A+ Guide to Hardware, 9th Edition

Chapter 4

Supporting Processors and Upgrading Memory

Objectives

- Compare characteristics and purposes of Intel and AMD processors used for personal computers
- Install and upgrade a processor
- Compare the different kinds of physical memory and how they work
- Upgrade memory

Types and Characteristics of Processors

- Processor
  - Installed on motherboard
  - Determines system computing power
- Two major processor manufacturers
  - Intel and AMD

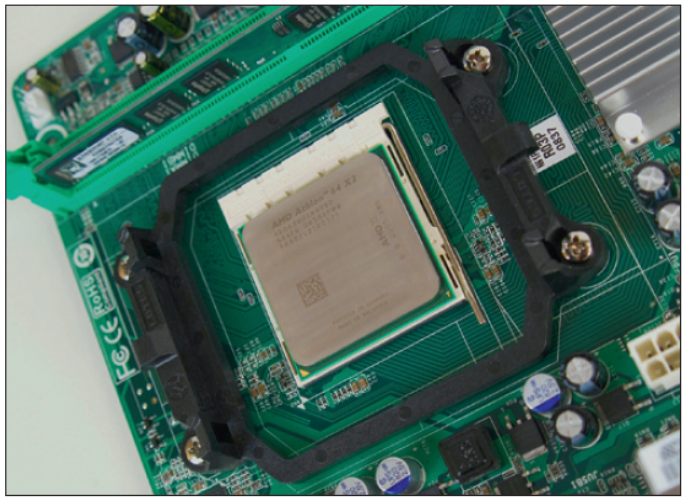

Figure 4-1 An AMD Athlon 64 X2 installed in socket AM2+ with cooler not yet installed

Types and Characteristics of Processors

- Features affecting processor performance and compatibility with motherboards
  - Processor speed
  - Socket and chipset the processor can use
  - Processor architecture
  - Multiprocessing abilities
    - Multiprocessing
    - Multithreading
    - Multicore processing
    - Dual processor

Types and Characteristics of Processors

- Features affecting processor performance and compatibility with motherboards (cont'd)
  - Memory cache
  - Security
  - Memory features on the motherboard that the processor can support
  - Support for virtualization
  - Integrated graphics

How a Processor Works

- Basic components
  - Input/output (I/O) unit
    - Manages data and instructions entering and leaving the processor
  - Control unit
    - Manages all activities inside the processor
  - One or more arithmetic logic units (ALUs)
    - Performs all logical comparisons, calculations

How a Processor Works

- Basic components (cont'd)
  - Registers
    - Small holding areas on processor chip
    - Holds counters, data, instructions, and addresses ALU is currently processing
  - Internal memory caches (L1, L2, L3)
    - Holds data and instructions to be processed by ALU
  - Buses
    - Connect components within the processor housing

How a Processor Works

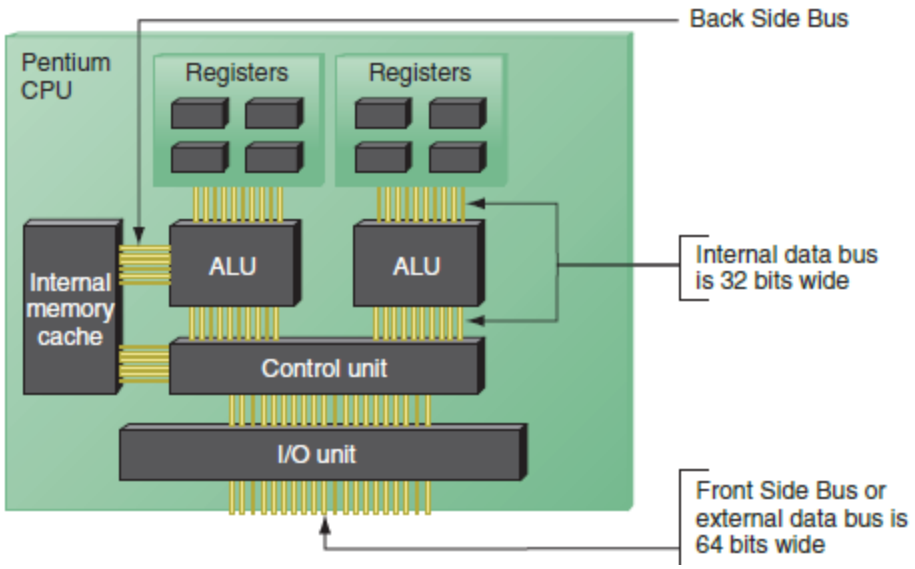

Figure 4-5 Since the Pentium processor was first released in 1993, the standard has been for a processor to have two arithmetic logic units so that it can process two instructions at once

How a Processor Works

- Processor frequency (speed)
  - Speed at which processor operates internally
- Multiplier
  - Factor multiplied against system bus frequency
    - Determines processor frequency
  - System bus frequency × multiplier = processor frequency
- Processors sold today contain ALUs and registers that can process 32 bits or 64 bits at a time

