Computer Hardware

Overview of Architecture

Revision 1.0.4

John Von Neumann

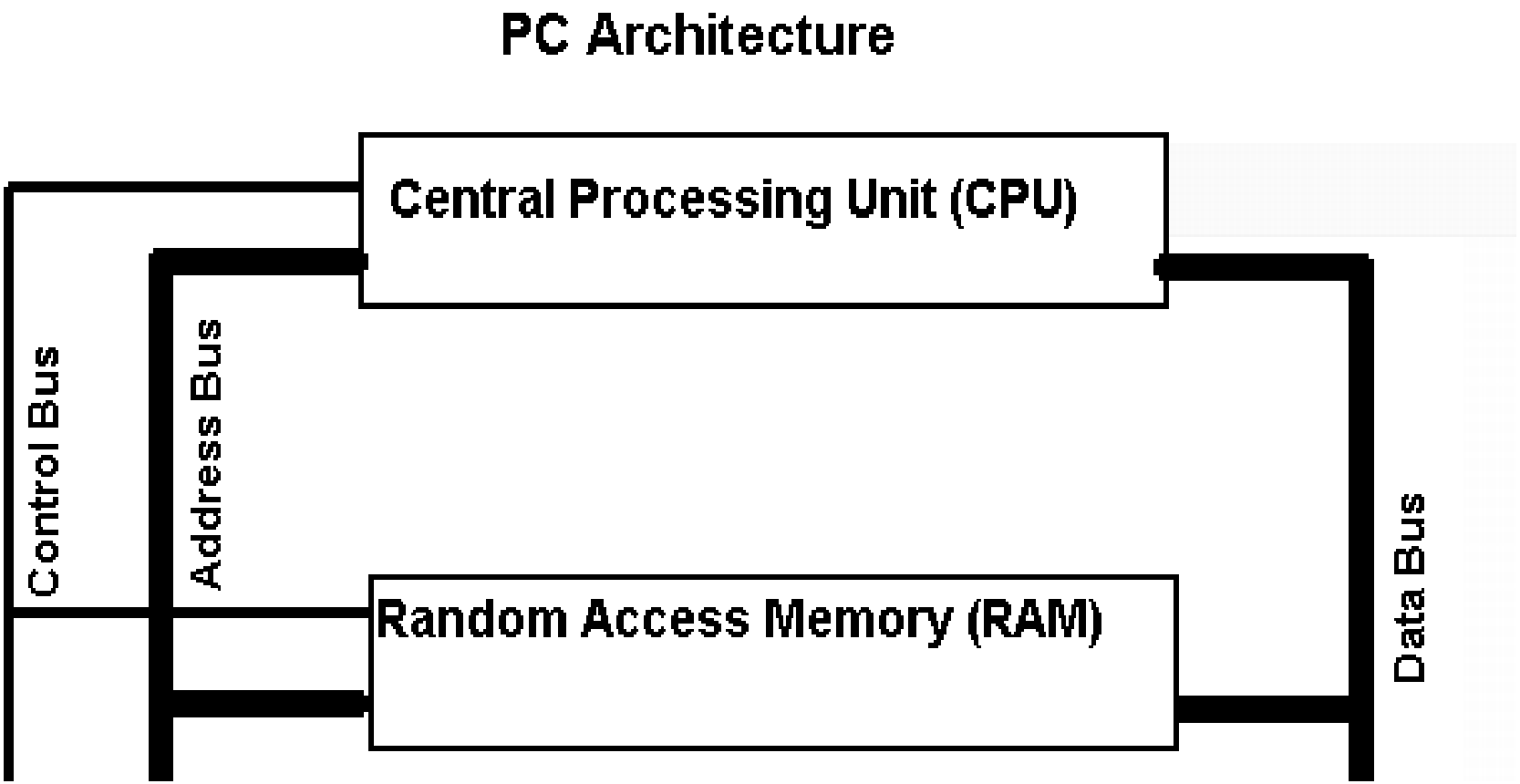
Dr Strangelove

Revision 1.0.4

Von Neumann architecture (1945)

- Electronic
- Digital
- Stored program
- Shared bus structure

Minimal Computer



Random Access Memory (RAM)

- Byte or Word as data unit
- Units addressable by number
  - Note: 0 is the first number
- Random access
- Read/Write access
- Typically volatile

Central Processing Unit (CPU)

- Initiates memory read/write via bus
- Reads memory to fetch instructions
- Executes the instruction
- Instruction may involve data read
- Instruction may involve data write
- Generates enough heat to cook itself without associated cooler

