

Component 4: Introduction to Information and Computer Science

Unit 3: Computer Hardware & Architecture

BMI540/640
Week 1

Unit Objectives

- List the major elements of a computer (motherboard, CPU, I/O devices, memory, secondary storage, buses, expansion cards, ports, etc.).
- Describe how data is stored in memory and in secondary storage.
- Describe how data is represented in binary.
- Describe the function of the CPU.
- Describe how data is input/output from the computer.
- Describe how a computer system works together.
- Introduce specialized architectures and embedded systems used in healthcare settings.

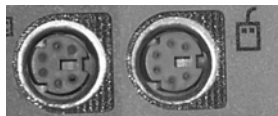
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2

Input / Output Ports

- Mouse (PS/2)
 - Round in shape, usually colored green and customized to fit a vintage mouse connection type.
- Keyboard (PS/2)
 - Round in shape, usually colored purple and also customized to fit a vintage keyboard connection type.



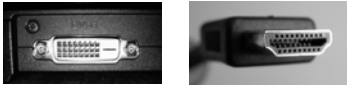
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Version 1.0/Fall 2010

3

Input / Output Ports (cont'd)

- **VGA (Video Graphics Array)**
 - Three row, 15-pin connector used to connect a monitor to the computer.
 - Provides basic resolution and is still in use today.
- **DVI (Digital Visual Interface)**
 - Port provides high-quality output to flat panel monitors, replaced the VGA standard since it provides better quality video.
- **HDMI (High-Definition Multimedia Interface)**
 - Small, rectangular monitor port that provides high-definition video output.



Component 4/Unit 3 Health IT Workforce Curriculum Version 1.0/Fall 2010 4

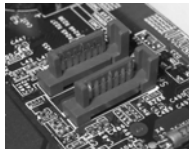
Input / Output Ports (cont'd)

- **USB (Universal Serial Bus)**
 - Rectangular in shape, created to replace most parallel and serial port connection requirements through a common interface type.
 - USB 2.0 provides approx. 480 Mbps throughput and found in most devices as of June 2010.
 - USB 3.0 theoretically provides approximately 5 Gbps throughput and should replace USB 2.0, FireWire, and eSATA devices because of its speed.
- **Microphone/speaker**
 - An analog audio connector, invented almost 100 years ago and used today in the same physical format.
 - Looks like a typical headphone jack.

Component 4/Unit 3 Health IT Workforce Curriculum Version 1.0/Fall 2010 5

Input / Output Ports (cont'd)

- **FireWire (IEEE 1394)**
 - Rectangular in shape, connect external hard disk and video equipment to the computer, latest standard provides approximately 3 Gbps throughput.
- **SATA (Serial Advanced Technology Attachment)**
 - Usually utilized to connect storage (internal or external) devices to the computer, latest standard provides approximately 3 Gbps throughput.



Component 4/Unit 3 Health IT Workforce Curriculum Version 1.0/Fall 2010 6

Input / Output Ports (cont'd)

- SCSI (Small Computer System Interface)
 - Port standard allows high-speed data transfer between devices and a computer; usually tape drives and/or hard disks.
 - While SCSI has existed for decades (since ca. 1986), it is an evolving technology and it still used in modern networks (backup devices and servers).



Component 4/Unit 3 Health IT Workforce Curriculum Version 1.0/Fall 2010 7

Input / Output Ports (cont'd)

- Modem (RJ-11)
 - Square RJ-11 jack allows a phone cable to connect the computer to a modem and to a wall phone jack for dialup network Internet access.
- Networking (RJ-45)
 - Installed 'onboard' modern computers. Vintage computers required owners to purchase and install a network interface card (NIC) in a motherboard PCI slot. The RJ-45 jack is a port on the NIC.
 - Square RJ-45 jack allows a networking cable to connect the computer to another device, such as a switch or home router.
 - Acronym "RJ" expands to the phrase "registered jack."

Component 4/Unit 3 Health IT Workforce Curriculum Version 1.0/Fall 2010 8

Input / Output Ports (cont'd)

- Parallel
 - Rectangular parallel, 25-pin (DB-25) port connects the computer to vintage printers.
 - ✓ Modern printers often connect to the computer via USB port.
 - Sends data on all 25 pins simultaneously, or in a parallel manner.



Component 4/Unit 3 Health IT Workforce Curriculum Version 1.0/Fall 2010 9

Input / Output Ports (cont'd)

- Serial
 - Round, 9-pin (DB-9) port connect the computer to modems and other devices.
 - Modern computers often do not include installed serial ports.
 - Sends data one bit at a time, or in a serial manner.
 - Used to connect to devices for terminal sessions. For example, some networking devices can be managed in this manner.
 - Since modern computers no longer include physical serial ports, USB devices and their accompanying software can emulate (imitate) their behavior.



Component 4/Unit 3

Health IT Workforce Curriculum
Version 1.0/Fall 2010

10

Storage Devices

- Storage devices can be classified as internal or external.
- An internal storage device is installed inside the computer's case, on the motherboard.
- An external storage device is connected to the computer via a port.

Component 4/Unit 3

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Version 1.0/Fall 2010

11

Primary Storage

- Random Access Memory (RAM)
 - The primary storage area used by programs running on a computer.
 - The operating system and running programs load into RAM. Anything stored in RAM is erased when power is lost. Also known as "volatile memory."
 - RAM is installed directly on the motherboard.



