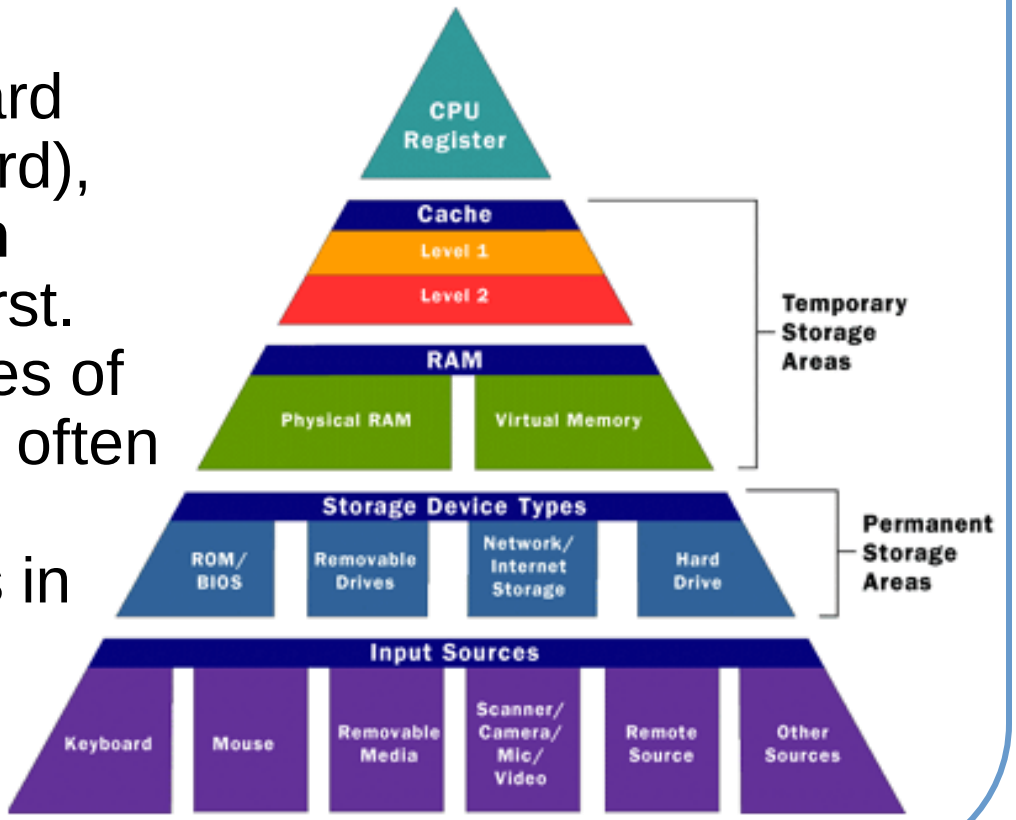
Memory

IT Essentials Chapter 1

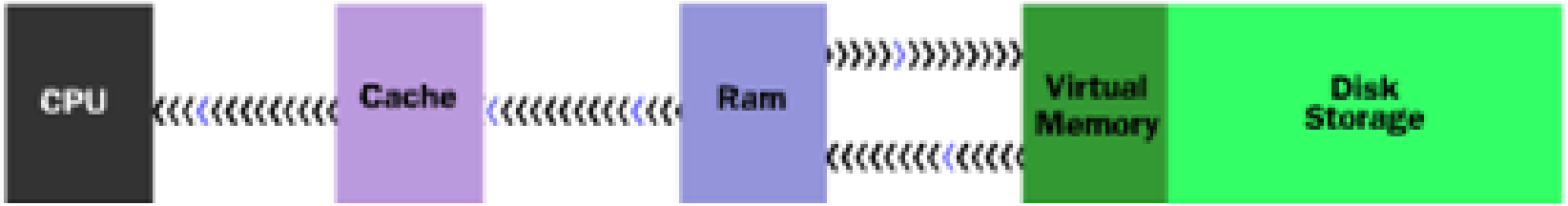
Memory Hierarchy

As you can see in the diagram, the CPU accesses memory according to a distinct hierarchy. Whether it comes from permanent storage (the hard drive) or input (the keyboard), most data goes in **random access memory** (RAM) first. The CPU then stores pieces of data it will need to access, often in a **cache**, and maintains certain special instructions in the **register**.



