A+ Guide to Hardware, 9th Edition

Chapter 3

All About Motherboards

Objectives

- Describe and contrast various types and features of motherboards
- Configure a motherboard using BIOS or UEFI firmware
- Maintain a motherboard, including updating drivers, flashing UEFI/BIOS, and replacing the CMOS battery
- Select, install, and replace a motherboard

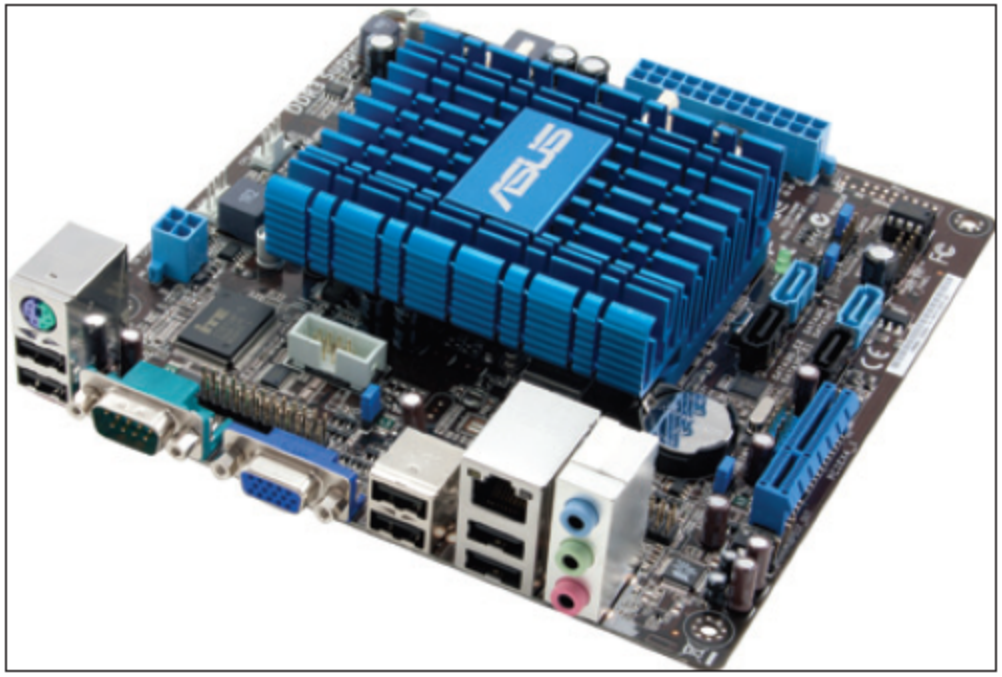
Motherboard Types and Features

- Motherboard
  - Most complicated computer component
  - One of the first items to consider when building a computer
- Consider the following when purchasing a motherboard:
  - Form factor
  - Processor socket and chipset
  - Buses and number of bus slots
  - Other connectors, slots, and ports

Motherboard Form Factors

- Determines motherboard size, features
  - Compatible with power supplies, cases, processors, expansion cards
- Most popular
  - ATX, MicroATX, and Mini-ITX
    - Mini-ITX is smaller than MicroATX and is also known as ITX
- The following slides show examples of form factors and comparisons of sizes and hold positions of several form factors

Motherboard Form Factors



Courtesy of ASUSTeK Computer, Inc.

Figure 3-3 A Mini-ITX motherboard

Motherboard Form Factors

Form Factor	Motherboard Size	Description
ATX, full size	Up to 12" × 9.6" (305mm × 244mm)	A popular form factor that has had many revisions and variations.
MicroATX	Up to 9.6" × 9.6" (244mm × 244mm)	A smaller version of ATX.
Mini-ITX (aka ITX)	Up to 6.7" × 6.7" (170mm × 170mm)	A small form factor (SFF) board used in low-end computers and home theater systems. The boards are often used with an Intel Atom processor and are sometimes purchased as a motherboard-processor combo unit.
NLX	Up to 9" × 13.6" (229mm × 345mm)	A low profile form factor used in low-end systems with a riser card.

Table 3-1 Motherboard form factors

Processor Sockets

- Processor socket – determines which processors a board can support
  - Socket holds Intel or AMD processors
- Sockets for Intel processors
  - Intel makes several Itanium and Xeon processors designed for servers

Processor Sockets

- Sockets and processor use different methods to make contacts between them:
  - Pin grid array (PGA) socket
    - Pins aligned in uniform rows around socket
  - Land grid array (LGA)
    - Uses lands (pads) rather than pins
    - Examples of LGA sockets: LGA775 and LGA1366
  - Flip-chip land grid array (FCLGA) socket
    - Chip is flipped over so that the top of the chip is on the bottom and makes contact with the socket

Processor Sockets

- Sockets and processor use different methods to make contacts between them (cont'd):
  - Staggered pin grid array (SPGA)
    - Pins staggered over socket
    - Squeezes more pins into a small space
  - Ball grid array (BGA)
    - Not really a socket
    - Processor is soldered to the motherboard

