Building a Computer System

Computing Hardware, Networking, and Mobile Devices : Building a Computer System

Lesson 4 Overview

Outside "the box," peripheral components add functionality to computers, including ways to display, print, and store data. External devices may also supply input to computers for various purposes.

4.1 Recognize common connector types, functions, and selection criteria

Ports

READING ASSIGNMENT

Read this section. Then, read the rest of Chapter 10 in your textbook.

Legacy Ports

Early computers didn't need to be connected to a lot of external components. This was before the days of mice, so computers typically had only a keyboard and monitor, maybe a printer, and maybe a modem. These four different devices—keyboard, monitor, printer, and modem—each place different demands on the computer, and those demands shaped the design of computer ports at that time. The AT

large DIN keyboard connector could accept data about as quickly as a user could type, and the CGA display adapter could display text and low-resolution graphics on a television screen or monitor about as quickly as a user could view it.

For those users who needed to connect to a business computer network, a telephone bulletin board system (BBS), or some other remote computer service, an analog telephone modem (not to be confused with today's broadband cable modems) allowed them to place a phone call to a modem connected to the remote host and link the two systems over the telephone network. The two modems would then transmit bits of data back and forth one bit at a time, sequentially, using two different frequency tones to represent the two possible bit states. If you've ever been involved in a conference call in which multiple people tried to speak at once, you'll understand that a telephone connection is only designed for one voice to be transmitted at a time. That holds true whether the voices are human or computer-generated tones. Thus, telephone modems operate serially, sending and receiving one bit at a time, and the ports they connect to support that serial communication and are called **serial ports**. The earliest of these serial ports employed a D-shaped DB-9 or DB-25 connector, and although they have more cables, only one is the data path; the others are for communication management between the computer and the modem. The connectors on the computer and modem were male, so the cables were female at both ends.

Unlike remote computers that sat miles away in other buildings, cities, or

even countries, printers typically sat right next to computers on users' desktops, so it was a simple matter to connect them via a wider-bandwidth media. Earlier lessons discussed the benefits of wider bus widths between a CPU, RAM, and external devices, and the same logic applies here. If there's only a single data wire between a computer and a printer, you can only send one bit of data to it at a time. However, if you have eight such wires, you can send a whole byte at a time.

Serial printers were an option, but they were much less common. Most printers at that time were known as **parallel printers**. They were connected to parallel ports and could accept eight bits of parallel data at a time. At the time, eight bits were enough to support the seven-bit ASCII character set, and the eighth bit was available for error checking or to access other special features the printer might offer (such as italics or a second ink color). Parallel ports had the extra communications management pathways that serial ports had as well. So, computers typically offered a female DB-25 connector, and printers typically came with a 36-pin Centronics connector.

USB

Advances in technology have improved the speed and accuracy of communication over serial pathways to the point that the costs of additional hardware, connectors, and cabling outweigh the benefits of parallel communication. That's why, except for monitors, virtually every peripheral you'll connect to a computer today will be a serial device. The vast majority of them will be standardized on the latest and greatest

version of serial connectivity: the **universal serial bus** (**USB**). However, if you need to connect an archaic serial or parallel device to a computer that no longer offers such ports, PCI and PCIe serial/parallel expansion cards or USB converter dongles are available. Conversely, if you need to connect a USB device to an older system, you can use PCI and PCIe USB expansion cards.

Capacity is one of the first differences between early serial ports and USB. A typical early computer might have had one physical serial port, which could only have one device connected to it. Today, even if it had more physical ports, the UART chip(s) are limited to as few as four or eight possible addresses through which it can communicate with serial devices. Each device needs to be manually configured with a unique address.

A USB host controller, by contrast, can support up to 127 USB devices, and connected devices typically configure themselves automatically. In reality, there may be other constraints; a chipset may not be designed to support 127 devices, a computer may not offer 127 physical ports, or available power may be insufficient to connect 127 devices. A USB actually supports up to 128 connections, but the computer's USB host controller counts as one of them, so it can only be connected to 127 other devices.

USB has gone through several revisions over the years. USB 1.1 was the first widely adopted version, and it can operate at a low speed of 1.5 Mbps or a full speed of 12 Mbps. USB 2.0 (and all later versions) is fully

backward-compatible with older devices on newer computers or newer devices on older computers. If both ends are capable, it offers a high speed of 480 Mbps. USB 3.0 and 3.1 are called *SuperSpeed* and *SuperSpeed 10Gbps*, respectively, and support 5Gbps and 10Gbps speeds. USB ports can be identified by color as to their version—white is USB 1.1, black is USB 2.0, blue is USB 3.0, and teal is USB 3.1. The USB icon for USB 3.0 and 3.1 is also embellished with "SS" to indicate SuperSpeed.

Connecting two USB host controllers would confuse them, causing communication and power problems. To prevent that, all USB connections are directional. The flat, duckbill-style Type-A connectors are used upstream, such as at the root hub and out from any downstream hubs. Various styles of Type-B connectors are used on downstream devices (including the one upstream-facing port on a USB hub). If you need to connect more devices than your bus can power, there are powered hubs.

Generally, USB devices configure themselves, but you may occasionally need to install their manufacturers' specific, nongeneric drivers. You also may need to tweak their options occasionally in the Device Manager.

Apple

FireWire and Thunderbolt are mostly, but not exclusively, found on Apple devices. FireWire gave USB a run for its money back in the day, as each alternately came out with new standards and capabilities to beat the other's. Ultimately, though, USB won out.

Thunderbolt is USB's latest competitor It runs on the PCI Express bus and can support up to six external devices. Thunderbolt 1 offers 10 Gbps throughput, so it's comparable to USB 3.1; Thunderbolt 2 doubles that to 20 Gbps, and Thunderbolt 3 doubles that again to 40 Gbps. Beware that Thunderbolt 3 connectors are identical to USB-C connectors, but they aren't cross-compatible. Pay attention to the iconography next to the connectors.