Memory Systems

- A typical computer has:
  - Level 1 and Level 2 caches
  - Normal system RAM
  - Virtual memory
  - A hard disk



Types of Memory

- ROM - Read Only Memory
  - CMOS
- RAM – Random Access Memory
- Cache

Types of ROM

- **ROM** stands for Read Only Memory. It is used to hold a computers POST, BootStrap, and BIOS programs.
- **PROM** stands for Programmable Read Only Memory. PROM is manufactured as blank memory so Information is written to a PROM chip after it is manufactured.. A PROM chip cannot be erased or re-written.
- **EPROM** stands for Erasable Programmable Read Only Memory. It can be discharged by applying ultraviolet light to the chip's surface through a quartz window in the package, erasing the memory contents and allowing the chip to be reprogrammed.
- **EEPROM** stands for Electrically Erasable Programmable Read Only Memory or Flash ROM. It allows the ROM BIOS to be upgraded without changing the ROM chip. Uses an electrical charge (usually 12 to 25 volts) to erase its contents and allow to be reprogrammed. Typical on most modern computers and is accessed by changing a jumper.

ROM BIOS

- ROM BIOS, more commonly called Firmware, supports different feature sets depending on the manufacturer of the chip. It can be upgraded by using a process called flashing.

Company	URL
American Megatrends, Inc. (AMI)	*www.megatrends.com* or *www.ami.com*
Phoenix Technologies (First BIOS, Phoenix, and Award)	*www.phoenix.com*
Compaq and Hewlett-Packard	*thenew.hp.com*
Dell	*www.dell.com*
IBM	*www.ibm.com*
Micro Firmware (BIOS upgrades)	*www.firmware.com*
Unicore (BIOS upgrades)	*www.unicore.com*

How to Access CMOS Setup

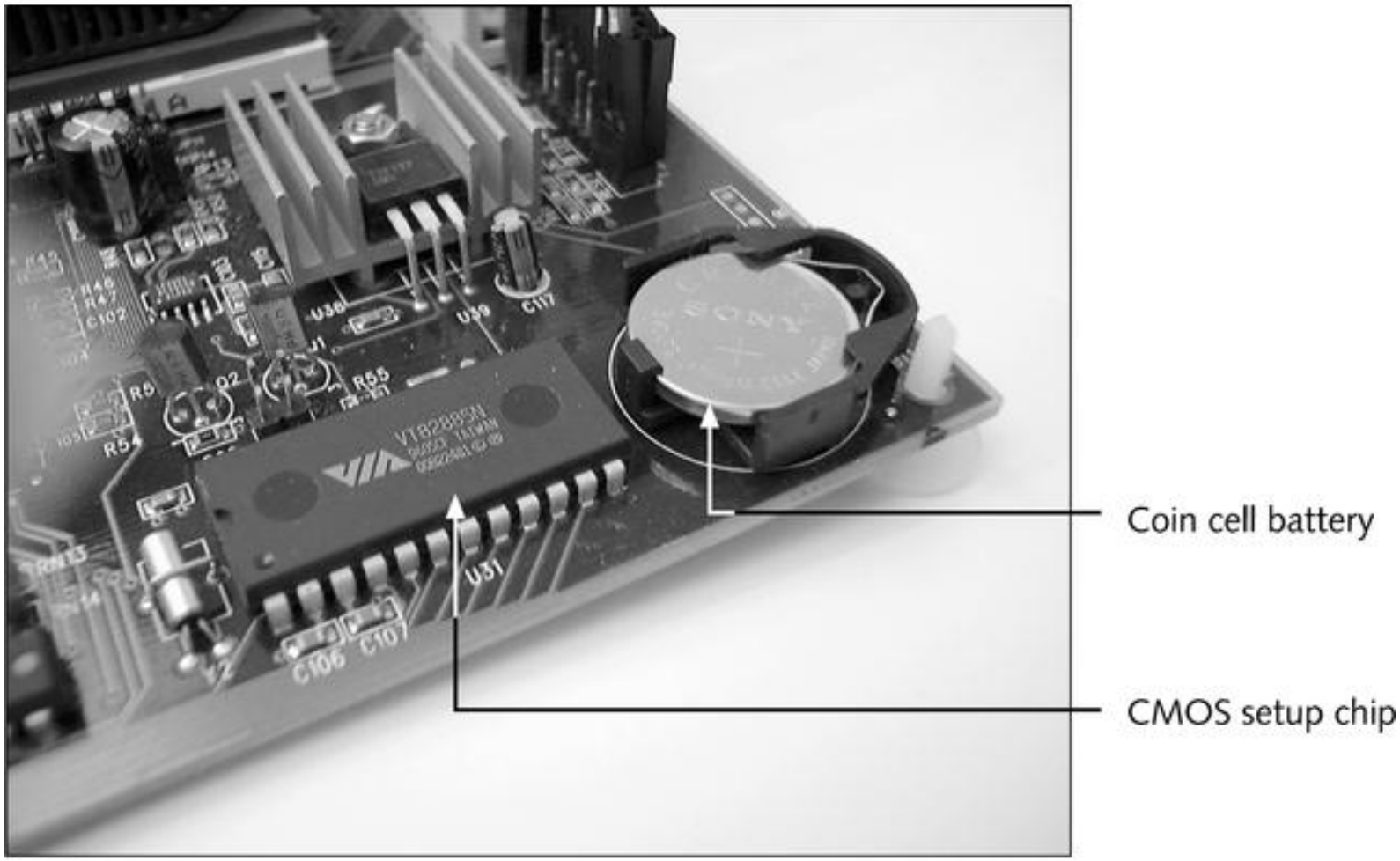
CMOS stands for Complementary Metal-Oxide Semiconductor. It is used to hold the computers BIOS settings. Power is supplied by a small battery.