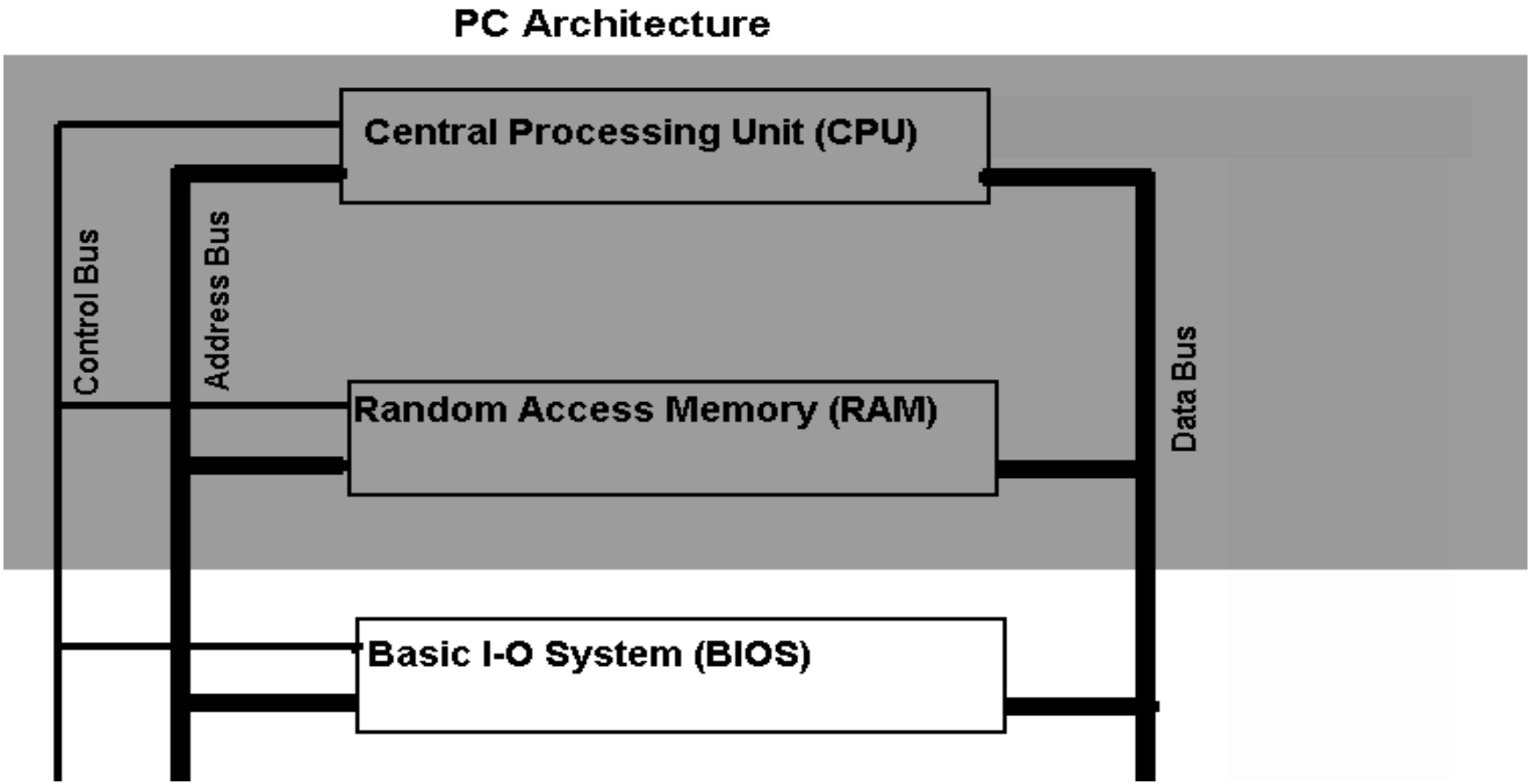
Computer Bus

- Address bus conveys address from CPU to RAM (20bit, 32bit, …)
- Data bus conveys data between CPU & RAM
  - Initially 8bit, …, now 128bit, …
- Control bus = read: RAM asserts data for CPU to read
- Control bus = write: CPU asserts data for RAM to read and store

What's Missing?

- Need mechanisms to get data and instructions into RAM (Input)
- Need mechanisms to view and store resultant data (Output)
- Need initial program to run when computer is started (Bootstrap)

