

Chapter Four

Memory

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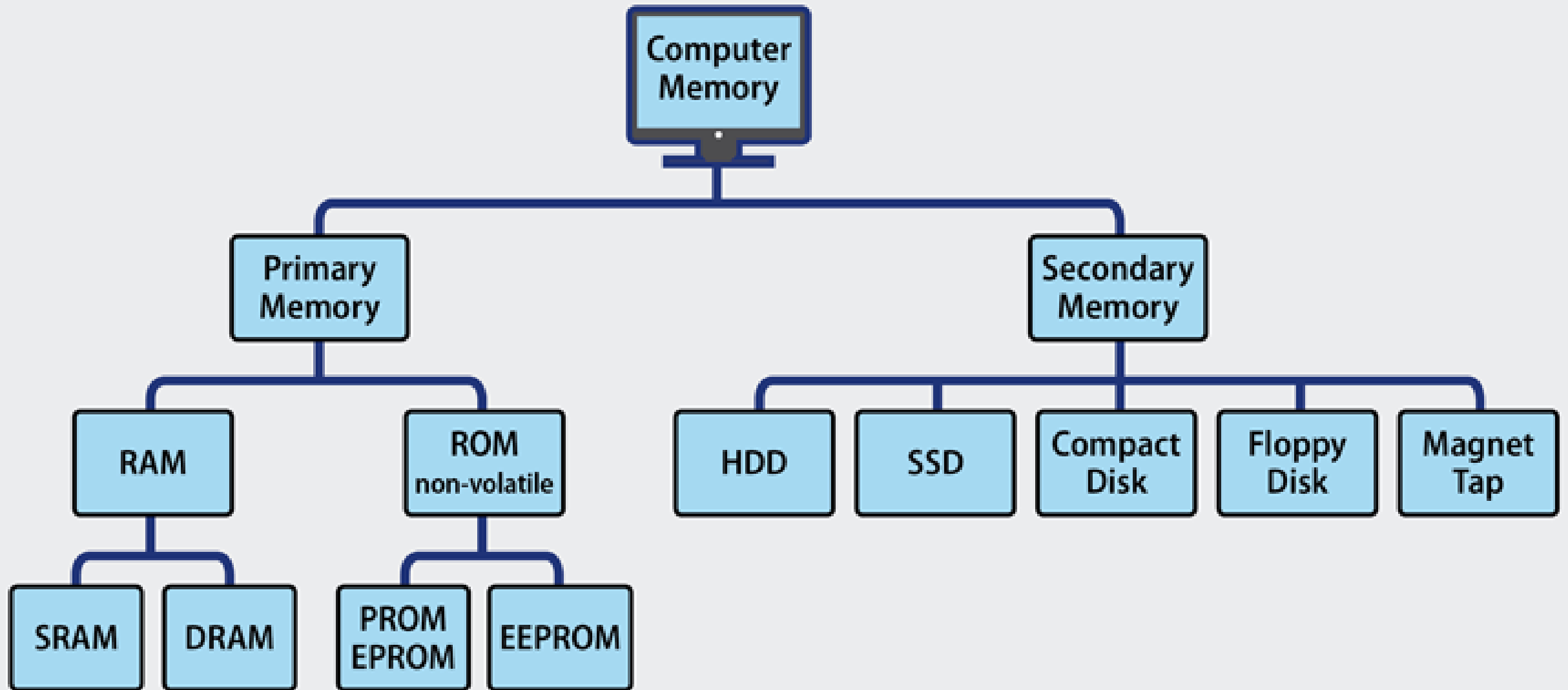
Computer Memory

Overview

- ▶ The term **memory** refers to anything that stores information either **permanently** or **temporarily**.
- ▶ You have **documents** and **applications** stored on the **hard drive**. When you want to work on these documents, you open them and place them in the computer's work area. The work area for a computer is **system memory**. When you want to work with any application or document, the computer must retrieve that information from the hard drive and execute it from **memory**.

Types of Memory

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Read-Only Memory (ROM)

- ▶ Is a type of memory that you cannot write to.
- ▶ Information is written to ROM chips by the manufacturer, and this information **cannot be changed**.
- ▶ Software written to a **ROM** chip is called **firmware**.
- ▶ One of the major uses for **ROM** is storing the system **BIOS** (*Basic Input-Output System*), which contains **Power-On Self-Test (POST)** routines and other routines that initiate the loading of the operating system. The BIOS also contains the low-level code that allows the system to communicate with hardware devices.

