



# Computer Fundamentals

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Lecture 9



# Memory

- Stores open programs and data
- Small chips on the motherboard
- More memory makes a computer faster



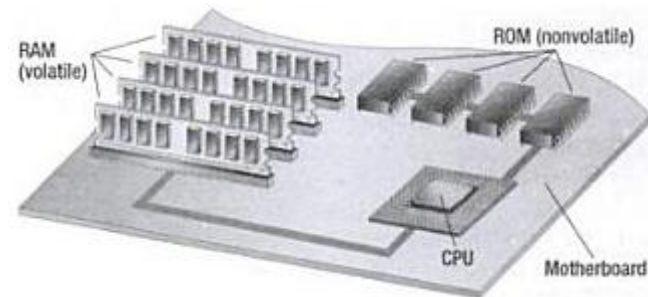
# Memory (cont.)

## ➤ Non-volatile memory

- ❑ Holds data when power is off
  - Read Only Memory (ROM)
- ❑ Basic Input Output System (BIOS)
  - Start-up instructions for turning on the system
  - Boot-up information
- ❑ Power On Self Test (POST)
  - Ensuring that system functioning properly
  - Ensure presence of necessary hardware

## ➤ Flash memory

- ❑ Data is stored using physical switches
- ❑ Special form of nonvolatile memory
- ❑ Camera cards, USB key chains





# Memory (cont.)

- Volatile memory
  - ❑ Requires power to hold data
    - Random Access Memory (RAM)
  - ❑ Data in RAM has an address
  - ❑ CPU reads data using the address
  - ❑ CPU can read any address





# Memory (cont.)

- **SIMM**
  - ❑ Single in-line memory module
  - ❑ Used from early 1980s to late 1990s
- **DIMM**
  - ❑ Double in-line memory module
- **SO-DIMM**
  - ❑ Small outline DIMM
    - Have small size
  - ❑ Designed for laptops



# Memory (cont.)

## ➤ SIMM vs. DIMM

- ❑ DIMM has twice as many pins compared to SIMM
  - Although the number looks similar
- ❑ Connectors on either side are connected to each other in SIMM
  - Electrical contacts redundant on both sides of module
- ❑ SIMMs have 32-bit data path, while DIMMs have 64-bit data path



# Memory (cont.)

## ➤ DRAM

- ❑ Dynamic RAM, often used as main memory
- ❑ Stores each bit of data in a capacitor
- ❑ Capacitor either charged or discharged
  - States represent two values of a bit,
- ❑ Storage cell is dynamic
  - Needs to be recharged periodically to compensate for charge leaks

## ➤ SRAM

- ❑ Static RAM, often used as cache
- ❑ Uses flip-flop circuitry to store each bit
- ❑ Storage cell is static
  - Needs no periodic recharging
- ❑ Still volatile, data lost when not powered

## ➤ SDRAM

- ❑ Synchronous DRAM
- ❑ Kind of DRAM synchronized with clock speed of microprocessor
  - Operation of external pin interface coordinated by clock signal

Source: <https://www.quora.com/What-is-the-difference-between-DRAM-SRAM-and-SDRAM-Which-one-is-the-best-RAM-technology>



# Memory (cont.)

## ➤ SDR SDRAM

- ❑ Single Data Rate SDRAM
- ❑ Transfers data on rising edges of clock signal
- ❑ Delivers single bit of data per signal line per clock cycle

## ➤ DDR SDRAM

- ❑ Double Data Rate SDRAM
- ❑ Transfers data on both rising and falling edges of clock signal
- ❑ Delivers two bits of data per signal line per clock cycle