BIOS	Key to Press During POST to Access Setup
AMI BIOS	Del
Award BIOS	Del
Older Phoenix BIOS	Ctrl+Alt+Esc or Ctl+Alt+s
Newer Phoenix BIOS	F2 or F1
Dell computers using Phoenix BIOS	Ctrl+Alt+Enter
Older Compaq computer such as the Deskpro 286 or 386	Place the diagnostics disk in the disk drive, reboot your system, and choose Computer Setup from the menu.
Newer Compaq computers such as the ProLinea, Deskpro, Deskpro XL, Deskpro XE, or Presario	Press the F10 key while the cursor is in the upper-right corner of the screen, which happens just after the two beeps during booting.*
All other older computers	Use a setup program on the disk that came with the PC to access setup.

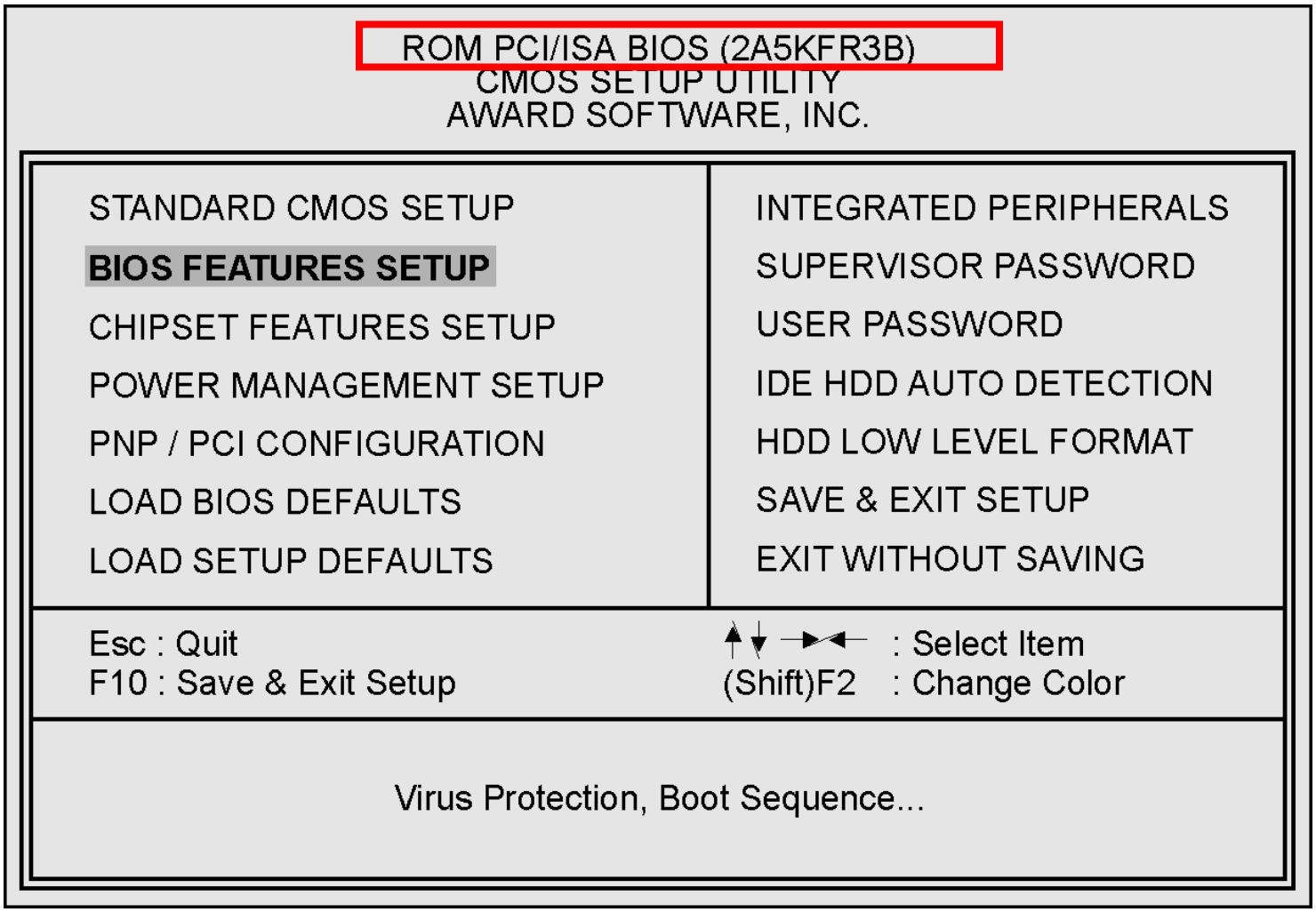
CMOS

- The purpose of CMOS and what are its basic parameters:
  - date/time
  - boot sequence
  - passwords
  - memory - parity, non-parity
  - printer parallel port - Uni., bi-directional, disable/enable, ECP, EPP
  - COM/serial port- memory address, interrupt request, disable
  - hard drive - size and drive type
  - floppy drive - enable/disable drive or boot, speed, density

Coin-Cell CMOS Battery



CMOS Main Menu Screen



Protecting Documentation and Configuration Settings

- Keep well-labeled, written record of:
  - All changes you make to CMOS