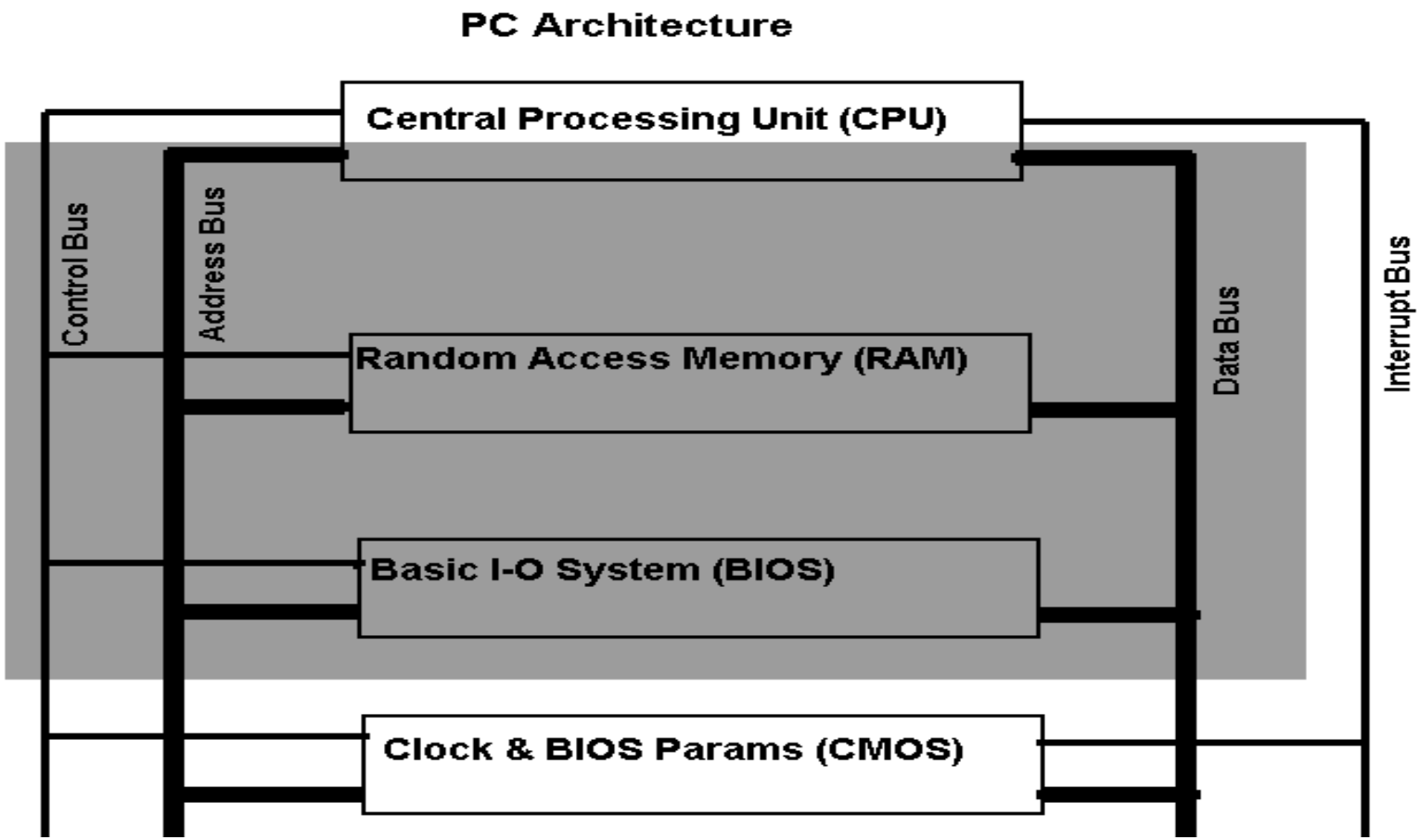
Basic Input-Output System (BIOS)



Basic Input-Output System (BIOS)

- Read-Only Memory (ROM)
- Non-volatile
  - (Also PROM, EEPROM
- Bootstrap code is pre-installed
- Configured to sit on the Address Bus at the CPU Reset address

CMOS



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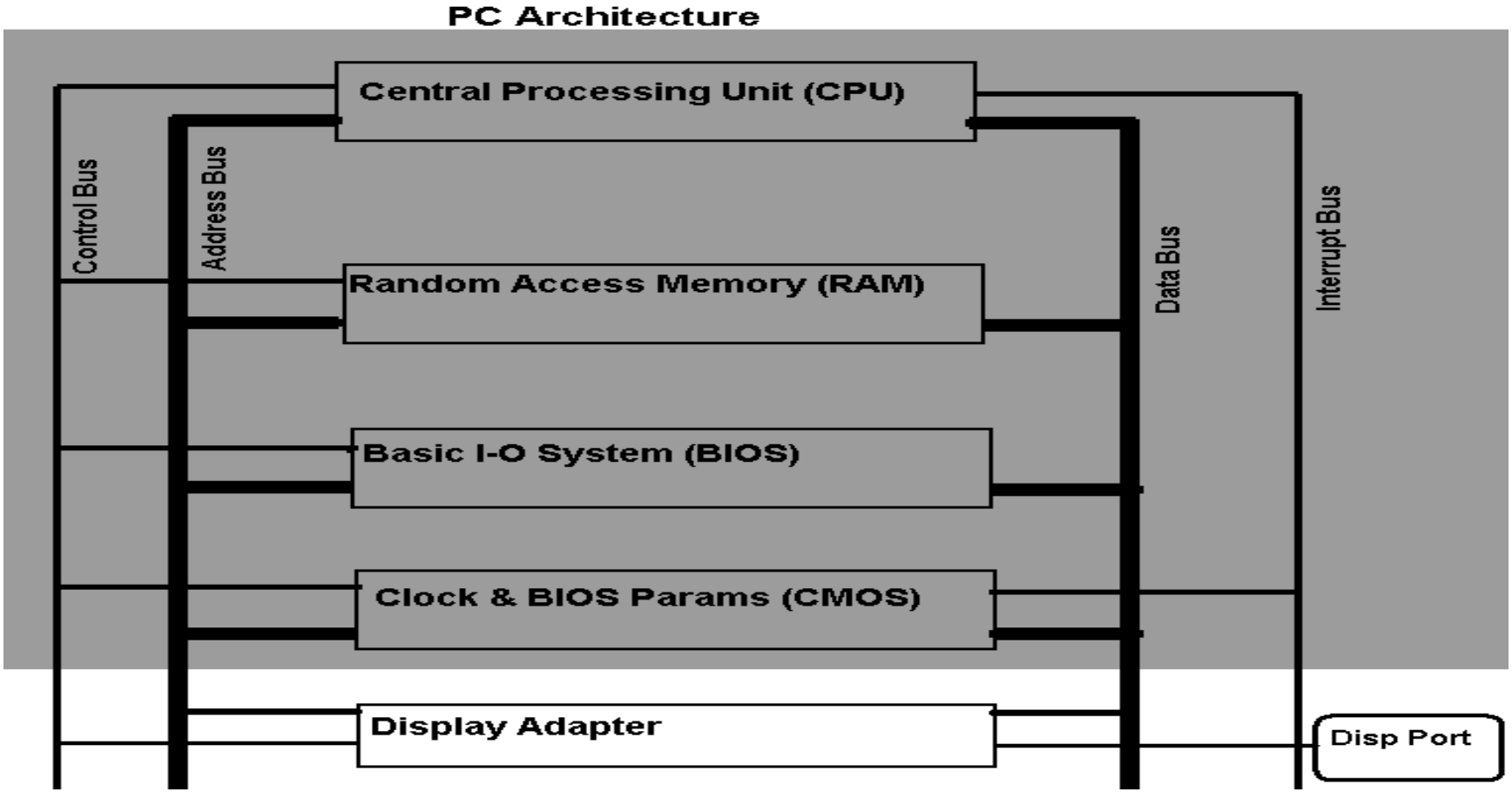
CMOS