## ➤ QDR SDRAM

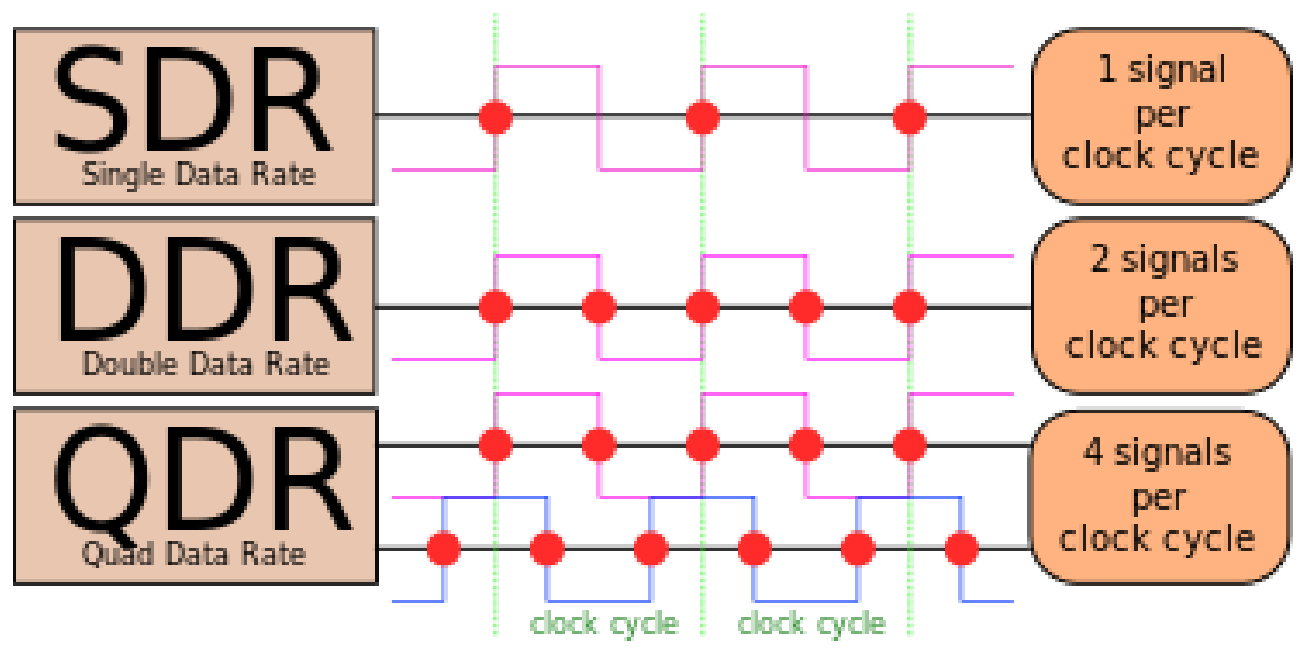
- ❑ Quad Data Rate SDRAM
- ❑ Transfers data on rising and falling edges, and two points in between
- ❑ Delivers four bits of data per signal line per clock cycle

Source: [https://en.wikipedia.org/wiki/Double\\_data\\_rate](https://en.wikipedia.org/wiki/Double_data_rate)





# Memory (cont.)



Source: [https://en.wikipedia.org/wiki/Double\\_data\\_rate](https://en.wikipedia.org/wiki/Double_data_rate)





# Components Affecting Speed

## ➤ Registers

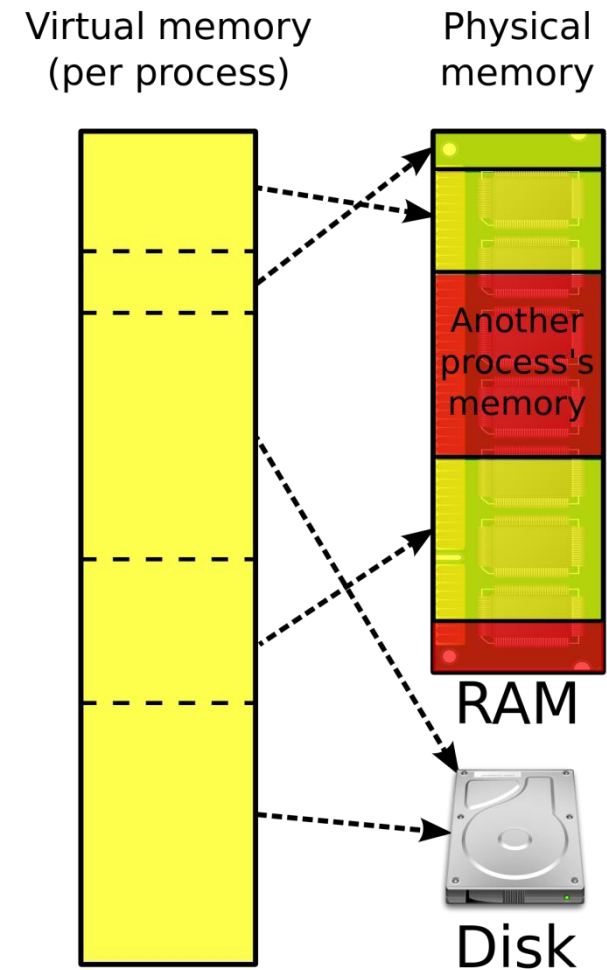
- ❑ Number of bits processor can handle
  - Word size
  - Indicates amount of data computer can work on at a time
- ❑ Larger indicates more powerful computer
- ❑ Increase by purchasing new CPU