How a Processor Works

- Three categories of processors:
  - 32-bit processors – known as x86 processors
    - Can handle 32-bit instructions from OS
  - Hybrid processors – known as x86-64 processors
    - Can handle a 32-bit OS or a 64-bit OS
    - AMD produced the first one (called AMD64)
  - 64-bit processors – known as x64 processors or IA64
    - Require a 64-bit OS and can handle 32-bit applications only by simulating 32-bit processing

How a Processor Works

- Memory cache (L1, L2, or L3)
  - Each core in a processor has its own L1 and L2 caches
  - All cores might share an L3 cache within the processor package
  - Improves performance
- Memory controller
  - Included in processor package
  - Significant increase in system performance

How a Processor Works

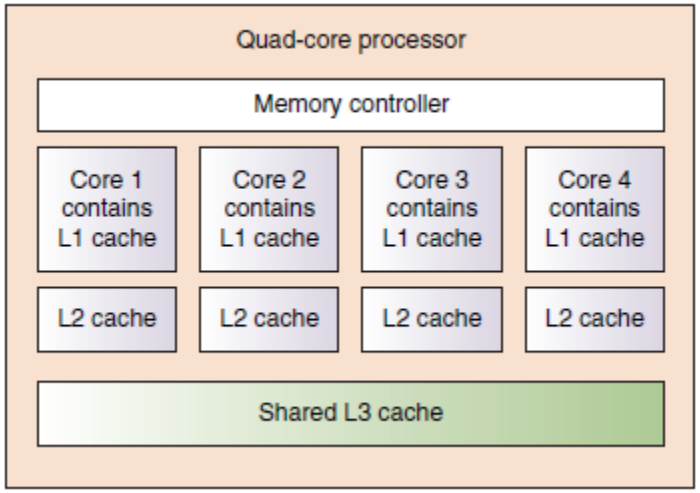

Figure 4-6 Quad-core processing with L1, L2, and L3 cache and the memory controller within the processor housing

Intel Processors

Processor	Speed	Description
Fifth-Generation (Broadwell) Processors		
Core i7	Up to 3.8 GHz	6-MB cache, quad core 1333/1600/1866 MHz DDR3 memory Dual-channel memory
Core i5	Up to 3.6 GHz	4-MB cache, quad core 1333/1600/1866 MHz DDR3 memory Dual-channel memory
Fourth-Generation (Haswell) Processors		
Core i7	Up to 4.4 GHz	8-MB cache, quad core 1333/1600 MHz DDR3 memory Dual-channel memory
Core i5	Up to 3.6 GHz	4- to 6-MB cache, quad or dual core 1333/1600 MHz DDR3 memory Dual-channel memory
Core i3	Up to 3.8 GHz	3- to 4-MB cache, dual core 1333/1600 MHz DDR3 memory Dual-channel memory
Third-Generation (Ivy Bridge) Processors		
Core i7	Up to 3.9 GHz	8-MB cache, quad core 1333/1600 MHz DDR3 memory Dual-channel memory
Core i5	Up to 3.8 GHz	6-MB cache, quad core 1333/1600 MHz DDR3 memory Dual-channel memory
Core i3	Up to 3.5 GHz	3-MB cache, dual core 1333/1600 MHz DDR3 memory Dual-channel memory
Second-Generation (Sandy Bridge) Processors		
Core i7 Extreme	Up to 3.9 GHz	15-MB cache, six cores 1066/1333/1600 MHz DDR3 memory Quad-channel memory
Core i7	Up to 3.9 GHz	8- to 12-MB cache, four or six cores 1066/1333/1600 MHz DDR3 memory Dual- or quad-channel memory
Core i5	Up to 3.8 GHz	3- to 6-MB cache, dual or quad core 1066/1333 MHz DDR3 memory Dual-channel memory
Core i3	Up to 3.4 GHz	3-MB cache, dual core 1066/1333 MHz DDR3 memory Dual-channel memory
Pentium	Up to 3.0 GHz	3-MB cache 1066/1333 MHz DDR3 memory Dual-channel memory
Previous-Generation Processors		
Core i7 Extreme	Up to 3.4 GHz	8- or 12-MB cache 1066 MHz DDR3 memory Triple-channel memory
Core i7	Up to 3.3 GHz	8- or 12-MB cache, four or six cores 800/1066/1333 MHz DDR3 memory Dual- or triple-channel memory

Table 4-1 Current Intel processors (continues)

Intel Processors

Processor	Speed	Description
Core i5	Up to 3.3 GHz	4- or 8-MB cache, dual or quad core 1066/1333 MHz DDR3 memory Dual-channel memory
Core i3	Up to 3.3 GHz	Dual core, 4-MB cache 1066/1333 MHz DDR3 memory Dual-channel memory
Atom	Up to 2.1 GHz	Up to 1-MB cache, some dual core 800/1066 MHz DDR3 memory 667/800 MHz DDR2 memory Single-channel memory
Celeron, Celeron Desktop, Celeron D	1.6 to 3.6 GHz 533/667/800 MHzFSB	128-KB to 1-MB cache
Core 2 Extreme, Core 2 Quad, Core 2 Duo	Up to 3.2 GHz 533 to 1600 MHz FSB	2- to 12-MB cache Dual or quad core
Pentium Extreme, Pentium, Pentium 4, Pentium D	Up to 3.7 GHz	Up to 4-MB cache, some dual core