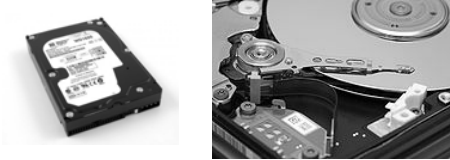
Component 4/Unit 3

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Version 1.0/Fall 2010

12

Secondary Storage

- Hard Disk Drive (HDD or HD)
 - The secondary storage area of a computer system.
 - Made up of magnetic platters that hold an electric charge, even when power is turned off or lost.
 - The operating system, programs, and data are stored on the HD.
 - Operates similar to a vintage record player (except that the head never touches the platter).



Component 4/Unit 3

Health IT Workforce Curriculum
Version 1.0/Fall 2010

13

Secondary Storage (cont'd)

- Hard Disk Drive (HDD or HD)
 - A hard disk's platter is divided into a track, which is a circular path around the platter.
 - Each track is made up of a number of sectors, which are 512 byte blocks of storage space.
 - Disk drives connect to the motherboard through a variety of cable types such as IDE or SATA.
 - Other types exist!
 - IDE (Integrated Drive Electronics) drives use a 40- or 80-pin cable to connect the HD to the motherboard.
 - SATA drives were designed to replace IDE drives.
 - Internal SATA drives connect to the motherboard by a 7-pin wire and operate much faster than IDE.

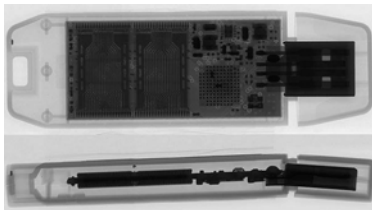
Component 4/Unit 3

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Version 1.0/Fall 2010

14

Secondary Storage (cont'd)

- Other storage devices include USB flash drives, SCSI drives, SATA disk drives, tape drives, and optical or DVD drives.



Component 4/Unit 3

Health IT Workforce Curriculum
Version 1.0/Fall 2010

15

Data is Stored in Memory

- Data is stored in electronic format on primary and secondary devices.
- When text, images, etc. are stored, each character or pixel must be converted into an electronic equivalent.
- Data stored in RAM is temporary and is erased when the computer loses power.
 - RAM is often referred to as primary storage.
- Data stored on the a hard disk drive is permanent and is retained when the computer loses power.
 - HDD storage is often referred to as secondary storage.

Data is Stored in Binary

- Computers utilize the binary number system, where electricity is recognized as being in one of two states – “on” or “off.”
- In the early 1940’s, Dr. John Atanasoff made a major contribution to computing through his understanding of electricity and Boolean logic.
 - He authored the idea that data could be stored and subsequently read by recognizing that only one of two real electrical values existed (on or off) at any given time.
- George Boole created the logic that governs the activities in electric circuits ca 1850.
- A 0 or 1 is referred to as a bit (binary digit) and bits are generally grouped together to form a “word.”

Data is Stored in Binary (cont'd)

- Each bit’s value indicates whether the software believes enough electricity was detected to set the bit to “on” (a value of 1) or “off” (a value of 0).
 - If a small impulse of electricity is detected, this is generally accepted as an indicator of a setting of off with a corresponding bit value of 0.
 - The term “small” is arbitrary.
 - If a large impulse of electricity is detected, this is generally accepted as an indicator of a setting of on with a corresponding bit value of 1.
 - The term “large” is also arbitrary.

Data is Stored in Binary (cont'd)

- A word can be 4-, 8-, 16-32-, 64-, (and so on) bits long.
 - Nintendo 64 used 64 bits to represent each pixel on its screen, meaning that each pixel could represent one of millions of colors (2^{24} number of colors per pixel).
 - While this system had major limitations and other issues, it was a huge success.

Data is Stored in Binary (cont'd)

- Binary words can be translated into decimal equivalents.
- Each bit represents a placeholder for a binary exponent, starting from the right and moving to the left.
- In an 8-bit word, placeholder values are:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
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- Any number raised to the zero power is always (the decimal value of) 1.
- If a bit's value is "on" (or set to the binary state of 1), then its placeholder value is added to the decimal equivalent calculation.
- If a bit's value is "off" (or set to the binary state of 0), then its placeholder value is ignored as the decimal equivalent is calculated.

Data is Stored in Binary (cont'd)

- For example, a 4-bit word is translated to:
 Binary value: 1001_b
 Decimal equivalent: 9
 Formula:
 $1001_b = 1 \times 2^3 + 0 \times 2^2 + 0 \times 2^1 + 1 \times 2^0 = 8 + 0 + 0 + 1 = 9$

 We ignore placeholder values considered to be "off".
- 8-bit words range in value from 00000000_b to 11111111_b , which is equivalent to the decimal values 0 – 255.

Data Storage Acronyms

- Storage of data is stated in megabytes, gigabytes, and terabytes.
 - 1024 bytes = 1 kilobyte (KB).
 - 1024 KB = 1 megabyte (MB).
 - 1024 MB = 1 gigabyte (GB).
 - 1024 GB = 1 terabyte (TB).

Data Storage Approximations

- As of February 2010, the Library of Congress holds an estimated 160 TB of data.
- A typical song or image stored on a hard disk might consume 3 MB of space.
- A chest x-ray typically consumes 20 MB of storage space.
- Hard disk manufacturers deviate from the “pure” binary outcome of 1024 and round down to 1000 for each item.
 - Therefore, 1000 MB = 1 GB and so on.
