Foundation of Information Systems Infrastructure

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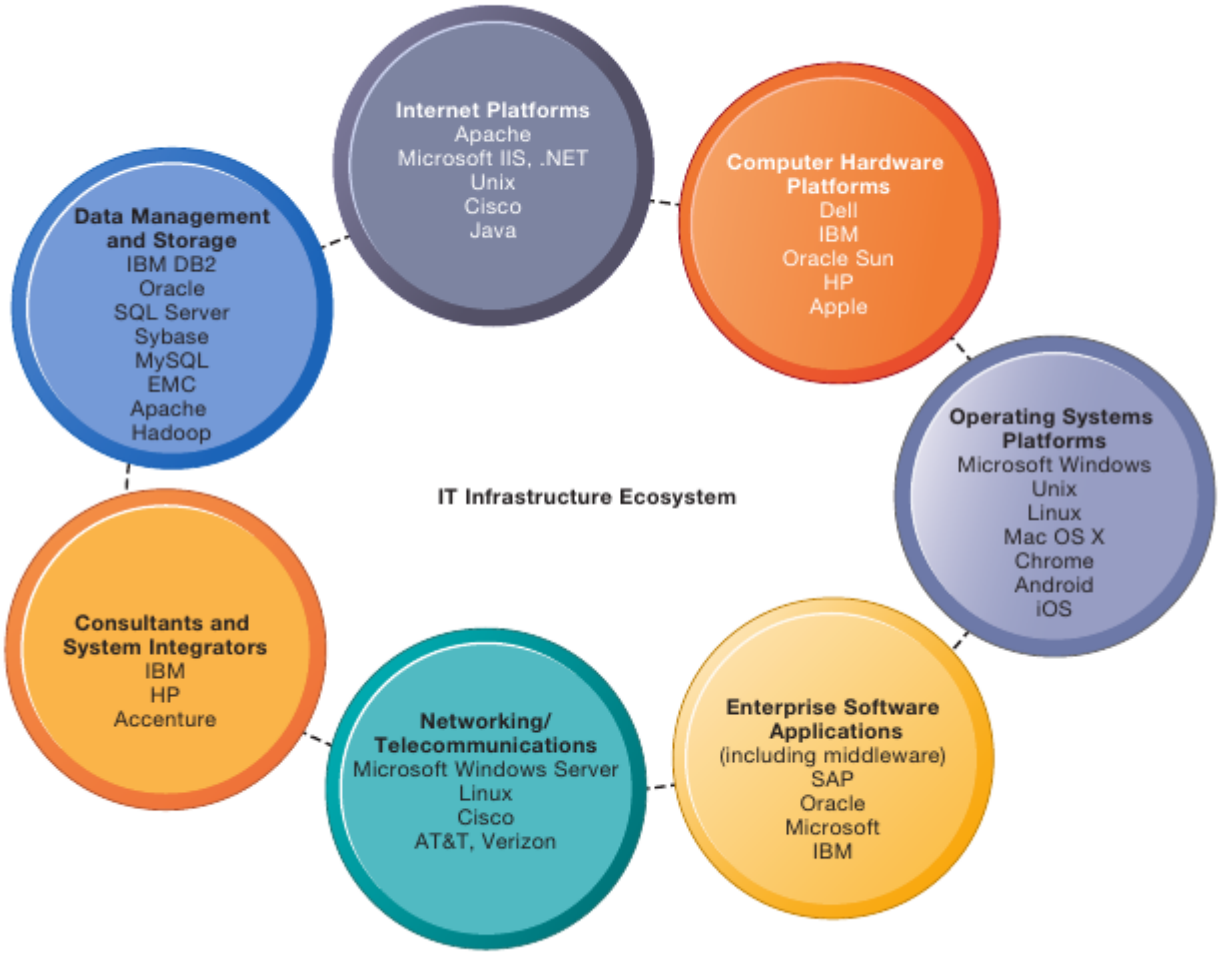
Managing Information Technology
LTB-FIST3UIT

Topics

- Technology briefing
  - IS hardware
  - IS software
  - Networks
  - The Internet
  - Databases

IT Infrastructure

FIGURE 5.8 THE IT INFRASTRUCTURE ECOSYSTEM



There are seven major components that must be coordinated to provide the firm with a coherent IT infrastructure. Listed here are major technologies and suppliers for each component.

IS hardware

- **Input** technology

FIGURE TB1

All computing devices utilize input technologies.

Sources: (a) Nikolai Sorokin/Fotolia; (b) Aaron Amat/Fotolia; (c) Jan Engel/Fotolia

IS hardware

- Entering **batch data**

TABLE TB1 **Specialized Scanners for Inputting Data**

Scanner	Description
Optical mark recognition	Used to scan questionnaires and test answer forms ("bubble sheets") where answer choices are marked by filling in circles using pencil or pen
Optical character recognition	Used to read and digitize typewritten, computer-printed, and even handwritten characters such as product specifications on sales tags on department store merchandise, patient data in hospitals, or addresses on postal mail
Bar code reader	Used mostly in grocery stores and other retail businesses to read bar code data at the checkout counter; also used by libraries, banks, hospitals, utility companies, and so on
Magnetic ink character recognition	Used by the banking industry to read data, account numbers, bank codes, and check numbers on preprinted checks
Biometric scanner	Used to scan human body characteristics of users to enable everything from access control to payment authorization

IS hardware

- Other **input** technologies
  - Smart cards
  - RFIDs
  - Biometric readers
  - GPS
  - Compass
  - IoT sensors
  - Audio & video
  - …

IS hardware

- Motherboard, **CPU**
  - Motherboard
  - Central processing unit (CPU)
  - CPU parameters: # of cores, clock speed, # of registers, cache memory
  - Clock speed up to 3GHz, first PCs 4.77 MHz
  - Responsible for processing of the data and executing programs