Common Peripherals

Just as computers have gotten more sophisticated over the decades, so too have peripheral devices. Keyboards are the oldest input device; they were originally DIN, then PS/2, and now predominantly USB, Bluetooth, or some other proprietary wireless format with a USB dongle. Basic ones are pretty straightforward and should self-configure. Yet if yours has special features, or if you have special needs, you may need to install drivers or configure properties. Physical cleaning of keyboards is a routine task for PC technicians; you can give it a vacuuming, shake out any dirt, and wipe down the keys. If it's especially dirty or sticky from spilled substances, a keyboard is cheap enough to replace.

The mouse is the next most common input device. Original mice were serial or PS/2 and had an internal ball and mechanical rollers. Later, optical mice came out that needed specially graduated mouse pads. Like keyboards, the latest mice are all USB, Bluetooth, or some other proprietary wireless format with a USB dongle, and they're all optical and able to detect motion on virtually any not-too-reflective surface.

Although they've gotten rid of their mechanical balls and rollers, many still have scroll wheels and buttons that need to be cleaned periodically or replaced. Mice have useful configurable features, so you should peruse Mouse Properties and the Mouse Settings if you aren't familiar with these features.

Specialized Peripherals

KVM switches enable you to connect multiple computers to a single set of keyboard, video, and mouse (KVM). They're useful in data centers where you might need to interact with a group of computers from a single workstation. Simple versions exist that only switch the basics between two systems. More complicated versions connect more systems and possibly include audio support.

Mice were the first in the class of pointing devices, which later came to include trackballs, TrackPoints (which have more in common with joysticks but were used as pointing devices), touchpads, trackpads, and finally touchscreens, upon which you can move your finger. Instead of thinking of touchscreens as entirely new devices, it may be easier to think of them as their two components: (1) an output display overlaid with (2) a touch-sensitive input device. In the case of SMART Boards, their dichotomy is more obvious. The projector gets a video connection, and the touch-sensitive board gets a USB connection. Each aspect works independently regardless of whether the other aspect is connected.

Joysticks were the first game controllers. They used to connect via a

special DB-15 joystick port on multimedia expansion cards. Today, though, they're all USB or wireless, like most other peripherals. The most advanced of these are also output devices, in that they provide haptic feedback to users through vibrations or resistance.

Biometric devices predominantly employ cameras to scan and compare various aspects of body parts, and they're generally used for access-control security. Alternate use of biometric devices is for nonsecurity recognition, such as in voice-command applications.

Smart cards are physical security tokens often issued to enterprise-level business users, and they're read by **smart card readers**. These are typically USB devices, and they need to remain connected and continue "seeing" the smart card during whatever operation is being performed.

Barcode and **QR code scanners** come in various form factors, from bulky stationary ones in line with supermarket checkout belts to portable "gun" models like those at self-checkout registers. There are even smartphone apps to allow your phone's camera to function as a barcode/QR scanner.

Before the advent of inexpensive touchscreens, artists used **digitizers** or **pen tablets** to draw or paint on computers. These devices are still more pressure-sensitive than touchscreens. **Signature pads** on credit card terminals are another example of this technology.

Multimedia Peripherals

A variety of multimedia devices can be connected to computers as well. Digital cameras can be connected directly, typically via USB, or their memory cards can be inserted into card readers. In either case, the camera's storage will appear to the computer in a file-and-folder hierarchy like any other connected storage device. Advanced cameras can even transfer photos wirelessly. Cameras such as webcams may also be designed to connect permanently and may rely on the computer for storage space.

Today's smartphones are also cameras, and they, too, can be connected to computers to offload their photos. Since they're internet-connected, most can also upload photos directly to internet sites (such as Facebook or Instagram) or cloud-based storage (for example, OneDrive or DropBox).

Besides video, computers can also capture, read, manipulate, record, and play sound. Most computers come with built-in sound capabilities such as microphone, headphone, and speaker jacks and their associated hardware and software. Portable devices tend to have built-in microphones and speakers rather than jacks for external ones. That's true of smartphones, too, but most of them go above and beyond what's needed for phone calls, providing good-quality stereo sound.

For audiophiles, recording studios, and sound engineers, specialized hardware and software are available that offer better control over the analog-to-digital conversion process, sound quality, and audio file formats. These tools also allow for the connection of musical

instruments, surround-sound speakers, and subwoofers. Sound cards with an optical or RCA-style Sony/Philips Digital Interface (S/PDIF) can be connected directly to hi-fi receivers and 5.1 speaker systems. Multiplayer gamers also appreciate a good headset to talk to their teammates or opponents while online gaming.

Open Device Manager and browse the various devices connected or built into your system. Mice and printers should be easy to recognize, but USB devices have a bunch of separately identified internal components that may make them more challenging to identify.

Next, look at the ports on the front and back of your computer. Familiarize yourself both with what types are available and what devices are connected to them.

One final topic for this section is file formats. The textbook mentions that audio files can be stored full-sized or in a compressed format. Professionally produced and distributed songs of your favorite artists are recorded in uncompressed **WAV** format. This employs a high-frequency sampling rate to reproduce sound more faithfully than the human ear can discern. Still, it does so at a tremendous cost in file size, which severely limits the number of these songs that could fit onto a CD. The large file sizes are also inconvenient to transfer over slow-bandwidth connections. Compressed **MP3** files chop these huge files down by cutting out the fidelity at and beyond the fringe of human discernment, and they do it very well. Only trained listeners would notice the differences between the fidelity of a WAV file and an MP3 file of the

same recording, yet the latter takes up a fraction of the space of the former. **Codecs** are the algorithms that perform this compression/decompression process by shrinking the files for storage and then expanding them (albeit with fidelity losses) for playback.

Even the briefest uncompressed video files are enormous, so all video file formats use codecs for compression. Their video and audio tracks are actually captured separately and then combined into a "wrapper" or "container" file, for which **MP4** is the most common format today. MOV and AVI are other names you should recognize. Review the codec names mentioned in your textbook so that you'll recognize them in the future.

Key Points and Links

READING ASSIGNMENT

Key Points

- Common legacy ports included serial and parallel ports, but now, most peripherals use a version of serial technology.
- USB, FireWire, and Thunderbolt are serial ports with various versions operating at different speeds.
- You'll need to recognize the various cables and connectors. Thunderbolt and USB-C connectors are identical but not compatible.
- Be familiar with common peripherals, their usual connections, and their configuration options.
- WAV is an uncompressed sound file format; MP3 employs

compression.