Processor Sockets

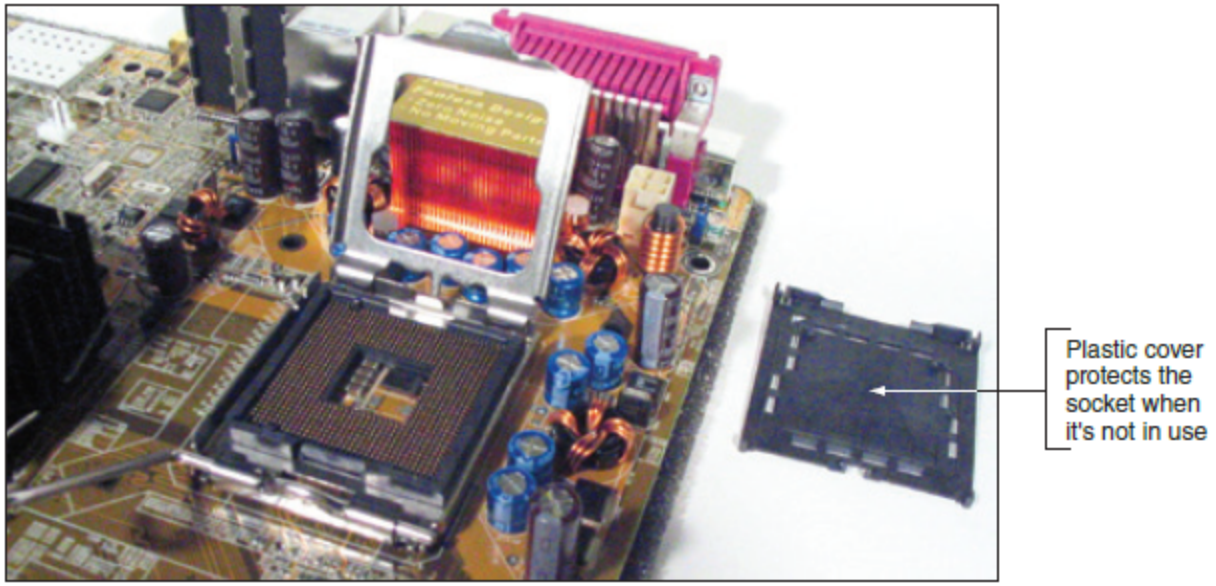


Figure 3-7 Socket LGA775 is the first Intel socket to use lands rather than pins

Processor Sockets

- Zero insertion force (ZIF) sockets
  - All current processor sockets
  - Side lever lifts processor up and out of the socket
- Sockets for AMD Processors
  - AMD uses the PGA socket architecture (desktops)

Processor Sockets

AMD Socket	Used by Processor Family	Description
FM2+	Used with the A10-, A8-, and A6-Series of processors	◢ 906 holes for pins (PGA) ◢ Uses AMD Steamroller architecture with integrated graphics controller in the processor ◢ Works with DDR3 memory
FM2	Used with the Trinity line of processors	◢ 904 holes for pins (PGA) ◢ Uses AMD Piledriver architecture with integrated graphics controller in the processor ◢ Works with DDR3 memory
FM1	AMD A4, A6, A8, E2, Athlon II	◢ 905 holes for pins (PGA) ◢ Works with DDR3 memory
AM3+	AMD FX	◢ 942 holes for pins (PGA) ◢ Uses Bulldozer architecture and is compatible with AM3 processors ◢ Works with DDR3 memory
AM3 or AMD3	Phenom II	◢ 941 holes for pins (PGA) ◢ Works with DDR3 or DDR2 memory

Table 3-3 Sockets for AMD processors used for desktop computers

Processor Sockets

- Match a processor to the socket and motherboard
  - Refer to motherboard, processor compatibility documentation

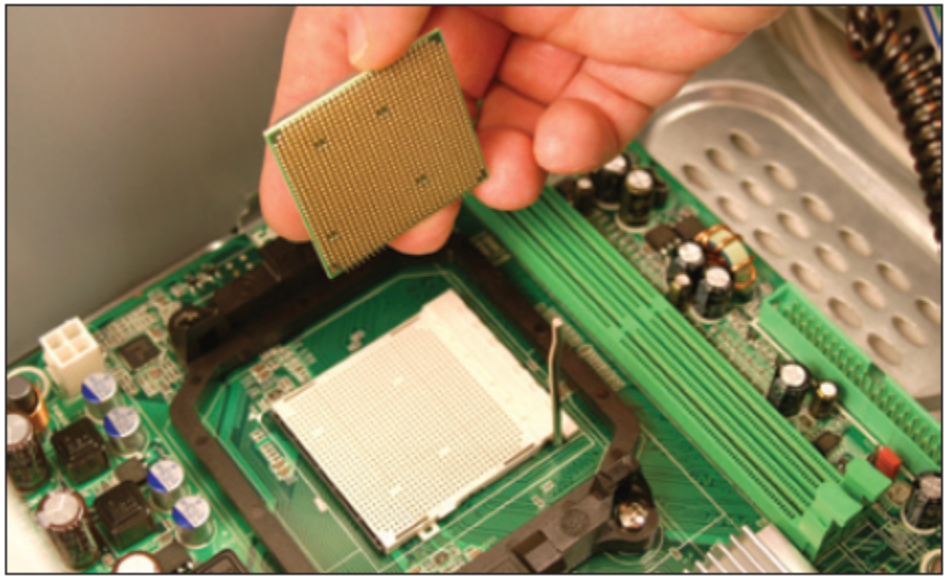


Figure 3-10 AMD Athlon 64 processor to be inserted into an AM2+ socket

The Chipset

- Chipset: set of chips on motherboard that work with processor to collectively control:
  - Memory, motherboard buses, some peripherals
- Major manufacturers
  - Intel and AMD
- Intel Chipsets
  - North Bridge and South Bridge - Uses hub interface
    - All I/O buses (input/output buses) connect to hub
      - Hub connects to system bus
    - North Bridge – fast end of hub
    - South Bridge – slow end of hub