  - Records of hardware and software installed
  - Network settings
- Keep documentation up to date and in a safe place
- Document before you flash or replace the BIOS chip.

RAM

- Stands for Random Access Memory
- It is volatile in nature
  - Loses its contents if the power is turned off
- Holds data and programs the CPU is using
- Main memory for the computer
- Can be shared with other devices, such as video

Amount of RAM

- Measured in MegaBytes (MB)
- The general rule of thumb is to install as much RAM as you can afford
- Upgrading RAM can speed up a slow system (to a point)

Minimum Amounts of RAM

OS	Minimum	Recommended	Best Performance
DOS 6.2	640 KB	640 KB	-
Windows 3.x	1 MB	1 MB	-
Windows 95	8 MB	8 MB	-
Windows 98	16 MB	32 MB	64 MB
Windows 2000	64 MB	96 MB	128 MB
Windows XP	64 MB	128 MB	256MB
Windows Vista	512 MB	1 GB	2 GB
Windows 7	512 MB	1 GB	2 GB

System RAM

- System RAM speed is controlled by **bus width** and **bus speed**.
- Bus width refers to the number of bits that can be sent to the CPU simultaneously.
- Bus speed refers to the number of times a group of bits can be sent each second.
- For example, a 100-MHz 32-bit bus is theoretically capable of sending 4 bytes (32 bits divided by 8 = 4 bytes) of data to the CPU 100 million times per second.