IS hardware

- Motherboard

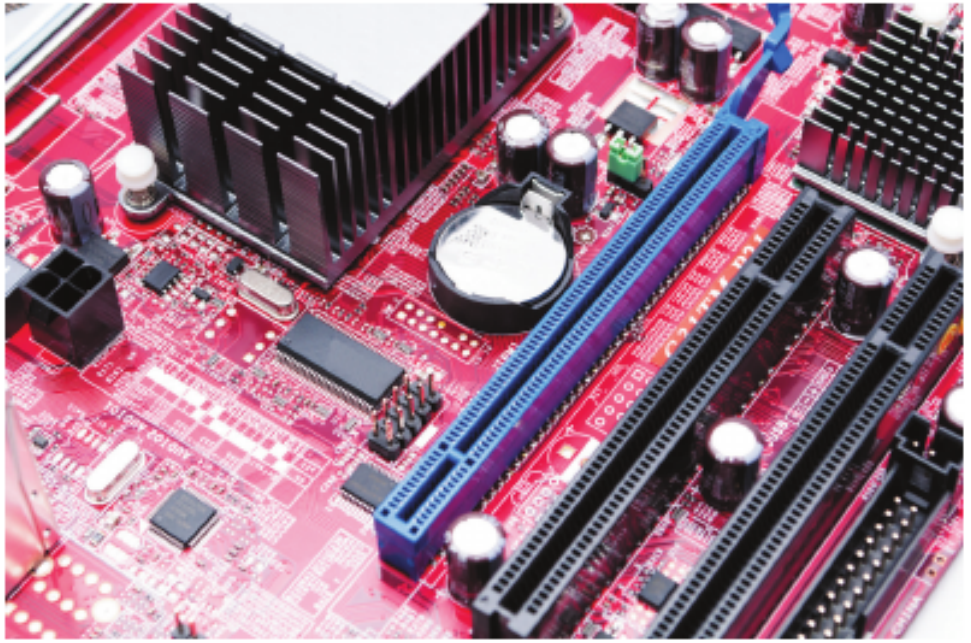


FIGURE TB2

A computer's motherboard holds or connects to all of the computer's electronic components.
Source: Bretislav Horak/Shutterstock.

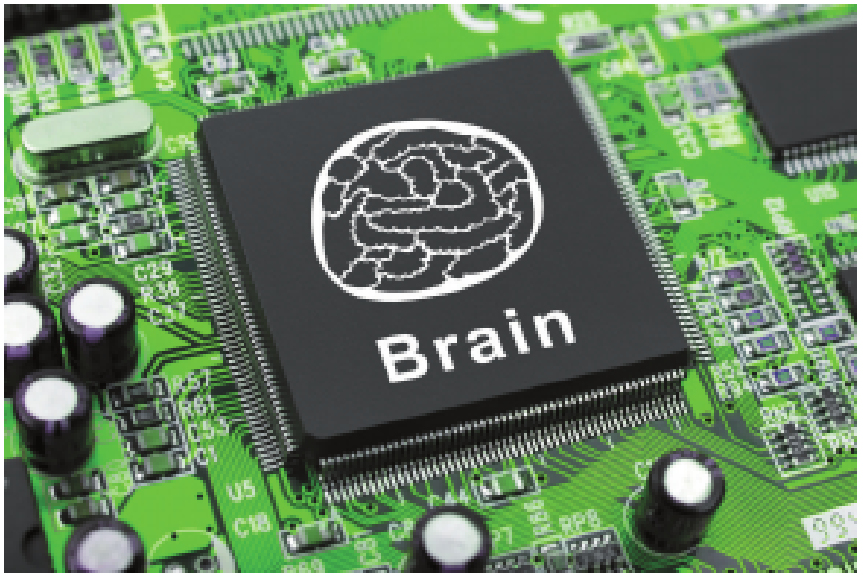
IS hardware

- CPU

FIGURE TB3

A CPU performs all operations of a computer.

Source: Tatiana Popova/Shutterstock.



IS hardware

- Storage

TABLE TB2 **Different Storage Technologies**

Name	Volatility	Speed	Access	Capacity	Usage
Register	Volatile	Extremely fast	Random	32 or 64 bits per register	Data directly used by CPU
Cache	Volatile	Extremely fast	Random	Typically up to 20 MB	Data and instructions used by CPU
RAM	Volatile	Very fast	Random	Depends on configuration; typically up to 128 GB	Programs and data currently used
ROM	Nonvolatile	Fast	Random	Very low	Instructions used before the operating system is loaded
SSD	Nonvolatile	Fast	Random	High	Storage of programs and data
Hard drive	Nonvolatile	Relatively slow	Random	High	Storage of programs and data
Optical disks	Nonvolatile	Slow	Random	Medium	Backup and long-term storage; software distribution; music and movies
Tape	Nonvolatile	Very slow	Sequential	High	Archiving of data

IS hardware

- Primary storage
  - Registers
  - Cache
  - RAM
  - ROM (i.e. BIOS), non-violatile

IS hardware

- Secondary storage
  - Hard disk drives
  - Redundant areas of independent disks (RAID)
  - Solid state drives (SSD), flash memory
  - Removable storage:
    - USB flash drives
    - SD cards
    - Optical disks (CD-R, CD-RW, DVD-R, DVD-RW)
    - Tapes

IS hardware

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    - Tapes

IS hardware

- Secondary storage

FIGURE TB4

A hard drive consists of several disks that are stacked on top of one another and read/write heads to read and write data.
Source: Alias Studiot Oy/Shutterstock.

IS hardware

- Ports

TABLE TB3 Common Computer Ports, Applications, and Descriptions

Port Name	Used to Connect	Description
Serial	Modem, mouse, keyboard, terminal display, MIDI	■ Transfers one bit at a time ■ Slowest data transfer rates
USB	Printer, scanner, mouse, keyboard, digital camera and camcorders, external disk drives	■ Extremely high-speed data transfer method ■ Up to 10 Gbps using USB3.1 ■ Up to 127 devices simultaneously connected
IEEE 1394 ("Fire Wire")	Digital cameras and camcorders, external disk drives	■ Extremely high-speed data transfer method ■ Up to 3.2 Gbps ■ Up to 63 devices simultaneously connected
Thunderbolt	Simultaneous transmission of DisplayPort (video and audio), PCI Express (data), and power	■ Extremely high-speed data transfer method ■ Up to 40 Gbps ■ Up to 7 devices simultaneously connected to a single port
Ethernet	Network	■ Most common standard for local area networks
VGA (Video Graphics Array), DVI (Digital Visual Interface)	Monitors	■ VGA is designed for transmission of analog video signals ■ DVI allows for transmission of digital video signals
HDMI (High Definition Multi-media Interface), DisplayPort	Monitors, home theater	■ HDMI and DisplayPort allow for simultaneous transmission of digital audio and video signals

IS hardware

- Power supply
  - 100-240 VAC input voltage
  - 3.3 to 12 VDC output, voltage requirements
  - Cooling fans, cooling requirements
  - Power requirements, max. current