Types of ROM

- ▶ **Erasable Programmable Read-Only Memory (EPROM)** is a special **ROM** chip that the manufacturer can reprogram by using a special programming device that uses **ultraviolet light**.
- ▶ **Electrically Erasable Programmable ROM (EEPROM), or flash ROM**. The manufacturer writes the software instructions into the ROM chip, but it can be updated by running a special software setup program provided by the **manufacturer**. The software setup program is usually provided at the manufacturer's Web site.

Random Access Memory (RAM)

- ▶ **RAM** is probably the more fundamental. **ROM** is permanent memory, or permanent storage of information.
- ▶ As the computer's primary working memory, **RAM (Random Access Memory)** stores information temporarily.
- ▶ **RAM** is volatile, meaning that it needs constant electrical current to maintain the information that resides in its chips. If the electrical current is lost, the contents of **RAM** are erased. When the computer is powered off, all the contents of **RAM** are flushed out.

Types of RAM

RAM can be categorized into two major parts: **DRAM** and **SRAM**.

- ▶ **Dynamic RAM (DRAM)** is probably the most popular type of memory today and the one that you are most often going to upgrade. **Dynamic RAM** gets its name from the fact that the information stored in DRAM needs to be constantly refreshed. Refreshing involves reading the bits of data stored in DRAM and then rewriting the same information back.
- ▶ **DRAM** is single ported — meaning that both reading and writing are possible on the memory but not at the same time.

- ▶ Older implementations of RAM measured the memory's performance based on the time it took the CPU to access that data. The measurement used to determine the speed of memory is **nanoseconds (ns)**.

E.g. If Memory1=50 ns and Memory2=70 ns, then _____ faster.

- ▶ The lower the number of nanoseconds, the better the performance. The speed of older DRAM ranges from **60 ns to 80 ns**.
- ▶ Today's implementations of DRAM measure the speed of memory in **megahertz (MHz)** — typically matching the motherboard speed. For example, Mr. X Pentium-II system uses 100 MHz memory because it runs on a 100 MHz motherboard.

- ▶ **Static RAM (SRAM)** — so-called because the information held in its memory cells doesn't need to be refreshed — requires less overhead than DRAM to maintain the information stored in memory.
- ▶ With speeds running from **10 ns to 20 ns**, SRAM is much faster than DRAM.
- ▶ Because SRAM is faster memory than DRAM it is also more expensive, which is why people add DRAM to their systems more often than they add SRAM.
- ▶ SRAM is typically used for **cache memory**.
- ▶ Because cache memory is faster than DRAM, retrieving information from cache means that the processor does not have to wait for the slower DRAM, thus enhancing system performance.

Types of DRAM

Standard DRAM

- ▶ **Memory** is organized into **rows and columns**, like a spreadsheet. The information is stored in the different cells, or blocks, that are created by the intersection of these rows and columns. With *standard DRAM*, the CPU requests data by sending the address of the row and the address of the column for every block of data that needs to be read to the memory controller. The memory controller then fetches the information from that memory location.
- ▶ *Figure 4-1 shows two memory cells that hold data that the CPU wants to have.*

	0	1	2	3	4	5
0						
1						
2						
3						
4						

The CPU follows these basic steps to request information from standard DRAM:

1. In the first clock cycle, it sends the row address (1).
2. In the second clock cycle, it sends the column address (2).
3. On the third clock cycle, the memory controller reads the information (Address 1-2).
4. In the fourth clock cycle, the row address for the second memory cell is given (1).
5. In the fifth clock cycle, the column address for the second memory cell is given (4).
6. In the sixth clock cycle, the second memory cell is read (Address 1-4).

Fast page mode

- ▶ **Fast Page Mode (FPM)** improves the performance of standard DRAM by not requiring a row address for each request to memory, assuming that the next block of data is on the same row (which in most cases will be true).
- ▶ The following list outlines the basic steps to access the same two blocks of data shown in Figure 4-1 via fast page mode memory:

1. In the first clock cycle, the CPU sends the row address (1).
2. In the second clock cycle, it sends the column address (2).
3. On the third clock cycle, the memory controller reads the information (Address 1-2).
4. In the fourth clock cycle, the column address is given (4).
5. In the fifth clock cycle, the second cell address is read (Address 1-4).