RAM Terminology includes:

- FPM RAM (Fast Page Mode RAM)
- EDO RAM (Extended Data Output RAM)
- DRAM (Dynamic RAM)
- SRAM (Static RAM)
- VRAM (Video RAM)
- WRAM (Windows Accelerator Card RAM)
- RAMDAC (RAM Digital to Analog Converter)

Shadowing

- Shadowing is copying ROM BIOS information into the Reserved Memory area of RAM for faster execution.

Types of RAM

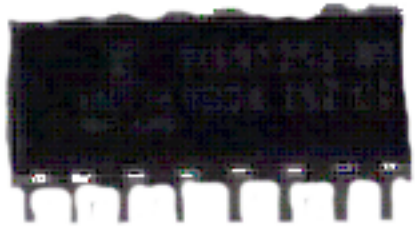
- DRAM
  - Dynamic Random Access Memory
  - Uses capacitors
  - Small and affordable, but slower than SRAM
- SRAM
  - Static Random Access Memory
  - Uses transistors
  - Large and expensive, but fast
  - Commonly used as cache

Drawbacks of DRAM

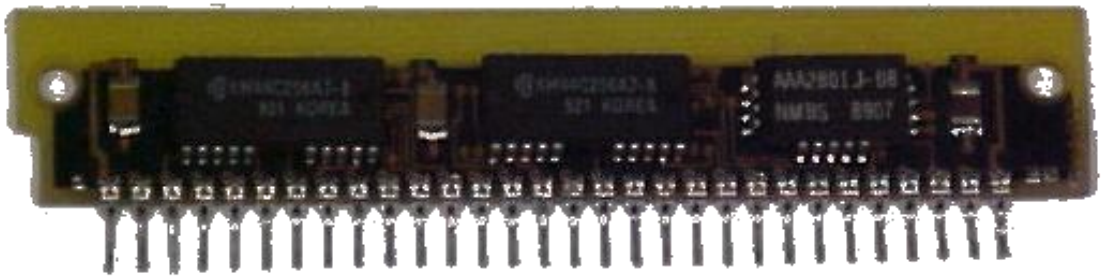
- The small capacitors need constant power to keep them from fading
- This process of charging is called *Refresh*
- Most DRAM needs to be refreshed every 2 ms

DRAM Types

- Started with DIP (Dual Inline Pin) socket types
  - Small amount of memory (>1MB)



- Next advancement was SIPP (Single Inline Pin Package)
  - Extinct because the pins were easy to bend and break

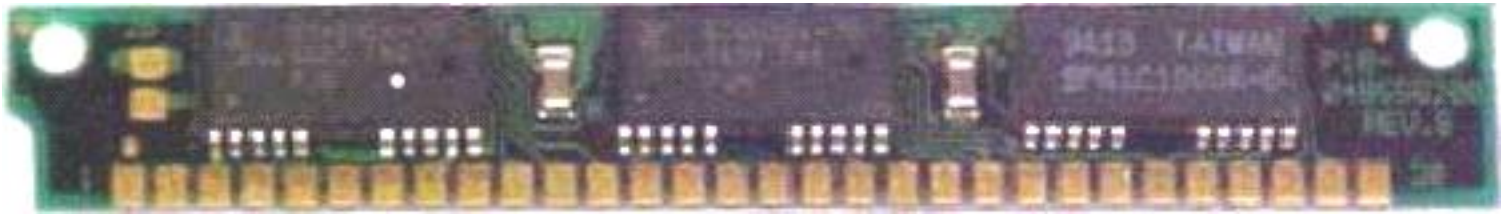


DRAM Types

- Changed styles to a SIMM (Single Inline Memory Module)
  - Small amounts of DIP chips on a single board
  - Used with 80286 – 80486 CPU's
  - Two different styles – 30 pin and 72 pin