# Components Affecting Speed (cont.)

## ➤ Virtual RAM

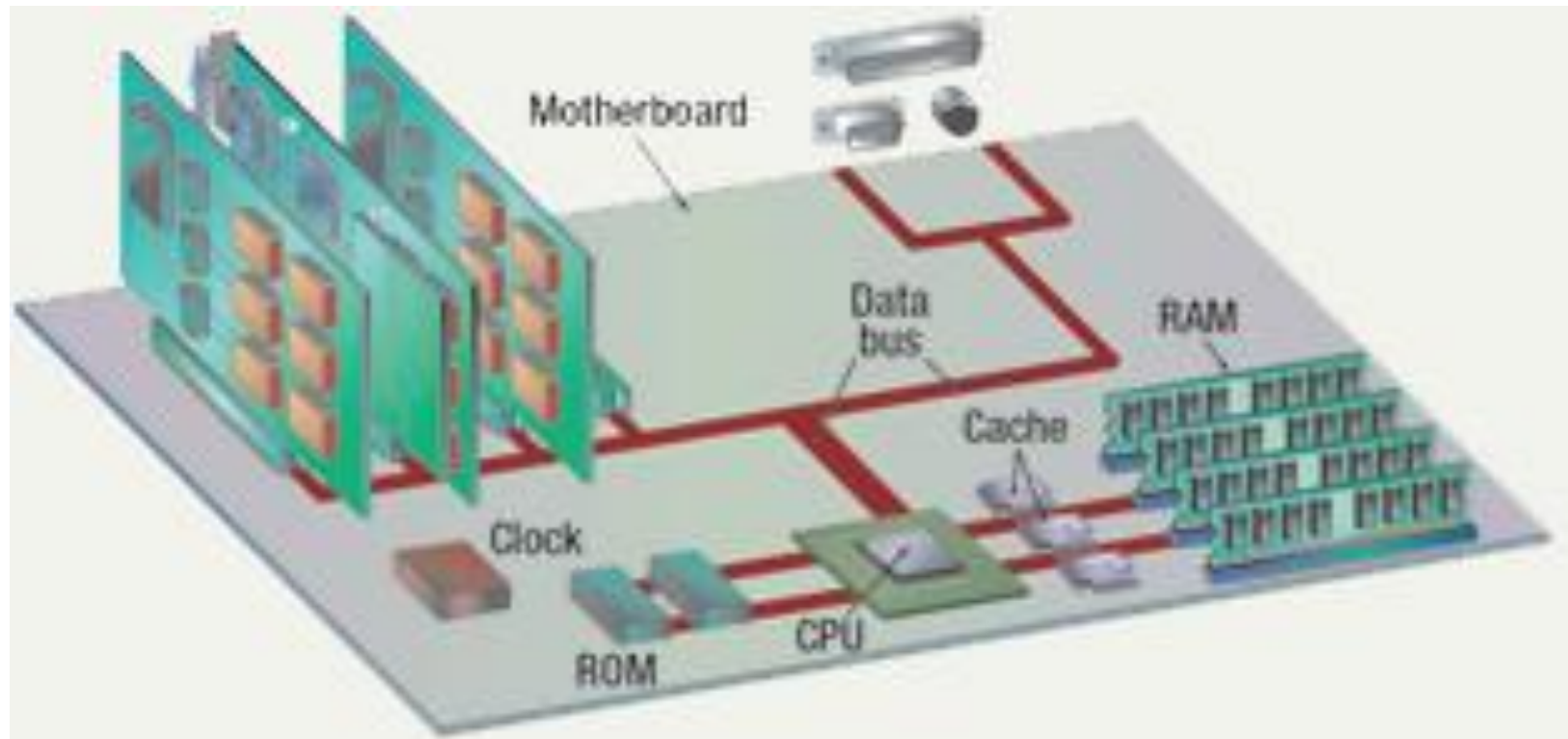
- ❑ Computer is out of actual RAM
- ❑ Another drive used to emulate RAM
- ❑ Computer swaps data to this virtual RAM
  - Least recently used data is moved