Table 4-1 Current Intel processors (continued)

Intel Processors

- Processor identification
  - Processor number
    - Example: two Core i7 processors are identified as:
      - i7-940 and i7-920
- Centrino technology improves laptop performance
  - Processor, chipset, wireless network adapter are interconnected as a unit
- Intel Atom processor
  - Low-powered processor
  - Used in low-cost desktops, laptops, and netbooks

AMD Processors

Processor	Core Speed	Description
FX Black Edition Family		
FX 4-Core Black Edition	Up to 3.6 GHz	Quad-core uses AM3+ socket
FX 6-Core Black Edition	Up to 3.3 GHz	Six-core uses AM3+ socket
FX 8-Core Black Edition	Up to 3.6 GHz	Eight-core uses AM3+ socket
Phenom Family		
Phenom II X6	Up to 3 GHz	Six-core uses AM3 socket
Phenom II X6 Black	Up to 3.2 GHz	Six-core uses AM3 socket
Phenom II X4	Up to 3.2 GHz	Quad-core uses AM3 socket
Phenom II X3	Up to 2.5 GHz	Triple-core uses AM3 socket

Table 4-2 Current AMD processors (continues)

AMD Processors

Processor	Core Speed	Description
Phenom II X2	Up to 3.1 GHz	Dual-core uses AM3 socket
Phenom X4	Up to 2.6 GHz	Quad-core uses AM2+ socket
Phenom X3	Up to 2.4 GHz	Triple-core uses AM2+ socket
Athlon Family		
Athlon II X4	Up to 2.3 GHz	Quad-core uses AM3 socket
Athlon X4	Up to 3.2 GHz	Quad-core uses FM2 socket
Athlon II X3	Up to 3.4 GHz	Triple-core uses AM3 socket
Athlon II X2	Up to 3 GHz	Dual-core uses AM3 socket
Athlon X2	Up to 2.3 GHz	Dual-core uses AM3 socket
Athlon	Up to 2.4 GHz	Single-core uses AM2 socket
Sempron Family		
Sempron	Up to 2.3 GHz	Single-core uses AM2 socket

Table 4-2 Current AMD processors (continued)

Selecting and Installing a Processor

- PC repair technician tasks
  - Assemble a PC from parts
  - Exchange a faulty processor
  - Add a processor
  - Upgrade an existing processor
- Must know how to:
  - Match processor to system
  - Install processor on motherboard

Select a Processor to Match System Needs

- First requirement
  - Select a processor that the motherboard is designed to support
- Select the best processor meeting general system requirements and user needs
  - May have to sacrifice performance for cost

Install a Processor

- Installing an Intel processor in socket LGA1150
  - 1. Read motherboard user guide and follow directions
  - 2. Use an ESD strap or antistatic gloves
  - 3. Remove the socket protective cover
  - 4. Open the socket by pushing down on socket lever and gently push away from socket to lift lever
  - 5. Remove protective cover from processor
  - 6. Hold processor with index finger and thumb and align processor so the two notches on the edge of the processor line up with the posts embedded on the socket

Install a Processor

- Installing an Intel processor in socket LGA1150 (cont'd):
  - 7. Ensure the processor is aligned correctly in socket
  - 8. Return lever to its locked position

Install a Processor

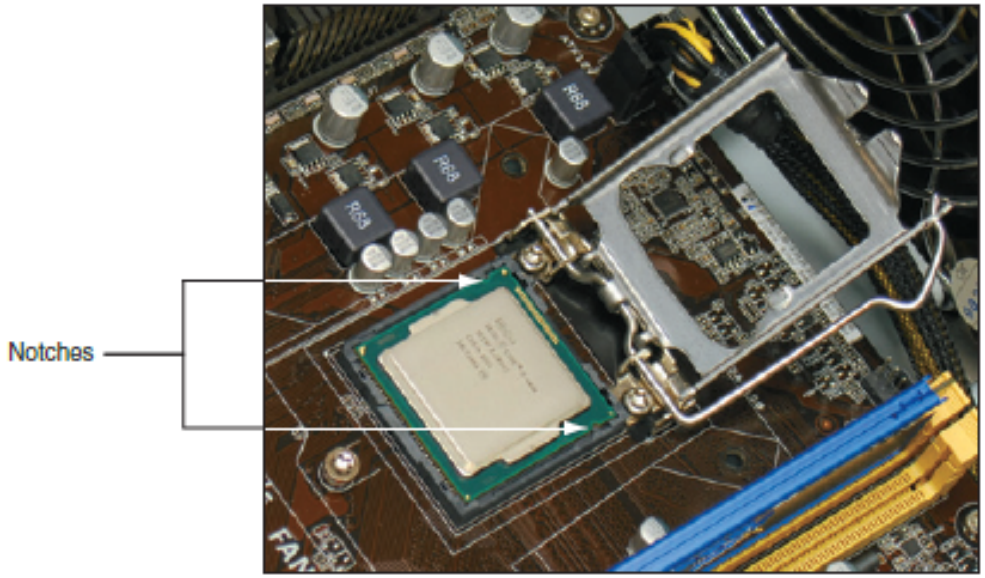

Figure 4-14 Orient the processor so the notches line up with the posts on the socket