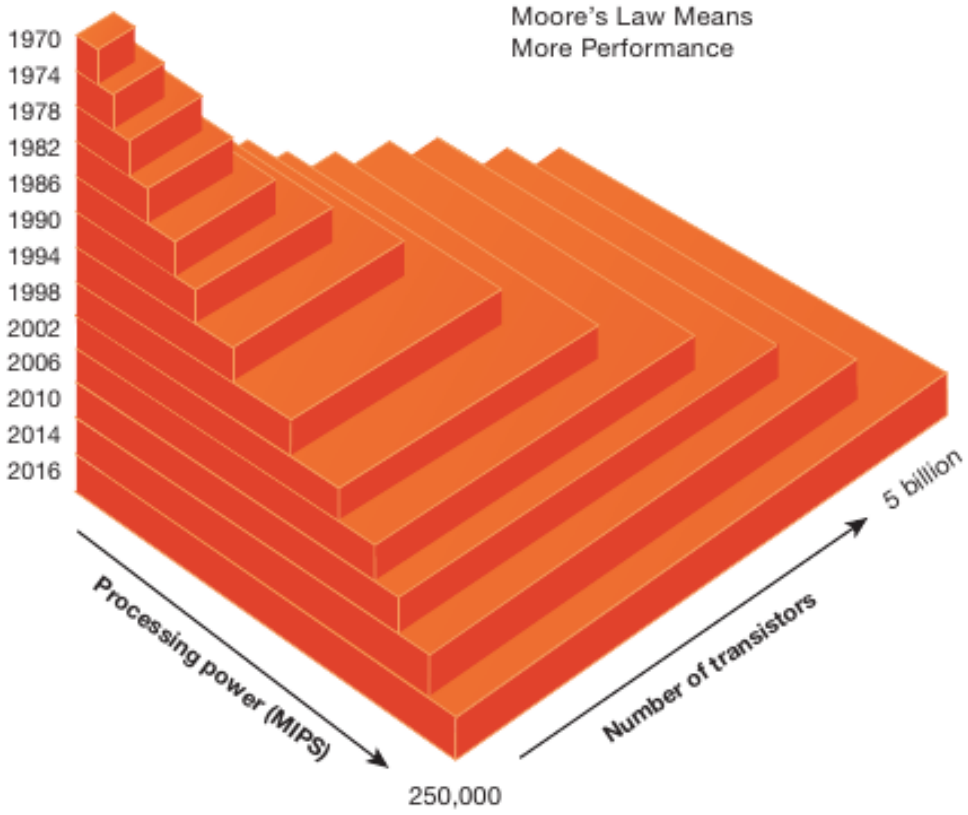
IS hardware

- Output technologies
  - Printers (laser, inkjet, matrix, ...)
    - Size, color, speed
  - Monitors
    - Cathode Ray Tubes (CRT)
    - Liquid Crystal Display (LCD)
    - Organic Light Emitting Diodes (OLED)
    - Various size, resolution, colors, speed
    - ...
  - Touch screens (output + input)

IS hardware

- Moore’s Law

FIGURE 5.4 MOORE’S LAW AND MICROPROCESSOR PERFORMANCE

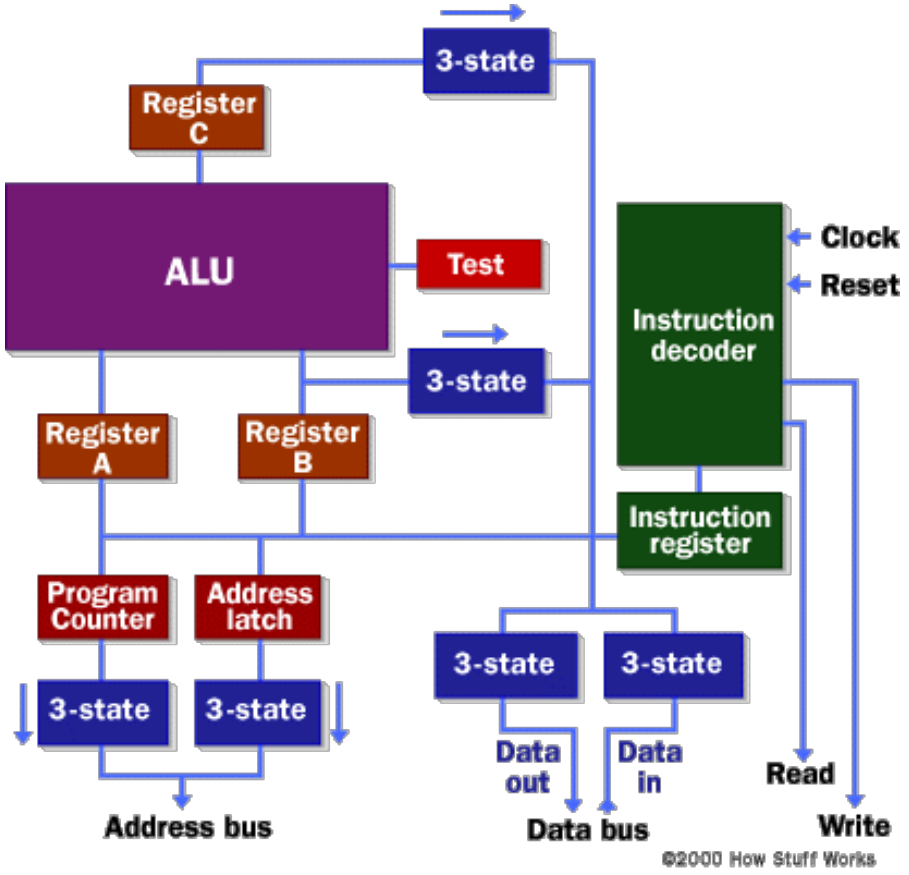


Packing more than 5 billion transistors into a tiny microprocessor has exponentially increased processing power. Processing power has increased to more than 250,000 MIPS (about 2.6 billion instructions per second).

Source: Authors’ estimate.