- All video file formats are compressed; a container or wrapper file packages the audio and video components together.
- Codecs are algorithms that perform compression/decompression.

Exercise: Connector Types, Functions, and Selection Criteria

Fill in the blank.

1. A/An _____ scans the chip embedded in such devices as ID badges to enhance access and security.
2. A/An _____ captures digital images on removable media; a/an _____ transmits digital images across the internet for video communication.
3. An algorithmic series of instructions telling a computer how to read a compressed file is called a/an _____.

Respond to the following based on your reading.

1. How many devices can a single USB host controller support?
2. What do digitizers enable people to do on a PC?

Exercise Answer Key:

Exercise: Connector Types, Functions, and Selection Criteria

1. smart card reader
2. digital camera; webcam
3. codec

4. 127
5. Draw, paint, and write

4.2 Describe display technologies and adapters

Monitors

READING ASSIGNMENT

Read this section. Then, read Chapter 17 in your textbook.

While the primary purpose of monitors—displaying output to users—hasn't changed over the years, the technology behind them has undergone a lot of revision and improvement. The earliest computer monitors employed a scanning electron gun to fire charged particles at a **cathode-ray tube** (**CRT**) to phosphoresce images onto the screen. Although monitors were dimensionally much deeper than current flat screens, they were also considerably more expensive, so they were frequently smaller in the two dimensions that counted: height and width. Many early home users connected computers to their television sets rather than spend the money on a dedicated display device. There's nothing on the certification exams about CRT technology except for how to safely dispose of it. CRT monitors contain toxic materials, so don't drop it into the household trash if you do come across one!

Today's monitors and TVs are all some variety of **liquid crystal display** (**LCD**). The textbook offers an exciting but overly detailed explanation of

how LCD technology works. If you've ever looked at film negatives or X-rays on a light board, it won't be a stretch for you to understand the basics: The liquid crystal in the monitor is a lot like the film or X-ray. While it determines what the images look like, it's largely unviewable without a light source.

Early LCD monitors used cold cathode fluorescent lamps (CCFL), which are a lot like smaller versions of the two- or four-foot fluorescent tube lamps more commonly used in offices or schools. They were somewhat fragile, and they ran on AC power, so each required a failure-prone inverter to convert the monitor's (or laptop's) DC power back to AC.

PC technicians don't often take apart video monitors, and when they do, it's generally in a laptop for one purpose: to replace a bad backlight or its power inverter. Yet even that's becoming a less common repair, as backlighting technology has changed. If you find yourself troubleshooting an old laptop that shows all the signs of booting up but won't display an image, hold a flashlight up to the monitor to see if the image is dimly there but not illuminated. If so, the laptop may need to have its backlight or inverter replaced.

Newer LCD monitors are sometimes called **LED monitors** because they use DC-powered **light-emitting diodes** (**LEDs**) instead of CCFLs as their backlights. Not only does this arrangement dispense with the need for a troublesome power inverter, but LEDs are also much less fragile than CCFLs. In fact, the advent of LEDs probably means the end of monitor repairs for PC technicians altogether.

LCD monitors come in various specifications, and these all affect the image quality and price. A **pixel** is the smallest unit that can display a different color. A **higher resolution** means more pixels, which means that more of an image or a higher quality of the image can be displayed. Pixels are arranged in a particular geometry, called an **aspect ratio**. The geometry of early TVs and computer monitors had four units of width for three units of height, which is known as a 4:3 aspect ratio. Contemporary monitors, TVs, tablets, and even smartphones have gone to various wide-screen formats; 16:9 is pretty common, but some devices use 3:2, 21:9, or some other unique ratio. The **color depth** of a monitor determines how many different shades of colors each pixel is capable of displaying. Most monitors today can display pixels in each of 16.7 million different colors, and that's known as **24-bit color**. It's eight bits (meaning 256 different levels) each of red, green, and blue.

The brightness of a display, measured in **nits**, typically ranges from 100 to 1,000 or more, although 300 is a very sufficient amount. Don't confuse this with the **contrast ratio**, which is the difference between the darkest and lightest spots the monitor can display.

The angle at which the monitor can be viewed may be considered a drawback or a security feature. Typical TN displays can be viewed from within a 70° arc, and IPS displays can be viewed from within a wider, 178° arc.

The **response rate** is the time it takes all of the pixels to change state; it's measured in milliseconds, and the lower the value, the better. The

refresh rate is the speed at which the screen can change or update completely. Movies in theatres are shown at 24 frames per second. For comparison, typical LCDs refresh at 60 times per second, and specialized, higher-end models go up to even four times that rate.

Projectors

Conceptually, a **digital projector** is nothing more complicated than an LCD monitor with a considerably brighter backlight and a lens to focus that light at a distance. It connects to computers through the same video ports as monitors and has many of the same specifications discussed previously for monitors.

LCD projectors were preceded by enormous and unwieldy CRT projectors. There's also one competing technology still in use called **digital light processing** (**DLP**). This uses a spinning color wheel and an array of tiny mirrors to project its image.

In any projector, the three main things you should understand are lumens, throw, and lamps. **Lumens** are a measure of the brightness of an image. **Throw** is a range of distance from the screen at which the projector is designed to operate; those with shorter throw distances need to provide a wider projection angle. A **lamp**, like the backlighting for a monitor, is the part that makes the digital image visible. As in older-technology slide projectors, movie projectors, and overhead projectors, when the lamp burns out, people aren't happy! Keep replacement spares on hand or a spare projector to swap in until you can replace the dead bulb.

VR Headsets

Virtual reality (**VR**) **headsets** blindfold you from the real world while providing a different generated image to each of your eyes. This enables the headsets to display 3D stereoscopic imagery, which becomes a completely immersive experience. Many incorporate headphones, too. These aren't yet mainstream devices, but they're growing in popularity as new applications develop. Many of them also employ **organic light-emitting diode** (**OLED**) screens, which emit their own light rather than requiring backlighting.

Ports and Connectors

For the A+ exam, you'll want to be familiar with various video ports and connectors. **VGA** is the oldest and least advanced, and it's an analog technology. **DVI** is a hodge-podge of analog and digital technology. The later technologies, **HDMI**, **DisplayPort**, and **Thunderbolt**, are all digital. HDMI carries both video and audio signals on the same cable.