Install a Processor

- General steps to install a cooler
  - 1. Understand how cooler posts work
  - 2. Apply thermal compound if necessary (may be preapplied)
  - 3. Verify locking pins are turned counter-clockwise as far as they will go
  - 4. Push down on each locking pin until it pops into the hole
  - 5. Connect power cord from cooler fan to motherboard
- Check BIOS/UEFI setup to verify the system recognized processor after system up and running

Install a Processor

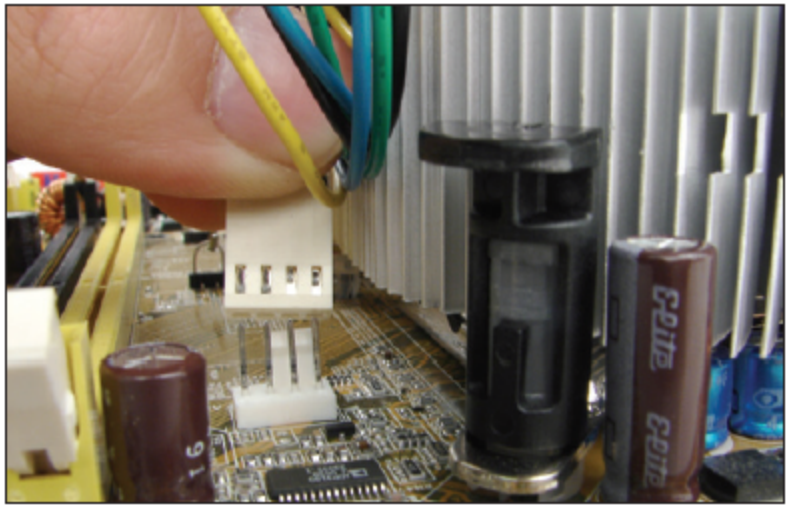

Figure 4-17 Connect the cooler fan power cord to the motherboard CPU fan header

Install a Processor

- Rest of examples are similar to that of installing a processor in Socket LGA1150
  - Differences will be highlighted
- Installing an Intel processor in socket LGA1155
  - 1. Open the socket by pushing down on socket lever and gently push away from socket
    - Remove socket protective cover
  - 2. Hold processor with index finger and thumb and align processor in socket using the gold triangle and right-angle mark
  - 3. Return lever to its locked position

Install a Processor

- Installing an Intel processor in socket LGA1366
  - 1. Open the socket and remove protective cover
  - 2. Line up processor with two posts on the socket (see Figure 4-25 on next slide)
  - 3. Lower the socket load plate and return lever to locked position

Install a Processor

- Installing an Intel processor in socket LGA775
  - 1. Push down lever and gently push it away from socket, lift socket load plate and remove socket protective cover
  - 2. Orient processor so notches on two edges of processor line up with two notches on the socket, place processor in socket
  - 3. Close the socket cover, push down lever and return it to its locked position

Install a Processor

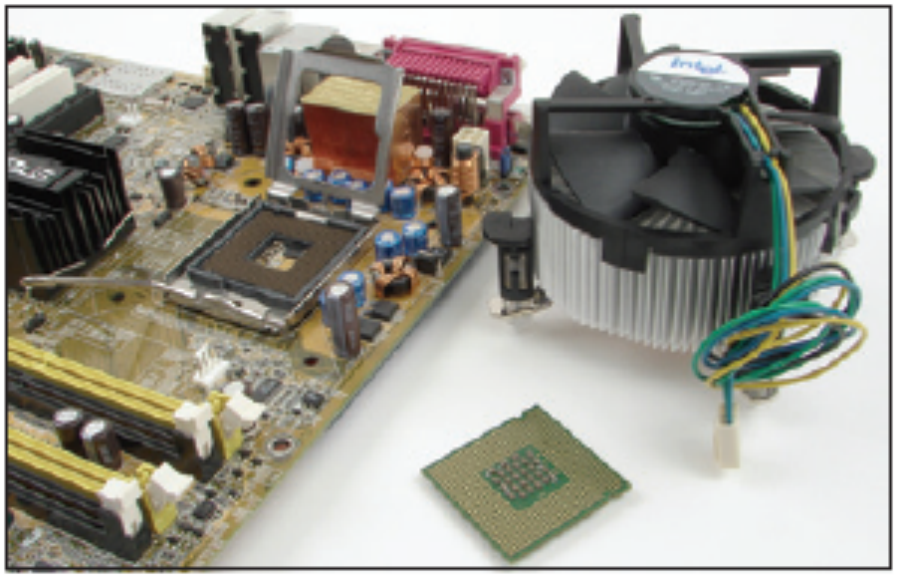

Figure 4-26 A Pentium, cooler, and open socket 775

Install a Processor

- Installing an AMD processor in socket AM2+
  - Summary of installation steps
    - 1. Open the socket lever and remove protective cover
    - 2. Place processor in the socket
    - 3. Verify processor pins sitting slightly into the holes
    - 4. Press the lever down and gently into position
    - 5. Apply thermal compound and install cooler
    - 6. Clip into place the clipping mechanism on one side of the cooler
    - 7. Connect fan power cord to power connection
  - Verify system works

