HCS 200a: Systems Architecture and Components

This lesson gives an introduction to the general architecture of health IT includes a brief overview of computer hardware, software, and network technology; Web services; and data storage. In-house architecture is contrasted with outside applications and service providers offering remote hosting. Medical and point-of-care devices that interact with information systems are discussed along with issues of connectivity and interoperability.

HIT Computer Hardware

HIT Computer Software

HIT Computer File Systems

Flashcards

Sorting Activity: Hardware

Practice Quiz

HIT Computer Hardware

Health IT makes it possible for healthcare providers to better manage patient care through secure use and sharing of health information. To use health IT to its fullest potential, healthcare professionals need a fundamental understanding of computers and computer science.

Computer Hardware

Computers vary in size from supercomputers and mainframes to midrange and personal computers. Size is most often associated with the speed and complexity of processing, number of devices supported, and amount of storage available. Regardless of size, computers share the same characteristics. For demonstration purposes, we use personal computers.

The following figure illustrates the primary elements of computer hardware.

COMPUTER HARDWARE
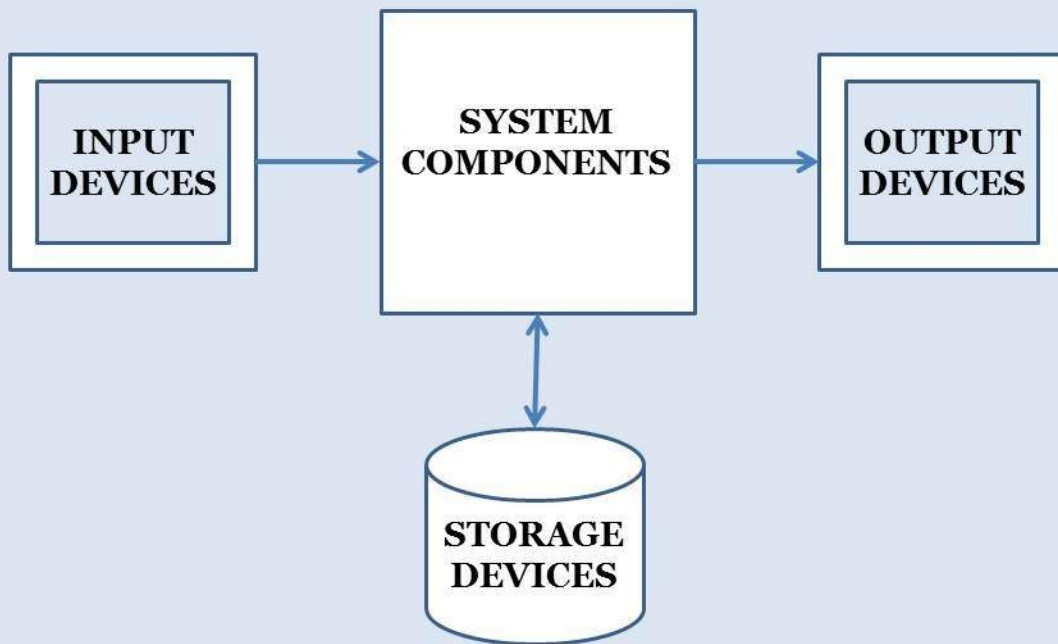
System Components

- The chassis is a metal and/or plastic case to house and protect the computer.

- The internal components, including the central processing unit (CPU), computer memory modules, and usually an internal hard disk drive, are held in place by internal bays and slots.

- Bays, ports, and slots provide openings to connect external devices and to allow increased computing power and functionality.

- Buses are internal circuitry and electrical channels that enable components to communicate.

- Lights and other indicators indicate power and access to external devices and networks.

- Bays are openings in the computer case that house mass storage devices such as CD–ROM/DVD, disk, and tape drives.

- Ports are interfaces for connecting input, output, storage, and communication devices.

- Slots are receptacles in the motherboard for plugging in expansion boards (modem cards, wireless-access cards, memory modules, and other functional add-ons).

External Components of the Desktop System Unit

This interactive exercise is designed to help you locate and understand the purpose of the various bays and ports on a desktop PC system unit. To identify components, move your mouse pointer over the name of the component or the image. Then be sure to click on each component to see a detailed view. In the detailed view, you can examine the cables of various peripherals and plug them into their respective ports by using your mouse. You also can see the most common bays and the way peripherals fit into them.

The location of bays, ports, and slots vary among types and brands of computers. Follow the instructions for the following activity to familiarize yourself with the differences you might find on a desktop computer.

You might have noticed the computer has an internal hard disk drive (HDD), as most computers do. You may observe in the next exercise that computers also have bays and ports that support external disk drives too.

Knowledge Check

What is the difference between a bay and a port?

A bay is always found on the front of the computer; a port is always found on the back.

A bay holds a piece of hardware; a port is a place where a plug or cable is inserted.

A bay is an area where cables and plugs are inserted; a port holds a piece of equipment.

You have a wireless mouse, a printer, a Bluetooth device, a camera-to-PC cable, and an external hard drive, all requiring USB connections to your desktop.

You will be able to connect all of these devices at the same time.

True

False

External Components of the Notebook and Tablet PC System Units

This interactive exercise is designed to help you locate and understand the purpose of the various bays, slots, and ports on a notebook or tablet PC system unit.

Computer Memory

Read-only memory (ROM) is permanent memory contained in chips mounted to the computer's motherboard. ROM is used to boot up the computer and to control internal devices such as hard disks and graphics cards.

Random access memory (RAM) is temporary storage used by the computer to hold data and information while the computer is working. RAM is emptied when the computer powers down. The amount and type of RAM greatly affects the computer's processing speed.

Central Processing Unit (CPU)

The CPU is the "brain" of the computer. It loads (fetches) and stores data and instructions from software programs, keeping track of all data and processes (threads) to be executed. The CPU contains an arithmetic logic unit (ALU), for performing arithmetic and logical operations, and a control unit, for extracting instructions from memory. It decodes and executes program instructions and data, using the ALU as necessary. As the CPU finishes one instruction, it moves on automatically to the next. The CPU is never idle until the computer is turned off.

Data Storage and Devices

Internal storage is any data storage device located inside the computer (e.g., in a bay or on a module) and connected directly to the motherboard. RAM, often called internal memory, is considered internal storage even though it stores data only temporarily. The HDD that is mounted in the computer case and plugged into the motherboard is also an internal storage device.

