*Technology in action*

Chapter 9

behind the scenes:   
A Closer Look at System Hardware

# CHAPTER REVIEW

**Buzz Words/Word Bank**

|  |  |  |
| --- | --- | --- |
| AGP | cache | Level 1 cache |
| ALU | control unit | Level 2 cache |
| ASCII | decoded | Level 3 cache |
| binary | DRAM | number system |
| byte | fetch | PCI |
| buses | instruction set | registers |

**Instructions:** Fill in the blanks using the words from the Word Bank.

Computers are based on a system of switches, which can be either on or off. The **(1) binary** number system, which has only two digits, models this well. A(n) **(2) number system** is a set of rules for the representation of numbers. Eight binary digits are combined to create one **(3) byte**, so they are easier to work with. The **(4) ASCII** code organizes bytes in unique combinations of 0s and 1s to represent characters, letters, and numerals.

The CPU organizes switches to execute the basic commands of the system. No matter what command is being executed, the CPU steps through the same four processing stages. First it needs to **(5) fetch** the instruction from RAM. Next the instruction is **(6) decoded**, and the **(7) control unit** sets up all of the CPU hardware to perform that particular command. The actual execution takes place in the **(8) ALU**. The result is then saved by storing it in the **(9) registers** on the CPU. Another form of memory the CPU uses is **(10) cache** memory. **(11) Level 1 cache** is the form of this type of memory located on the CPU. **(12) Level 2 cache** is located a bit farther from the CPU.

RAM comes in several different types. **(13) DRAM** must be refreshed each cycle to keep the data it stores valid. The pathways connecting the CPU to memory are known as **(14) buses**. The speeds at which they can move data, or the data transfer rates, vary. **(15) AGP** is a bus designed primarily to move three-dimensional graphics data quickly.

**Self-Test**

**Instructions:** Answer the multiple choice and true/false questions below for more practice with key terms and concepts from this chapter.

**MULTIPLE CHOICE**

1. Electronic switches are:
   1. devices inside the computer that can be flipped between two states: 1 or 0.
   2. always built out of layers of semiconductor.
   3. very small regions of semiconductor material that support many transistors.
   4. None of the above

ANSWER: A

1. Binary number notation is based on:
   1. powers of 10.
   2. powers of 8.
   3. powers of 2.
   4. powers of 16.

ANSWER: C

1. The Unicode encoding system notation can represent:
   1. only uppercase letters.
   2. only letters and symbols in English.
   3. most (but not all) of what the ASCII system can represent.
   4. the alphabets of all modern languages.

ANSWER: D

1. A CPU’s clock speed
   1. is the only important factor in system performance.
   2. is measured in units of billions per second.
   3. depends on which time zone the machine is in.
   4. is a measure of the number of transistors on the chip.

ANSWER: B

1. The Fetch stage of the CPU cycle is used to:
   1. gather data from the registers.
   2. execute an instruction in the ALU.
   3. pull data from the Level 1 cache.
   4. transfer data from RAM into the CPU’s registers.

ANSWER: D

1. Dynamic RAM is called “dynamic” because:
   1. it is faster than static RAM (SRAM).
   2. it must be refreshed to keep the data valid.
   3. it has a great personality.
   4. it changes its value every clock cycle.

ANSWER: B

1. A computer bus is characterized by:
   1. its speed (data transfer rate).
   2. its width (how many bits move at one time).
   3. the standard it follows (such as ISA or AGP).
   4. All of the above

ANSWER: D

1. Pipelining is a technique that allows:
   1. the CPU to be more efficient at handling multiple tasks at one time.
   2. data to be read more quickly by the CPU.
   3. RAM to be copied to the hard disk drive very quickly.
   4. cache memory to be ignored.

ANSWER: A

1. Computers can be designed to use:
   1. more than one CPU in the same system.
   2. only one CPU but several different types of RAM.
   3. multiple CPUs, but only if each has its own hard disk drive.
   4. multiple CPUs, but only if each has its own operating system.

ANSWER: A

1. There is a “hierarchy” of memory in a computer system because:
   1. there are large amounts of slow, cheap memory and smaller amounts of fast, expensive memory in the system.
   2. faster memory is more expensive so the system has less.
   3. there is a need for both volatile and nonvolatile storage.
   4. All of the above

ANSWER: D

**TRUE/FALSE**

**True** 1. Binary numbers use only two digits.

**True** 2. DDR SDRAM is standard in most new home desktop systems.

**False** 3. The system clock runs at different speeds depending on the workload.

**False** 4. CPU designers use pipelining to bring in data more quickly from RAM.

**True** 5. There are several different types of buses inside a computer system.

**Critical Thinking Questions**

**1. Processors of the Future**

Consider the current limitations of the design of memory, how it is organized, and how a CPU operates. Think radically—what extreme ideas can you propose for the future of processor design? What do you think the limit of clock speed for a processor will be? How could a CPU communicate more quickly with memory? What could future cache designs look like?

