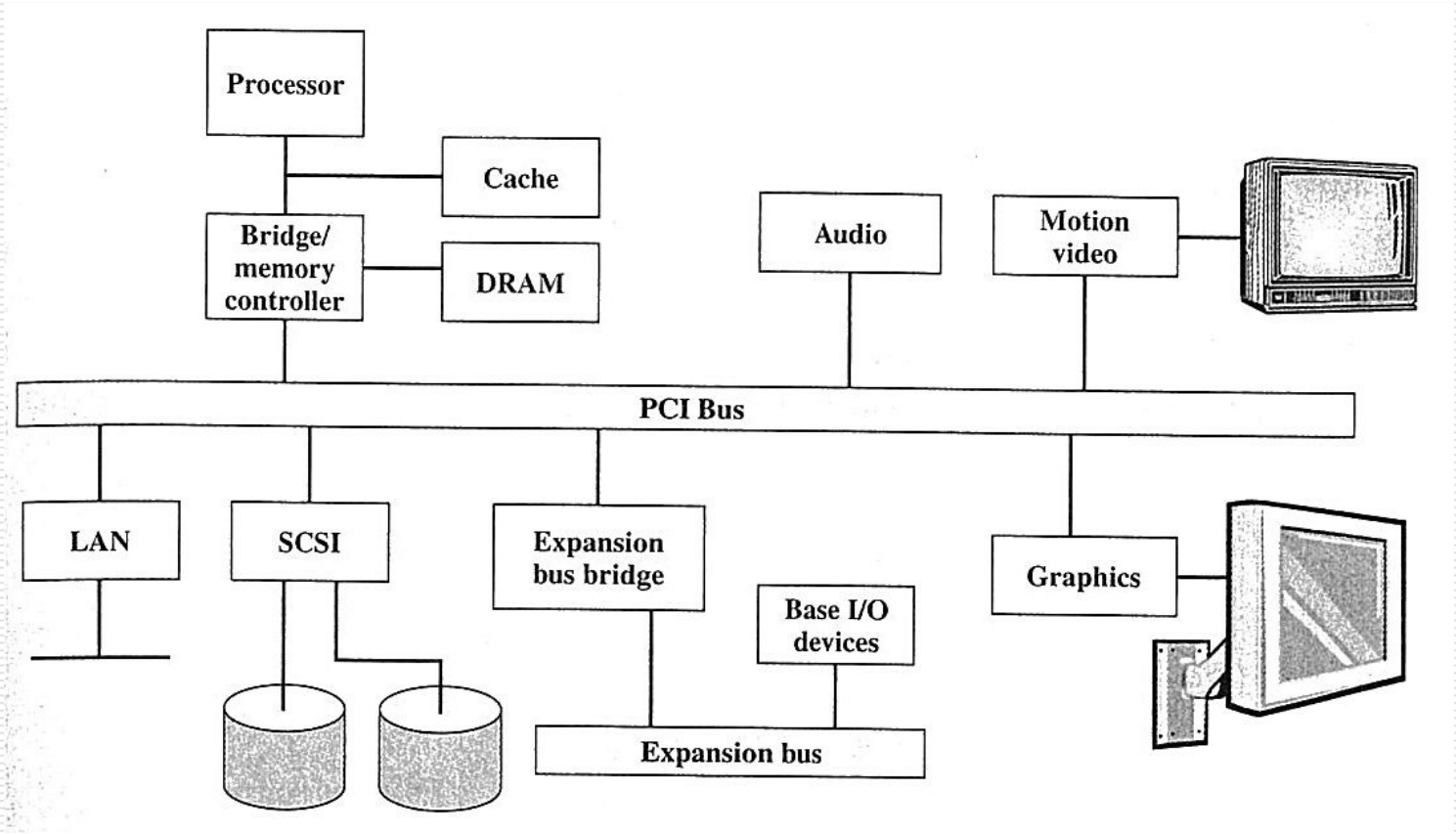
- Mezzanine architecture



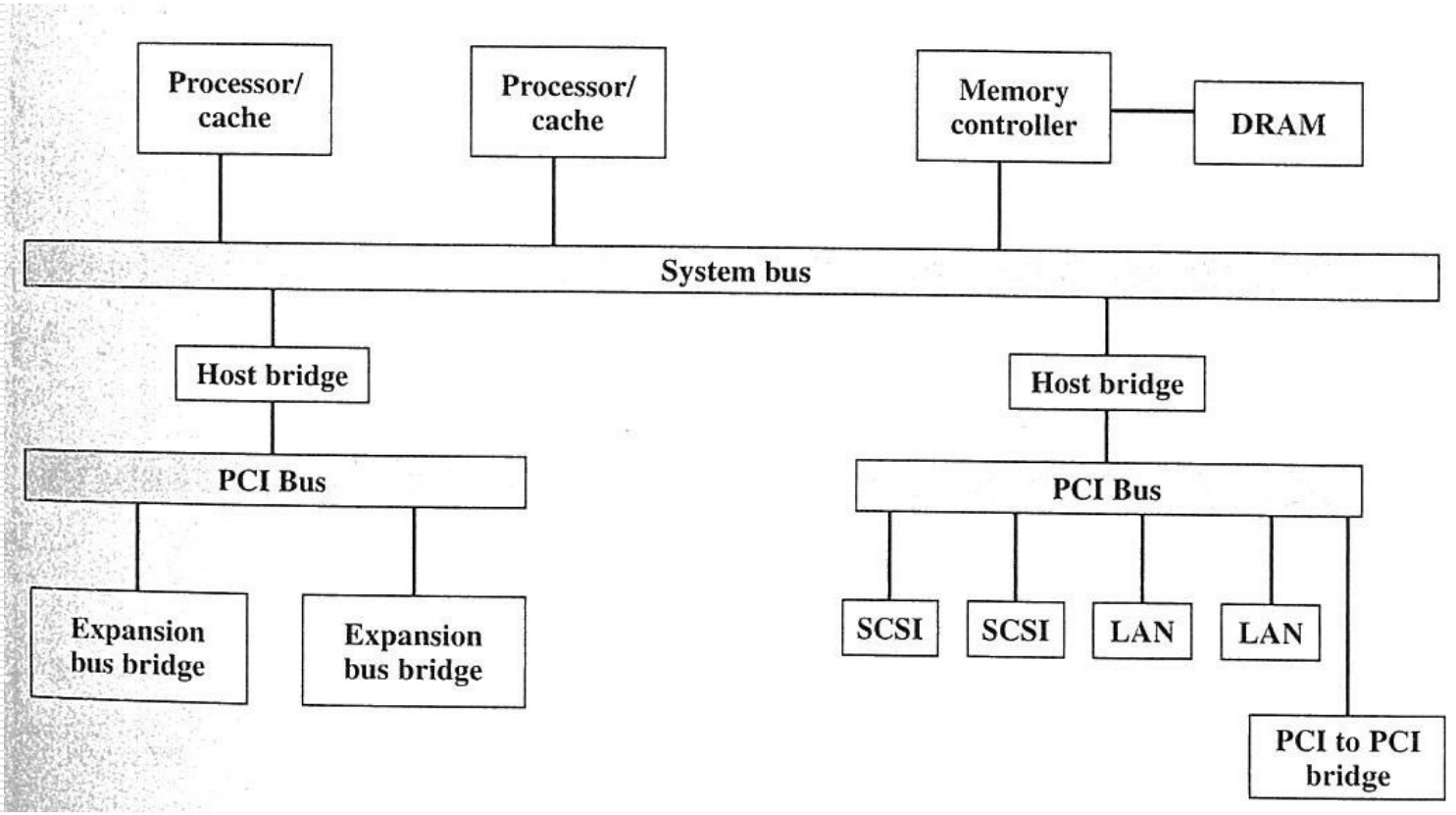
PC Interconnection

- Serial Port
- Parallel Port
- Mouse Port
- SCSI (Small Computer System Interface) "scuzzy"
- IDE (Integrated Drive Electronics)
- Expansion Slots : PCI (Peripheral Component Interconnect), ISA, EISA, VL BUS (obsolete), USB (Universal Serial Bus)

Typical desktop system



Typical Server System



Conclusion

- Basic components of computer systems
  - CPU
  - Memory
  - I/O devices
  - External memory
    - System interconnections -> system buses
- Basic Operations of computers
  - Instruction cycle = fetch cycle + execute cycle
  - Interrupt