External storage is any data storage that is connected to the computer via a port. Network drives, external hard drives, and removable media such as CD–ROMs and thumb drives are all considered external storage devices.
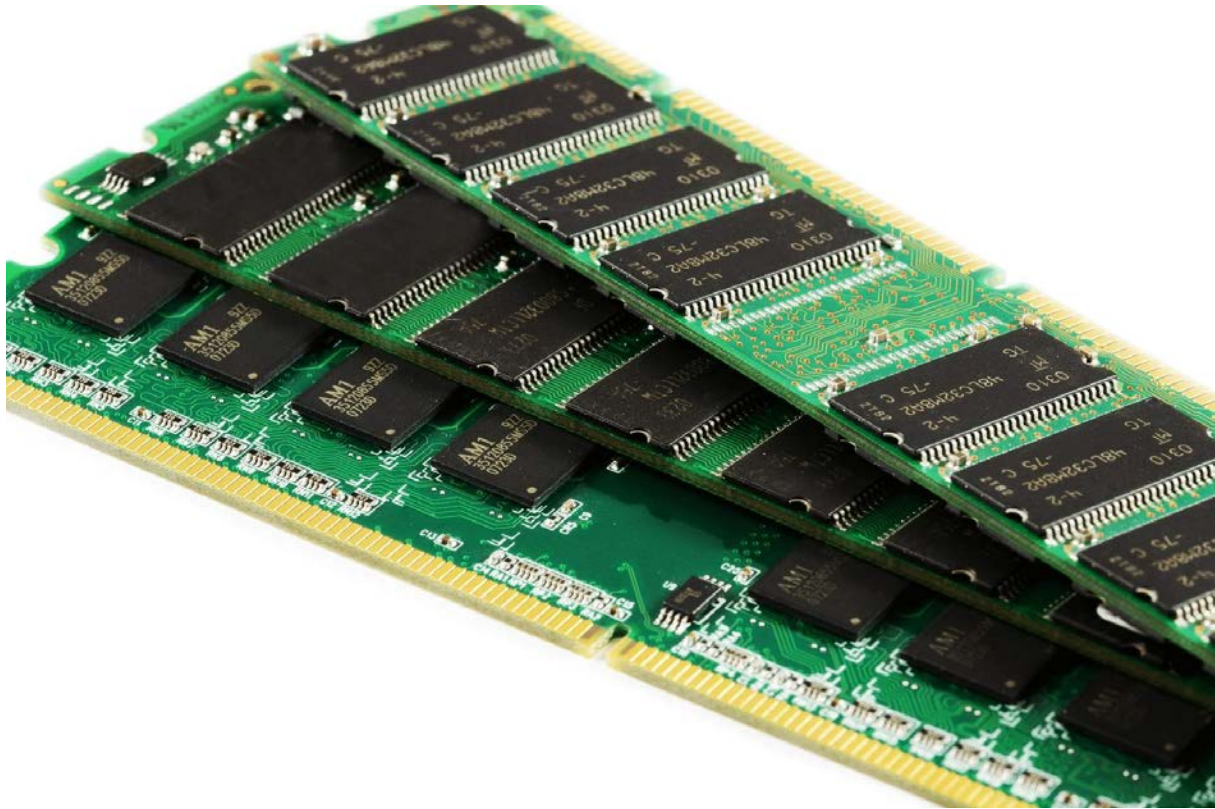
RAM is considered primary storage because the CPU can access data directly from RAM through the memory bus. Because of the high-speed capability, RAM is used to store data and instructions as needed from the operating system and from active software programs.

Secondary storage is data storage that is not directly accessible by the CPU. Most computers have an internal HDD that provides permanent storage for the operating system, application software, and data, and it is considered secondary storage.

Other secondary and external storage devices include universal serial bus (USB) 1ash drives, tape drives, and optical CD or DVD drives.

Image of storage devices

These external storage devices serve a variety of purposes:

- Data backup and recovery in the event a computer HDD fails

- Archival storage

- Mobility (e.g., data can be stored on a USB flash drive and accessed on a different computer)

Storing Data: Bits and Types

Computer data is stored in electronic format. Each input character is converted into a series of electronic bits (short for binary digits). Each bit is either OFF or ON.

The concept of OFF/ON led computer scientists to use the binary number system in which each OFF bit is given a value of 0 (zero) and each ON bit is given a value of 1 (one).

Binary Number System

The decimal number system is a base–10 system with numerals ranging from 0 (zero) to 9 (nine). To express a value greater than 9, a position is added to the left of the numeral, so ten is expressed as 10.

The binary number system has just two numerals: 0 (zero) and 1 (one). As with the decimal system, a digit is added to the left of the first numeral to express values higher than 1. So, in binary, 3 (three) is expressed as 11_2.

The subscript 2 indicates that this is a binary (base-2) number and is not the same as 10 in the decimal number system. To be completely scientific about it, when we write a three in decimal it should be written as 3_{10}.

Computer scientists use several different number systems for various purposes related to computer speed and eficiency.

If you find this an interesting topic, visit the [Math Is Fun](#) website for more about the binary numbering system. The Counting demonstration box is particularly illustrative.

Storage Capacity

Data storage device capacity is important when estimating storage requirements for a particular application. A byte is a unit of data that is 8 bits long. Common measures of storage capacity are expressed in bytes:

Storage Capacity Measure

1024 bytes	=	1 kilobytes (KB)	=	1,024 bytes
1024 kilobytes	=	1 megabyte (MB)	=	1,048,576 bytes
1024 megabytes	=	1 gigabyte (GB)	=	1,073,741,824 bytes
1024 gigabytes	=	1 terabyte (TB)	=	1,099,511,627,776 bytes

Image of storage capacity

The following examples offer an idea of the memory space required to store data:

- A typical song or an image stored on a hard disk is about 3 megabytes.

- A chest x-ray typically requires about 20 megabytes.

- As of September 2011, the Library of Congress holds an estimated 160 terabytes of data.

Address Storage

The computer must be able to locate data stored in primary and secondary storage. Each piece of data is assigned a physical memory address by the CPU. Whenever data is accessed by the computer, the assigned physical address is used to find it.

File addresses start with the first character of the file and end with the file's last character. Characters in the file are strung together in a stream, and when the file is opened, each character is read in sequential order.

Knowledge Check

RAM storage is best described by which statement?

Primary, internal, and temporary

Secondary, external, and permanent

Secondary, internal or external, and permanent

What storage unit is equal to 1024 byte

Kilobyte (KB)

Megabyte (MB)

○   Gigabyte (GB)

○   Terabyte (TB)

Data versus Information

What is saved on a hard disk is data, not information. Data has no meaning or value on its own.

Information is data presented so that it has meaning.

When Data Becomes Information

Each time a patient sees a primary care physician (PCP), the diagnosis and procedure codes related to the visit are recorded in the electronic medical record (EMR) system as *healthcare data*.

Health data becomes information when the patient sees a specialist at a later date. The data recorded during the PCP visits informs the specialist's diagnosis and patient treatment plan.

Health data becomes information when gathered to address a Joint Commission accreditation process.

Healthcare data becomes information when collected and combined with data from many like patients, then analyzed for quality measures.

The use of health data gives it meaning and transforms it into information.

Healthcare-Specific Hardware

Computer hardware concepts provide an essential technological foundation for health IT. Healthcare technology includes a number of highly specialized medical devices that require use of very specific and complex computer hardware.

These specialized medical devices produce complex images of internal aspects of the human body and its functions. When these images are input and stored in a computer, they require large capacity and sophisticated storage hardware. When they are displayed for use by a healthcare practitioner, the computer output device must display an image that is clear and accurate down to the cellular level.

Imaging Requires Advanced Hardware

Medical imaging such as *computed tomography (CT)* [1] and *magnetic resonance imaging (MRI)* [2] scans require specialized computer hardware. The GE Healthcare CT750 Hard Disk Computed Tomography Scanner, for example, scans and stores hundreds of terabytes of data at a time. This type of equipment, which features Intel's Xeon-based CPU, must discern the patient's soft tissue and organs at an almost molecular level in real time.

When physicians and other healthcare professionals view CT and MRI scans as computer output, they often make life-and-death diagnoses and decisions about patient treatment. When CT or MRI scans are input, processed, stored, and then accessed through computer output devices, that molecular level must be completely discernible.

To support this functionality, the CPU must also be optimized for speed and performance. Perhaps obviously, at this time, desktop and server CPUs cannot provide the required type of performance.

CT and MRI are good examples of healthcare technologies that require advanced computer hardware support. Many other medical devices require similar sophisticated computer hardware:

- Positron-emission tomography (PET) scan – is a nuclear imaging technique that produces a three-dimensional image of functional processes in the body and reveals metabolic changes occurring in an organ or tissue at the cellular level.

- Ultrasound – uses high frequency sound waves to look at organs and structures inside the body.

- Electrocardiogram (EKG or ECG) – is a simple, painless test that records the hearts electrical activity.

References/Sources

1 Medline Plus and the U.S. National Library of Medicine (2013). CT Scan. http://www.nlm.nih.gov/medlineplus/ency/article/003330.htm.

2 Medline Plus and the U.S. National Library of Medicine (2013). MRI Scans. http://www.nlm.nih.gov/medlineplus/mriscans.html.