If ports don't match between a monitor and a computer that need to be connected, a simple adapter can convert between analog VGA and analog DVI-A. Inexpensive adapter cables exist to convert between the various digital formats. However, converting from analog to digital is a more expensive proposition; when this must be done, it's often better to upgrade the analog device.

If you've never played with the buttons on your monitor, this might be a good time to familiarize yourself with the adjustments they offer.

Also, examine the back of your monitor. Monitors are usually wall-mounted or pedestal-mounted, but most can accommodate either arrangement. When you buy a monitor, it comes with a removable pedestal, and it also has standardized mounting holes on the back to allow it to be attached to a stand or wall-mount instead. The spacing of those mounting holes is a function of the size and weight of the monitor; the holes are designed to be compatible with mounts that can support that monitor size and weight. The various arrangements follow what's called the **VESA standard**.

Some monitors also offer USB ports. When computer towers are buried under desks or in cabinets, these ports offer a great way to bring easy-access USB connectivity to a user's desktop by connecting flash drives and other removable peripherals. The technology behind this is simply a USB hub built into the case of the monitor. Behind it, there will be a USB cable to connect it to the computer's USB hub controller.

Display Adapters

Computer display adapters have gone through a long list of older technologies. However, today, there are only four you'll need to know. First, the motherboard may have a built-in display adapter. Otherwise, there are three different ways to install an add-in display adapter: PCI, AGP, or PCIe.

PCI is the oldest and least capable of the methods. The bus is only 32 bits wide and operates at 33MHz. This is shared with other PCI devices, so effective display throughput is probably less than 132MBps.

Accelerated graphics port (**AGP**) is pretty old, too. It's a specially dedicated port used solely for video, so there was only a single port built into motherboards that offered it. AGP is better than PCI but still pales in comparison with PCIe. **PCIe** is the most common method of connecting display adapters today, and all PCIe video cards use the highest-capacity PCIe x16 connector.

When a motherboard includes a built-in display adapter, this is called **onboard video**, and it's usually not very powerful. Think of it as the minimum capability that a typical user might need. However, if you're dealing with a specialized user, such as a gamer, graphic artist, or presenter, onboard video probably won't be sufficient for him or her.

When selecting an add-in display adapter, the main features to compare are the graphics processor and the video memory. Connector types, naturally, are the same as those previously discussed for monitors. Many display adapters are even capable of driving multiple connected monitors simultaneously, creating duplicated or extended screens. Inside the computer case, try to select a slot in which the card won't interfere with other components, and preferably, leave some room for airflow around it.

Key Points and Links

READING ASSIGNMENT

Key Points

- Pixels are the units of display on a monitor. Resolution is their

number, the aspect ratio is their geometric arrangement, the response rate is their latency in changing state, and color depth is how many different shades of colors they can represent.

- LCD monitors use CCFL or LED backlights. Brightness is the strength of that backlighting; contrast ratio is the difference between the brightest and darkest spots that can be displayed.
- Projectors use technology similar to monitors but with brighter backlights and focusing lenses.
- Monitors connect to computers via VGA, DVI, HDMI, DisplayPort, or Thunderbolt connectors.
- Display adapters are either built into motherboards or connect via PCI, AGP, or PCIe slots.

Exercise: Display Technologies and Adapters

Fill in the blank.

1. An aspect ratio of 16:9 is _____ than an aspect ratio of 4:3.
2. PCI, PCIe, and _____ are the only display-adapter card technologies you're likely to encounter today.

Respond to the following based on your reading.

3. What measure determines the range of shades of each pixel's red, green, and blue components that can be displayed?

Match the term on the left with its description on the right.

Term	Description
4. DVI-I	a. Analog
5. VGA	b. Digital
6. DisplayPort	c. Both analog and digital

Exercise Answer Key:

Exercise: Display Technologies and Adapters

1. wider
2. AGP
3. Color depth
4. c
5. a
6. b

4.3 Describe printer technologies, the laser printing process, and troubleshooting of printers

Printer Technologies

READING ASSIGNMENT

Read this section. Then, read Chapter 26 in your textbook.

After the keyboard, mouse, and monitor, the printer is the next most common computer peripheral. Thus, PC technicians need to know how to install, configure, and troubleshoot it.

Early printers mimicked typewriter technology; they would slam a retrieved letter, number, or symbol into an ink ribbon to leave its impression on a piece of paper. Desktop versions of these came as "daisy-wheel" printers, which were conceptually similar to IBM Selectric typewriters. Industrial versions came as high-speed band printers.

Virtually all of those have been retired, and today, the only remaining form of impact printer is the **dot-matrix printer**. Its printhead contains tiny pinheads that it fires at an ink ribbon to leave an impression on paper, requiring a bunch of dots to form each of the various letters, numbers, and symbols while a carriage carries it back and forth across the page. Draft-quality models use nine pins per character, and near-letter quality models use 24 pins per character. Most use tractor-fed, continuous paper. Dot-matrix printers are rare and getting rarer, but for printing on multipart forms, they're the only game in town.

Inkjet printers also use a carriage to oscillate the printhead back and forth across the page. Yet rather than pinheads slamming against the page, inkjet printheads contain tiny nozzles that spray ink directly onto the page. Earlier versions were either black and white or employed a black ink cartridge alongside a separate, multicolor cartridge. Of course, replacing a cartridge of three colors when only one color ran out wasn't economical or efficient. Now, most inkjet printers have individual cartridges for black, cyan, magenta, and yellow inks, respectively, which can be combined to produce any color.

Over time, dot-matrix printheads get dirty and need maintenance. Still,

inkjet printheads are built into the replacement ink cartridges, so you're getting a fresh new printhead every time you replace an ink cartridge (which is one of the arguments against using refilled ink cartridges). However, to reduce operating costs, some manufacturers recently have begun selling refillable-tank inkjet printers. These have a permanent printhead and reservoirs of each color that can be refilled from cheaper, bulk-packaged ink bottles. Presumably, these will be more prone to clogs from dried ink than those with replaceable ink cartridges so they could generate more work for PC technicians.