The Chipset

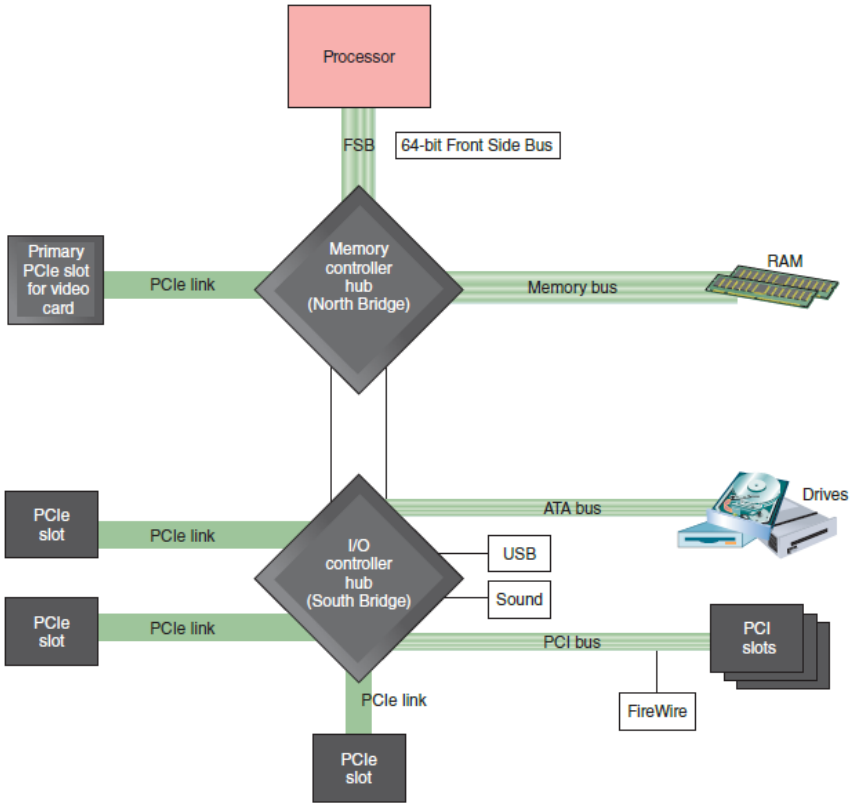


Figure 3-11 The chipset's North Bridge and South Bridge control access to the processor for all components

The Chipset

- Intel Chipsets (cont'd)
  - Nehalem chipset
    - Contain memory controller within processor housing
    - Memory connects directly to processor
    - Has QuickPath Interconnect (QPI) technology
      - Has 16 lanes for data packets
  - Sandy Bridge chipset
    - Memory and graphics controller in processor
    - Second Generation Core i7 processor is an example
    - Sandy Bridge motherboards use DDR3 memory

The Chipset

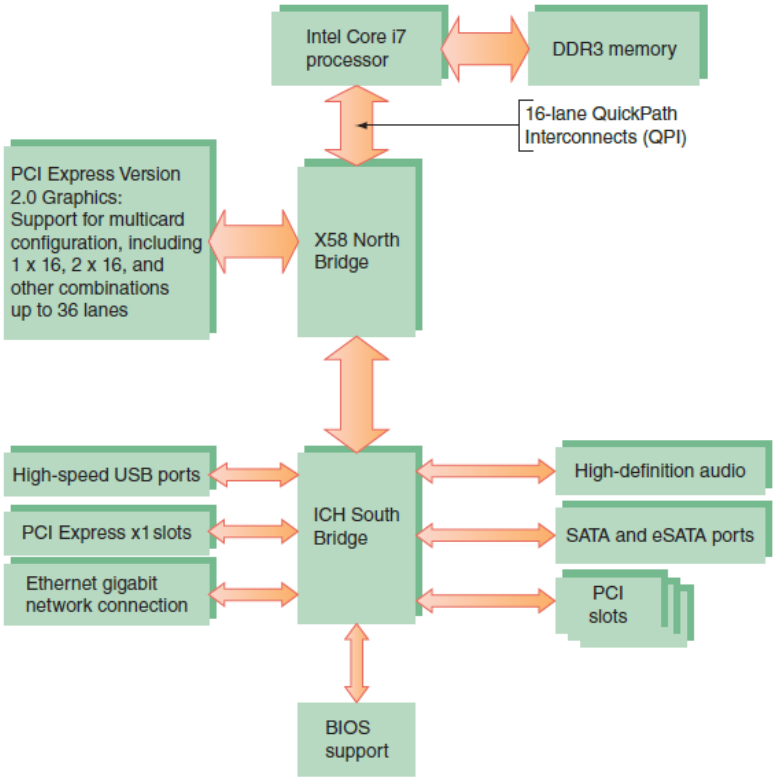


Figure 3-12 X58 chipset architecture

The Chipset

- Intel Chipsets (cont'd)
  - Ivy Bridge chipset – 3rd generation processors released in 2012
    - Use less power
    - More transistors in a smaller place
    - Perform better than earlier products
    - Uses a single Platform Controller Hub