You can see in this example that it takes less time to read both blocks of data from memory with fast page mode DRAM. Therefore, FPM memory is a faster DRAM memory type than standard.

Synchronous DRAM

- ▶ **Synchronous DRAM (SDRAM)** is memory synchronized to the system board speed. This synchronized speed means that the data stored in memory is refreshed at the system speed, and data is accessed in memory at the system speed as well.
- ▶ **SDRAM** is one of the most popular types of DRAM found in later Pentium systems, such as the Pentium II. When you upgrade memory on your system, if you determine that you need SDRAM, you will then need to determine what speed SDRAM. Because you are running at the system speed, you must match the DRAM speed with the motherboard speed. Thus, if you have a 100 MHz motherboard, you need 100 MHz SDRAM. If you have a 133 MHz motherboard, you need 133 MHz SDRAM.

Rambus DRAM

- ▶ At the time that SDRAM was popular, there was a high-speed flavor of DRAM on the market called **Rambus DRAM (RDRAM)**, which runs at speeds around 800 MHz.
- ▶ The **RDRAM** chips have a 16-bit internal bus width and are packaged together in a 184-pin, gold-plated memory module called a **Rambus Inline Memory Module (RIMM)**.
- ▶ In order to take advantage of this type of memory, you need a motherboard and chipset that support **RDRAM**.

DDR

- ▶ **DDR SDRAM** is a stack of acronyms. **Double Data Rate (DDR) Synchronous Dynamic Random Access Memory (SDRAM)** is a common type of memory used as RAM for most every modern processor.
- ▶ It is the advance version of **SDRAM** (Synchronous Dynamic Random-Access Memory).

- ▶ **Double Data Rate (DDR) memory** gets its name from the fact that it can transfer data twice during each clock cycle, whereas SDRAM can transfer data only once per clock cycle. **DDR memory** chips in 184-pin DIMM modules for desktop computers and 200-pin **SO-DIMMs** for laptop systems.
- ▶ The speed of DDR memory is measured in MHz, like SDRAM is, and is labeled to indicate the speed. The labeling of DDR memory may look obscure at first because it also indicates the bandwidth by taking the speed and multiplying it by 8 bytes of data (64 bits).

- ▶ So if DDR memory is labeled PC1600, that label breaks down like this:
- ▶ If you divide the 1600 by 8 bytes, you get the speed of the memory; in this case, you're looking at 200 MHz memory. PC2700 runs at 338 MHz, while PC3200 runs at 400MHz. When you upgrade memory on systems that require DDR memory, you need to know the speed of the DDR memory.

DDR2

- ▶ **DDR2** memory runs at speeds 400 MHz and higher, which is where DDR memory left off. DDR2 memory uses 240-pin memory modules and runs at 1.8 volts (as opposed to 2.5 volts for DDR memory). This results in less power consumption for more memory — which is great for laptop users. Popular modules of DDR2 memory are PC3200 (400 MHz), PC4200 (525 MHz).
- ▶ Voltage - 1.8 to 1.55 Volt
- ▶ Bus clock rate - 200 to 533 MHz
- ▶ Transfer rate - 400 to 1066 MT/s

DDR3 SDRAM

- ▶ **DDR3** RAM also transfers data twice at the same time. But DDR3, is capable of transferring data faster than DDR2 and DDR1.
- ▶ It is upgrade version of DDR2.
 - ▶ Voltage - 1.5 to 1.35 Volt
 - ▶ Clock rate - 400 to 1066 MHz
 - ▶ Transfer rate - 800 to 2133 MT/s

DDR4 SDRAM

- ▶ **DDR4** RAM also transfers data twice at the same time with high bandwidth. But DDR4, is more capable of transferring data faster than DDR1, DDR2 and DDR3.
- ▶ It is upgrade version of DDR3.
 - ▶ Voltage - 1.2 Volt
 - ▶ Clock rate - 800 to 1600 MHz
 - ▶ The minimum transfer rate of 2133 MT/s