Dye-sublimation printers use heat to melt ink onto the page before letting it dry and harden back into its solid state. It's a technology mainly used for photo printing and high-end imaging, so it's somewhat specialized. Two other heat-based printer technologies you should know about are thermal printers and solid-ink printers. **Thermal printers** rely on heat-sensitive paper to enable a heated printhead to leave its marks on the page. Early fax machines operated on this principle, as did some receipt printers. **Solid-ink printers** work much like inkjet printers, but their ink begins in a crayon-like solid state at room temperature, is melted before it's sprayed onto the page, and then dries and hardens back into its solid state. The latest 3-D printers operate on a similar principle.

The most revolutionary technological advance in printing, however, has been the electro-photographic imaging process, which this lesson will cover in detail later.

When comparing printers, typical factors to consider are print quality or resolution in **dots per inch** (**dpi**), the number of pages per minute (**ppm**) they can print, latency in printing the first page, purchasing price, ongoing operating costs, and connection options. Depending on your needs, you might also want to consider the number, capacities, and sizes of various paper trays and feeders. Special applications such as printing on multipart forms, transparencies, or glossy paper may further affect your choices.

One last thing about printers is that the term can be ambiguous. What you think of as a *printer* is that physical object that sits on the desk next to your monitor. Yet Microsoft refers to that object as a *print device* and regards a **printer** as the software which you can send a document through for rendering. In the case of printing to paper, a Microsoft "printer" is the printer driver through which the job is prepared for the physical "print device." Similarly, in the case of printing to a file format such as PDF, XPS, or a graphic format, Microsoft's "printer" is the software that makes that conversion by preparing the file. In the case of printing to a remote fax machine, Microsoft's "printer" is the fax driver software that renders your document, transmitting it out over your phone line in analog audio format. Collectively, nonphysical printing devices may also be called **virtual printers**.

Multifunction Devices

Offices used to keep printers, copiers, and fax machines as separate appliances. However, what's trending now is to lump all of those

functions and more into a single device. These devices are commonly known as **multifunction devices** (**MFDs**), and they're very convenient. There are shared components between the various functions; for example, the same paper trays are used for both desktop printing and for receiving faxes. Generally, you should consider your individual requirements for each of the components to ensure selecting the best model for your needs.

Scanners may be flatbed-style or offer an automatic document feeder (ADF), and those same features will work with the device's photocopier function. Speed and resolution are the other main factors to consider. There are also special-purpose scanners designed for photographs or negatives. There are even dedicated business card scanners that come with software to extract contact information from each card and populate it into a contact database.

Copying is simply the combined process of scanning and then printing, so the printer and scanner specifications will be the primary considerations. However, for high-volume copying, besides a high ppm and an ADF, you might also prefer a model with larger-capacity paper trays and inks.

Faxing is simply the two processes of photocopying but with a communication step between the scanning and printing processes. More specifically, only the scanning or the printing will take place at your device for each job, and that communication step will connect your device with another device performing the other process. Consequently,

the important factors are the same as those for copying, plus communication speed. Over analog telephone connections, 9,600 bps is about as fast as your fax will ever operate—or maybe 14,400 bps if it's a pristine connection and both devices are compatible. This connection speed is going to be your faxing bottleneck, but virtually every machine built today supports up to 14,400 bps, so it's not even a consideration.

All MFDs need to be connected to computers somehow, and there are a variety of common means. If the device only needs to be used from one computer, a USB cable is the easiest way to go. However, you'll need to configure where the scanner will save documents if there are multiple users at multiple computers. You also may need to configure outbound fax headers for each user, and if the MFD is going to save received faxes to files (rather than print them), that save location also needs to be configured. Of course, you'll need to configure access-control permissions and network-sharing for the device and for the locations to which it may save files for its users.

The Laser Printing Process

Laser printers print quickly and at good quality, and in the case of black-and-white models, they're very cheap to operate. Consequently, they're very common in offices today, and PC technicians should know how to install, configure, and troubleshoot them. The laser-printing process is somewhat extraordinary and so different from any other printing process. Even the composition of its seemingly simple toner powder is remarkable: Each microscopic grain consists of resin,

pigment, and ferrous material, and in a minute, you'll understand why.

The laser-printing process involves seven steps:

1. ***Processing.*** As your computer's print spooler begins to render the print job and starts streaming it to your printer, the printer's processor receives the data and begins determining how to image the job.
2. ***Charging.*** A **primary corona wire** applies a uniform, negative electrical charge to a rotating drum inside the printer.
3. ***Exposing.*** Rotating mirrors and a laser draw the image to be printed on the negatively charged drum; the particles struck by the laser lose their negative charge.
4. ***Developing.*** The ferrous material in each grain of toner allows it to be negatively charged as well. While the negatively charged parts of the drum repel the negatively charged toner, the toner is attracted to the particles of the drum that lost their charge to the laser.
5. ***Transferring.*** Now, a **transfer corona wire** puts a positive charge onto a sheet of paper, which is then rolled past the drum, strongly attracting the toner that had been weakly attracted to the drum in the previous step.
6. ***Fusing.*** The paper with the loose toner particles simply sitting on it at this point is passed through a heated roller. This melts the resin in each grain, permanently adhering the pigment to its place on the page. A static-charge eliminator then removes the paper's positive charge.

7. ***Cleaning.*** A cleaning blade akin to a windshield wiper removes any stray toner left over on the drum, and an erase lamp neutralizes the drum's remaining electrical charge.

Some texts regard cleaning as the first step. But since the process is cyclical, the steps still occur in the order above.

Troubleshooting Printers

Setting up printers in Windows is pretty simple; most are simply plug-and-play, autodetected, and self-installing. If all of the features aren't available on an MFD device, it may need to have its driver manually installed, either from a disc that accompanied it or downloaded from the manufacturer's website. You may also need to manually install a printer or MFD that's being accessed over a network connection. When in doubt, download the latest driver or software from the manufacturer's website, uninstall the existing driver, and manually install the new driver or software.

Access permissions and network shares may need to be configured for network printers and MFDs and for the folders to which they write their documents. One good place to start when troubleshooting connectivity is to see if the printer's web-based configuration page is accessible to the user via a web browser. Of course, also check that both ends of the network cable are firmly connected or that the wireless configuration is properly set and that it sees the network.