Replacing the Processor in a Laptop

- Before replacing, consider the laptop might still be under warranty or it might be more cost effective to replace the laptop rather than replacing processor
- If decide to replace:
  - Use CPU supported by manufacturer and notebook model
  - For many laptops, remove the cover on the bottom to expose the processor fan and heat sink assembly
  - Some laptops may require you to remove the keyboard and keyboard bezel to reach the fan assembly and processor

Replacing the Processor in a Laptop

- If decide to replace (cont'd):
  - Lift the CPU from the socket
    - Lift straight up, without bending the CPU pins
  - Before placing the new processor into the socket
    - Be sure the socket screw is in the open position
  - Place the processor into its socket
  - Use thermal compound on top of the processor

Memory Technologies

- Random access memory (RAM)
  - Holds data and instructions used by CPU
  - Dynamic RAM (DRAM)
    - Memory modules used on a motherboard

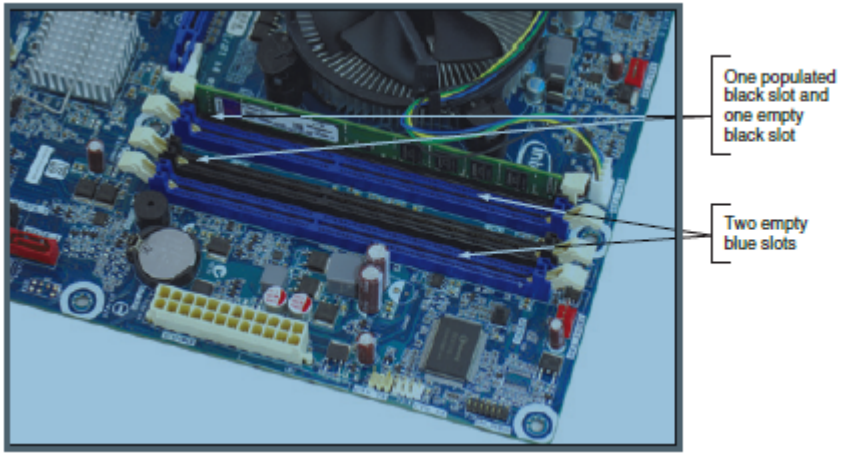

Figure 4-36 RAM on motherboards today is stored in DIMMs

Memory Technologies

- Variations of DRAM
  - DIMM – dual inline memory module
  - small outline DIMM (SO-DIMM) – used on laptops
  - microDIMMs – used on subnotebook computers
  - RIMM and SIMM (outdated)
- Differences among variations of DRAM:
  - Data path width each module accommodates
  - How data moves from system bus to module

Memory Technologies

Description of Module	Example
288-pin DDR4 DIMM is currently the fastest memory with lower voltage requirements. It can support quad or dual channels or function as single DIMMs. It has one notch near the center of the edge connector.	
240-pin DDR3 DIMM can support quad, triple, or dual channels or function as single DIMMs. It has an offset notch farther from the center than a DDR2 DIMM.	
240-pin DDR2 DIMM can support dual channels or function as single DIMMs. It has one notch near the center of the edge connector.	
184-pin DDR DIMM can support dual channels or function as a single DIMM. It has one offset notch.	
168-pin SDRAM DIMM has two notches on the module. The positions of these notches depend on the memory features the DIMM uses.	
RIMM has 184 pins and two notches near the center of the edge connector.	
72-pin SIMMs were installed in groups of two modules to each bank of memory.	
30-pin SIMMs were installed in groups of four modules to each bank of memory.	

Table 4-3 Types of memory modules

DIMM Technologies

- DIMM (dual inline memory module)
  - 64-bit data path
  - Independent pins on opposite sides of module
  - Older DIMMs
    - Asynchronous with system bus
  - Synchronous DRAM (SDRAM)
    - Runs synchronously with system bus
    - Two notches
    - Uses 168 pins

DIMM Technologies

- Double Data Rate SDRAM
  - Also called DDR SDRAM, SDRAM II, DDR
    - Two times faster than SDRAM and uses 184 pins
  - DDR2 SDRAM
    - Faster than DDR and uses less power
  - DDR3 SDRAM
    - Faster than DDR2 and uses less power
  - DDR2 and DDR3
    - Use 240 pins
    - Not compatible: use different notches
  - DDR4 – faster and uses less power than DDR3
    - Uses 288 pins