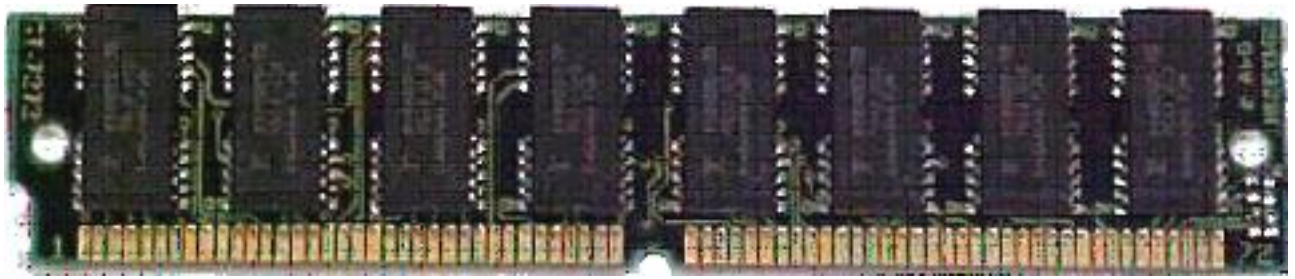
30 Pin SIMM

- Has contacts on both sides of the module
- Only contacts one side
- Used in later 80286 and 80386 CPU's
- 16 bit data bus



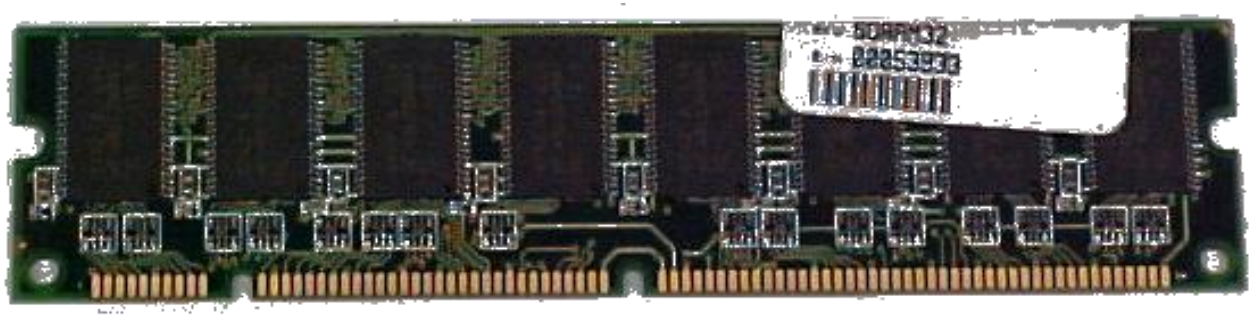
72 Pin SIMM

- Has contacts on both sides of the module
- Only contacts one side
- Notch in the middle of the chip
- Used in later 80386 and 80486 CPU's
- 32 bit data bus



DIMM or SDRAM

- Next DRAM was the DIMM (Dual Inline Memory Module)
  - 168 pins long (84 contacts per side)
  - Also called **SDRAM** (Synchronous DRAM)
  - Runs at the same speed as the processor
  - 64 bit data bus
  - +3.3v



DDR

- Next DRAM was the DDR-SDRAM (Double Data Rate Synchronous DRAM)
  - 184 pins
  - Twice as fast as SDRAM
  - Will not interchange with SDRAM
  - 64 bit data bus

DDR

Standard name	Memory clock	Time between signals	I/O Bus clock	Data transfers per second	Module name	Peak transfer rate
DDR-200	100 MHz	10 ns	100 MHz	200 Million	PC-1600	1.600 GB/s
DDR-266	133 MHz	7.5 ns	133 MHz	266 Million	PC-2100	2.133 GB/s
DDR-333	166 MHz	6 ns	166 MHz	333 Million	PC-2700	2.667 GB/s
DDR-400	200 MHz	5 ns	200 MHz	400 Million	PC-3200	3.200 GB/s

DDR2

- Next DRAM was the DDR2
  - Faster than DDR-SDRAM memory
  - Improves performance by decreasing noise and crosstalk between the signal wires
  - 240 pins