For print-quality issues, you can use alcohol to clean printheads, or you

can replace a troublesome inkjet cartridge (including its printhead) to confirm that the printhead was the problem. Many printer utilities include a tool to clean printheads by spraying lots of ink through them, but this can be wasteful, so use it sparingly.

If the printer appears to be completely dead, check that it's powered on and that both ends of its power cable are firmly connected. Also, check that its electrical outlet is powered. If the printer has any visible fuses or power switches, check them, too.

For troubleshooting laser printers, a lot of the things that can go wrong are resolved by replacing the toner cartridge. Like inkjet printer cartridges, toner cartridges contain several components of the printing process. If the paper feeder isn't reliably grabbing sheets, or if the squeegee isn't completely cleaning the drum after printing (leaving specks), many printer manufacturers offer maintenance kits to replace those parts. Scratches on the drum will produce blanks every time the drum rotates around to those spots, so if you're getting repeating white marks at a fixed interval (typically every 10–12"), it may be time to replace the drum. Ghost images from previous pages indicate that the erase lamp may be bad. If the paper ejects perfectly but then smudges, the heated fusing roller may be bad. If the pages stick together in the output tray, the static charge eliminator may be bad. Understand what symptoms will result from the various possible failures, and you'll know where to begin your web search for replacement parts.

Printers with multiple printheads occasionally get their printheads

misaligned, so one or more colors may appear out of sync with the other colors. For printers that this can happen to, their utilities usually offer an alignment tool to resolve it. A printer may print samples and ask you to tell it which one looks best, or an MFD may print a test pattern and ask you to run the page through its scanner so it can decide for itself which one looks best.

Open the Printer and Scanners tool in Settings to see what printers and scanners are available to your computer. Do you recognize any as print devices that are actually virtual printers rather than print devices? Click through all of them. Each should offer you a Manage button to configure it; some may also prompt you to get an app if the manufacturer offers a management utility that you haven't yet installed.

Key Points and Links

READING ASSIGNMENT

Key Points

- Impact printers push letters or symbols onto an ink ribbon to leave a mark on paper; they're the only technology that can print onto multipart forms.
- Inkjet printers spray ink onto paper; it's fast and cheap, and printheads are typically replaced in each new ink cartridge.
- Dye-sublimation printers melt pigments onto paper and let them cool back to a solid-state; these printers are used for photo printing and high-end imaging.
- Thermal printers heat specially formulated paper to leave marks on

it; this was common in early fax machines and certain receipt printers.

- Laser printers employ an electro-photographic process, attracting electrically charged toner into position on an electrically charged drum, transferring that toner to paper, and melting it permanently into place. It's fast, offers good quality, and the black-and-white models are inexpensive to operate.

Exercise: Printers

Fill in the blank.

1. A printer that strikes an ink ribbon against paper is known as a/an _____ printer.
2. Laser printers use mirrors and a laser to draw the image onto a _____.
3. A printer's resolution is measured in _____.

Respond to the following based on your reading.

4. How is an image transferred from the drum of a laser printer onto the page?
5. If your inkjet printer no longer prints in yellow but otherwise works fine, what are the likely problems to diagnose?
6. Ghost images from previous pages are appearing on later pages. What's the likely cause?

Match the term on the left with its description on the right.

Term	Description
7. ADF	a. Nonphysical printer
8. Print device	b. Applies uniform negative charge
9. Virtual printer	c. Printer speed
10. Primary corona wire	d. Physical printer
11. Transfer corona wire	e. Sheet feeder
12. ppm	f. Applies positive charge

Exercise Answer Key:

Exercise: Printers

1. impact
2. drum
3. dots per inch (dpi)
4. The transfer corona wire applies a positive charge to the paper, which is then rolled past the drum, electrostatically attracting the toner from the drum onto the page.
5. It may be out of yellow ink, or the nozzles on the yellow cartridge's printhead may be clogged.
6. If the erase lamp has gone bad, remnants of the charge differential from the laser may remain from one cycle to the next.
7. e
8. d
9. a
10. b

11. f
12. c

4.4 Describe factors in selecting or building a specialized PC

Windows Editions

READING ASSIGNMENT

Read this section. Then, read Chapter 11 in your textbook.

Windows comes in three different editions, with feature sets to accommodate three different profiles of users. For most home users, **Windows 10 Home** is perfectly well suited, and it's the least expensive of the three. Windows 10 Pro offers BitLocker, Encrypting File System (EFS), and the ability to join a domain-based network along with additional security, file-sharing, and management tools. Finally, Windows 10 Enterprise offers all that and even more such tools. Pro edition can be purchased anywhere Windows is sold, but Enterprise edition comes only through a volume-licensing agreement.

As previously covered, Windows also comes in 32-bit and 64-bit versions, and the biggest difference between the two is memory size. 32-bit machines (or 64-bit machines running 32-bit operating systems) are only able to address 4GB of RAM, whereas 64-bit operating systems running on 64-bit hardware can address more RAM than you would ever

need to install in a computer. Thus, for memory-intensive applications or for users who switch back and forth between many simultaneously-open apps, the RAM limitations of 32-bit systems may be an issue.

Specialized PC Considerations

The needs of many users today can be satisfied by comparatively inexpensive, mass-produced, off-the-shelf computer system packages. However, there remain applications for which customized solutions are needed, and PC technicians should be prepared to address those users' needs.

Thin Clients

The computer users covered in this lesson so far are what are known as **thick clients**. They have everything they need to work independently, without a network connection. **Thin clients** are systems designed to rely on additional, backend resources. Individually, they're smaller and cheaper because they require fewer internal resources, but they must be connected to a more powerful server to function. These are common in point-of-sale (POS) systems where a backend server maintains an inventory, SKU, and pricing database(s) while tracking the bookkeeping for each transaction. The transactions themselves are performed at "dumb" terminals at each checkout station. Thin terminals at checkout stations rely on the server for all of their lookup functions, to store data about each transaction, and possibly for credit-card processing; even their POS app may be a virtualized or web app running on the server. If the server goes down, the system goes down. Thin clients can't perform

useful work without a connection to a server; they have only the most basic built-in tools to configure such connections, and basically can do nothing else on their own.