Source: [https://en.wikipedia.org/wiki/Virtual\\_memory](https://en.wikipedia.org/wiki/Virtual_memory)



# Components Affecting Speed (cont.)





# Components Affecting Speed (cont.)

- The computer's internal clock
  - ❑ Quartz crystal
    - Molecule vibrate at a fixed rate when electricity provided
    - Frequency determined by thickness of crystal
  - ❑ Every tick causes a cycle
    - Time for turning transistor off and back on again
  - ❑ Speeds measured in Hertz (Hz)
    - Modern machines use Giga Hertz (GHz)
  - ❑ Each instruction require a given number of clock cycles



# Components Affecting Speed (cont.)

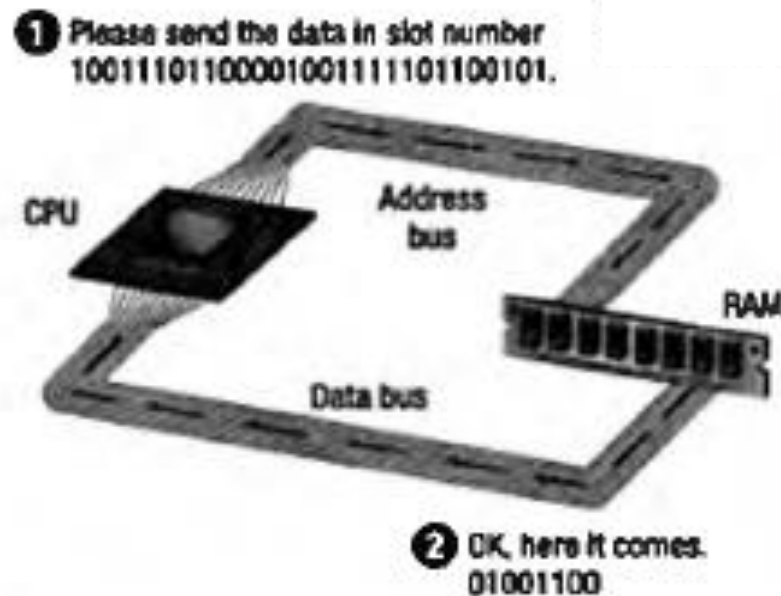
## ➤ The bus

- ❑ Electronic pathway between components
- ❑ Expansion bus connects to peripherals
- ❑ System bus connects CPU and RAM
  - Data bus
  - Address bus
- ❑ Bus width is measured in bits
- ❑ Speed is tied to the clock



# Components Affecting Speed (cont.)

- System bus operation and sizes
  - ❑ Data bus connects CPU, memory and hardware
  - ❑ Address bus connect only CPU and memory
    - Carries memory addresses





# Components Affecting Speed (cont.)

## ➤ Bus standards

- ☐ Industry Standard Architecture (ISA)
- ☐ Local bus
- ☐ Peripheral component interconnect (PCI)
- ☐ Accelerated graphics port (AGP)
- ☐ Universal serial bus (USB)
- ☐ IEEE 1394 (FireWire)
- ☐ PC Card





# Components Affecting Speed (cont.)

- Industry Standard Architecture (ISA) bus
  - ❑ 16-bit data bus
  - ❑ Widely used in 80's
  - ❑ Later on used for attaching slow devices
    - Modems
    - Input devices
    - Etc.
- Local bus
  - ❑ Used to attach fast devices
  - ❑ Runs between components on motherboard