DDR2

Standard name	Memory clock	Time between signals	I/O Bus clock	Data transfers per second	Module name	Peak transfer rate
DDR2-400	100 MHz	10 ns	200 MHz	400 Million	PC2-3200	3.200 GB/s
DDR2-533	133 MHz	7.5 ns	266 MHz	533 Million	PC2-4200	4.264 GB/s
DDR2-667	166 MHz	6 ns	333 MHz	667 Million	PC2-5400	5.336 GB/s
DDR2-800	200 MHz	5 ns	400 MHz	800 Million	PC2-6400	6.400 GB/s
DDR2-1066 (planned)	266 MHz	3.75 ns	533 MHz	1066 Million	PC2-8500 (planned)	8.500 GB/s

DDR3

- Higher bandwidth performance increase (up to effective 1600 MHz)
- Performance increase at low power (+3.3v)
- Improved thermal design (cooler)
- Modules up to 16 GB
- 240 pins

DDR3

Standard name	Memory clock	Time between signals	I/O Bus clock	Data transfers per second	Module name	Peak transfer rate
DDR3-800	100 MHz	10 ns	400 MHz	800 Million	PC3-6400	6.40 GB/s
DDR3-1066	133 MHz	7.5 ns	533 MHz	1.066 Billion	PC3-8500	8.53 GB/s
DDR3-1333	166 MHz	6 ns	667 MHz	1.333 Billion	PC3-10600	10.67 GB/s[
DDR3-1600	200 MHz	5 ns	800 MHz	1.6 Billion	PC3-12800	12.80 GB/s

RAMBUS

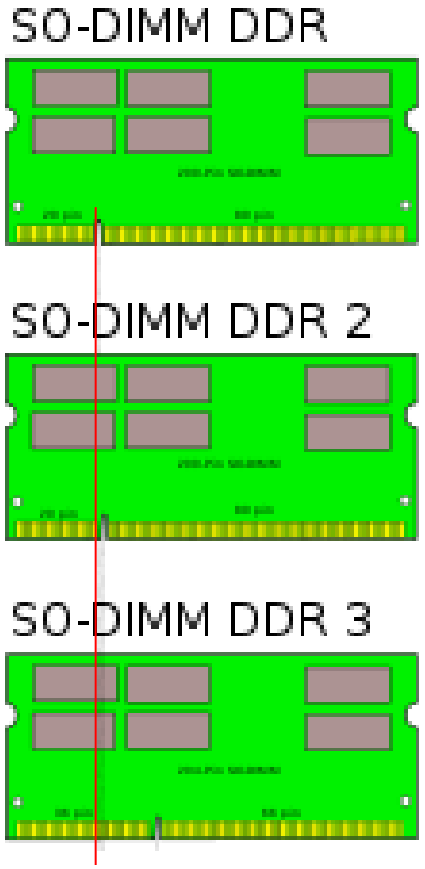
- Rambus
  - Also called RDRAM and RIMM
  - Runs up to 800 MHz
  - All memory slots on the motherboard must be filled
  - Unused slots must have continuity modules installed
  - New version called nDRAM will run at 1600 MHz.
  - 16 bit data bus

SO-DIMM

- A SO-DIMM, or small outline dual in-line memory module, is a smaller alternative to a DIMM, being roughly half the size of regular DIMMs.
- SO-DIMMs are often used in systems which have space restrictions such as notebooks, small footprint PCs (such as those with a Mini-ITX motherboard), high-end upgradable office printers, and networking hardware like routers.

SO-DIMM

- Most types of SO-DIMMs can be recognized at a glance by the distinctive notches used to “key” them for different applications:
  - 100-pin SO-DIMMs have two notches,
  - 144-pin SO-DIMMs have a single notch near (but not at) the center, and
  - 200-pin SO-DIMMs (DDR & DDR2) have a single notch nearer to one side. The exact location of this notch varies
  - 204-pin SO-DIMMs for DDR3



Installation of DRAM

Type of DRAM	Amount Required
30 pin SIMM's (16 bits)	4 to a set
72 pin SIMM's (32 bits)	2 to a set
168 pin DIMM's (64 bits)	Single modules
184 pin DDR (64 bits)	Single modules
Rambus (16 bits)	All slots filled

Remember that it takes two 32-bit SIMM modules to make a bank for a 64-bit data bus such as the Pentium.