DIMM Technologies

- Factors that affect capacity, features, and performance of DIMMS:
  - Number of channels they use
  - How much RAM is on one DIMM
  - Speed
  - Error-checking abilities
  - Buffering

DIMM Technologies

- Early single channel DIMMs
  - Memory controller is accessed one DIMM at a time
- Dual channels
  - Memory controller communicates with two DIMMs at the same time and doubles memory access speed
- Triple channels
  - Accesses three DIMMs at once
- DDR, DDR2, DDR3, and DDR4 DIMMs use dual channels
  - DDR3 DIMMs can also use triple channels
  - DDR3 and DDR4 can use quad channels

DIMM Technologies

- Quad channeling
  - Introduced with Intel Sandy Bridge chipsets and processors
  - Processor can access four DIMMs at a time

Courtesy of Intel Corporation

Figure 4-41 The Intel Desktop Board DX79T0 has eight memory slots and supports two quad channels

DIMM Technologies

- Setting up dual channeling
  - Pair of DIMMs in a channel must be equally matched
    - Size, speed, features
    - Use same manufacturer (recommendation)

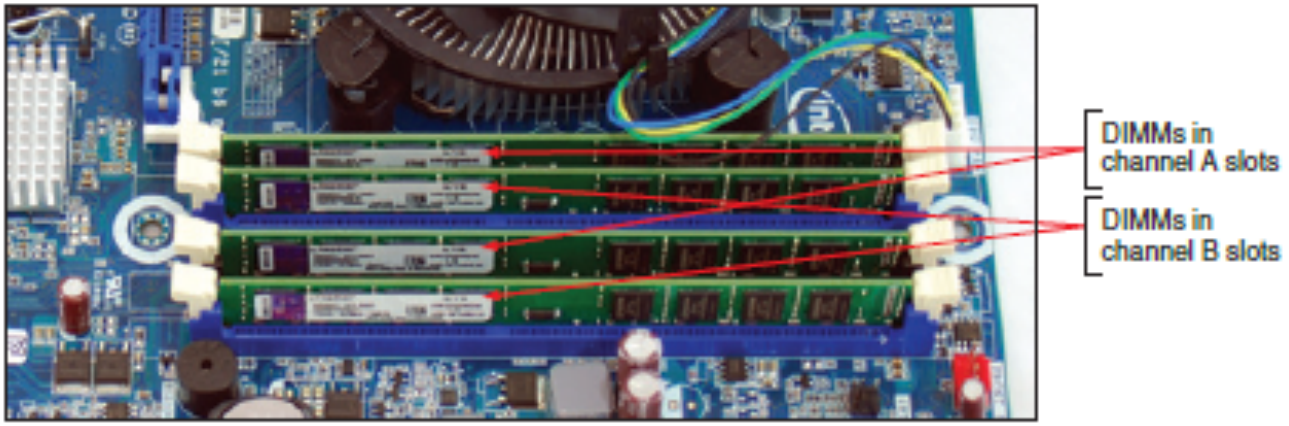

Figure 4-39 Matching pairs of DIMMs installed in four DIMM slots that support dual channeling

DIMM Technologies

- Setting up triple-channeling
  - Three DIMM slots populated with three matching DDR3 DIMMs

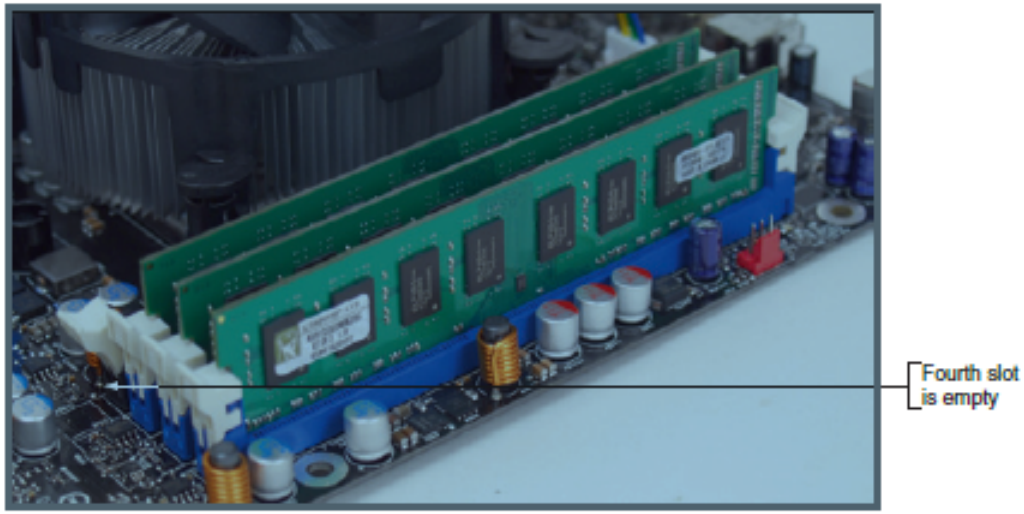

Figure 4-40 Three identical DDR3 DIMMs installed in a triple-channel configuration