The Chipset

- Intel Chipsets (cont'd)
  - Haswell and Broadwell chipsets
    - Haswell - released in 2013
      - Work with the LGA1150 and LGA2011 sockets
      - Work with DDR3 and DDR4 memory and use less power than previous chipsets
    - Broadwell – released in 2015
      - Faster than the Haswell chipsets
      - Use the LGA1150 socket

The Chipset

- AMD chipsets
  - AMD A-series
    - Designed to support the AMD Accelerated Processing Unit (APU), which is a combination of a CPU and a graphics processing unit (GPU)
    - Support AMD CrossFire technology, which uses dual video cards in the same system
  - AMD 9-series
    - Designed to support AMD processors that can have up to eight cores

Buses and Expansion Slots

- Bus
  - System of pathways used for communication
- Carried by bus:
  - Power, control signals, memory addresses, data
  - These lines are sometimes called data bus
- Data and instructions exist in binary
  - Only two states: on and off
- Data path size: width of a data bus
  - Examples: 8-bit bus has eight wire (lines) to transmit

Buses and Expansion Slots

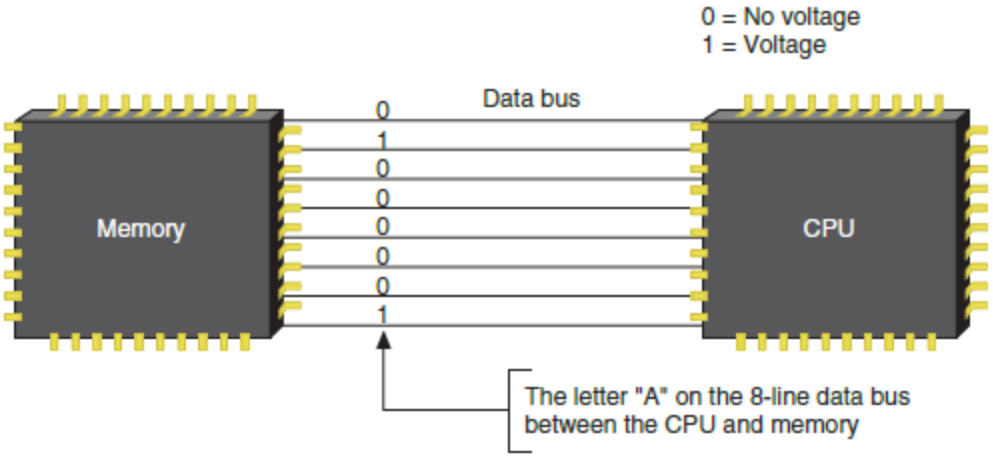


Figure 3-17 A data bus has traces or lines that carry voltage interpreted by the CPU and other devices as bits

Buses and Expansion Slots

- System clock (system timer) – times activities on the motherboard
- Speed of memory, Front Side Bus, processor, or other component is measured in **hertz (Hz)**, which is one cycle per second
  - Megahertz (MHz): one million cycles per second
  - Gigahertz (GHz): one billion cycles per second
- Motherboards can have more than one bus
  - Table 3-4 on the following slide lists many buses

Buses and Expansion Slots

Bus	Bus Type	Data Path in Bits	Address Lines	Throughput(Bandwidth)
PCI Express Version 4.0 (not yet released)	Local video and local I/O	Serial with up to 32 lanes	Up to 32 lanes	Up to 64 GB/sec for 16 lanes
PCI Express Version 3.0	Local video and local I/O	Serial with up to 32 lanes	Up to 32 lanes	Up to 32 GB/sec for 16 lanes
PCI Express Version 2.0	Local video and local I/O	Serial with up to 32 lanes	Up to 32 lanes	Up to 16 GB/sec for 16 lanes
PCI Express Version 1.1	Local video and local I/O	Serial with up to 16 lanes	Up to 16 lanes	Up to 8 GB/sec for 16 lanes
PCI-X	Local I/O	64	32	Up to 8.5 GB/sec
PCI	Local I/O	32 or 64	32 or 64	133, 266, or 532 MB/sec
FireWire 400 and 800	Local I/O or expansion	1	Serial	Up to 3.2 Gbps (gigabits per second)
USB 1.1, 2.0, and 3.0	Expansion	1	Serial	12 or 480 Mbps (megabits per second) or 5.0 Gbps (gigabits per second)

