Expansion Bus

Chapter 6
Overview

• In this chapter, you will learn to

  – Identify the structure and function of the expansion bus

  – Explain classic system resources

  – Identify the modern expansion bus slots

  – Install expansion cards properly

  – Troubleshoot expansion card problems
Historical/Conceptual

Structure and Function of the Expansion Bus
Connections

• Expansion slots connect to both the Northbridge and Southbridge
Two Crystals—Two Speeds

- All ICs are regulated by a **clock crystal**
- **System crystal** controls CPU, RAM, and chipset on the frontside bus
- Expansion bus crystal controls boards on expansion bus

1. The system crystal pushes the CPU, RAM, and chipset. It’s fast!
2. The expansion crystal pushes the expansion cards at a slower, standardized speed,
PC Bus (8-bit ISA)

- IBM XT had 8088 processor, 8-bit external data bus, and speed of 4.77 MHz
- Expansion bus ran at about 7 MHz (faster than the system bus)
- AKA PC bus, XT bus, or ISA bus
AT Bus (16-bit ISA)

- **AT bus** is a 16-bit bus running at 8.33 MHz
- Added 8 bits to the end of the PC bus
- **PC/XT** AKA 8-bit ISA
- **PC/AT** AKA 16-bit ISA
Modern Expansion Bus
False Starts—Dead Today

- **Microchannel Architecture (MCA)**
  - MCA had a 32-bit bus to match the 386 CPU’s external data bus with a speed of 12 MHz

- **Extended ISA (EISA)**
  - (EE-sah) was a 32-bit self-configuring expansion bus that was cheaper than MCA

- **Video Electronics Standards Association (VESA)**
  - Designed to solve the problems of speed and throughput
PCI

- **Peripheral Component Interconnect (PCI)** provides a stronger, faster, and more flexible alternative to other expansion buses

  - The flexible design enables the PCI to coexist with other buses and scale up in speed and throughput

  - PCI devices are self-configuring (now known as plug and play)

  - PCI Special Interest Group (SIG)
    - Defined I/O addresses and IRQs for most devices
    - Used a sharable Interrupt Channel instead of IRQs
PCI

- Fully implements DMA—allowing PCI devices to transfer data among themselves

- Divides its chipset duties between two chips
  - Northbridge (or PCI controller) performs the classic functions and controls the PCI bus
  - Southbridge (PCI to ISA bridge or just PCI bridge) acts as an intermediary between the PCI bus and the other bus
AGP

- Accelerated Graphics Port (AGP)
- PCI slot dedicated to video only
- Brown-colored connector found on modern motherboards
- More in Chapter 17
Other PCI

- **PCI-X**
  - Answers the need for speed

- **Mini-PCI**
  - Designed to use low power and lie flat
  - Ideal in laptop applications

- **PCI Express**
  - Lanes of 2 Gbps
  - Devices can use multiple lanes
System Resources
System Resources

• Expansion cards and the CPU need some way to communicate

• **System resources** help to define how communication occurs
  - I/O addresses
  - IRQs
  - DMA channels
  - Memory addresses

• Rarely need to adjust today
  - Plug and play takes care of most of the work
I/O Addresses

- All devices must have an I/O address
- Most devices use more than one I/O address (or a range of I/O addresses)
- Devices must use different I/O addresses
- The I/O memory wire signals that a device is being addressed
I/O Address Terminology

- When talking about I/O addresses, drop the leading zeroes (1F0...not 01F0)

- Every device gets a range of addresses

- The first I/O address is base I/O address

- Put an “h” on the end of the value to specify hex (1F0h)

- I/O addresses provide two-way communication (CPU to/from device)
Hexadecimal Compared to Binary

- Representing ten in binary and hex
  - Binary 1 0 1 0 (1 eight and 1 two)
  - Hexadecimal Ah (pronounced “A hex”)

Hexadecimal Table

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Hexadecimal Compared to Binary

- **Counting to 10**
  - Decimal 0, 1, 2 ... 9, 10
  - Binary 0, 1, 10
  - Hexadecimal 0, 1, 2... E, F, 10

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<tr>
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Interrupts

• The CPU can initiate a conversation with any device at will

• Any device may talk to the CPU, but how does a device get the CPU’s attention?