3 Cooper, K. L., Meng, Y., Harnan, S., et al (2011). "Positron Emission Tomography (PET) and Magnetic Resonance Imaging (MRI) for the Assessment of Axillary Lymph Node Metastases in Early Breast Cancer: Systematic Review and Economic Evaluation." Health Technology Assessment. Volume 15. Number 4. http://www.ncbi.nlm.nih.gov/books/NBK109185/.

4 Medline Plus and the U.S. National Library of Medicine (2013). Ultrasound. http://www.nlm.nih.gov/medlineplus/ultrasound.html.

5 National Institutes of Health: National Heart Lung and Blood Institute (2010). What Is an Electrocardiogram?. http://www.nhlbi.nih.gov/health/health–topics/topics/ekg/.

Continue with other activities/quizzes...

HIT Computer Software

Without software, a computer would be a very sophisticated appliance with no real purpose. This may seem like an extreme notion, but the element of computer science that makes the computer such an important and innovative tool for mankind is software.

It is particularly important to realize that healthcare and healthcare information computer systems are unique, primarily because healthcare-specific software, including electronic health record (EHR) and electronic medical record (EMR) applications, are designed to meet the needs of patient care, safety, and quality of care.

Software Definition

Software provides the machine-readable instructions that a computer follows. There are two basic categories of software:

System software consists of programs that interact directly with the hardware and includes the operating system and utility programs. It operates the computer and serves as a layer between the application software programs and the hardware. System software runs in the background and coordinates all the tasks the active application software programs need to perform.

Application software consists of programs that run on top of the system software and enable end users to perform specific tasks. Application software has been developed for countless uses, from personal to educational to business and beyond, and many industries and infrastructures rely heavily on its performance.

Software Components

The basis of all software is code, the programming instructions that make the software work by communicating with the system hardware. Here are some simple examples of software code instructions that are not actually keyed in by the user but are triggered, for instance, when the user selects a name, types a "1," or clicks the Save icon:

-Read that patient's file

–Add 1 to the patient count

-Record this diagnosis code

These examples are stated in English, but in reality, code instructions are not so discernible to the untrained eye. Software code instructions are written in programming languages, which are machine readable and are normally not human readable.

Files are used by software for storing and retrieving data. In an HIT EMR system, for example, a user might create, open, and edit a patient demographic file or send an e-prescription file to a pharmacy.

Databases are software systems optimized for storing and retrieving large amounts of data quickly, correctly, and securely. A good example is the data repository associated with most EMR systems. All patient information, including demographics, visit and inpatient stay history, laboratory and scan results, and much more, is stored in that database.

Software Hardware Needs

Every software program relies on the computer's hardware. High-resolution graphics and video software, for instance, require a high-performance graphics card with built-in memory, a fast processor and a large amount of RAM, a monitor with fast response time, high-quality speakers, and large secondary storage. For example, MRI scans, which produce very high-resolution images, are captured, stored, and displayed in an EMR system.

Data-intensive applications, such as an HIT quality-measure statistical program, need a fast processor, a large amount of RAM, and large secondary storage, but they generally do not require a high-end graphics card. Understanding the minimum hardware and software requirements for the many computerized tasks carried out in the healthcare setting is critical to achieving desired results.

Software Installation and Maintenance

Software, like hardware, must be installed, maintained, and sometimes uninstalled. Software is usually stored on a hard disk device (HDD) and activated on the computer either automatically when the computer boots (starts up) or on demand.

Software, like other products, must be purchased. Most software, particularly the specialized programs used for health IT, is copyrighted and requires a license for use, and professionals must ensure that the appropriate rights to the software are in place. Licensing can authorize installation of the software on one or more computers, or it can be purchased for a given number of users.

Knowledge Check

Computers used in healthcare are unique because of which of the following characteristics?

The software used to perform the tasks needed

Their hardware that handles high-resolution graphics

Their different system components

A set of programming statements and instructions that make software work is considered software code.

Yes

No

Software utilizes computer hardware devices in each of these ways except that software_____.

uses simple files and database files as a source and as a repository for data.

might require special hardware to efficiently serve its purpose.

pretty much ignores hardware and lets the computer handle it.

System Software

System software consists of programs that control and maintain the operations of the computer: the operating system and utility programs.

Operating System (OS)

The OS of a computer is the set of software programs that coordinates all the activities of the computer, including all computer resources such as the system components and input/output and storage devices. The OS is usually unique to each individual hardware system: the same version of Windows OS running on a desktop may not run at all on a smartphone.

Operating System Functions

The functions of an OS include the following:

- Interface with the user to achieve what the user wants to do

- Boot the computer when it is powered on

- Configure and interface with any hardware devices attached to the computer

- Manage processes (running application and utility software programs)

- Manage hardware resources

- Manage memory

- Manage files

- Provide basic security

OS User Interface

The OS is the layer between the hardware and the application software. Without the OS, the application software would have no way to communicate with the hardware.

Technical users, such as programmers and systems analysts, might enter computer commands at the command line. Some OSs that use command lines are DOS, UNIX, and Linux.

Most OS systems, and the application software they support, provide a graphical user interface (GUI) through which users interact with the computer. The GUI provides visual representations of files and allows mouse movements to select and click what the user wants to open, run, print, copy, input, or otherwise act on.

The OS behind the GUI

An admissions clerk at a physician office needs to add a new patient's demographics to the EMR patient file. She first clicks on the appropriate EMR application software icon on her desktop. The OS finds and loads the patient data entry screen from the EMR application and presents the EMR patient data screen in the GUI.

When the clerk completes the data entry, she clicks on the icon to save it. The EMR application sends a request to the OS to find the patient file and to add the new patient record.

The OS sends commands and data to the HDD to write the new record and sends back a notice to the EMR application to indicate the record has been saved. The EMR application notifies the clerk.
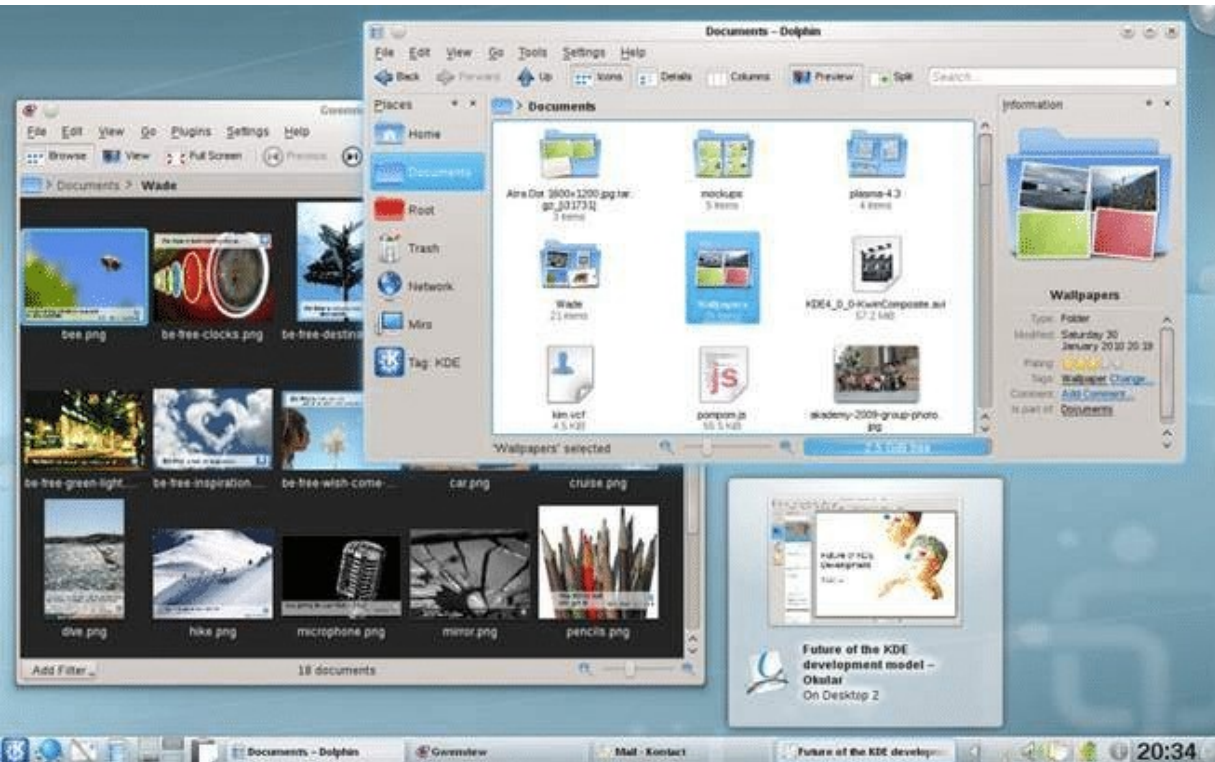
Image courtesy of