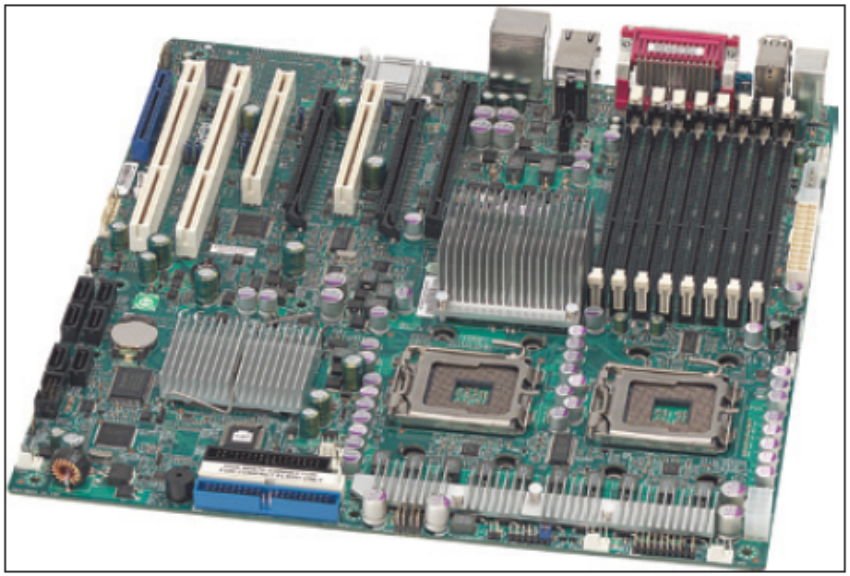
Table 3-4 Buses listed by throughput

Buses and Expansion Slots

- Conventional PCI
  - Improved several times
  - PCI Version 2.x introduced the 64-bit, 3.3 V PCI slot, doubling the data throughput of the bus
  - Four types of slots and six possible PCI card configurations

Buses and Expansion Slots

- PCI-X
  - Uses 64-bit data path
  - Latest revision is PCI-X 3.0 (all revisions are backward-compatible)



Courtesy of Super Micro Computer, Inc.

Figure 3-20 The two long white PCI-X slots can support PCI cards

Buses and Expansion Slots

- PCI Express (PCIe)
  - Not backward compatible with conventional PCI or PCI-X
  - Expected to replace both PCI and PCI-X
  - Uses a serial bus, which is faster than parallel
  - Comes in four different slot sizes
    - PCI Express x1, x4, x8, and x16
  - Latest version is PCIe 4.0 which doubles the throughput of version 3.0

Buses and Expansion Slots

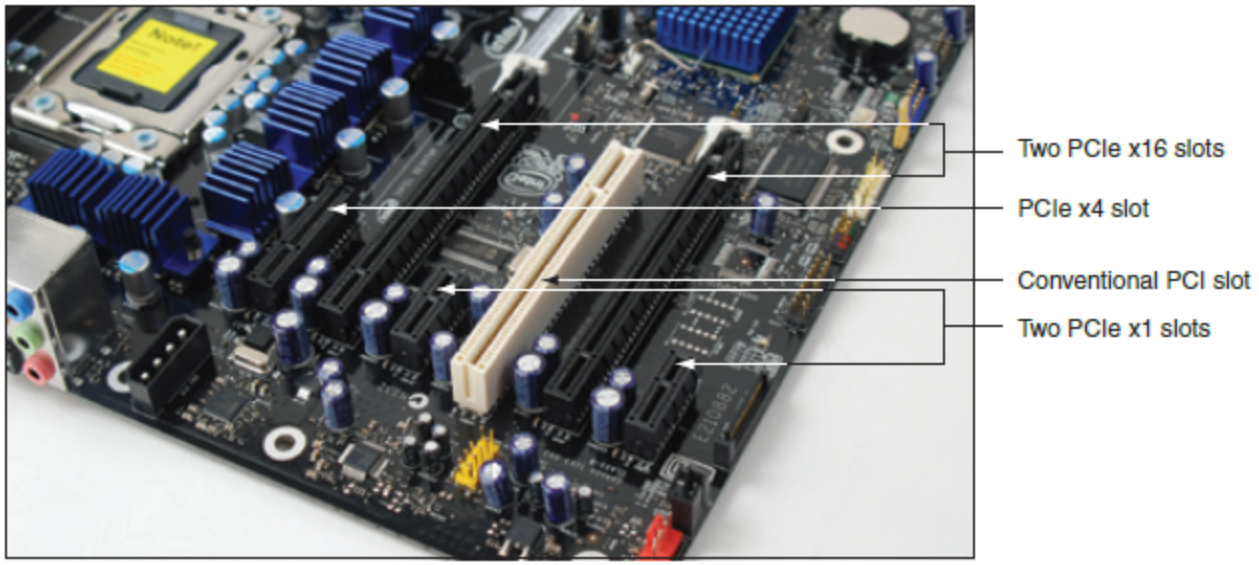


Figure 3-21 Three types of PCIe slots and one conventional PCI slot

Buses and Expansion Slots

- MiniPCi and MiniPCIe in Laptops
  - Smaller versions of the PCI and PCIe slots
  - Mini PCIe slots have 52 or 54 pins and one notch offset from the center of the slot
  - Mini PCI slot is wider with 100 or 124 pins