Virtualization Workstation

Virtualization allows you to run what amounts to a simulation. A computer can run a program that simulates a second computer. This second computer, the **virtual computer**, can be made to run its own operating system and applications. It can be allowed to share all or a specified subset of the host computer's resources so that it can access files and folders on the host's hard drive, print to the host's printers, and reach out over the host's network connection.

Virtual computers can run entirely different operating systems and don't even need to represent the same hardware. Thus, Macs can run a Windows emulator, and even various cell phone operating systems can be virtualized on desktop hardware, which is useful for smartphone app development and testing. In addition, a host computer can simultaneously run more than one virtual computer. The host computer can even run virtual network services to allow the virtual computers to interact with the host and each other.

Each virtual computer running on a host computer places more demands on the host's actual physical resources in addition to the host's own internal demands. It's easy to overwhelm a physical computer if it doesn't have enough processing power, memory space, storage capacity (with quick access time), and network throughput. Computers

intended as virtualization workstations should definitely be 64-bit machines with a great deal of RAM and numerous, fast CPU-processor cores. Virtual computers' simultaneous access to hard drives and network connections may require wide bandwidth connections to those resources as well. If not, they may lag.

Gaming PCs

Computer gaming is one of the strongest driving forces of computer technology. Computing technology that works fine for word processing might not run the latest computer game, and that's a pretty strong motivator for some people to upgrade their hardware. Similarly, hardware sales are a pretty strong motivator for manufacturers to keep coming out with newer and better systems for consumers to buy.

In the realm of gaming, video cards are king. Gamers want a smooth, crisp, clear, engaging display without lags, jerkiness, drop-outs, or distractions. They want it to be instantly responsive to their gaming actions in addition to promptly indicative of the actions of their fictional, on-screen enemies. Gamers want speed and clarity; they want realistic motion and shadow; they want life-like lighting and reflectivity. All of this requires incredible processing power, so be sure to outfit a gaming PC with the best multicore processor, a high-end/specialized video card with its own graphics processing unit (GPU), enough RAM, and a high-definition sound card. Many of these machines draw so much power and produce so much heat that conventional cooling isn't enough, so consider liquid- or refrigerant-based cooling systems.

Conduct a web search for some of the latest and greatest computer games on the market, and read up on their minimum and recommended hardware specifications. If you can't find any titles that interest you, pick from *Fortnite*, *Minecraft*, *Grand Theft Auto*, or *World of Warcraft*.

Graphics/CAD/CAM Design Workstation

Graphics capabilities are also important to graphic artists, photographers, architects, and engineers using their systems for computer-aided design (CAD). These users typically work with huge file sizes, and to hold them in memory and retain the processing power to manipulate them requires resources. These systems may not need the high-definition sound cards or liquid cooling that a gamer might require. Still, they need powerful video capabilities along with multicore CPUs, plenty of RAM, lots of storage space, and the appropriate software for their tasks. Those software requirements are probably a good place to start; you can check their minimum and recommended specifications to be sure the system you design will support them.

Audio/Video Editing Workstation

Similarly, audio- and video-editing applications place high demands on a computer system. In addition to everything recommended previously for a graphics design system, these systems also need good multimedia sound cards, including whatever audio interfaces may be required for any external hardware that will be connected (such as musical instruments, mixing boards, recording/playback decks, synthesizers, and so on). You also wouldn't believe the range of options available in

high-end microphones and headsets, and you may be asked to help select suitable models. Dual monitors may also be useful for this sort of application, so be sure the display adapter can support that if needed.

Network Attached Storage

This last type of specialized computer is one that doesn't necessarily have a user sitting at it. **Network-attached storage** (**NAS**) is simply a hard drive or storage array that's network-connected for users to save and access files. Common applications for this include a centralized home media center that stores music and movies, which are shared with the users of other devices on the home network. Another example is a business's backup computer that stores daily data from multiple users' workstations. The advent of streaming, internet-based media sources (such as Amazon Prime, Netflix, and Hulu) as well as cloud-based backup and storage services (such as Carbonite, OneDrive, and DropBox) satisfy a huge chunk of typical users' needs in this realm. However, there are still applications in which ownership of data must remain in-house, where data security is paramount, or where access speed is a factor. For these, a powerful NAS system is the solution.

These computers need a great deal of storage space and must have fast access times and fast connectivity. Fault tolerance is also often a requirement, so RAID is a common way of satisfying all the requirements.

Key Points and Links

READING ASSIGNMENT

Key Points

- Windows comes in 32- and 64-bit versions with different RAM limitations.
- Windows comes in Home, Pro, and Enterprise editions with different connectivity options and different security and management tools.
- Specialized applications may require specialized computers.

Exercise: Selecting or Building a Specialized PC

Fill in the blank.

1. For gamers, a powerful _____ is the most important feature.
2. A good starting place when specifying a computer for an architect would be to check the requirements of the _____ software.
3. 32-bit Windows is limited to _____ of RAM.

Respond to the following based on your reading.

4. What are the primary considerations when building a computer to be used as NAS?
5. What's the primary consideration when selecting an edition of Windows for a nonbusiness user?

Exercise Answer Key:

Exercise: Selecting or Building a Specialized PC

1. graphics card (or video card, display adapter, or GPU)
2. computer-aided design (CAD)
3. 4 GB
4. Network-attached storage (NAS) typically needs quickly accessible storage, lots of it, and often requires fault tolerance.
5. Home users typically don't require special networking, security, or management tools, so for them, price is typically the primary consideration. This makes Windows 10 Home the appropriate edition.