Some examples of operating systems with a GUI are Microsoft Windows, Mac OS X, iOS, and Linux graphical desktop environments such as Gnome and KDE.

Knowledge Check

What are the two basic categories of software?

An operating system and application software

An operating system and system software

System software and application software

An application program and system software

OS Boot

When a computer is turned on, it boots. The permanent startup instructions stored in read-only memory (ROM) executes and starts the OS. The OS continues to run the entire time the computer is on.

When it starts, the OS checks to see what devices are connected and whether their drivers are available and are functioning properly. The OS generates error messages if issues are encountered.

After the device and driver checks are successfully completed, the application software programs will start immediately or as the user requests them.

OS Manages Processes and Resources

The OS tracks every process and every computer resource used by every user. Because RAM is of a limited size, the OS may load only a portion of each process at a time to RAM and switch parts in and out as needed.

The OS implements a scheduler for sharing the computer CPUs and resources so that each process gets a fair share. The OS performs this control so quickly as to be barely noticeable.

OS Manages Security

The OS provides low-level security and can be configured to provide user accounts and access rights to protect access to the computer and files.

Current operating systems include integrated firewalls to provide some protection from unwanted network access. However, computers need commercial security applications to

protect against viruses, worms, spyware, and malware.

System Software Utilities

Utility programs are part of the system software. These programs perform system tasks such as the following:

- File backup

- System diagnostics

- File search

- File compression

- Font size and other display screen adjustments

The OS and the utility programs work together to make computer resources usable.

Knowledge Check

System software consists of programs that control and maintain the operations of the computer, including each of the following except

○   the operating system (OS)

○   utility program

○   random access memory (RAM)

Users communicate with the OS through one of two basic methods. Which of the following is NOT one of those methods?

○   Graphical User Interface (GUI) for application software users

○   Command line for more technical users

○   Common software interface

Application Software

As stated earlier, application software has been developed for countless uses. It enables users to perform tasks in minutes or hours that, just two decades ago, might have taken days or weeks.

Following are just a few of the many types of application software. Some of these categories of software are not exclusive or distinct: for example, some business applications are used for home purposes.

- Business applications include word processors, spreadsheets, database applications, presentation software, project management software, accounting applications, to name a few.

- Science and mathematical software includes statistical, mathematical modeling, computational science software, and more.

- Graphics and multimedia applications are used to create graphics, edit images, create and edit videos, create and edit audio, and create video games.

- Home and personal use applications comprise the broadest software category, including apps now available on most smartphones, and represent the ubiquitous computing era we live in today. Examples include GEO location, social networking, satellite radio, online banking, and many more.

- Communications software is the software that helps users communicate through networks, including Internet browsers, email, instant messaging (IM), file transfer, and video conferencing, among others.

- Artificial intelligence (AI) applications use knowledge, reasoning, learning, and other human characteristics for approximating human intelligence. Some examples are voice recognition software, automated online help, and expert systems.

Application software comes in different forms:

- Licensed software is packaged, copyrighted, and commercially available for purchase. For example, Microsoft Ofice Home Edition (includes Word, Excel, and PowerPoint); Business software for accounting, payroll, project management, and so on; and EMR systems for hospitals and/or physician ofices

- Custom software is created for a particular purpose, generally when no commercially available application offers the needed functionality. For example, the Informatics Shared Resource at Oregon Health Science University often creates custom applications for clinical researchers.

- Web applications are software that runs on particular websites. For example, free applications such as email (Yahoo!, Google, MSN) and applications such as online tax preparation software available for a fee.

These are the most common forms that application software takes—particularly for business and home or personal use.

Healthcare Application Software

Healthcare and HIT computer systems are unique, primarily because of the healthcare application software programs specifically designed to meet the needs of patient care, safety, and quality of care.

Many different applications are available for healthcare. Following are just a few examples:

- EMR/EHR systems

- Expert systems/clinical decision support systems

- Medical ofice management systems

- Patient registries

- Medical imaging

- Telemedicine

These are some of the more common healthcare applications, but healthcare is a field in which the application software systems are growing quickly. In part, this growth is because medicine itself is constantly developing new technologies and computer systems are evolving to support those technologies.

EHR and EMR Systems

EHR and EMR systems are used for the medical and health information of individual patients. Healthcare providers are being encouraged to install these systems by the HITECH Act and its associated incentives.

Health information systems are larger systems, typically used in hospitals or large clinics, that include an EMR as well as features such as physician ordering, medications, decision support, billing, and scheduling.

Many vendors are competing to provide the EHR/EMR systems, including

- EpicCare

- GE Centricity

- Practice Fusion

The Veterans Health Administration (VHA) has developed a full-featured EHR/EMR system called VistA that is used by all VHA providers. This system tracks all inpatient and outpatient care provided to veterans who are treated by VHA providers.

Image courtesy of the United States Department of Veterans Affairs.

Expert Systems

Expert systems, such as clinical decision support systems (CDSS), use artificial intelligence to analyze knowledge and make decisions as a human expert would.

Following are just a few examples of the many expert systems used in healthcare:

- IBM Watson, IBM's intelligent computer system, is being adapted to be an expert CDSS in healthcare. It will analyze massive amounts of up-to-date information: journal articles, studies, similar cases, and clinical and laboratory findings, among other information, to help medical personnel make decisions in patient care.

- For over two decades, DXplain (pronounced dee-explain) has provided doctors with diagnosis support in the form of case analysis and an electronic medical textbook. In a clinical setting, given a set of signs, symptoms, and laboratory values, DXplain can provide a list of possible diagnoses along with explanations. As a medical textbook, it provides detailed information about more than 2,400 diseases.

- MYCIN was developed at Stanford University in the 1970s and was one of the first expert systems used in a medical setting. It was capable of identifying bacteria and recommending antibiotics and dosages for treatment.

Medical Office Management Systems

When we show up to the present moment with all of our senses, we invite the world to fill us with joy. The pains of the past are behind us. The future has yet to unfold. But the now is full of beauty simply waiting for our attention.