Figure 3-23 Mini PCIe slot with a wireless Mini PCIe card installed

Buses and Expansion Slots

- PCI Riser cards
  - Installs in a PCI slot and provides another slot at a right angle
  - Used to fit PCI, PCIe, and PCI-X cards into a low-profile or slimline case

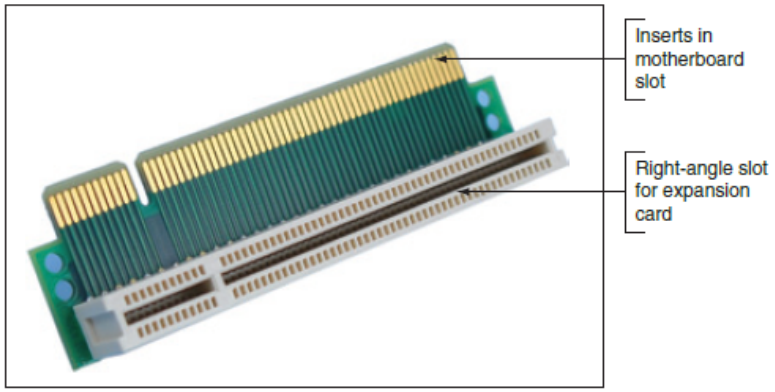


Figure 3-25 PCI riser card provides a 3.3-V slot or 5-V slot depending on which direction the card is inserted in the PCI slot

Onboard Ports and Connectors

- Onboard ports (integrated components)
  - Ports coming directly off the motherboard
    - USB, sound, network, FireWire, video, eSATA ports
    - Older motherboards might have mouse and keyboard ports, parallel and serial ports
- I/O shield
  - Plate installed in computer case providing holes for on-board ports
- Internal connectors
  - SATA, USB or FireWire (IEEE 1394) connectors

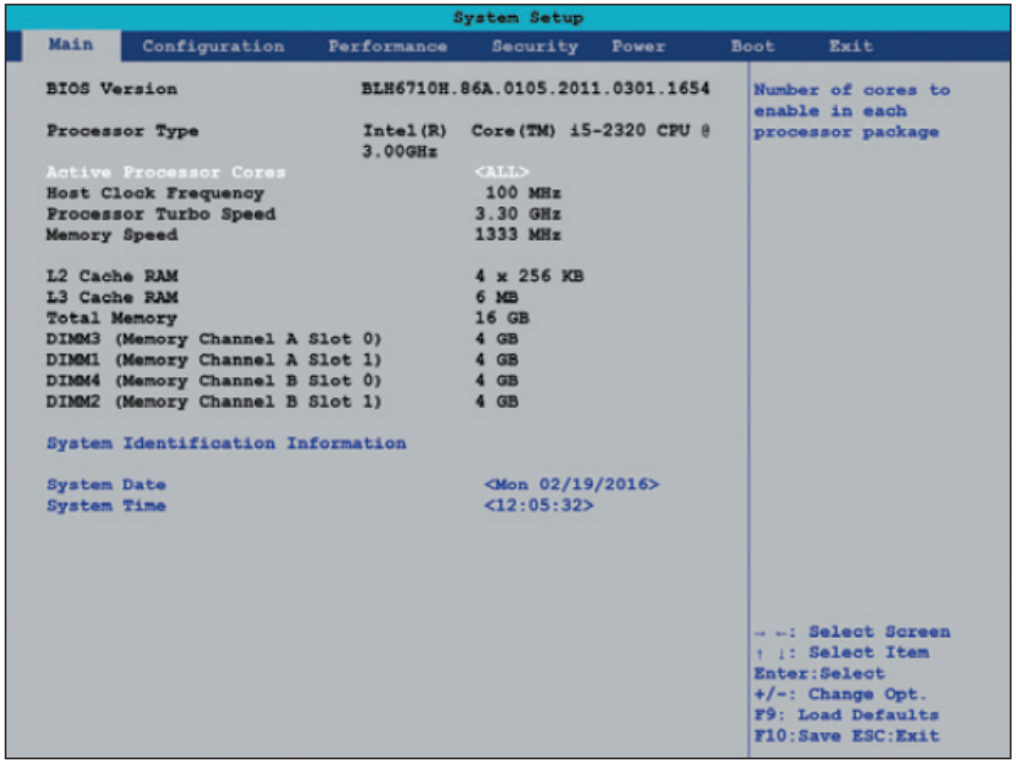
Configuring a Motherboard

- Motherboard settings
  - Enable or disable connector or port
  - Set CPU frequency, system bus, other buses
  - Control security features
  - Control what happens when PC first boots
- Motherboards may use these types of firmware:
  - BIOS – used on older motherboards
  - UEFI – replacing BIOS
  - UEFI with BIOS – for backward compatibility

Using BIOS Setup To Configure a Motherboard

- Access the BIOS Setup Program
  - Press a key or combination of keys during the boot process
    - Varies from one manufacturer to another
    - See documentation for your motherboard or watch the screen near the beginning of the boot
  - Setup screen appears with menus and Help features