*Students need to understand how CPUs are currently built in order to ponder this question. One vision could be the invention of an organic CPU, in which the processor and RAM are one “device.” Using nanotechnology, CPUs could be built even smaller, transferring data at higher rates of speed.*

**2. Increasing Processor Speed**

SIMD and 3DNow! (used by AMD in its processors) are two approaches to modifying the instruction set to speed up graphics operations. What do you think will be the next important type of processing users will expect from computers? How could you customize the commands the CPU understands so that processing occurs faster on the CPU you are designing?

*In a processor of the future, perhaps data input, processing, and output could all occur within the same nano-sized device. Perhaps instruction sets could be modified by voice-activated technology, or occur fluidly on demand.*

**3. The Impact of Registers**

How would computer systems be different if we could place 1 GB of registers on a single CPU? How would that impact the design of video cards? Would it change the way RAM is used in the system?

*Data could be moved much more quickly from the ALU into the registers. From that, students could deduce that video games could become more complex, or perhaps be played at faster rates.*

**4. The CPU Processing Cycle**

The four stages of the CPU processing cycle are fetch, decode, execute, and store. Think of some real-world tasks that you perform that could be described the same way. For each example, describe how it would be changed if it were pipelined. What additional resources would the pipelined task require?

*Baking a cake could be an example of such a task: (1) fetch the ingredients and recipe (input), (2) decode the recipe (instructions), (3) execute by combining the ingredients according to the recipe and baking, and then (4) store the finished product (result). Additional resources would include hardware, such as bowls, spoons, pans, and an oven, not to mention the “human” resource, which would function as the control unit. To change this simple four-step task to a pipelined task, ask students to consider a bakery. One baker (or group of bakers) gathers the ingredients and recipe, the next group decodes the recipe, and so on. As each group completes its portion of the task, it passes it on to the next group and begins working on the next cake. In this way, as one cake is being boxed up, another one (or more) is having its ingredients gathered, its recipe read, or is baking.*

**5. Binary Style**

Binary events, things that can be in one of only two positions, happen around you all the time. A common example is a light switch that is toggled on or off. How about a coin? It must always be either heads up or heads down. What other events or objects behave in a binary style?

*Potential answers could include making a turn (left or right), riding an elevator (up or down), going through a door (in or out), answering questions (true or false, yes or no), and so on.*

**6. Lots of Ways to Remember**

Why does there need to be a memory hierarchy within a computer system, such as the one drawn in Figure 9.10? How would you design a system if it were very inexpensive to produce lots of CPU registers and very expensive to build hard disk drives? What if someone discovered a way to make hard disk drives a million times faster than they are today? How would you design a system then?

*Students might indicate that the memory hierarchy helps to prioritize how memory is used. Inexpensive CPU registers and expensive hard disk drives might cause their positions on the pyramid to flip. Students may believe that, depending on the price, faster hard disk drives might ultimately replace the need for CPU registers.*

**Team Time**

**Balancing Systems**

*This exercise helps students explore how the various subsystems affect total system performance, and also helps them learn how to maximize system performance while working with limited funds. The following rubric may be useful for grading purposes.*

| **Rubric** | **Beginning**  **1 point** | **Developing**  **2 points** | | **Proficient**  **3 points** | | **Exemplary**  **4 points** | **Score** |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Individual Effort** | There was very little effort or understanding of the topic shown. | There was evidence of effort but it lacked in preparation and understanding. | | Clear learning on the topic has occurred. | | A sound understanding of the topic was exhibited with enthusiasm and creativity. |  |
| **Team Effort** | Team members did not function as a group when given the opportunity. There was only individual work with no evidence of collaboration. | Team members had some major problems working as a group. There was little collaboration and teamwork evident. | | The team members mostly worked well together, with few problems. There could have been improvement in the level of teamwork that was utilized. | | The team worked as a cohesive unit. There was mature collaboration, compromise, and discussion evident at all times. |  |
| **Final Product** | The final presentation had major factual, grammatical, spelling, and formatting errors. It seemed rushed and incomplete. | The final presentation had factual, grammatical, spelling, or formatting errors but was complete. | | The final presentation was a carefully developed product with few factual, grammatical, spelling, or formatting errors. | | The presentation was developed with care and creativity making it interesting, polished, and error-free. |  |
| **Instructor Feedback** | Little or no attempt was made to receive or incorporate feedback from the instructor. | Feedback was received, but none of the suggestions were incorporated into the presentation. | | Feedback was received and some suggestions were incorporated into the presentation. | | Feedback was received and the suggestions were incorporated into the presentation. |  |
| **Evaluation** | 0 points  No assessments were completed and handed in to the instructor. | | 1 point  One assessment was completed and handed in to the instructor. | | 2 points  All assessments were completed and handed in to the instructor. | |  |

**Multimedia**

**ACTIVE HELPDESK**

These exercises are designed to provide the student with an interactive experience that will help them to extend their knowledge of topics in this chapter. The student plays the “role” of a Helpdesk analyst and provides answers to commonly asked questions in a rich, simulated online experience. Helpdesk calls can be found on the Train and Assess IT Web site, through your online course, or on the Student CD. After successfully completing the Helpdesk call, students will be able to access the Helpdesk Cheat Sheet, which summarizes the key points in each call.