- Complementary Metal Oxide Semiconductor
- Button-battery backup when power off
- Stores BIOS parameters
- Clock keeps time as long as battery lasts
- Jumper allows CMOS data to be cleared

Interrupt Bus

- 16 Interrupt Channels
- Interrupt Request (IRQ) enables device to demand attention of CPU
- Clock (probably) uses this to handle scheduled events
- Clock (apparently) can wake system from Standby or Hibernate status

Frame Buffer



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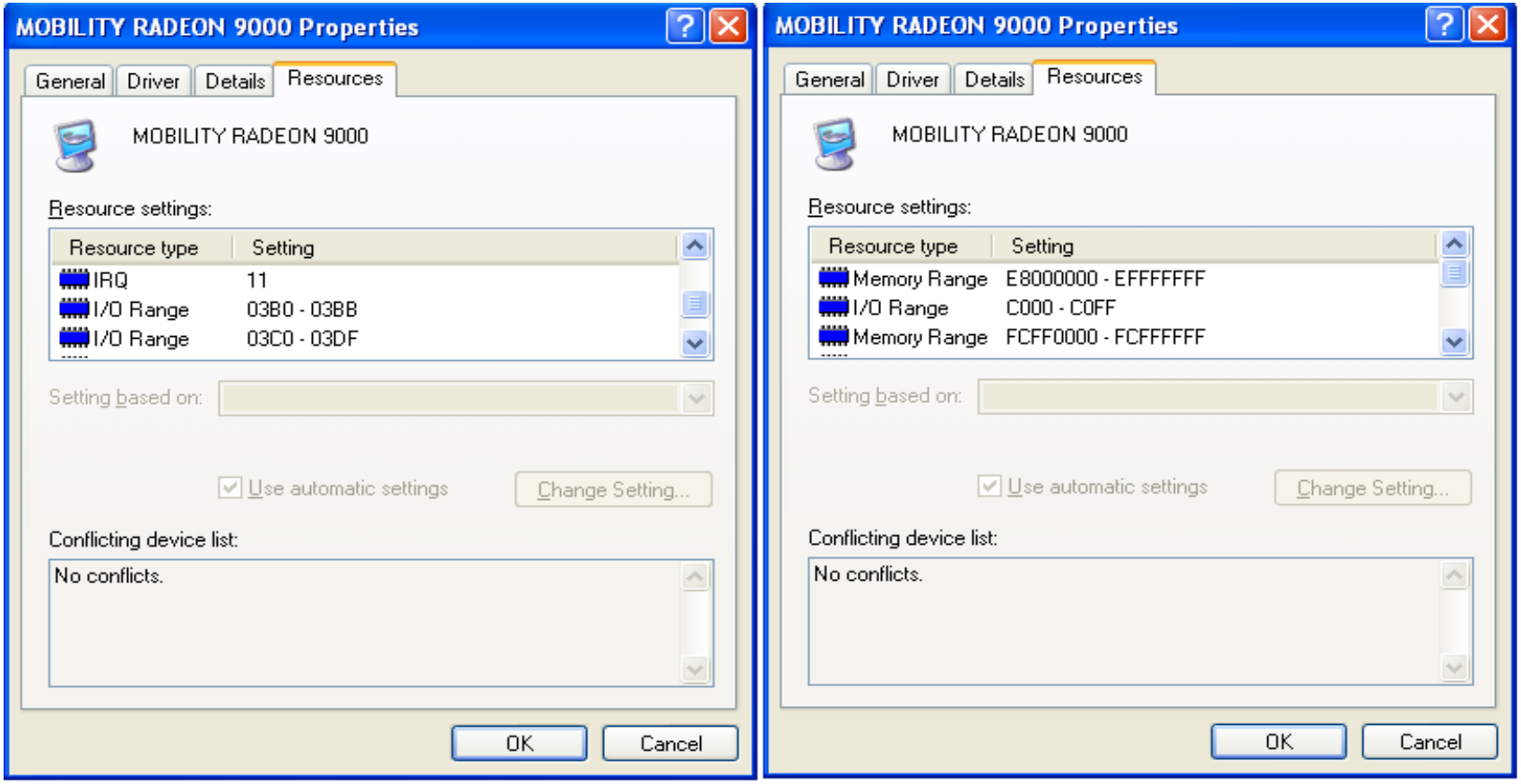
Frame Buffer