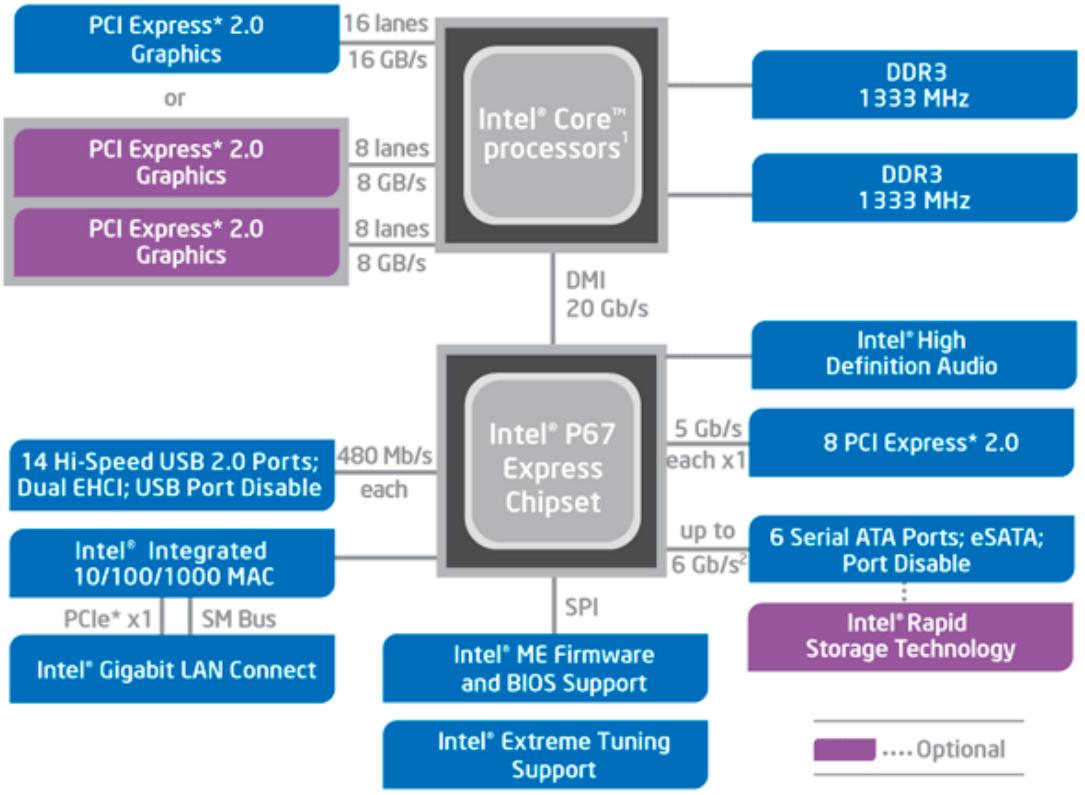
IS hardware

- CPU concept



IS hardware

- Sandy Bridge Motherboard Example



[1] Compatible with 2nd generation Intel® Core™ processor family

[2] All SATA ports capable of 3 Gb/s. 2 ports capable of 6 Gb/s.

IS software

- Foundation topics in **Software management**

IS software

- **System** software
  - Operating system
    - Windows
    - Linux
    - BSD
  - Utility software
- Application software
  - Of-shelf
  - Custom

IS software

- Operating systems
  - Booting, starting up of a computer
  - Loading programs into memory, memory management allocation
  - Managing where files and programs are located in the secondary storage
  - Maintaining the structure of files and directories (file system)
  - Formatting disks
  - Controlling the computer screens/monitors
  - Sending files to printers

IS software

- Operating systems

TABLE TB4 Common Operating Systems

Operating System	Description
z/OS	A proprietary operating system developed specifically for large IBM mainframe systems.
Unix	A multiuser, multitasking operating system that is available for a wide variety of computer platforms. Commonly used because of its superior security.
Windows	Currently, the Windows desktop operating system is by far the most popular in the world. Variations are also used to operate large servers, tablets, and smartphones.
Mac OS	The first commercial graphical-based operating system, making its debut in 1984. The operating system of Apple computers.
Linux	An open source operating system designed in 1991 by a Finnish student. Known as a secure, low-cost, multiplatform operating system. Linux powers about one-third of all web servers. Linux users can choose between different "flavors" (or distributions) depending on their needs (such as the novice-friendly Ubuntu).
Android	Google's Linux-based operating system for mobile devices.
iOS	Apple's mobile operating system.

IS software

- Utility programs

TABLE TB5 Common Types of Computer Software Utilities

Utility	Description
Backup	Archives files from the hard drive to tapes, flash drives, or other storage devices.
File defragmentation	Converts fragmented files (i.e., files not stored contiguously) on your hard drive into contiguous files that will load and be manipulated more rapidly.
Disk and data recovery	Allows the recovery of damaged or erased data from hard drives and flash drives.
Data compression	Compresses data by substituting a short code for frequently repeated patterns of data, much like the machine shorthand used by court reporters, allowing more data to be stored on a storage medium.
File conversion	Translates a file from one format to another so that it can be used by an application other than the one used to create it.
Antivirus	Scans files for viruses and removes or quarantines any virus found.
Device driver	Allows the computer to communicate with various different hardware devices.
Spyware detection and removal	Scans a computer for spyware and disables or removes any spyware found.
Media player	Allows listening to music or watching video on a computer.

IS software

- Utility programs

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IS software

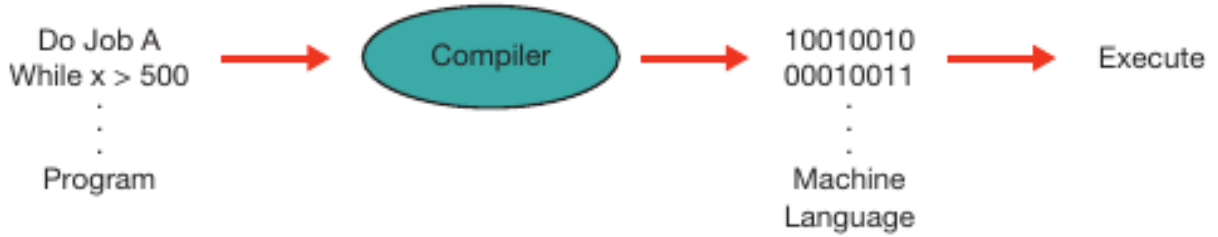
- Programming languages, development tools
  - Languages (C, C#, Python, Java, PHP, …)
  - Compilers and interpreters
- Source code vs. executable

IS software

- Compiler vs. interpreter

FIGURE TB5

A compiler translates the entire computer program into machine language, then the CPU executes the machine language program.



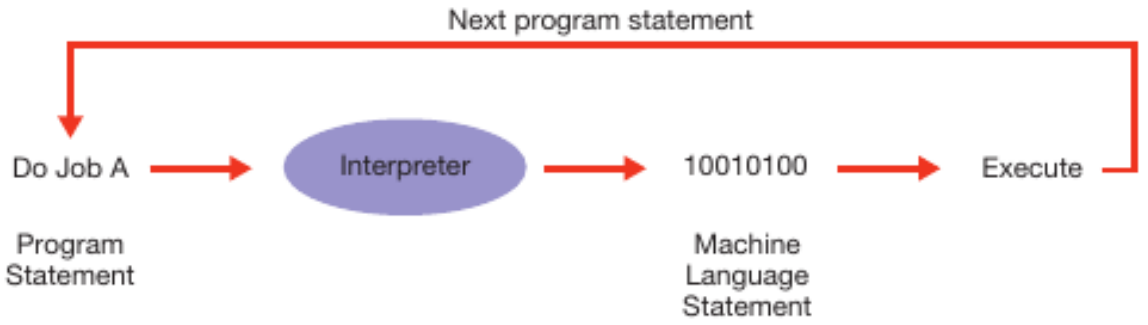


FIGURE TB6

Interpreters read, translate, and execute one line of source code at a time.