The Helpdesk calls related to this chapter are:

* Understanding the CPU
* Understanding Types of RAM

***Understanding the CPU Helpdesk Cheat Sheet***

***A. The CPU***

***1. Basics:*** *The* ***central processing unit*** *(****CPU****) executes every instruction given to a computer. The entire CPU fits on a tiny chip, called the microprocessor****,*** *which**contains many millions of* ***transistors****. The CPU sits on the* ***motherboard,*** *the main circuit board that connects the CPU, memory, expansion slots, and all of the electrical paths that connect these components.*

*2.* ***The Machine Cycle:*** *All CPUs perform a series of steps to perform their tasks. These steps are the machine cycle and include: (1)* ***Fetch:*** *The 1s and 0s that make up the program’s binary code are “fetched” from RAM and moved to the CPU registers, (2)* ***Decode****: The program’s binary code is decoded into commands the CPU understands, (3)* ***Execute****: The CPU performs the work described in the command, (4)* ***Store:*** *The result is stored back in registers.*

*3.* ***The System Clock:*** *In order to move from one stage of the machine cycle to the next, the motherboard contains a built-in system clock.*

*4.* ***The Control Unit:*** *The control unit of the CPU remembers the sequence of processing stages and how each switch in the CPU should be set for each stage.*

***5. The Arithmetic Logic Unit (ALU):*** *The**ALU**is the part of the CPU designed to perform mathematical and logical operations and to test comparing values.*

***B. CPU Memory***

***1. Registers:*** *As specific instructions from the program are needed, they are moved from RAM into registers****,*** *special storage areas located on the CPU, where they wait to be executed. The registers allow the fastest memory access of all*

***2. Cache Memory:*** *Cache memory consists of small blocks of memory located directly on and next to the CPU chip itself. These blocks are holding places for recently or frequently used instructions or data that the CPU needs the most. CPU designs include a number of levels of cache memory.* ***Level 1 cache*** *is a block of memory that is built onto the CPU to store data or instructions that have just been used.* ***Level 2 cache*** *is located on the CPU but is slightly farther away than Level 1 cache, or it is on a separate chip next to the CPU. Some newer CPUs have a third level of cache memory called* ***Level 3 cache****.*

***C. The Instruction Set***

*The collection of commands a specific CPU can execute is called the* ***instruction set*** *for that system. Each CPU has its own unique instruction set. Since humans write the instructions initially, the commands in an instruction set are written in a language that is easier for humans to work with, called* ***assembly language****. However, these commands are translated into strings of binary code, called* ***machine language.***

***D. CPU Manufacturers***

*Only a few major companies manufacture CPUs for desktop computers. For PCs, manufacturers include Intel (the Xeon, Celeron, and Pentium) and AMD (the AMD-K6, Athlon XP, and Athlon 64-FX). Macs use a different CPU design manufactured by Motorola (the PowerPC G4) and IBM (the PowerPC G5).*

***Understanding Types of RAM Helpdesk Cheat Sheet***

***A. RAM***

***1. Basics: Random access memory (RAM)*** *is a computer’s volatile storage area, meaning that when the computer is turned off, the data stored in RAM is erased. RAM is located as a set of chips on the motherboard. Its capacity is measured in megabytes (MB) and gigabytes (GB).*

***2. Access Time:*** *The time it takes a device to locate data and instructions and make them available to the CPU for processing is known as its* ***access time.***

*3.* ***Different Types of RAM:*** *Like all computer components, improvements have been made to RAM design. Each type of RAM on the market today has a different internal design, allowing some to work faster than others.*

***B. DRAM***

***1. What’s Dynamic: DRAM*** *is short for* ***dynamic RAM****. It is the most basic type of RAM. In storing a bit of data in DRAM, a transistor and a capacitor are used. A* ***transistor*** *is a switch that can be turned on (allowing electrical current to flow) or off (blocking current). A* ***capacitor*** *acts like a bathtub, or storage space, for the charged electrons coming from the transistors. To store a 1 (or an “on” bit), the transistor is turned to the “on” position, and it fills the capacitor with charge.*

***2. Types of DRAM:*** *A variety of types of DRAM are on the market, with different performance levels and prices, including* ***SDRAM (synchronous DRAM), DDR SDRAM (double data rate synchronous DRAM)****, and* ***RDRAM (Rambus DRAM)****.*

***C. SRAM***

***Static RAM (SRAM)*** *is faster than DRAM. However, SRAM is more expensive, so it is used only in places like the CPU cache, where the system needs the fastest storage.*

***D. ROM***

***ROM (read only memory)*** *stores data and instructions, but it cannot be changed or erased. ROM chips usually contain the start-up instructions the computer needs to boot up.*