- May be dedicated or shared memory
- Occupies block of Memory Address
- One bit/byte/word per screen pixel
- Electronics convert memory contents to appropriate signal for display device
  - VGA almost always supported
- CPU changes display by writing to Frame Buffer

DeviceManager View



Start>ControlPanel>System>Hardware>DeviceManager>(device)>Resources

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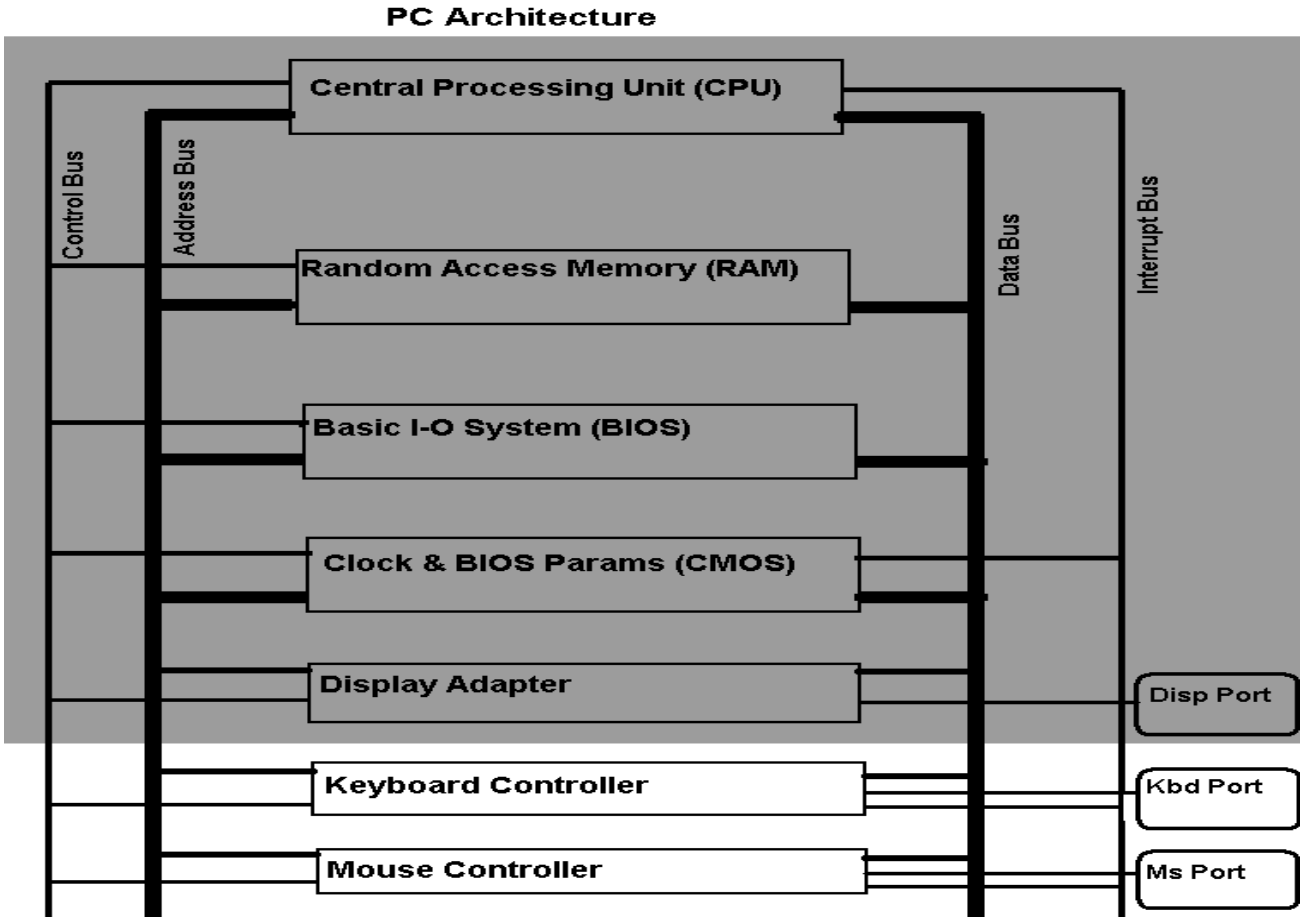
Keyboard & Mouse Ports