Medical ofice management systems include capabilities such as scheduling and billing. Following is a screenshot from the OpenEMR system that shows the scheduling feature of that software package.
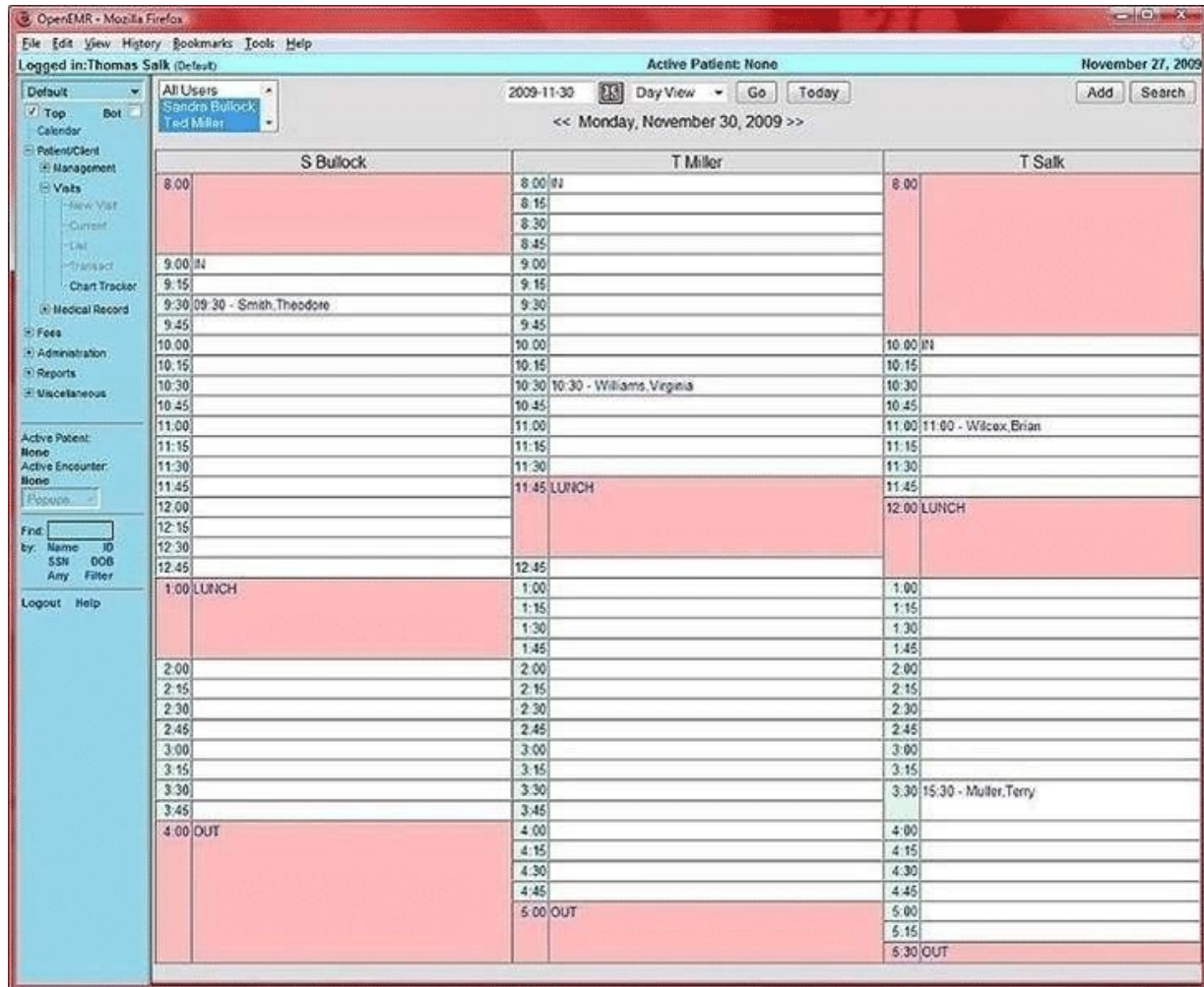
Image courtesy of Bradygmiller.

EMR systems developed for use in physician ofices often include these same functions. However, a medical ofice management system might be installed before the physician upgrades to a full-featured EMR system.

Patient Registries

Patient registries bring together data related to a particular medical issue or population, used to track changes in patients over time. They provide a more global view of all patients that EMRs generally does not provide. According to an article by Labresh and colleagues,

A patient registry can be a powerful tool to observe the course of disease; to understand variations in treatment and outcomes; to examine factors that influence prognosis and quality of life; to describe care patterns, including appropriateness of care and disparities in the delivery of care; to assess effectiveness; to monitor safety and harm; and to measure quality of care. Through functionalities such as feedback of data, registries are also being used to study quality improvement. [1]

EXAMPLE

The Centers for Disease and Control Prevention (CDC) established a National Program of Cancer Registries (NPCR) that encourages states and US territories to maintain cancer registries that can be used to improve the completeness, timeliness, and accuracy of cancer-related health data and to improve public health.

Registries across the country share examples of innovative ways in which they have collaborated to reduce the burden of cancer in the face of dwindling resources.

The CDC site supports the NPCR registry program.

Medical Imaging Software

Medical imaging is the capturing, storing, and viewing of images of human structures. Images can be generated from diagnostic tools such as x-rays, MRIs, and CT scans. The software used in this equipment then displays the images for viewing by medical personnel.

Image of an xray of the brain

High-resolution video software requires a high-performance graphics card with built-in memory, a fast processor and large amount of RAM, a high-quality monitor, large secondary storage, and sometimes speakers if audio is included.

Telemedicine

Telemedicine is technology aimed to improve care, particularly for patients who are homebound. Telemedicine enables users to consult or manage medical procedures remotely. Software that supports telemedicine is crucial—it must be comprehensive and reliable so that the remote work can be done.

Knowledge Check

What are application software programs specifically designed to do?

meet the needs of the computer user

meet all the needs of all possible users in one package

fulfill the capabilities from the operating system software

protect the user from the operating system software

Healthcare and HIT computer system applications are unique, primarily because healthcare applications are_____.

very dependent on specialized hardware

used by physicians to perform billing

designed to meet patient care needs

Which of the following is NOT a reason that healthcare application software systems are an evolving and dynamic field?

Physicians constantly look for way to change their practice, and computerization promises improvement.

The HITECH Act encourages the use of healthcare systems like the EMR

Medical science is constantly advancing

References/Sources

1 Labresh, K. A., Gliklich, R., Liljestrand, J., et al (2003). "Using "Get with the Guidelines" to Improve Cardiovascular Secondary Prevention." Joint Commission Journal on Quality and Safety. Volume 29. Number 10. 539–550 Pages.

Continue with other activities/quizzes...

HIT Computer File Systems

Data is contained in a computer system in the form of files. The files must be managed and protected, a responsibility that is especially important in health information technology (HIT) systems, which contain confidential patient data. A file system is used to organize files and their data on a storage device. The operating system (OS) includes the file system and acts as an intermediary between the file system and the applications, including software and OS utilities.

Files

A file is a block of program instructions or data stored on a hard disk drive (HDD) or other form of secondary storage disk. There are many different file types:

- An executable file is a program file that executes the software application. An executable file contains a series of machine code instructions. For example, when the user clicks the icon to open the electronic medical record (EMR) system, an executable file is activated to start the application.

- A text file is a collection of binary representations of characters that can be translated into human-readable text, numbers, or special characters. Such a file might hold a patient's demographic information or medical history.

- Other types of files include those with special formats, such as Microsoft Word and Excel files, images, and videos. MRI and a CT scan results are examples of special file formats.

File Names and Extensions

File names generally must follow naming conventions. OS and system file names, for example, might limit the number of characters in the name or might be case sensitive.

Part of a file name is the file extension, which is the suffix, preceded by a dot (.), at the end of a file name. The file extension indicates the file type. For example, the .txt in "readme.txt" indicates that "readme" is a plain text document.

Most file extensions contain three characters, although some have fewer and some more. When a user double-clicks a file, the computer references the file extension to determine which program should open it. If the file extension is altered, the file might become inaccessible.