IS software

TABLE TB6 Examples of Popular Programming Languages

Language	Application	Description
BASIC	General purpose	Beginner's All-Purpose Symbolic Interaction Code. An easy-to-learn language, BASIC works on almost all PCs.
C/C++	General purpose	C++ is a newer version of C. Developed at AT&T Bell Labs. Complex languages used for a wide range of applications.
COBOL	Business	COmmon Business-Oriented Language. Developed in the 1960s, it was the first language for developing business software. COBOL is still frequently used for many business transaction processing applications on mainframes.
FORTRAN	Scientific	FORmula TRANslator. The first commercial high-level language developed by IBM in the 1950s. Designed for scientific, mathematical, and engineering applications.
Java	World Wide Web	An object-oriented programming language developed by Sun Microsystems in the early 1990s. It is a popular programming language for the Internet because it is highly transportable from one computer to another. Java is also used for programing Android apps.
.NET Framework	World Wide Web	A variety of programming languages (e.g., ASP.NET and C#) offered by Microsoft that can easily be integrated into web applications.
LISP	Artificial Intelligence	LISt Processor. Dates from the late 1950s. One of the main languages used to develop applications in artificial intelligence and high-speed arcade graphics.
PERL	World Wide Web	A dynamic programming language commonly used for writing scripts for websites, as well as for batch processing of large amounts of data.
Python	General purpose	Popular object-oriented scripting language
Objective-C	App development	Evolved from C, Objective-C is used for developing apps for iPhones, iPads, and Apple computers.

IS software

- OO concepts

TABLE TB7 Concepts Related to Object-Oriented Languages

Concept	Description	Example
Class	A set of objects having the same properties and behaviors (but the values of the properties can differ for each individual object). Classes can be reused for different programs.	A "student" has an address and a grade-point average (GPA) (properties) and can enroll in courses (behavior).
Object	Instantiation of a class.	Student Jeff Smith has a GPA of 3.94 and enrolls in MIS250.
Encapsulation	Data and behavior of a class are hidden from other classes and are thus protected from unexpected changes.	The registrar doesn't need to know how the GPA is calculated within the "student" class; the registrar cares only that it is updated.
Inheritance	More specific classes include the properties and behaviors of the more general class.	Both "distance degree student" and "on-campus student" inherit properties (such as address and GPA) and behaviors (such as enroll in a course) from the general class "student."
Event-driven program execution	The programmer does not determine the sequence of execution for the program; the flow is determined by user input (e.g., mouse clicks) or messages from other applications.	A word processor reacts to your typing and clicking.

IS software

- Web development languages
  - HTML
  - CSS
  - JavaScript
- Web applications
  - PHP
  - Java, JSP

IS software

- HTML, Markup language

TABLE TB8 Common HTML Tags

Tag	Description
<html>…</html>	Delineates an HTML document
<head>…</head>	Contains the title, scripts, styles, metadata and other elements that are not displayed on the web page itself
<body>…</body>	Contains the visible portion of the document
…	Creates bold text
…	Creates a hyperlink
…	Creates a link creating a new e-mail message
…	Creates a new paragraph
<table>…</table>	Creates a table

IS software

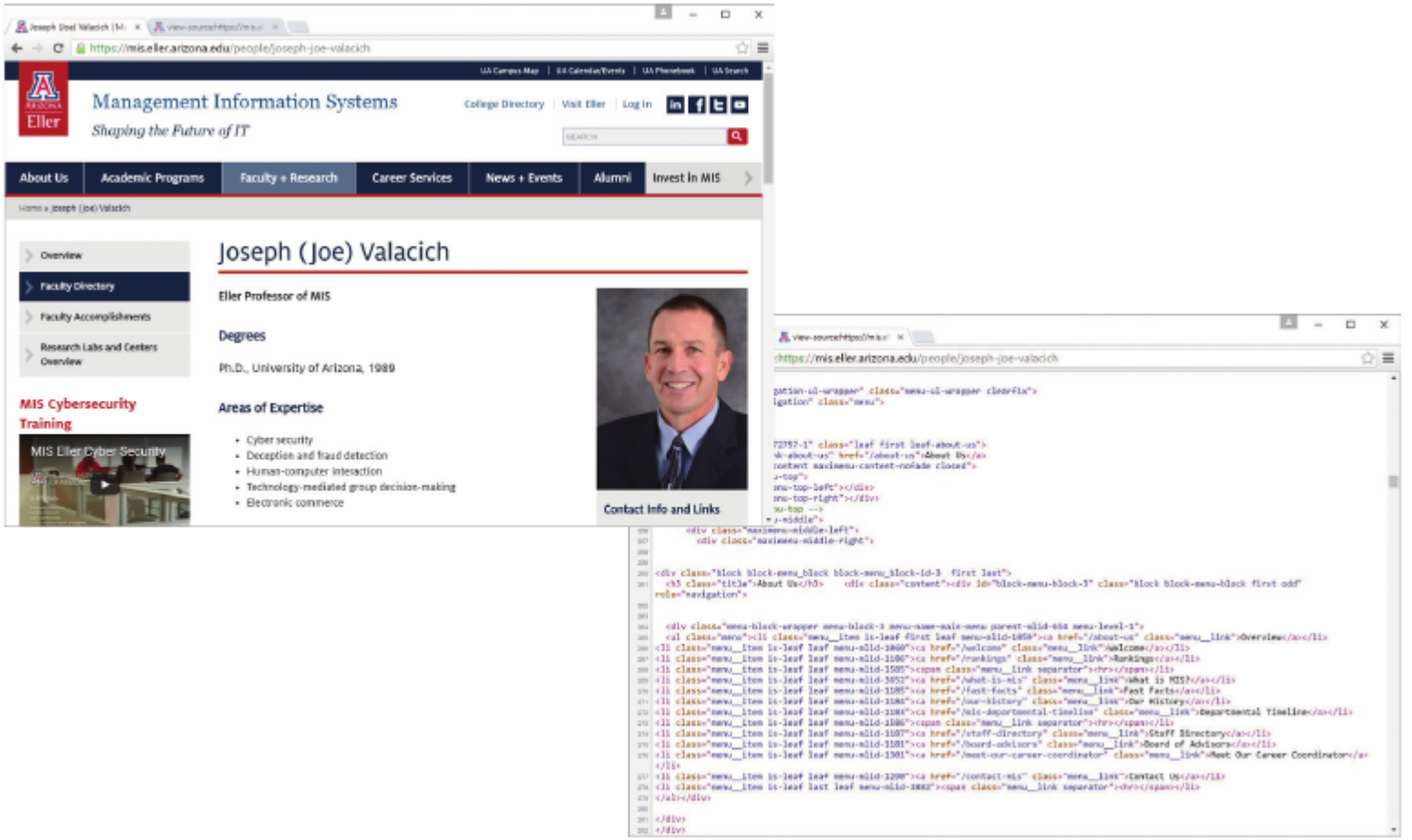


FIGURE TB8

A web page and the HTML source code used to create it.
Source: Visio 2016, Windows 10, Microsoft Corporation.