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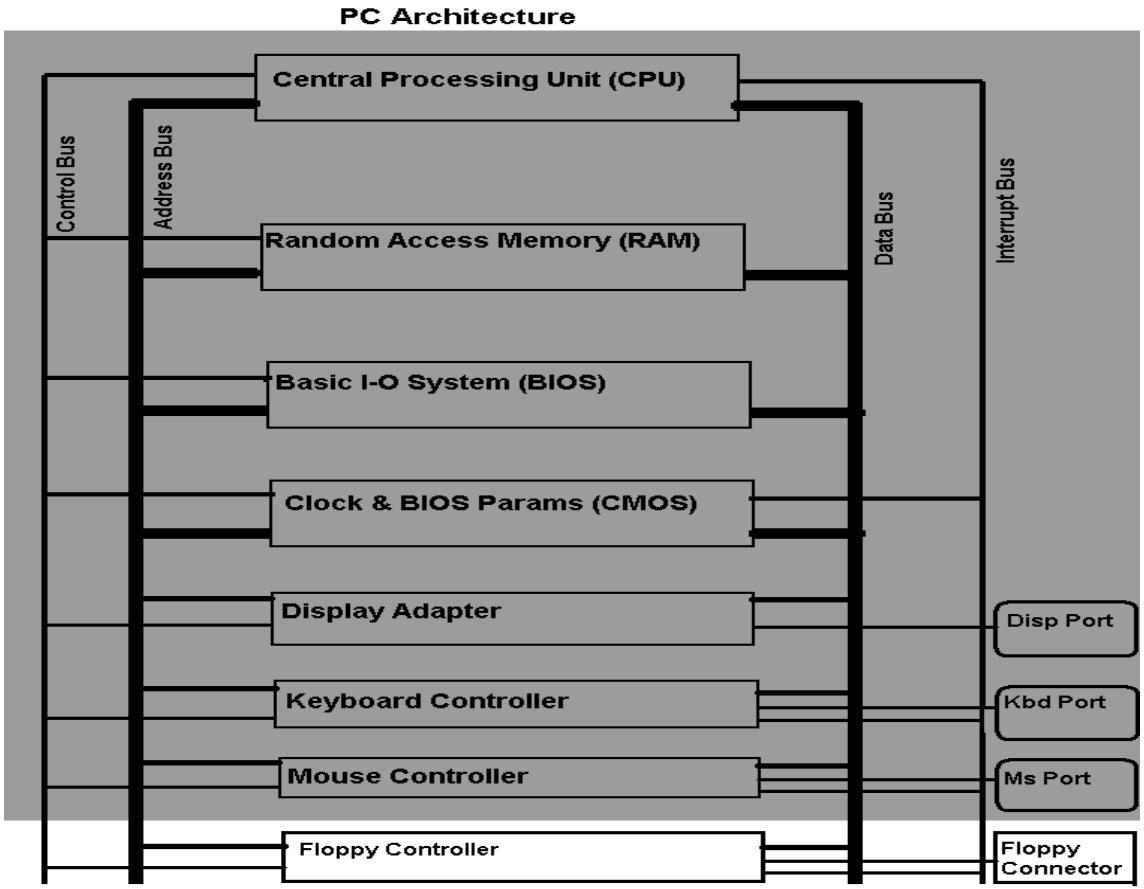
Floppy Disk Controller



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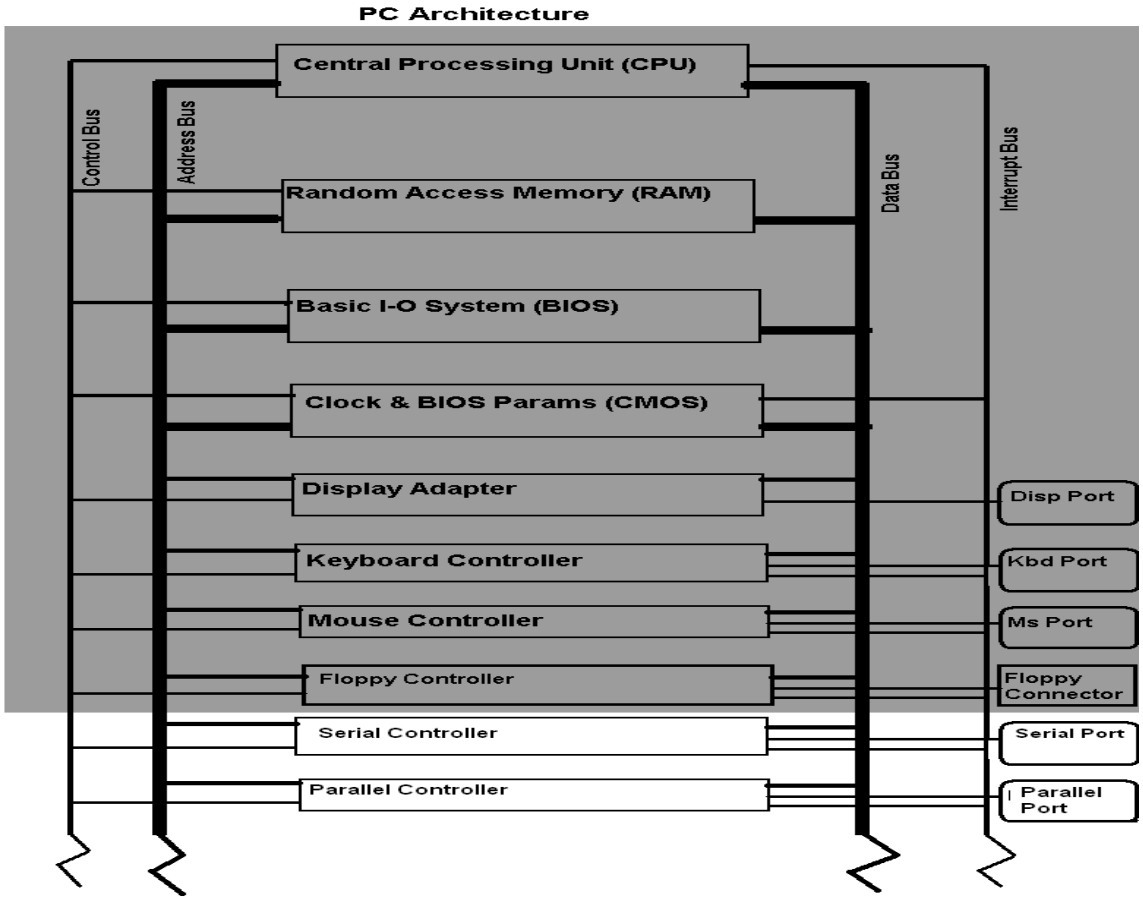
Serial & Parallel Ports