DDR5 SDRAM

- ▶ **DDR5** RAM also transfers data twice at the same time with high bandwidth.
- ▶ DDR5 was planned to reduce power consumption, while doubling bandwidth.
- ▶ It is upgrade version of DDR4.
 - ▶ Voltage - 1.1 Volt
 - ▶ Clock rate - 1600 to 3200 MHz
 - ▶ Transfer rate - 5 giga transfers/second

Memory Packaging

- ▶ **Single Inline Memory Modules (SIMMs)** used to be one of the most popular types of memory modules, but they have been replaced by DIMMs in recent years.
- ▶ **SIMMs** come in two flavors, 30-pin and 72-pin, which describe the number of connectors that make contact with the motherboard. Before buying a SIMM to install in a computer, review the documentation for the computer or look at the system board to determine what size SIMM module you need.

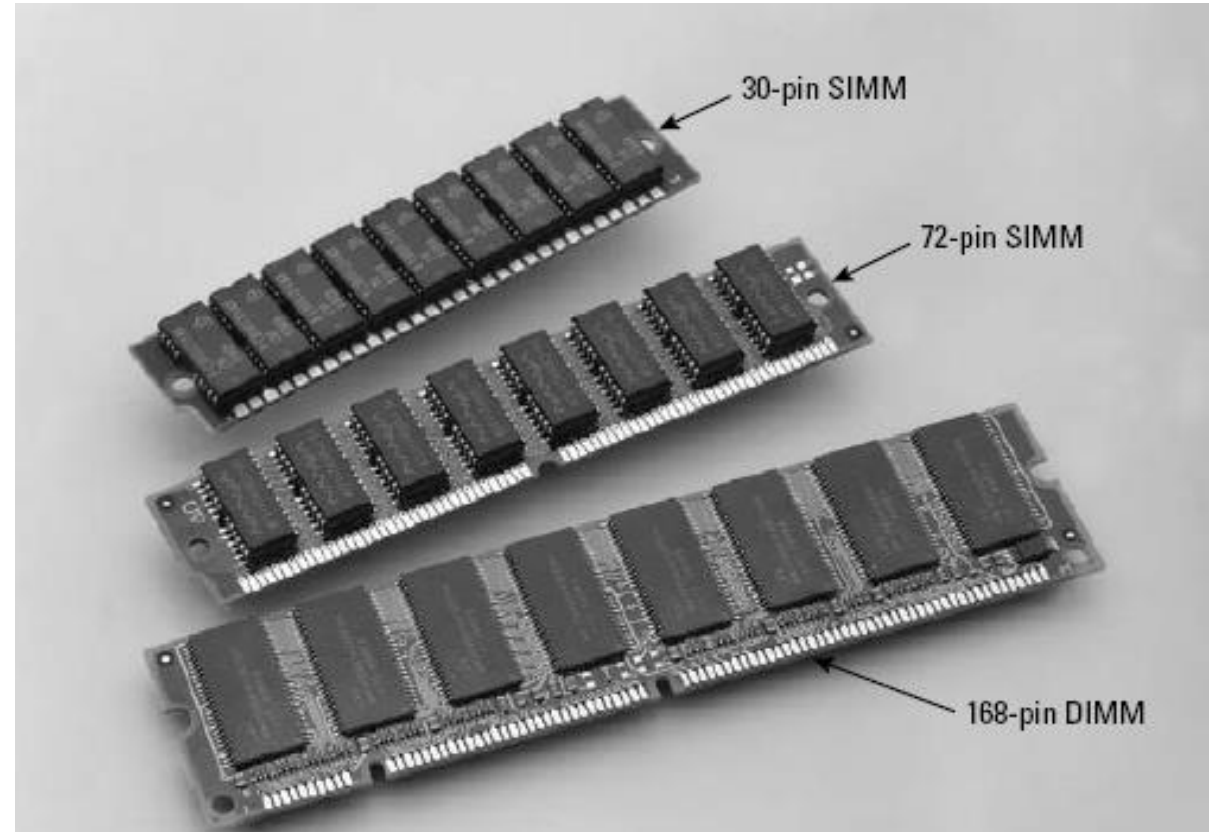
- ▶ The 30-pin SIMMs have an 8-bit data path, meaning they supply information in 8-bit blocks. When installing memory into a system, you *must* install enough SIMMs to fill a memory bank. **A memory bank** is the number of SIMMs it takes to fill the data path of the processor.
- ▶ For example, if you have a system with a **486 processor**, the processor is a **32-bit processor**. Therefore, the processor wants to deal with information in 32-bit chunks. When using 30-pin SIMMs, you need to install four of them at a time to fill a memory bank because each 30-pin SIMM only supplies 8 bits of data (8 bits X4 SIMMs = 32-bit chunks).