IS software

- JavaScript, Flash
  - Dynamic content within web pages
- HTML5
  - Rich, interactive, web pages
- Web applications
  - PHP
  - Java, JSP

IS software

- Automated development environments
  - **CASE** tools, Computer Aided Software Engineering
    - Creation fo design document
    - Management of the information
    - Business process and diagramming tools
    - Automated code generation

IS software

- CASE tools

TABLE TB9 General Types of CASE Tools

CASE Tool	Description
Diagramming tools	Tools for graphically representing a system's processes, data, and control structures.
Screen and report generators	Tools that help model how systems look and feel to users. Screen and report generators also make it easier for the systems analyst to identify data requirements and relationships.
Analysis tools	Tools that automatically check for incomplete, inconsistent, or incorrect specifications in diagrams, screens, and reports.
Repositories	Tools that enable the integrated storage of specifications, diagrams, reports, and project management information.
Documentation generators	Tools that help produce both technical and user documentation in standard formats.
Code generators	Tools that enable the automatic generation of program and database definition code directly from the design documents, diagrams, screens, and reports.

Source: Valacich and George (2017).

IS software

- CASE diagramming tools

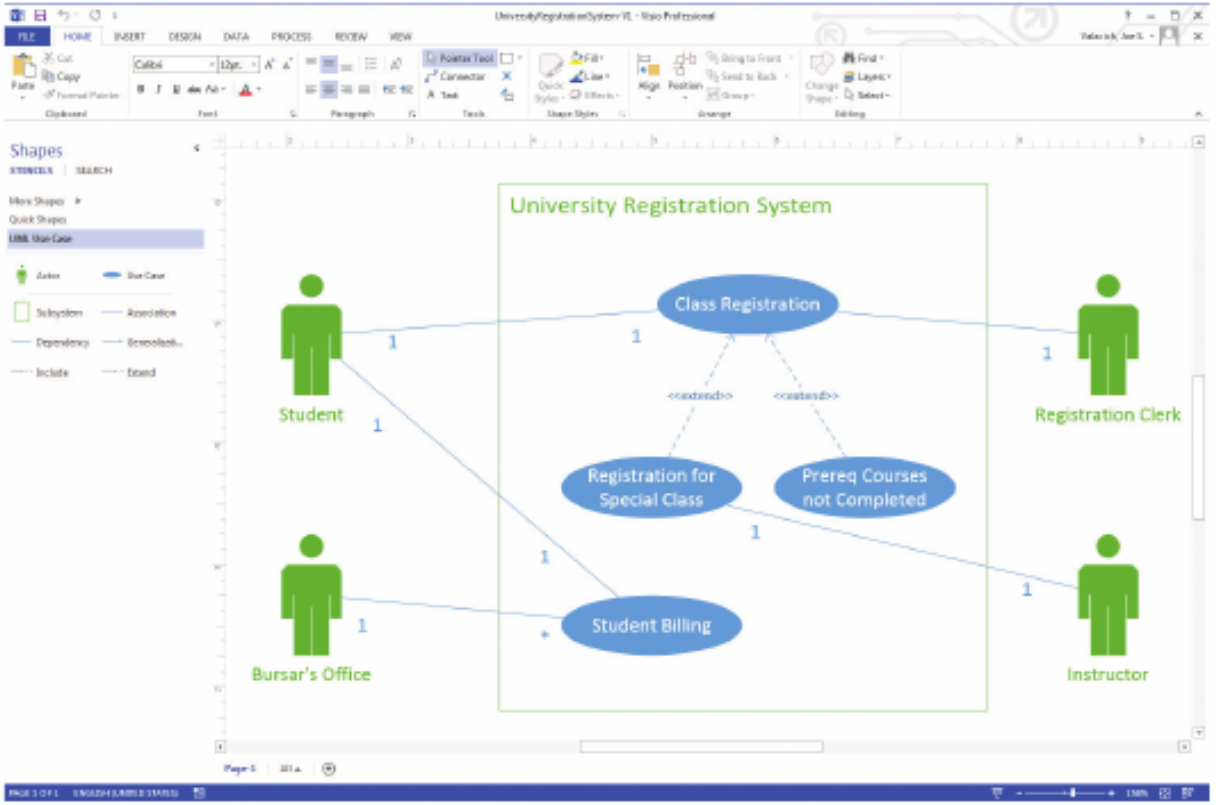


FIGURE TB9

System design diagram from Microsoft Visio.

Source: From *Modern Systems Analysis and Design*, 8ed, published by Pearson Education, Inc.