DIMM Technologies

- DIMM Speed
  - Measured in MHz and PC rating
- PC rating
  - Total bandwidth between module and CPU
  - DDR2 PC rating
    - Usually labeled PC2
  - DDR3 PC rating
    - Usually labeled PC3
  - DDR4 PC rating
    - Usually labeled PC4

DIMM Technologies

- Single-sided DIMM
  - Memory chips installed on one side of module
- Double-sided DIMM
  - Memory chips installed on both sides of module
- Memory bank
  - Memory a processor addresses at one time
  - 64 bits wide
- Dual ranked
  - DIMMs providing two or more banks
    - Reduces overall memory price at the expense of performance

DIMM Technologies

- Error-correcting code (ECC)
  - Detects and corrects error in a single bit
  - Application: ECC makes 64-bit DIMM a 72-bit module
- Parity – used by older SIMMs
  - Error-checking based on an extra (ninth) bit
  - Odd parity
    - Parity bit set to make odd number of ones
  - Even parity
    - Parity bit set to make even number of ones
- Parity error
  - Number of bits conflicts with parity used

DIMM Technologies

- Buffered and registered DIMMs
  - Hold data and amplify signal before data written
  - Registered DIMM
    - Uses registers
  - Unbuffered DIMM
    - No buffers or register support

DIMM Technologies

- CAS latency and RAS latency
  - Column access strobe (CAS) latency
  - Row access strobe (RAS) latency
  - Both refer to number of clock cycles it takes to write or read a column or row of data off a memory module
    - CAS latency is used more than RAS latency
    - Lower values are better than higher
  - Memory module ads
    - Provide CAS latency value within series of timing numbers
      - Example: 5-5-5-15

Types of Memory Used in Laptops

- Today's laptops use DDR, DDR3L, DDR3, or DDR2 SO-DIMM memory
- Only use the type of memory the laptop is designed to support
- The number of pins and the position of the notches on a SO-DIMM keep you from inserting the wrong module in a memory slot

How to Upgrade Memory

- To upgrade memory means to add more RAM to a computer
- Adding more RAM might solve:
  - Slow performance
  - Applications refusing to load
  - An unstable system
  - Windows “Insufficient memory” error message

How to Upgrade Memory

- Questions to ask
  - How much RAM do I need and how much is currently installed?
  - How many and what kind of memory modules are currently installed on my motherboard?
  - How many and what kind of modules can I fit on my motherboard?
  - How do I select and purchase the right modules for my upgrade?
  - How do I physically install the new modules?

How Much Memory Do I Need and How Much Is Currently Installed?

- Best answer: “All you can get”
  - Windows 8/7 require at least 2 GB RAM
    - But more is better
  - RAM limit for a 32-bit OS
    - 4 GB installed RAM
  - 64-bit installation of Windows 8
    - Can use up to 128 GB of RAM
  - 64-bit installation of Windows 7 Home Premium
    - Can use up to 16 GB of RAM

How Many and What Kind of Modules Are Currently Installed?

- Open the case and look at memory slots
  - How many slots?
  - How many filled?
  - Review module imprint
- Examine module for physical size and notch position
- Read motherboard documentation
  - See if board supports dual, triple, or quad channels
- Last resort
  - Take motherboard and old memory modules to a good computer parts store for confirmation

How Many and What Kind of Modules Can Fit on My Motherboard?

- Read motherboard documentation
  - Indicates how much memory motherboard can physically hold
- DIMM modules
  - DIMMs can be installed as single modules
  - Motherboard supporting dual channeling
    - Install matching DIMMs in each channel for best performance
  - DDR3 board supporting triple channeling
    - For best performance install three matching DIMMs in triple-channel slots

How Many and What Kind of Modules Can Fit on My Motherboard?

- Motherboard Using DDR3 Dual-Channel DIMMs
  - Install matching DIMMs in the two blue slots and matching DIMMs in the two black slots
  - Possible to use only three DIMMs and dual channeling
    - Must install matching DIMMs in the two blue slots and a third DIMM in a black slot
      - Third DIMM must be equal in speed and total size of the DIMMs in the blue slots

How Many and What Kind of Modules Can Fit on My Motherboard?

- Motherboard using DDR3 triple-channel DIMMs
  - Use three matching DIMMs in the three blue slots
    - If fourth slot populated, board reverts to single channeling
  - Dual channeling:
    - Install two matching DIMMs in two blue slots farthest from processor
    - Leave other two slots empty
  - For one installed DIMM:
    - Place it in the blue slot farthest position from processor

How Many and What Kind of Modules Can Fit on My Motherboard?

- Motherboard using DDR3 triple-channel DIMMs (cont'd.)
  - Follow motherboard documentation
  - Serial Presence Detect (SPD)
    - DIMM technology that declares module's size, speed, voltage, and data path width to system BIOS at startup
    - Today's memory always supports SPD

How Many and What Kind of Modules Can Fit on My Motherboard?