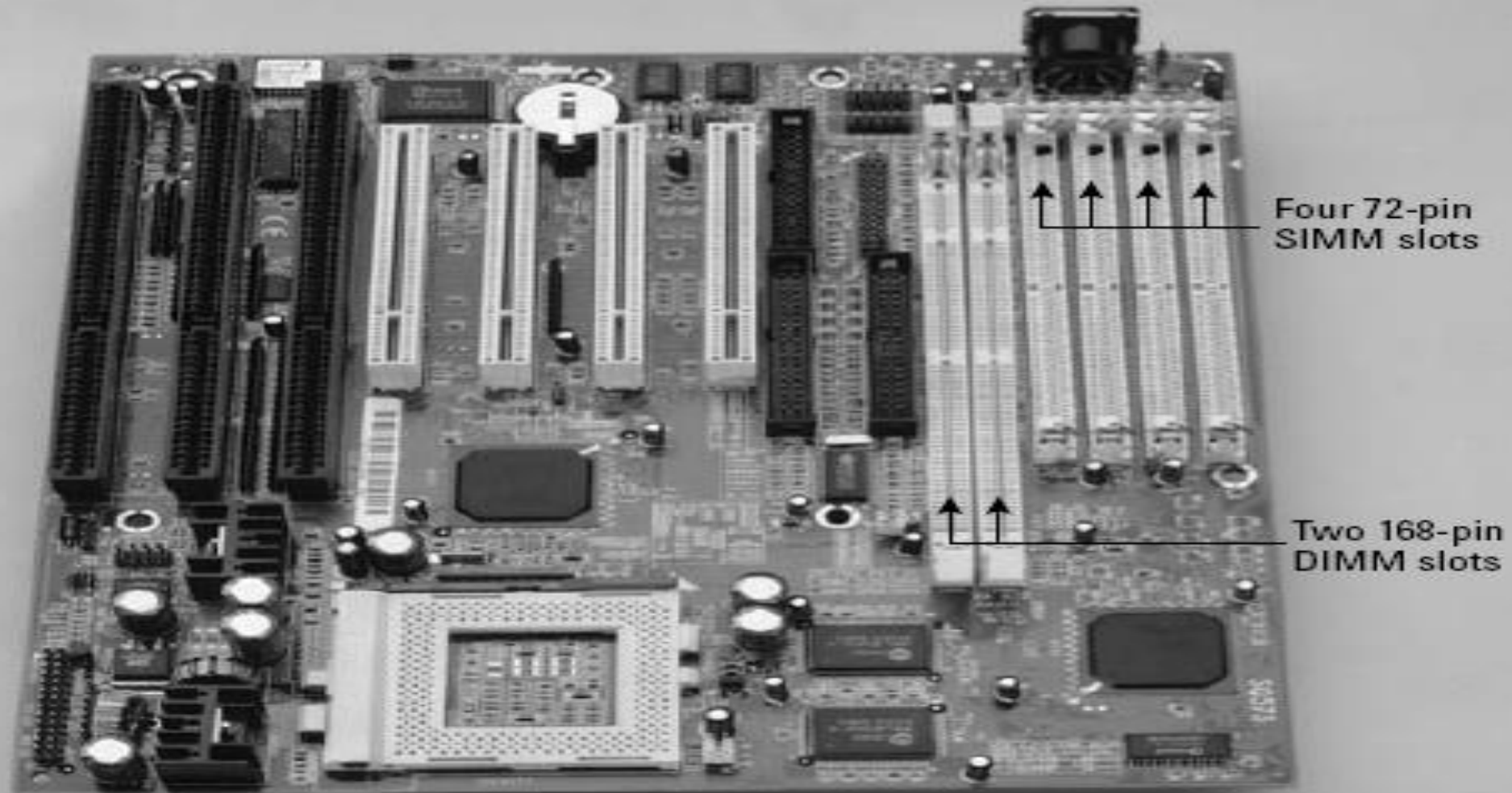
- The 72-pin SIMMs supply information in 32-bit chunks. Therefore, if you are installing 72-pin SIMMs on a system using a 32-bit 486 chip, you need just one SIMM to fill a memory bank and the data path. If you're installing 72-pin SIMMs in a Pentium system, you must install SIMMs in pairs because the Pentium data path is 64-bit; to fill a bank on these systems, you need two 32-bit modules (72-pin SIMMs).