Following are examples of common PC–based computer file names with extensions:

–– winzip.exe: An executable program named winzip
–– essay.docx: A Microsoft Word 2010 document named essay
–– budget.xls: A Microsoft Excel spreadsheet named budget
–– photo1.jpg: A JPEG image named photo1

Winzip.exe   essay.docx   budget.xls   photo1.jpg

File Extensions

If you work on a particular computer, such as on a PC (personal computer), it is helpful to learn the most common file extensions for that system. "Because there are tens of thousands of software programs available, there are also tens of thousands of file extensions. It is simply not possible to learn them all. Therefore, whenever you come across a file extension you don't recognize, visit FileInfo.com to find out what kind of file it is." [1]

File Owner and Permissions

Each file has an owner and is given permissions to establish who can read, write, or save the file. The OS provides file utilities to manage ownership and permissions of a file. If the file is an executable program, permissions determine who can run it. Permissions are an important security feature because they protect files from being accessed by users who are not authorized.

File Size

File size is expressed in bytes, kilobytes (KB), megabytes (MB), gigabytes (GB), and so on. The size of the file depends on the amount and type of data stored in it. A long Microsoft Word document is larger in file size than a short one and possibly longer than an MRI image file.

Knowledge Check

A file might contain any of the following except_____.

software

hardware

images

text

What would an executable file probably contain?

MRI images

Patient demographic data

Software ready to run

What might a text file contain?

MRI Images

Patient demographic data

Software that is ready to run

File Groups and Utilities

Most OS file systems allow users to group files. In some systems, such as Windows and MAC OS, the groups are called folders. In others, such as UNIX and Linux, the groups are called directories. Folders/directories contained in other folders/directories are called subfolders and subdirectories. The concept of nesting folders/directories is called a hierarchy, or folder/directory tree.
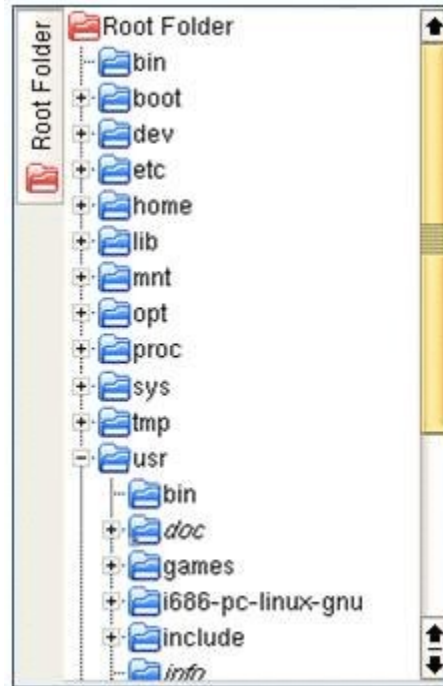
OS file systems provide file utility programs to manage files and folders, or directories, as shown in the following table.

System	File Utility
Windows	Explorer
Mac OS	Finder
UNIX	Command-line commands

These utilities provide a wide variety of useful file management tools that enable the following functions:

- Create folders

- View files and their properties

- Find, move, copy, and paste files or folders

- Rename files or folders

- Search folders by file name, content, date created/modified, extension

- Compress and archive files

- Back up and restore files

- Defragment disk

- Manage security

- Transfer files

Application software running under certain OS systems, such as Windows, use these file management utilities when users access files.

Using and Managing Files

When a user performs a file operation, such as open, close, read, or write, the following steps take place:

1 The operating system translates the operation into one understood by the file system.

2 The file system locates the file on the disk and tells the hardware what operation needs to be done and at what location.

3 If the operation returns any data, the data is transferred from the hard drive to the file system and then to the OS where it is brought into RAM memory.

4 The OS then provides the data to the application or the user who requested it.

Because files hold the data necessary to achieve the purpose the computer system addresses, the files must managed and protected. Following are some important best practices for managing files:

- Use descriptive names for files and folders/directories

- Maintain proper file extensions

- Group similar files together into folders or directories

- Organize folders/directories in a proper hierarchy

- Delete or archive files no longer needed

- Compress files and defragment disk drives regularly

- Back up files often, on a schedule, and whenever a significant data event is about to occur or has just occurred.

Database Files

In many computer systems, including HIT systems, data requirements are complex and sophisticated. The data must be quickly accessed and efficiently stored, and the database file format is designed to provide these data storage requirements.

Database File Format

Most files, including powerful files such as Microsoft Excel spreadsheets, have several significant limitations.

- Files do not accommodate complex, structured relationships among files, and data redundancy and inconsistency result.

- Security of files is limited.

- Multiple users cannot use the same file at the same time.

Following is an example of a file containing a patient demographic information specifically related to the patient's employment:

Patient File

Name	Work Address	City	ST	Company
Bill Robeson	1312 Main	Portland	OR	Community Hospital Inc.
Walter Schmidt	14 12th St.	Oakland	CA	Oakland Providers LLC
Mary Stahl	14 12th St.	Oakland	CA	Oakland Providers LLC
Albert Brookings	1312 Main	Portland	OR	Community Hospital Incorporated
Catherine David	14 12th Street	Oakland	CA	Oakland Providers LLC

Now consider these questions:

- Do Bill Robeson and Albert Brookings work for the same company?

- What is the difference between Catherine David's and Walter Schmidt's workplace addresses?

- Would an application program easily recognize the similarity or difference between their addresses?

- What if this file had 10,000 entries rather than five, and it needed to be sorted by last name?

- How would the user update the information if Oakland Providers LLC became Oakland General?

Database and DBMS

A database is a structured data file that comes with its own database management system (DBMS). The DBMS performs the same functions as the OS file system with additional

functions unique to database files. Common DBMSs include IBM DB2, Oracle, and Microsoft SQL Server.

The database structure most commonly used in healthcare systems is the relational database. A relational database consists of one or more tables defined by a database designer in a meaningful and efficient fashion.

Following is a reconstruction of the patient table as it might appear in a relational database:

Company Table

CO ID	Company Name
CO1	Community Hospital Incorporated
CO2	Oakland Providers LLC

Patient Table

PID	Last Name	First Name	Work Address	City	State	CO ID
P01	Robeson	Bill	1312 Main	Portland	OR	CO1
P02	Schmidt	Walter	14 12th Street	Oakland	CA	CO2
P03	Stahl	Mary	14 12th Street	Oakland	CA	CO2
P04	Brookings	Albert	1312 Main	Portland	OR	CO1
P05	David	Catherine	14 12th Street	Oakland	CA	CO2

How has the relational database improved the manageability of the data?

- It is immediately apparent that Bill Robeson and Albert Brookings work for the same company.

- The difference between Catherine David's and Walter Schmidt's workplace addresses has been eliminated.

- The table can be readily sorted by last name.

- If Oakland Providers LLC becomes Oakland General, the user needs to update only one data item in one row in one table.

With good database design and the relational database structure, data redundancy and inconsistencies can be eliminated, a significant amount of space is saved, and data file maintenance effort is minimized.

Notice that each row in each relational database table has a unique ID (the CO ID in the company table and the PID in the patient table) called a primary key.

When stored in the patient table, the CO ID is viewed as a secondary key.

These keys provide users with quick and efficient access to individual rows in the database tables and allow them to find subsets of the data more efficiently.

If a physician practice provides healthcare screenings for employer worker's compensation purposes, the practice might occasionally need to write to the companies they service. The database designer therefore creates an index in the database that represents the relationship between the patient and the company tables.

The index has just two columns, the CO ID secondary key field from each row in the patient table and the PID primary key field of that row.

If the physician practice needs a list of all patients who work for Community Hospital Incorporated (CO ID C01), the DBMS uses this index to read just rows P01 and P04 from the patient table.

The index eliminates the need to read and test every row in the patient table, which saves a great deal of processing time.

Index

CO ID	PID
C01	P01
C01	P04
C02	P02
C02	P03
C02	P05

Database Security and Access

The DBMS allows for complex levels of data security. Database views can be constructed to control which users can access not only each table but each column in each table. The DBMS also enables multiple users to access the same tables at the same time while still ensuring each item of data is properly protected.

EXAMPLE

Healthcare Databases

An electronic medical record (EMR) primary database, or data repository, serves the healthcare delivery needs of the physicians, nurses, and other practitioners

who treat patients. The EMR is a front-end application, and the users require immediate responses to their inquiries.