Installation of DRAM

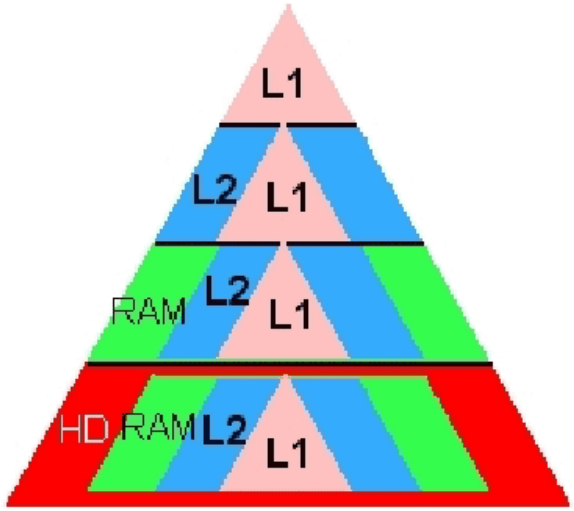
- Install DRAM starting from Bank 0-Slot 0.
- Some motherboards have a combination of socket types. You can only use one type.
- Largest chips in the first bank/slot.
- Slowest chips in the first bank/slot.

Error Checking

- Memory errors occur when the data is not stored correctly in the RAM chips. The computer uses different methods to detect and correct data errors in memory. Three different methods of memory error checking are:
  - **Nonparity:** Nonparity memory does not check for errors in memory.
  - **Parity:** Parity memory contains eight bits for data and one bit for error checking. The error-checking bit is called a parity bit.
  - **ECC:** Error Correction Code memory can detect multiple bit errors in memory and correct single bit errors in memory.

Cache

- **Caching** is a technology based on the memory subsystem of your computer. The main purpose of a cache is to accelerate your computer. Caching allows you to perform computer tasks more rapidly.
- The idea behind caching is to use a small amount of expensive memory to speed up a large amount of slower, less-expensive memory. Without L1 and L2 caches, an access to the main memory takes 60 nanoseconds, or about 30 wasted cycles accessing memory.



Cache Subsystems

- Cache can also be built directly on **peripherals**. Modern hard disks come with fast memory. The computer doesn't directly use this memory -- the hard-disk controller does. When the computer asks for data from the hard disk, the hard-disk controller checks into this memory before moving the mechanical parts of the hard disk. If it finds the data that the computer asked for in the cache, it will return the data stored in the cache without actually accessing data on the disk itself, saving a lot of time.

L1 Cache

- The fastest memory and smallest size
- Used to store frequently used information that the CPU needs
- Part of the CPU chip
- Uses SRAM technology
- Memory accesses at full microprocessor speed (10 nanoseconds, 4 kilobytes to 16 kilobytes in size)

L2 Cache

- Next fastest memory
- Used to store frequently used information that cannot be held in L1 cache
- On the CPU board (Pentium Pro and up)
- On the motherboard
- Uses SRAM technology

L3 Cache

- Used to store frequently used information that cannot be held in L1 or L2 cache
- Built into motherboards between the microprocessor and the main memory. Becoming standard on new CPUs.
- Uses SRAM technology

Intel i7 Processor Design

Standard Cache Sizes

Processor	Level 1	Level 2	Level 3
Pentium	16KB	0KB	-
Pentium MMX	32KB	0KB	-
Pentium Pro	16KB	256KB	-
Pentium 2	32KB	512KB	-
Celeron	32KB	0KB	-
Pentium 3	32KB	512KB	-
Pentium 4	20KB	256-1MB	-
Core 2	20KB	2-6MB	-
Pentium Xeon MP	64KB	512-16MB	1MB
Itanium	256KB	2-24MB	4MB
i7	64KB	256KB	8MB

Smart Cache