Dual Inline Memory Modules (DIMMs)

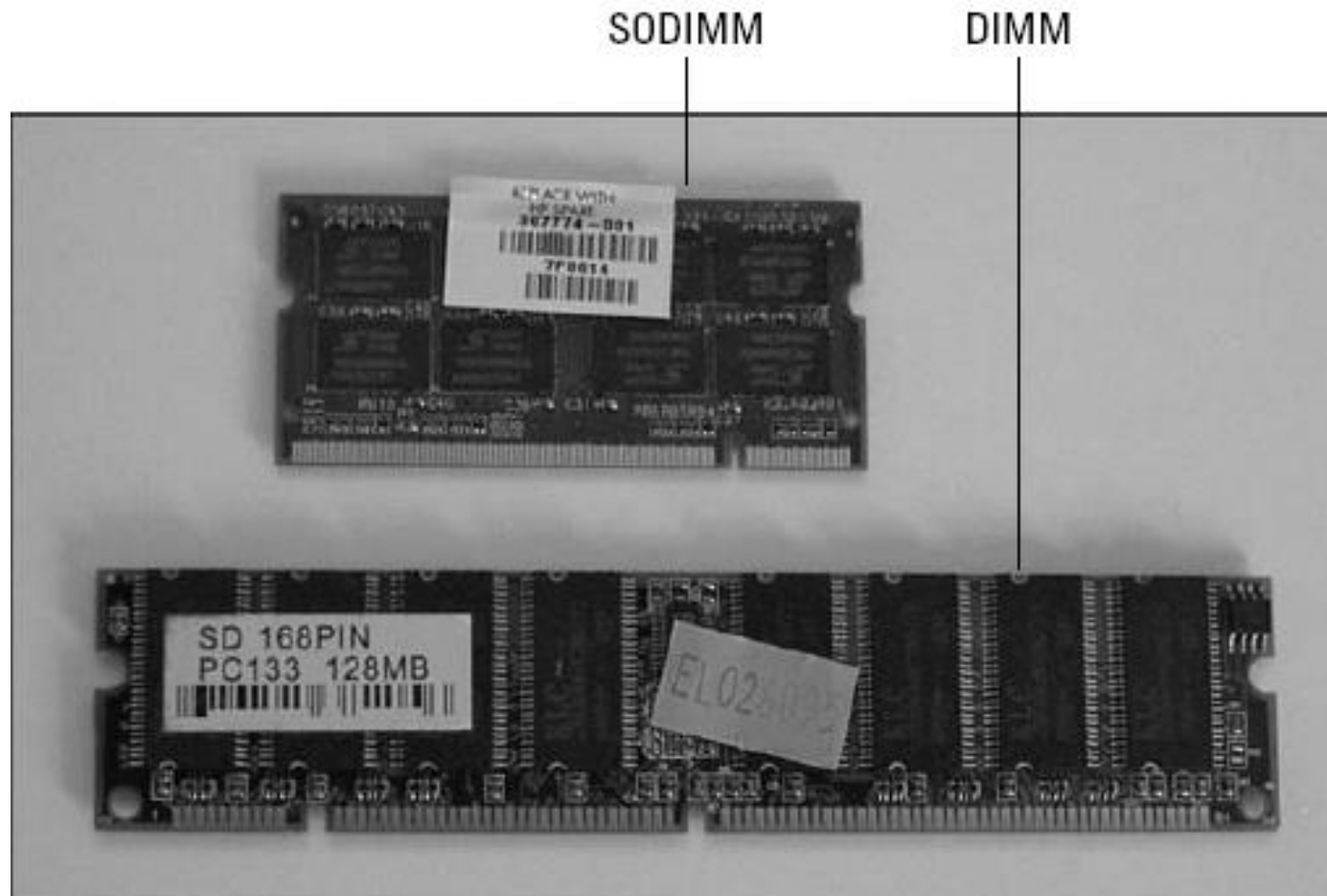
- ▶ Are like SIMMs, only they supply information in **64-bit** chunks.
- ▶ **DIMMs** use **168 pins** on the module and are a little larger than the **72-pin** SIMMs.