An enterprise data warehouse (EDW) database, on the other hand, meets the needs of back-end reporting, which does not require immediate response. Also, back-end reporting requires only a subset of the data used in the EMR. Applications such as quality measure analysis, regulatory reporting, and other reporting needs can be best addressed by an EDW database.

Knowledge Check

A file is managed by the OS file system. A database file is managed by a/an

Database management system

Database management tool

OS data manager

Choose the weakness found in an OS file system that a DBMS can and does address.

Complex data images

Complex structured relationships among files

Data security

The most common form of database and the form used most often in healthcare systems is the_____database.

relational

hierarachial

systematic

Choose the weakness found in the OS file system that a DBMS can and does address.

Data redundancy and inconsistency

Complex data images

Data storage capacity and file size issues

References/Sources

1   FileInfo.com Help Center (2013). What Is a File Extension?.
    http://www.fileinfo.com/help/file_extension.

Continue with other activities/quizzes...

Sorting Activity: Hardware

Sort the devices by type.

Input Devices

Keyboard	Mouse
Mic	Barcode Reader
Touch Screen Monitor	Digital Pen
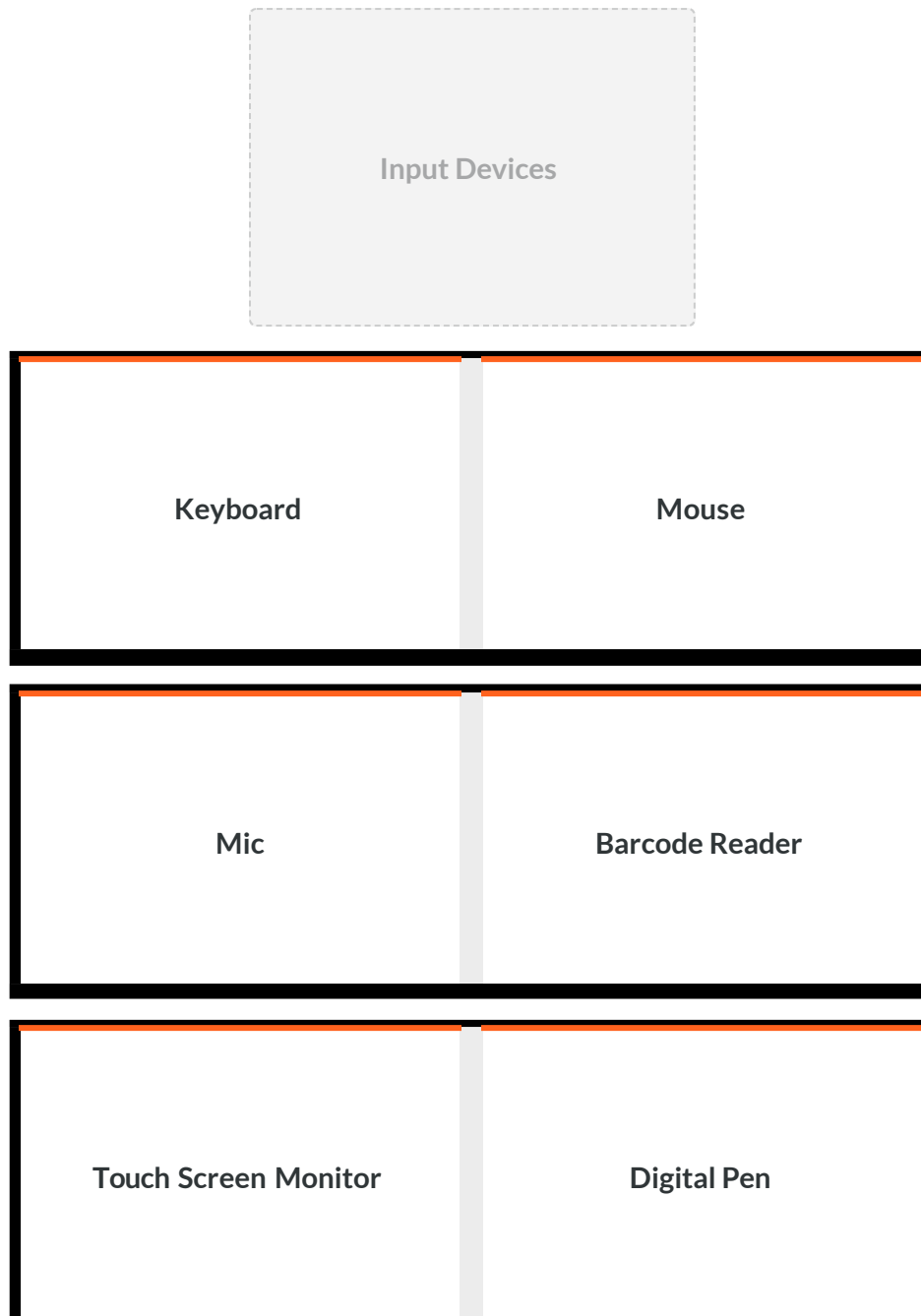
Output Devices

Speakers	Headset

Printer	Monitor

Storage Devices

USB Drive	Floppy Disk
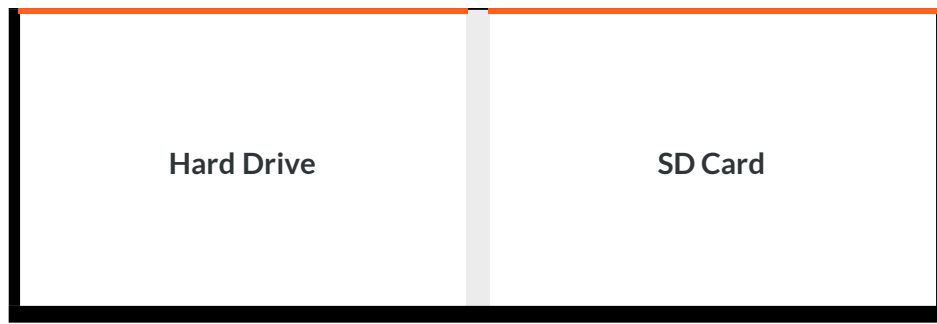
| Hard Drive | SD Card |

Practice Quiz

_____is permanent memory contained in chips mounted to the computer's motherboard.

ROM

RAM

WAM

CPU

_____is temporary storage used by the computer to hold data and information while the computer is working.

ROM

RAM

WAM

CPU

The_____is the "brain" of the computer.

ROM

RAM

WAM

CPU

An adapter card would be install here.

Expansion card slot

RAM slot

ROM slot

Fan slot

This is what the PC uses to receive the electrical power it needs to operate.

Power supply

Processor chip/CPU

Memory module

Hard drive

This component contains a control unit and an arithmetic logic unit.

Power supply

Processor chip/CPU

Motherboard

Memory module

This thin, flat piece of circuit board directly or indirectly connects all other components and peripherals.

Power supply

Processor chip/CPU

Motherboard

Memory module

This component stores instructions, data, and results during processing.

Power supply

Memory module

Processor slots

Hard drive

Primary or additional processors are inserted here.

Motherboard

Expansion slot

Processor slot

Hard drive slot

This component stores instructions, programs, data, and information for future use.

Power supply

Memory module

Motherboard

Hard drive

What is the difference between a bay and a port?

A bay is always found on the front of the computer, a port is always on the back.

A bay holds a piece of hardware; a port is a place where a plug or cable is inserted.

A bay is an area where the cables and plugs are inserted; a port holds a piece of equipment.

A bay is always connected inside the system unit on the motherboard; a port is always connected from the back.

_____is any data storage device located inside the computer (e.g., in a bay or on a module) and connected directly to the motherboard.