• Devices use the interruption mechanism to gain the attention of the CPU by placing a voltage on a special wire called the INT (interrupt) wire
Interrupts

• Multiple devices, but only one INT

• Devices use IRQs (interrupt requests)
  – Separate IRQ for each device
  – I/O Advanced Programmable Interrupt Controller (IOAPIC) manages IRQs

• IRQs numbered 0 through 23
  – Used to be only 16

• Open IRQs are unassigned
  – Plug and Play assigns IRQs to new devices as needed
COM and LPT Ports

- Communication & Line Printer (LPT) ports
- IBM created standard preset combinations of IRQs and I/O addresses
- The **COM port** and **LPT port** preset combinations:

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Direct Memory Access (DMA)

- **Direct memory access (DMA)** is the process of accessing memory without using the CPU
- It enables the system to run background applications without interrupting the CPU

![Diagram showing the process of Direct Memory Access (DMA)]
Bus Mastering

- **Bus mastering** devices use the DMA without accessing the 8237 or CPU

- Circuitry allows them to watch for other devices accessing the external data bus
  - No two devices can use the external data bus at the same time

- Extremely popular in hard drives
  - All EIDE hard drives take advantage of bus mastering

- Floppy drives still use the old DMA
Memory Addresses

• Some (not all) expansion cards need memory addresses

• Two reasons for this:
  1. May have onboard RAM that the CPU needs to address
  2. A few cards have onboard ROM (adapter, option type; see Chapter 5)

• RAM or ROM may steal memory addresses from main system RAM

• Memory addressing is fully automatic
Installing Expansion Cards
Steps to Installing Expansion Cards

1. Knowledge

2. Physical installation

3. Device drivers

4. Verify
Step 1: Knowledge

1. Learn about the device by reading the documentation

- Do you have device drivers for your operating system (Windows, Linux, etc.)
- Does the device work with your operating system?
- Check the Windows Marketplace
  - http://testedproducts.windowsmarketplace.com
  - Devices on this list have been certified by Microsoft to work with Windows
2. Install the card

- Hold the card on its edges—don’t touch connectors or the components on the card
- Insert at the proper angle
- Use the connection screw, which helps to ground the card and prevent card creep
- Use proper ESD procedures
Step 3: Device Drivers

• All devices require BIOS, which for expansion cards is almost always a device driver
  − Devices will come with device drivers on the installation CD
  − It is recommended that you get the latest drivers from the manufacturer’s Web site

• Which one first?
  − Driver or device? Usually device first
  − If USB or FireWire, driver first
Removing the Driver

- Right-click on the device in Device Manager and choose Update Driver...
  - Choose Uninstall to remove the current driver

- May also be able to uninstall via Add/Remove Programs
Unsigned Drivers

- Manufacturers submit drivers and devices to Microsoft for testing
  - Once tested and verified, they are digitally signed
  - Unsigned drivers give a warning

- Drivers that haven’t been tested may still work fine despite the scary message
Installing the New Driver

- Use the CD that came with the device
  - May install extra unwanted programs

- Use the Add Hardware Wizard in Control Panel
Driver Rollback

• Right-click the device in Device Manager and choose Properties, then the Driver tab

• If you installed the wrong driver you can roll back to the previous driver
Step 4: Verify

- Check the device properties in Device Manager to verify it is working properly.
Troubleshooting Expansion Cards
Device Manager

• Check for the device in Device Manager

  – Right-click My Computer | Properties | Hardware tab | Device Manager

  – If the device does not show up in Device Manager

    • Run the Add/Remove Hardware Wizard in Control Panel

    • If it still doesn’t show up, the device is damaged or is a legacy device whose system resources are not configured properly
Device Manager Symbols

- **Black ! on a yellow circle**
  - Device is missing, Windows doesn’t recognize it, or a device driver problem
  - Device may still work

- **Red X**
  - Disabled device—enable it
  - Damaged device—double-check work
  - Device will not work

- **Blue I on a white background**
  - System resources were configured manually
  - Only seen on non-ACPI systems
  - Information only—device will work
Device Manager

- Device Manager allows you to see what resources are being used by your devices
  - Right-click My Computer | Properties | Hardware tab | Device Manager button