▶ Consider the memory bank issue again. Because the DIMM supplies data in **64-bit** chunks, and the data path of a Pentium processor is **64-bit**, you can install DIMMs singly in a Pentium system. On the other hand, you must install SIMMs in pairs in a Pentium system.





- **Small Outline Dual Inline Memory Modules (SODIMMs)** are memory modules that are smaller than normal **DIMMs** and are used in laptops. A **SODIMM** comes in three different-sized modules: a **32-bit 72-pin** module; a **64-bit 144-pin** module (**SDRAM**); and a **64-bit 200-pin** module (**DDR**).



- ▶ **A Micro Dual Inline Memory Module (MicroDIMM)** is another memory module that is used in laptop computers. The **MicroDIMM** is smaller than the **SODIMM** and comes in a **144-pin** module for SDRAM and a **172-pin** module for DDR memory.

Error-Checking Memory

- ▶ Two types of error-checking systems

Parity versus non-parity

- ▶ *Parity memory* is a type of error-checking memory, which is memory that verifies the information stored in memory is what is actually read from memory at a later time.
- ▶ *Non-parity memory* is simply memory that does not perform any kind of error checking to ensure that the data written to memory is what is actually read when it is retrieved.
- ▶ Note that parity memory cannot correct the error; it just reports that an error exists.

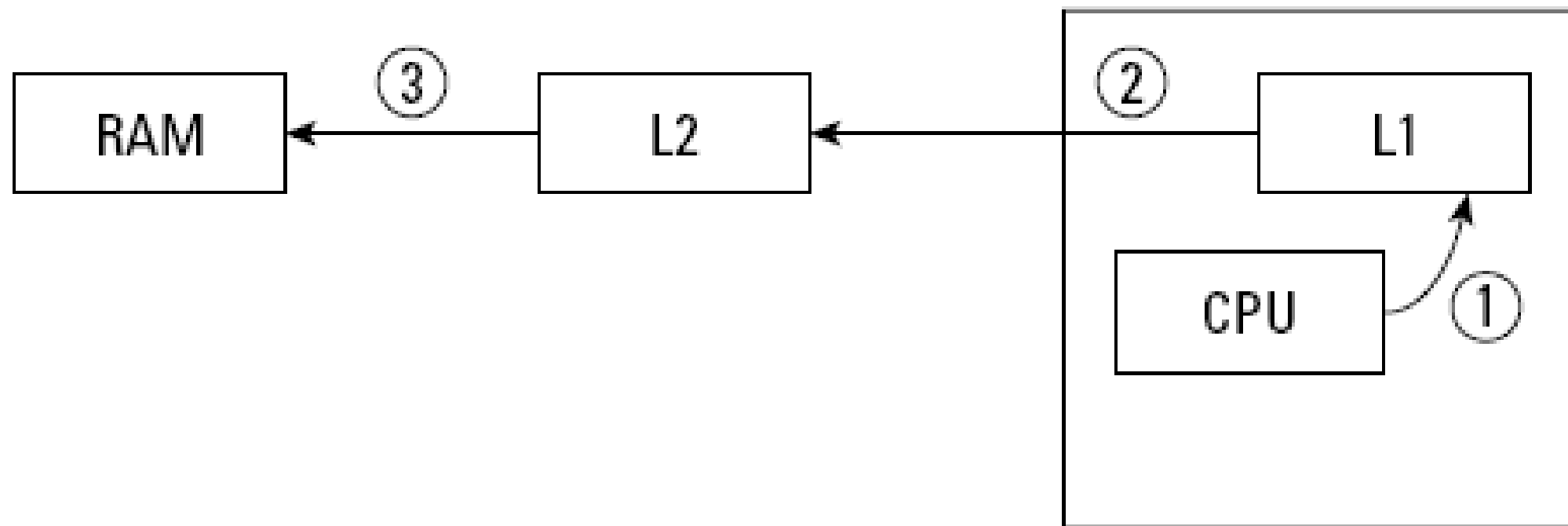
ECC (Error-checking and correction) memory

- ▶ ECC memory is memory that can detect data integrity problems the way that parity memory can, the difference being that ECC memory can recover from the error and attempt to fix the problem with the data being read.