Internal storage

External storage

Private storage

Public storage

_____is any data storage that is connected to the computer via a port.

Internal storage

External storage

Private storage

Public storage

Bits is short for _____

Big Internal Time Styles

Binary digits

Binary Number System

Bisectional Devices

Which of the following is NOT an external storage device?

USB

External drive

Cloud storage

Hard drive

What is a byte?

2 nanobits

8 bits

4 bits

1 nibble

What are the values of a bit?

0

1

2

0 and/or 1

RAM storage is best described by which statement?

Primary, internal, and temporary

Secondary, external, and permanent

Secondary, internal, and permanent

Primary, external, and permanent

What is a KB?

---

keg byte

kile bit

kilo byte

kinder bit

What is the storage capacity of 1 KB?

1024 bytes

1024 KB

1024 MB

1024 GB

What is a MB?

milo bit

mile byte

mega bit

mega byte

Question

22/80

What is the storage capacity of 1 MB?

1024 bytes

1024 KB

1024 MB

1024 GB

What is a GB?

---

gilo byte

gilo bit

giga bit

giga byte

What is the storage capacity of 1GB?

1024 bytes

1024 KB

1024 MB

1024 GB

What is a TB?

tilo byte

tilo bit

tera bit

tera byte

What is the storage capacity of 1 TB?

1024 bytes

1024 KB

1024 MB

1024 GB

_____is data presented so that it has meaning.

Information

Data

Numbers

Text

_____software consists of programs that interact directly with the hardware and includes the operating system and utility programs.

Programming

System

Applications

Commercial

_____software consists of programs that run on top of the system software and enable end users to perform specific tasks.

Programming

System

Application

Commercial

Computers used in healthcare are unique because of which of the following characteristics?

The software used to perform the tasks needed.

Their hardware that handles high-resolution graphics.

Their different system components.

Their software that supports different system components.

The basis of all software is considered software code. True or False.

True

False

A set of programming statements and instructions that make software work is considered software code. True or False.

True

False

A set of orders to the computer to perform actions is considered software code.

True or False.

True

False

Software utilizes computer hardware devices in each of these ways except that software_____.

---

uses simple files and database files as a source and as a repository for data.

might require special hardware to efficiently serve its purpose.

pretty much ignores hardware and lets the computer handle it.

uses complex files to find hardware needed for processing.

Installation is required for software. True or False.

True

False

Maintenance is required for software. True or False.

True

False

Tightening is required for software. True or False.

True

False

Licensing if it is copyrighted is required for software. True or False.

True

False

What are the two basic categories of software?

An operating system and system software

An operating system and application software

System software and application software

An operating system and application software

System software consists of programs that control and maintain the operations of the computer, including each of the following except

_____.

the operating system (OS)

utility programs

random access memory (RAM)

read only memory (ROM)

Without the OS, the user would have no way to communicate with the hardware.

Interface with users

Boot

Configure devices

Security

The computer is turned on, ROM BIOS starts the OS, and the OS kernel takes residence.

Boot

Configure devices

Manage processes and resources

Security

The OS checks active devices and their device drivers to ensure they function properly.

Boot

Configure devices

Manage processes and resources

Security

The OS tracks every active application software and every computer resource used by every user at all times.

Boot

Configure devices

Manage processes and resources

Security

The OS provides minimal firewall and user access control.

Boot

Configure devices

Manage processes and resources

Security

What are application software programs specifically designed to do?

meet the needs of all possible users in one package

meet the needs of the computer user

fulfill the capabilities of the computer hardware

protect the user from the operating system software

This software type includes statistical software, mathematical modeling software, and computational science software.

Business application

Science applications

Communications software

Home and personal use applications

This software type includes word processing, spreadsheets, database applications, presentation software, project management software, and accounting applications.

Business applications

Science applications

Home and personal use applications

Communications applications

This software type is packaged, copyrighted, and made commercially available for purchase, examples include Microsoft Ofice Suite Home Edition, business accounting applications, and EMR healthcare systems.

Licensed application software

Custom application software

Web application software

System software

This software type is created for a particular purpose and functionality; for example, the Informatics Shared Resource at Oregon Health Science University creates applications for clinical researchers.

Licensed application software

Custom application software

Web application software

System software

This software type runs on internet sites; examples include free applications such as email, and online tax preparation software available for free.

Licensed application software

Custom application software

Web application software

System software

What healthcare application software type tracks patient care provided by the provider who owns the system; for example, VistA?

EMR/EHR

Expert/Clinical Decision Support System (CDSS)

Medical office management

Patient registries

What healthcare application software type uses artificial intelligence to analyze knowledge and assist a physician or model decisions as a physician expert might; for example, MYCIN?

EMR/EHR

Expert/Clinical Decision Support System (CDSS)

Medical office management

Patient registries

What healthcare application software type features physician scheduling and patient billing?

EMR/EHR

Expert/Clinical Decision Support System (CDSS)

Medical office management

Patient registries

What healthcare application software type has data sets or databases related to a particular medical issue used to track changes in patients over time; for example, CDC's Cancer Registry?

EMR/EHR

Expert/Clinical Decision Support System (CDSS)

Medical office management

Patient registries

Telemedicine is technology aimed to improve care, particularly for patients who are homebound. True or False.

True

False

_____is the capturing, storing, and viewing of images of human structures.

Medical expulsion

Medical imaging

Medical evasion

Medical scanning

Utility programs are part of the system software. These programs perform all the following system tasks except:

File backup

File search

File compression

File storage

A_____is a block of program instructions or data stored on a hard disk drive (HDD) or other form of secondary storage disk.

record

field

file

object

_____files contain a program file that executes the software application.

Executable

Text

Source

Picture

_____files is a collection of binary representations of characters that can be translated into human-readable text, numbers, or special characters.

Executable

Text

Source

Picture

The_____is the sufix, preceded by a dot (.), at the end of a file name.

---

executable extension

text extension

file extension

picture extension

A file might contain any of the following except_____.

software

hardware

media

text

A/an_____is a way of organizing files and their data.

file manager

operating system

file system

operating manager

patient1.exe is what type of file?

---

executable program

Microsoft Word document

Microsoft Excel document

An image

patientdemo.docx is what type of file?

executable program

Microsoft Word document

Microsoft Excel document

An image

patientbills.xlsx is what type of file?

---

executable program

Microsoft Word document

Microsoft Excel document

An image

patienttwig.jpg is what type of file?

executable program

Microsoft Word document

Microsoft Excel document

An image

Some systems use this term to refer to groups of files as_____.

files

folders

records

fields

Using descriptive names for files and folders/directories is an important best practices for managing files. True or False.

True

False

Maintaining proper file extensions is an important best practices for managing files. True or False.

True

False

Grouping similar files together into folders or directories is an important best practices for managing files. True or False.

True

False

Organizing folders/directories in a proper hierarchy is an important best practices for managing files. True or False.

True

False

A user has a folder named Patient and another folder called Patient Advance Directives. If the user puts the Patient Advanced Directives folder under the Patient folder, the Patient Advanced Directives folder would be called a _____.

subfile

subfolder

hidden folder

hidden file

A_____is a structured data file that comes with its own database management system (DBMS).

database

worksheet

record

relational database

A_____consists of one or more tables defined by a database designer in a meaningful and eficient fashion.

database

record

worksheet

relational database

A file is managed by the OS file system. A database file is managed by a/an

_____.

database management system

database management tool

OS database manager

Application database manager

_____that allow users to readily access rows of data in a relational database. Through the creation of index tables and keys, a good database designer can streamline data access.

Database Key

Primary Key

Secondary Key

Main key

A unique ID that is assigned to every row in every table in a relational database.

Database key

Primary key

Secondary key

Main key

When a key is stored in a table other than the table where it is primary, it replaces actual data content they saving space, ensuring consistency in the data, and minimizing redundancy.

Database key

Primary key

Secondary key

Main key