Using BIOS Setup To Configure a Motherboard



Source: Intel

Figure 3-31 BIOS setup main menu

Using Setup BIOS To Configure a Motherboard

- Change the boot sequence
  - Might need to change boot sequence from hard drive to DVD for a new Windows install
  - After the OS is installed, change setup BIOS to boot first from the hard drive
    - To prevent accidental boots from a DVD or other media
  - If troubleshooting a boot problem, be sure to set BIOS to perform a full POST

Using Setup BIOS To Configure a Motherboard

- Configure onboard devices
  - Enable/disable a port or group of ports
- View hard drive and optical drive information
- Processor and clock speeds
  - Some motherboards allow changing the processor speed and/or the memory multiplier (overclocking)
- Monitor temperatures, fan speeds, and voltages
- Intrusion detection
  - Can enable event logging (logs when case is opened)

Using Setup BIOS To Configure a Motherboard

- Power-on passwords
  - Assigned in BIOS setup to prevent unauthorized access to the computer and/or BIOS setup utility
  - May be possible to set a supervisor and user password
    - If both passwords are set, must enter a valid password to boot the system
  - How to set passwords varies depending on motherboard and BIOS

Using Setup BIOS To Configure a Motherboard

- BIOS Support for Virtualization
  - Virtualization is when one physical machine hosts activities that are normally done on multiple machines
  - Virtual machine (VM) is software that simulates the hardware of a physical computer
    - Each VM works like a physical computer and is assigned virtual devices such as virtual motherboard and virtual hard drive
  - Virtualization must be enabled in BIOS setup

Using Setup BIOS To Configure a Motherboard

- LoJack for Laptops Technology
  - Technology embedded in the BIOS of many laptops to protect a system against theft
  - Must subscribe to service
  - Software and BIOS work together to locate a laptop whenever it connects to the Internet
- Drive Encryption and Drive Password Protection
  - Some motherboards allow you to set a password in order to access the hard drive
  - Password is kept on drive so that it still works even if drive is moved to another computer

Using Setup BIOS To Configure a Motherboard

- TPM chip – Trusted Platform Module chip
  - BitLocker Encryption in Windows 8/7/Vista works with this chip
  - Encryption key is kept on chip
  - Assures that a drive cannot be used in another computer
  - Can be used with other encryption software that may be installed on the hard drive other than BitLocker
  - If the motherboard fails and is replaced, you'll need a backup copy of the startup key to access data on the hard drive

Using Setup BIOS To Configure a Motherboard

- Exiting the BIOS setup menus
  - Most exit screens give several options

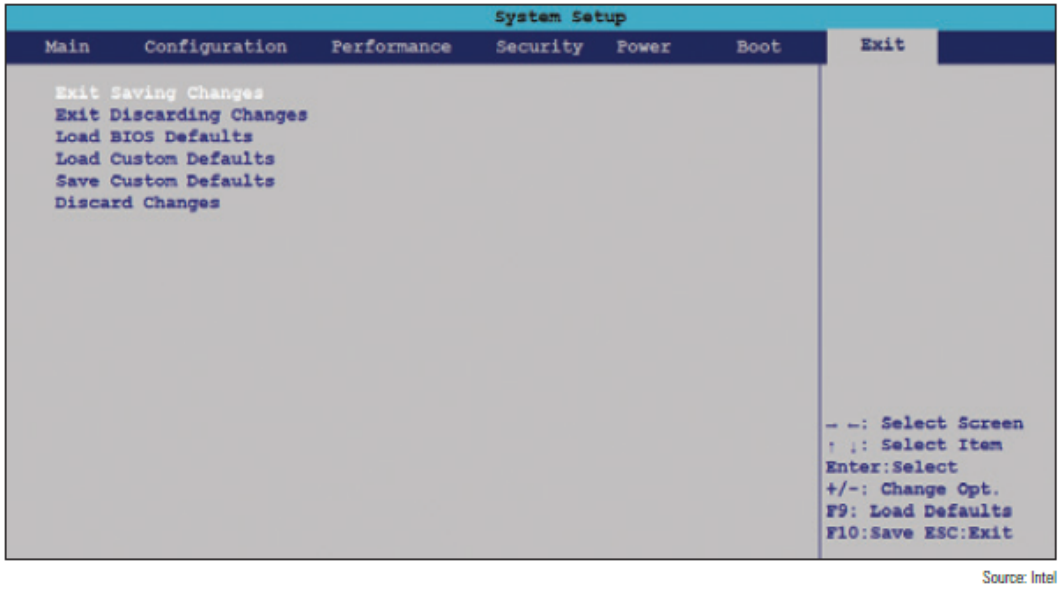


Figure 3-40 BIOS setup Exit menu

Using UEFI Setup to Configure a Motherboard

- Extensible Firmware Interface (EFI), original version first developed by Intel
- Improves on BIOS in these ways:
  - Faster and better booting
  - Mouse-enabled interface
  - Secure boot
  - Support for hard drives larger than 2 TB
- Provides a BIOS boot through its Compatibility Support Module (CSM)

Maintaining a Motherboard

- Motherboard is considered a field replaceable unit
  - Need to know how to:
    - Update motherboard drivers
    - Update flash BIOS or UEFI
    - Replace CMOS battery

Updating Motherboard Drivers

- Device drivers are small programs that allow software to interact with certain hardware
- Use Windows internal drivers, bundled CD drivers, or download drivers from manufacturer site
- Always use 32-bit drivers with a 32-bit OS and 64-bit drivers with a 64-bit OS