Working with Cache Memory

- ▶ **Level 1 cache**, or **L1 cache**, gives the processor instant access to this memory with no wait time.
- ▶ **Wait time** is the amount of time it takes between the processor requesting information stored in memory and actually receiving the information.
- ▶ **Level 2 cache**, also known as **L2 cache**, some delay occurs when the processor accesses the information in L2 cache due to the distance between the processor and the L2 cache.

- ▶ One of the selling points of different processors is the amount of cache memory that comes with the processor. Many processors today typically have at least **32K of L1** cache and **512K, 1MB, or 2MB** of **L2** cache inside the casing of the processor. The more cache memory a system has, the bigger the bucket to store more frequently used information.
- ▶ **L3 cache**
- ▶ Because processors today provide a small amount of L1 cache *and* a large amount of L2 cache, some people are now using the term *L3 cache* to identify cache that resides on the motherboard.



Some Common RAM problems and their solutions

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► 1. Your PC is slow

You turn on your computer and in the first few minutes everything is fine. But as you launch programs, you notice a decrease in performance. It then becomes more and more difficult to go from one software to another, to load web pages, or even: the mouse begins to freeze at times for several seconds.

- **Solution** : You encounter this kind of problem when the RAM is almost 100% occupied, especially due to the execution of demanding programs. You can then buy larger capacity modules.
- If you are running a 32-bit version of Windows, it limits RAM memory usage to 4 GB, even if more is available. **It will therefore be necessary to switch to a 64-bit Windows version.**

► 2. Your PC experiences unwanted restarts

Your computer restarts unexpectedly and unexpectedly while performing your tasks. It could also be that the computer does not start altogether at some point. It could be a sign of failing RAM.

► **Solution** : After trying other solutions like removing viruses and checking hard drive, **make sure that none of the memory modules are defective**. If you have more than one, you can test by removing them one at a time to identify the problematic one.

► 3. Windows keeps showing blue screens

In Windows, the blue screen is displayed when the system encounters a fatal error after reaching a critical state. It is also called the blue screen of death or BSoD (*Blue Screen of Death*). In some cases, displaying a blue screen can be caused by corruption of the RAM memory.

► **Solution** : The blue screen is always displayed with a code or an indication allowing to get an idea of the source of the problem. If it concerns memory, you should be able to read a message like **MEMORY_IMAGE_CORRUPT**. The problem might not repeat itself after a simple restart, but if it persists, all of the stop codes and their meanings can be viewed on Microsoft's Bug Check Code Reference page.

► 4. You can no longer install new programs

There may be times when you are unable to install a new program. The installation repeatedly fails for unknown reasons.

► **Solution** : There may be several reasons for the inability to install a program. This could be due to a software compatibility issue with your system. It could also be a RAM failure, in which case a test of your RAM would identify it.

► 5. Frequently Used Files Get Corrupted

Another problem that occurs due to faulty computer memory is that frequently accessed files get corrupted. This is because the file structure slowly degenerates due to faulty RAM chips.

► **Solution:** Replacing the faulty RAM chip should solve the problem.

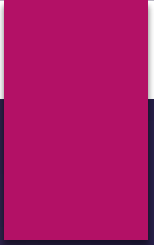
► Common ways to fix the memory errors

Depending on what is causing the memory errors, you can try the following options:

- Replace the RAM modules (most common solution)
- Set default or conservative RAM timings
- Increase the RAM voltage levels
- Decrease the CPU voltage levels
- Apply BIOS update to fix incompatibility issues

Installing or Upgrading Memory

- ▶ In general, upgrading memory is a simple task — assuming you purchase the proper type of memory for the upgrade.
- ▶ Factors that affect the proper type of memory are
 - ❑ Type of memory (FPM, EDO, SDRAM, DDR)
 - ❑ The speed of the memory
 - ❑ Pin connector type
 - ❑ Parity versus non-parity



End of Chapter Four