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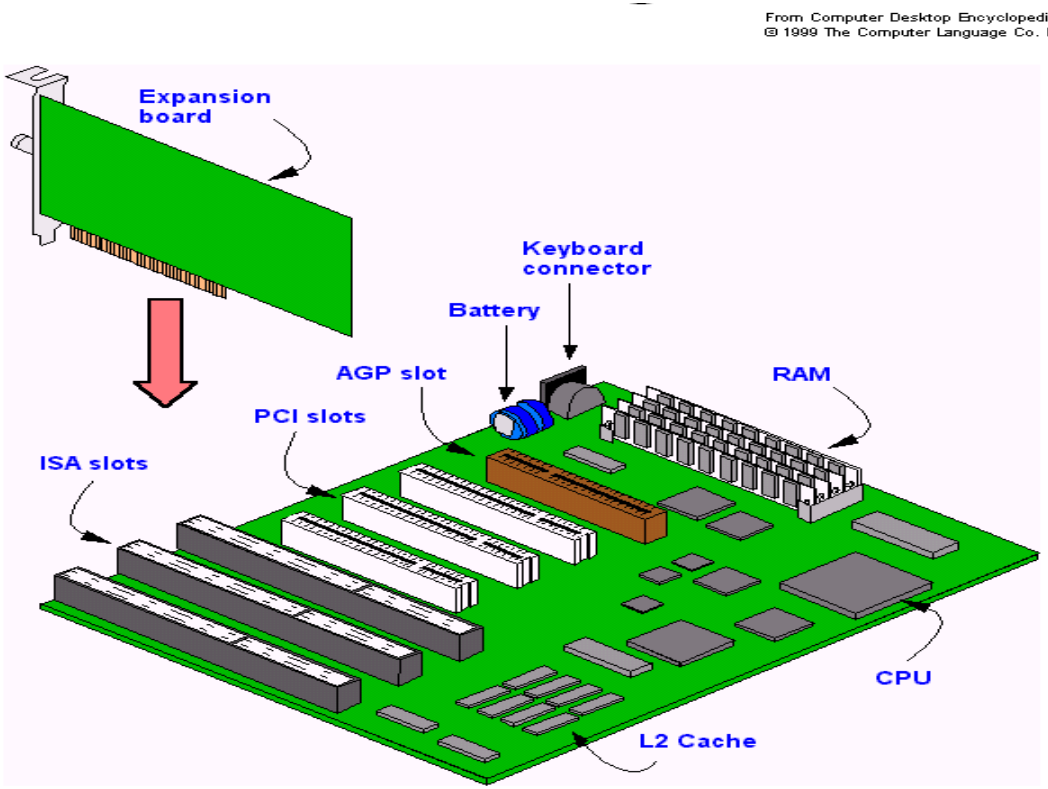
Motherboard ca. 2000



Motherboard
This is a Baby AT style motherboard for a PC. The adapter cards (expansion boards) plug into the expansion slots on the motherboard.

From http://images.yourdictionary.com/motherboard

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Hard Drive & CD/DVD

- Typically use same ATA/IDE interface
- Parallel ATA (PATA) uses ribbon cable
  - Evolved through 33, 66, 100, 133 MBs
  - Initially 40, then 80 wire
  - Primary & Secondary on each cable
  - 3.5” & 2.5” drives use different connectors
- Serial ATA (SATA) uses 7-wire cable
  - Evolved through 1.5, 3.0, 6.0 Gbs

Universal Serial Bus (USB)

- Hot-swappable
- Evolved through backward-compatible versions
  - 1.0 12Mbs
  - 2.1 480Mbs
  - 3.0 5Gbs
- Tending to supercede serial, parallel, mouse and keyboard ports

Firewire (IEEE 1394)

- Originated as Apple/Sony development
- Evolved through backward-compatible versions
  - 100 Mbs
  - 200 Mbs
  - 400 Mbs
  - 800 Mbs