IS software

- CASE diagramming tools

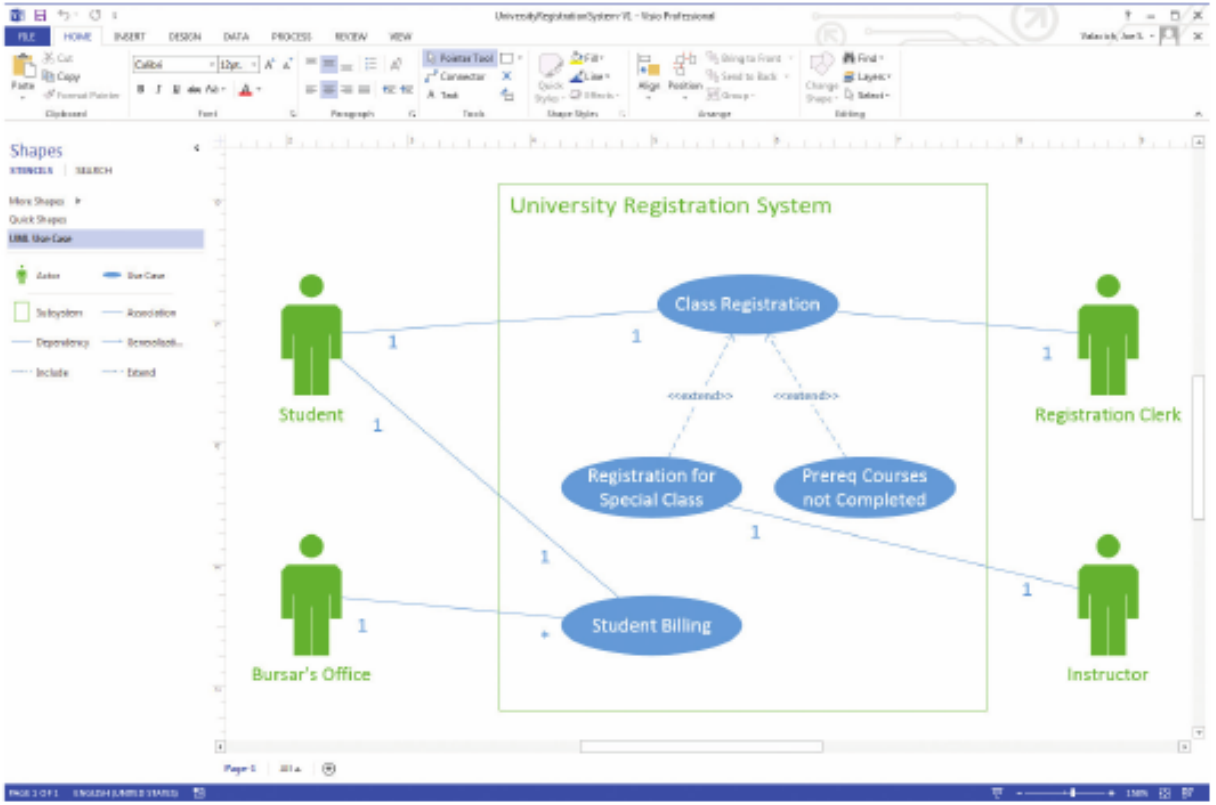


FIGURE TB9

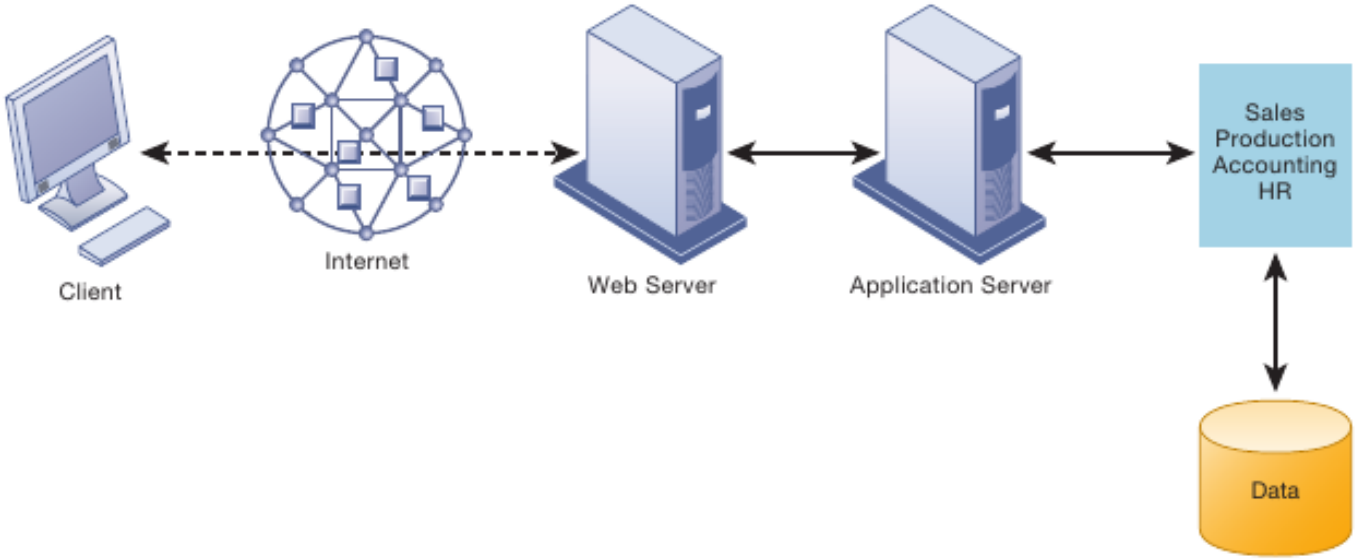
System design diagram from Microsoft Visio.

Source: From *Modern Systems Analysis and Design*, 8ed, published by Pearson Education, Inc.

IS software

- Multi-layered architecture

FIGURE 5.3 A MULTITIERED (N-TIER) CLIENT/SERVER NETWORK



In a multitiered client/server network, client requests for service are handled by different levels of servers.

Networks

- Foundation topics in **Network management**

Networks

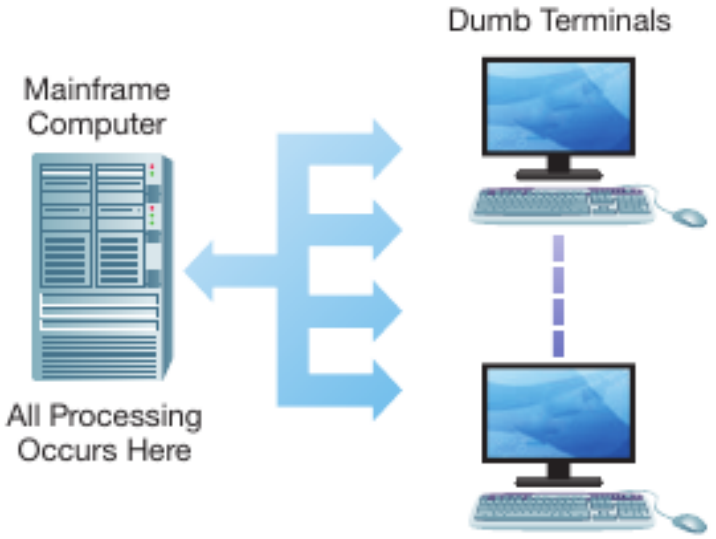
- Computer networking evolution
  - Centralized computing
  - Distributed computing
  - Collaborative computing

Networks

- Centralized computing

FIGURE TB10

In the centralized computing model, all processing occurs in one central mainframe.