# Components Affecting Speed (cont.)

- Peripheral control interface (PCI) bus
  - ❑ Connects video and sound cards to motherboard
    - Card can not access system memory directly
    - Card can only access its own memory
  - ❑ Found in most modern computers
- Accelerated Graphics Port (AGP) bus
  - ❑ Connects modern video cards to motherboard
    - Allows video card to access system memory directly
  - ❑ Extremely fast bus
    - 3-D support
- Universal Serial Bus (USB)
  - ❑ Connects external devices
  - ❑ Hot swappable
  - ❑ Allows up to 127 devices
    - Hub layout or daisy chain
  - ❑ For cameras, printers and scanners



Source: [https://www.reddit.com/r/raspberry\\_pi/comments/4upogl/question\\_daisy chaining\\_of\\_usb\\_for\\_up\\_to\\_10](https://www.reddit.com/r/raspberry_pi/comments/4upogl/question_daisy chaining_of_usb_for_up_to_10)



# Components Affecting Speed (cont.)

- IEEE 1394 (FireWire) bus
  - ❑ Connects cameras on Macintosh and IBM
- PC Card bus
  - ❑ Used on laptops
  - ❑ Hot swappable
  - ❑ Devices are the size of a credit card
  - ❑ Expansion of memory



Performance Specifications of Common Buses			
Bus Type	Width (bits)	Transfer Speed	Hot Swappable
AGP 8	32	2.1 GHz	No
FireWire	32	400 MHz	Yes
ISA	16	8.33 MHz	No
PC Card	32	33 MHz	Yes
PCI	32	33 MHz	No
USB 2.0	32	480 MHz	Yes



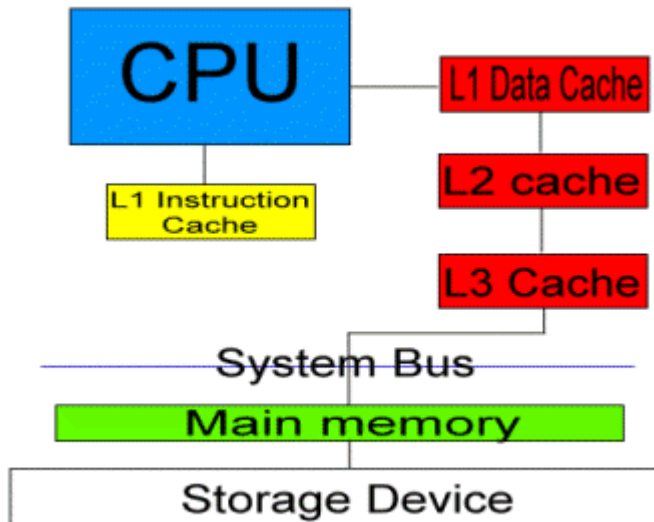
# Components Affecting Speed (cont.)

- Modern microprocessors process data in short time
  - ❑ However, quick access to data required
- If data not available, processor has to wait
  - ❑ Results in reduced performance
- Current processors process instruction in nanoseconds (ns)
- Time for fetching data from main memory is about 100 ns
  
- Solution???



# Components Affecting Speed (cont.)

- Make main memory faster
  - ❑ 1 ns memory extremely expensive
  - ❑ 100 ns memory widely used
- Add cache memory right next to microprocessor
  - ❑ Placed on the same chip
  - ❑ Frequently used data and instructions resides in cache
  - ❑ Also RAM type
  - ❑ Improves overall performance
    - Fast access to frequently-used data and instructions



Source: <http://www.pantherproducts.co.uk/index.php?pageid=cpucache>



# Components Affecting Speed (cont.)

## ➤ Cache memory

- ❑ Very fast memory
- ❑ Holds common or recently used data
- ❑ Speeds up computer processing
  - Moving data between CPU and RAM takes time as RAM is slow
  - CPU checks if data is in cache
- ❑ Most computers have several caches
  - L1 holds recently used data
  - L2 holds potential upcoming instructions
  - L3 holds possible upcoming instructions