Flashing BIOS

- Flashing BIOS is the process of upgrading or refreshing the programming stored on the firmware chip
  - BIOS updates are downloaded from motherboard manufacturer's Web site or third party site
  - Performed if:
    - System hangs at odd times or during boot
    - Motherboard becomes unstable
    - Incorporating new feature, or component

Flashing BIOS

- Methods of installing BIOS updates
  - Express BIOS update
  - Update from a USB flash drive using setup BIOS
  - Update using a bootable CD
  - Recovery from a failed update
- "If it's not broke, don't fix it" – only update if you're having trouble with a motherboard
- Don't update unless the update is a later version than the one installed
- Update should not be interrupted while in progress

Flashing UEFI

- UEFI updates are more secure than BIOS updates
  - Require digital signatures for update to be verified
- UEFI firmware, drivers, and databases can be updated by way of a USB flash drive or from within Windows
- Windows updates sometimes include UEFI updates
  - When Windows receives a UEFI update, it hands off the update to UEFI
  - Firmware is responsible for applying the update and displays a screen letting user know not to disturb the system while the update is in progress

Using Jumpers to Clear BIOS Settings

- Jumper – two small posts or metal pins that stick up off the motherboard that is open or closed
  - Open jumper has no cover and a closed jumper has a cover on the two pins
- Jumpers can be used to clear a forgotten supervisor or power-on password
- If flashing BIOS fails, a jumper can be set to undo the update

Replacing the CMOS Battery

- CMOS (complementary metal-oxide semiconductor) RAM is a small amount of memory stored on the motherboard that retains data
  - Even when computer is turned off
  - If the CMOS battery is disconnected or fails, setup information is lost
- To replace the CMOS battery:
  - Choose correct replacement battery
  - Power down system, unplug it, press power button to drain the power, remove case cover
  - Use ESD strap, remove old battery using a flat-head screwdriver, pop new battery into place

Installing or Replacing a Motherboard

- A motherboard is considered a field replaceable unit
- A technician needs to know how to:
  - Select an appropriate motherboard
  - Install or replace one in a desktop or laptop computer

How to Select a Desktop Motherboard

- Three approaches to selecting a motherboard:
  - Select the board that provides the most room for expansion, so you can upgrade and exchange components and add devices easily
  - Select the board that best suits the needs of the computer's current configuration
  - Select a motherboard that meets your present needs with moderate room for expansion

How to Select a Desktop Motherboard

- Consider the following when selecting a motherboard:
  - Form factor
  - The brand (Intel or AMD) and model processors the board supports
  - Chipset and memory speeds the board supports
  - Expansion slots (type and how many needed)
  - Hard drive controllers
  - Case
  - Price and warranty
  - Support

How to Install or Replace a Motherboard

- General process for replacing a motherboard:
  - 1. Verify right motherboard is selected
  - 2. Get familiar with documentation, features, settings
  - 3. Remove components to reach old motherboard
  - 4. Install the I/O shield (metal plate)
  - 5. Install motherboard
  - 6. Install processor and processor cooler
  - 7. Install RAM
  - 8. Attach cabling (case switches, power supply, drives)

How to Install or Replace a Motherboard

- General process for replacing motherboard (cont'd.)
  - 9. Install video card on motherboard
  - 10. Plug in PC, attach monitor, keyboard
  - 11. Boot system, enter UEFI/BIOS setup
  - 12. Observe POST, verify no errors
  - 13. Verify Windows starts with no errors
  - 14. Install the motherboard drivers
  - 15. Install other expansion cards and drivers
  - 16. Verify system operating properly, make final OS and UEFI/BIOS adjustments
    - setting power-on passwords

Replacing a Laptop System Board

- May need to fully disassemble the entire notebook
  - Consider alternatives before proceeding
- General procedure for replacing the motherboard:
  - Remove the keyboard, optical drive, and mini PCIe card
  - Remove the notebook lid and keyboard bezel assembly
  - Lift up the assembly and disconnect two cables connecting it to the motherboard
  - Remove CPU and DVD drive
  - Remove screw that hold motherboard in place

Summary

- The motherboard is the most complicated of all components inside a computer
- Most popular motherboard form factors are ATX, MicroATX and Mini-ITX
- Motherboard will have one or more processor sockets
- Chipset embedded on the motherboard determines what kind of processor/memory are supported
- Major advancements in Intel: Accelerated Hub Architecture, Nehalem chipsets, and Sandy Bridge

Summary

- Buses include conventional PCI, PIC-X, and PCI Express
- Some components can be built into the motherboard, called on-board components
- Firmware that controls a motherboard and the boot is the older BIOS and the newer UEFI
- Settings that can be changed include: changing boot order, enabling or disabling onboard devices, support for virtualization, and security settings

Summary

- Motherboard drivers and/or BIOS might need updating to fix a problem
- CMOS battery might need replacing
- When selecting a motherboard pay attention to the form factor, chipset, expansion slots, memory slots, and processors supported
- Study motherboard manual before installing it
- For laptops, it's usually more cost effective to replace the laptop than to replace a failed system board