Lesson 4 Review

Self-Check

1. How many devices can a single USB host controller theoretically support?

a. 63

b. 255

c. 256

d. 127

2. Which of the following types of USB ports is found on a PC?

a. Type-A

b. Type-B

c. Mini-B

d. Micro-B

3. Which of the following types of USB ports is common on smartphones?

a. Mini-B

b. Type-A

c. Micro-B

d. Type-B

4. Thunderbolt 3 offers throughput up to _____ Gbps at half the power consumption of Thunderbolt 2.

a. 40

b. 10

c. 20

d. 30

5. Which of the following is the most common removable storage media used in modern digital cameras?

a. Compact flash (CF) unit

b. CD-R

c. Secure digital (SD) card

d. USB flash drive

6. Which of the following components in an LCD monitor sends AC power to backlights?

a. TFT

b. CCFL

c. Inverter

d. Rectifier

7. Which of the following characteristics of a monitor can be calculated

by multiplying its number of horizontal pixels by its number of vertical pixels?

a. Resolution

b. Dot pitch

c. Size

d. Aspect ratio

8. Which of the following aspect ratios is common in widescreen monitors?

a. 16:9

b. 4:3

c. 10:16

d. 3:2

9. Like any other processor, a graphics processor needs

a. RAM.

b. HDMI.

c. GPU.

d. AGP.

10. Which of the following display technologies does *not* require a backlight?

a. LED

b. CCFL

c. DLP

d. OLED

11. Which of the following technologies creates an image on paper by striking an ink ribbon into the page?

a. Impact

b. Laser

c. Thermal

d. Dye-sublimation

12. The term "sublimation" means to cause something to change from solid to _____ and then back to solid.

a. liquid

b. vapor

c. gel

d. plasma

13. Which of the following types of printers employs a photoconductive process?

a. Inkjet

b. Laser

c. Thermal

d. Dye-sublimation

14. In the laser-printing process, which of the following is charged by the primary corona wire?

a. Toner

b. Paper

c. Laser

d. Drum

15. Which of the following symptoms would you expect if the erase lamp were broken in a laser printer?

a. Stray marks

b. Ghost images

c. Smudged ink

d. Repeating white marks

16. Which of the following is a type of system designed to handle only very basic applications that require a minimum amount of hardware?

a. Thick client

b. Thin client

c. Virtualization workstation

d. Virtual computer

17. Which of the following is the most important consideration for a home server PC that streams media?

a. High-end graphics

b. Theatre-quality sound

c. Fast network connection

d. Security settings

18. Which of the following is the most important feature of a NAS system?

a. Large monitor

b. Theatre-quality sound

c. Powerful display adapter

d. Fault tolerance

19. To use a particular application, you need to run a different operating system from the one installed on a computer. This is a case in which _____ may be useful.

a. copy-and-paste

b. a thin client

c. virtualization

d. network-attached storage

20. Which of the following are the most important resources on a virtualization workstation?

a. RAM capacity and CPU cores
b. RAM speed and CPU cores
c. RAM capacity and L1 cache
d. RAM speed and L2 cache

Self-Check Answer Key

1. 127
   Explanation: Theoretically, a USB host controller can support 127 other devices, but there may be more-restrictive hardware, software, or power limitations.
   Reference: Section 4.1

2. Type-A
   Explanation: Type-A ports are provided on upstream USB devices such as USB host controllers and USB hubs.
   Reference: Section 4.1

3. Micro-B
   Explanation: Micro-B is the most common connector currently on smartphones, but Type-C connectors are rapidly gaining popularity. Type-B would be too large, and Type-A would be out of compliance with the upstream/downstream standard.
   Reference: Section 4.1

4. 40

   Explanation: At 40 Gbps, Thunderbolt 3 is twice as fast as Thunderbolt 2.

   Reference: Section 4.1

5. Secure digital (SD) card

   Explanation: For considerations of physical size and storage capacity, most modern digital cameras use secure digital (SD) cards.

   Reference: Section 4.1

6. Inverter

   Explanation: An inverter converts DC power to AC for CCFL backlights that need it.

   Reference: Section 4.2

7. Resolution

   Explanation: The resolution of a monitor is its total number of pixels. Since they're arranged in a grid pattern, you calculate resolution by multiplying the number in height by the number in width.

   Reference: Section 4.2

8. 16:9

   Explanation: There are exceptions, but most widescreen monitors standardize on a 16:9 aspect ratio. 10:16 would be tall-screen

rather than widescreen.
Reference: Section 4.2

9. RAM.
   Explanation: All processors require a workspace to store their active programs and current register values. Most graphics cards include onboard VRAM rather than relying on motherboard RAM.
   Reference: Section 4.2

10. OLED
    Explanation: OLED displays use organic compounds between the glass layers that light up when given an electrical charge.
    Reference: Section 4.2

11. Impact
    Explanation: Daisy-wheel, high-speed band, and dot-matrix printers are all varieties of impact printers that leave an impression on paper by striking something into an ink ribbon to leave a mark.
    Reference: Section 4.3

12. vapor
    Explanation: Dye-sublimation printers melt a film to vapor that's deposited on the page, where it cools and reverts to a solid.
    Reference: Section 4.3

13. Laser

Explanation: Laser printers employ an electro-photographic imaging process in which certain components conduct electricity when exposed to light.
Reference: Section 4.3

14. Drum
    Explanation: The primary corona wire applies a highly negative charge to the drum during the charging step of the laser-printing process.
    Reference: Section 4.3

15. Ghost images
    Explanation: The erase lamp neutralizes all charge from the drum after a page is printed and freshens it to receive the next page image. Without this step, remnants of the prior image will remain on the drum and will be "ghosted" onto subsequent pages.
    Reference: Section 4.3

16. Thin client
    Explanation: A thin client is a machine with just basic applications; it's designed to connect to a backend server that it completely relies on to perform any useful work.
    Reference: Section 4.4

17. Fast network connection
    Explanation: The media will be streamed and viewed on other

devices, so sound and graphics performance at the server aren't important, and on a home network, security probably isn't a big issue, either. The ability to stream data quickly will be the most important of the factors offered here.
Reference: Section 4.4

18. Fault tolerance
    Explanation: As a NAS is primarily centralized storage and sharing for your local network, it might not ever have a user sit at its workstation. Thus, display and sound considerations are secondary to features that will promptly and reliably serve data to other workstations over the network.
    Reference: Section 4.4

19. virtualization
    Explanation: Virtualization allows an entire "fake" computer to be simulated within another computer, and the fake computer can be configured in whatever operating system is needed.
    Reference: Section 4.4

20. RAM capacity and CPU cores
    Explanation: Each guest machine consumes memory and processing power, so RAM capacity and CPU cores are the two most important resources.
    Reference: Section 4.4