- Motherboard using DDR DIMMs with dual channeling
  - Allows three different DDR DIMM speeds in one to four sockets, supports dual channeling
  - Two blue memory slots and two black slots
  - For dual channeling
    - Matching DIMMs must be installed in the two blue sockets
  - If two DIMMs installed in the two black sockets
    - They must match each other

How Do I Select and Purchase the Right Memory Modules?

- Compromises if the exact match is not available:
  - Mixing unbuffered memory with buffered or registered memory will not work
  - Match memory module manufacturer, if possible
    - In a pinch, try using memory from two different manufacturers
  - If mixing memory speeds:
    - All modules perform at slowest speed

How Do I Select and Purchase the Right Memory Modules?

- Using a web site to research your purchase
  - Look for search utility matching modules to board

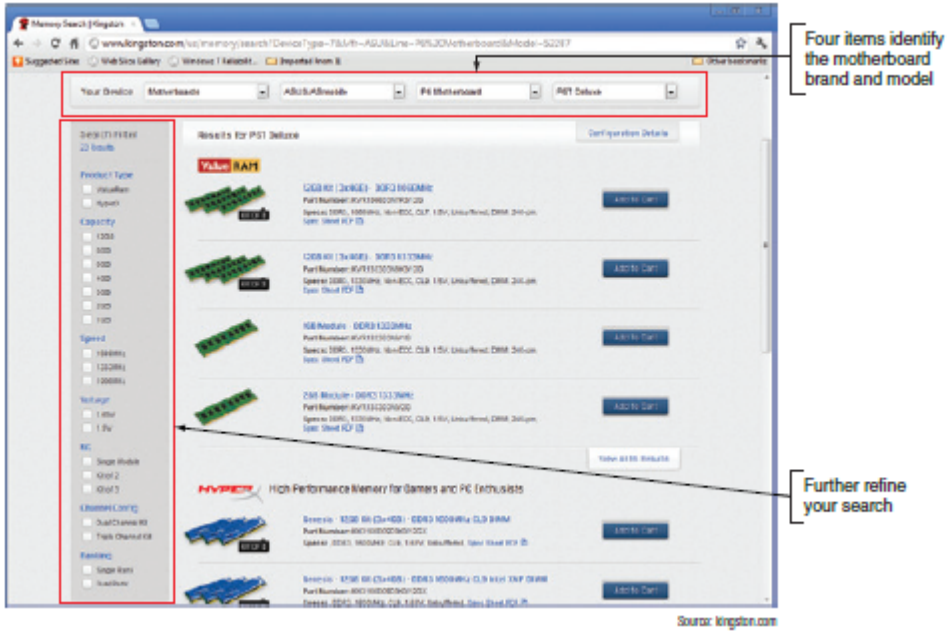

Figure 4-52 The Kingston web site DIMM recommendations for a particular motherboard

How Do I Install the New Modules?

- Precautions:
  - Always use an ESD strap
  - Turn off power, unplug power cord, press power button, remove case cover
  - Handle memory modules with care
  - Do not touch edge connectors on memory module or memory slot
  - Do not stack cards or modules
  - Look for notches on one side or in the middle for correct orientation

How Do I Install the New Modules?

- Installing DIMMS
  - Pull out supporting arms on the sides of the slot
  - Use notches on DIMM edge connector as a guide
  - Insert DIMM straight down into the slot
  - Ensure supporting arms lock into position
- New installations are generally uncomplicated
  - Usually involve placing memory on motherboard
  - Older computers may need change to BIOS setup
  - If new memory not recognized try reseating the module

How to Upgrade Memory on a Laptop

- Upgrade process is similar to desktops
  - Considerations:
    - Make sure warranty not being voided
    - Search for best buy on a suitable and authorized part
  - General steps:
    - Decide how much memory to upgrade
    - Purchase memory
    - Install it
  - Be sure to match the type of memory to the type the laptop supports

Summary

- Processor: most important motherboard component
  - Two major manufacturers are Intel and AMD
- Processors are rated by speed of the system bus, the socket and chipset, processor architecture, multi-core rating, internal memory cache, amount and type of RAM and computing technologies
- Memory cache inside the processor housing can be L1, L2, and L3 cache
- Core of processor has two arithmetic logic units (ALUs) and each core can process two threads at once

Summary

- Current families of Intel processors include Core, Atom, Celeron, and Pentium
- Current AMD processor families include FX, Phenom, Athlon, and Sempron
- Select a processor that the motherboard supports
- When installing, always follow directions in motherboard user guide
- DRAM is stored on DIMMs for desktops and SO-DIMMs for laptops
- DIMMs can be single-sided or double-sided

Summary

- DIMMs can work together in dual, triple, or quad channels
- DIMM speeds are measured in MHz or PC rating
- The memory controller can check memory for errors and possibly correct those errors using ECC
- Buffers and registers are used to hold data and amplify a data signal
- CAS Latency and RAS Latency measure access time to memory
- When upgrading memory, use the type, size, and speed the motherboard supports