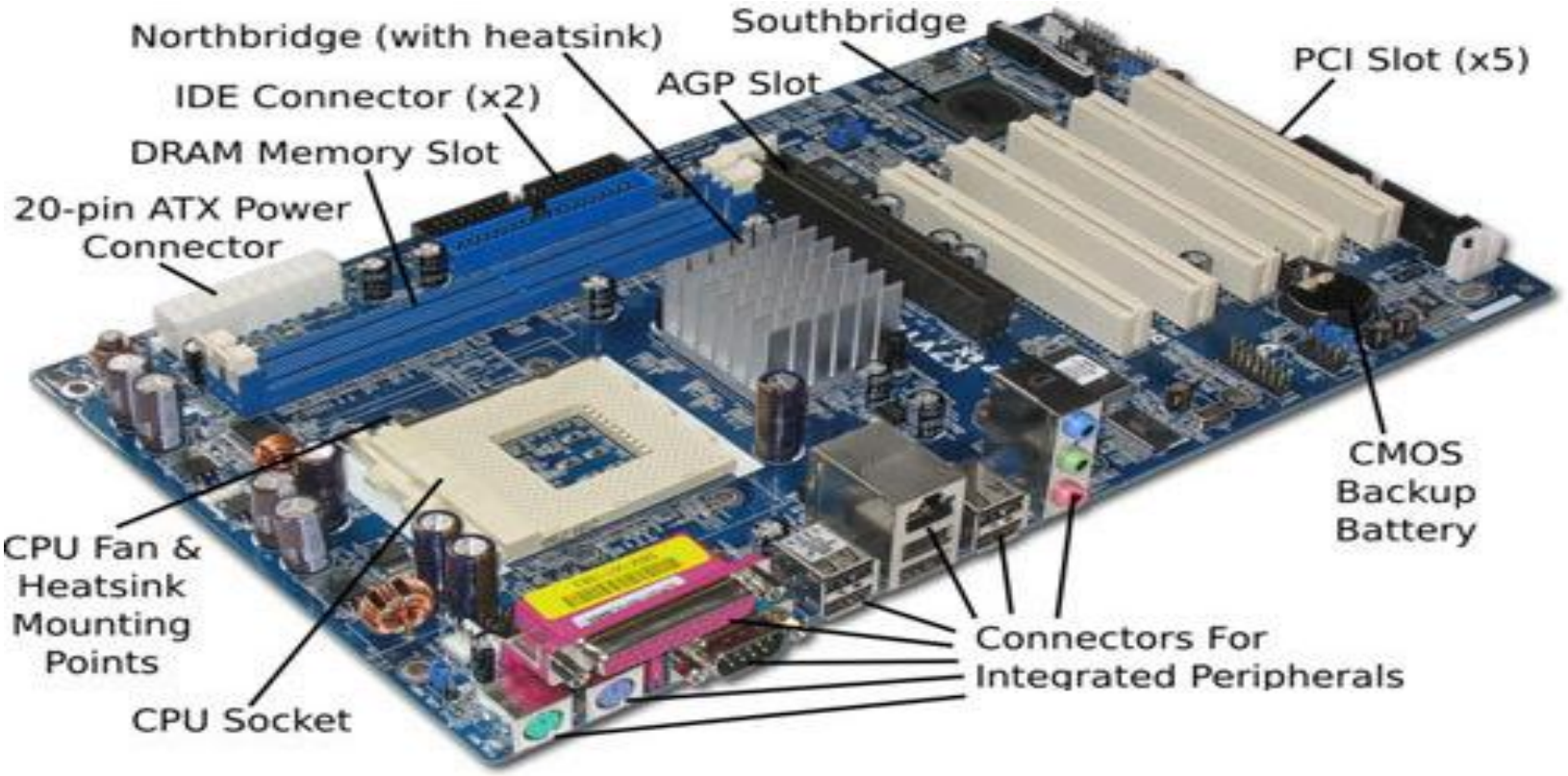
Ethernet (IEEE 802.x)

- Evolved from coax to serial and wireless
- Wired speeds to 100Gbs (LOL)
- Wireless - actual mileage may vary
  - 802.11b to 11Mbs
  - 802.11g to 54Mbs
  - 802.11n to 300 Mbs (theoretically)
- Used for LAN/WAN
  - Speed controlled by the slowest link(s)

Audio Ports

- Line Out (green)
  - Analog line level stereo output
  - For headset or amplifier
- Line In (blue)
  - Analog input at level of Line Out
- Microphone (pink)
  - Analog microphone (low level) input
- Usually accepts 3.5mm TRS phone jacks
- Quality (if you care) will differ

Motherboard ca. 1995



From http://thecustomizewindows.com/2011/03/components-of-a-motherboard/

Central Processing Unit (CPU)

- Instruction Set (50-500 instructions)
  - "Machine Instruction" is characteristic of each given architecture, e.g. Intel 386
  - Compactly coded in a few bytes (e.g. 4)
- Program Counter
  - Points to next instruction to execute
- Working Registers (2-16)
- Condition Code

Program to Compute a Factorial

```
;To compute N! for some value N
;This program would (probably) execute on a DECsystem10
;Suppose N was stored at memory location INPUT
;Suppose that we want to put resultant N! at location OUTPUT
Start:  move   R1, INPUT      ;Fetch input to register 1
        movei  R2, 1          ;Set register 2 to 1
Loop:   mul    R2, 1          ;Multiply contents of register 2
                              ;by contents of register 1
        subi   R1, 1          ; subtract 1 from register 1
        jumpg   Loop          ;if result was greater than 0, go to Loop
        movem  R2, OUTPUT     ;else done: store result at OUTPUT
```