Networks

- Distributed computing

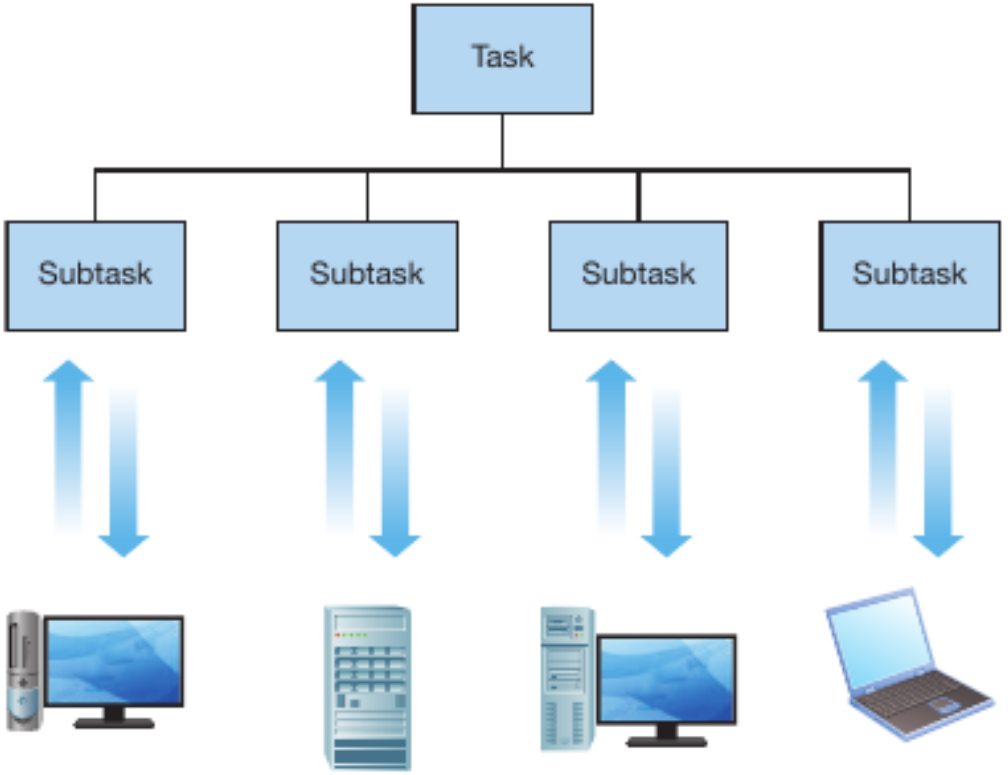


FIGURE TB11

In the distributed computing model, two or more networked computers work independently to accomplish subsets of a complex computing task.

Networks

- Collaborative computing

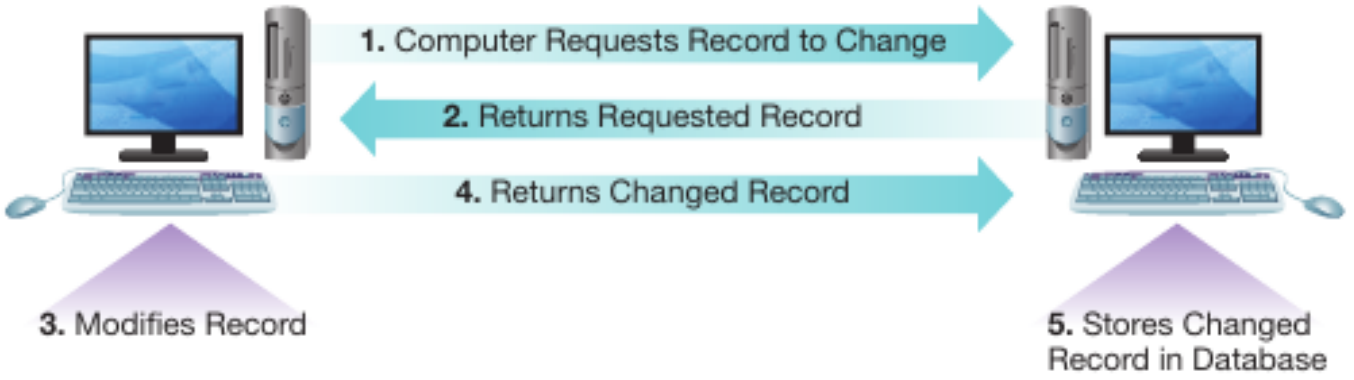


FIGURE TB12

In the collaborative computing model, two or more networked computers work together to accomplish a common task.

Networks

- Types of networks
  - Private branch exchange (PBX)
  - Local area network (LAN)
  - Wide area network (WAN)

Networks

- LAN

FIGURE TB13

A LAN allows multiple computers located near each other to communicate directly with each other and to share peripheral devices, such as a printer.

Networks

- WAN
  - Large geographic area
  - Often, multiple LANs connected
  - Examples/Levels:
    - Campus area network
    - Metropolitan area network
    - Enterprise WAN
    - Value-added network (B2B)
    - Global networks

Networks

- WAN

FIGURE TB14

An enterprise network allows an organization to connect distributed locations into a single network.

Networks

- Personal area networks

FIGURE TB15

Bluetooth is used by many for hands-free communication.

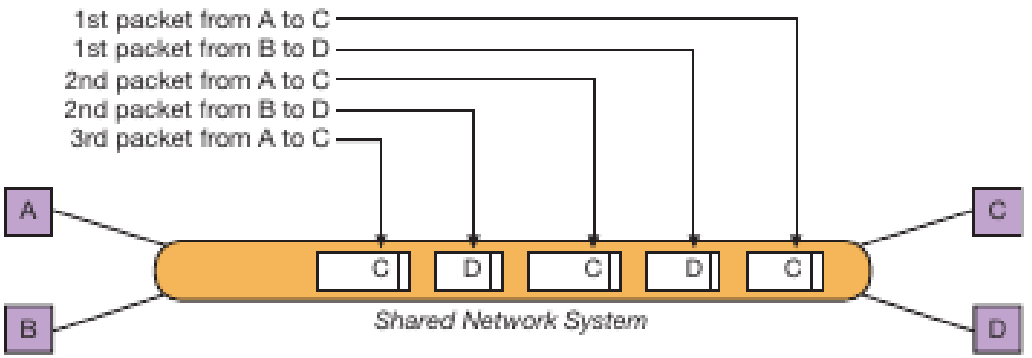
Source: Jupiterimages/Stockbyte/Getty Images.

Networks

- Packet switching

FIGURE TB16

Computers A and B use packet switching to send messages or files to computers C and D.



Networks

- Network **standards** and **protocols**
- **TCP/IP** (Transport Control Protocol/Internet Protocol)
  - **TCP** breaks message into smaller packets
  - **IP** addressing and routing the packets from source to destination

Networks

- The OSI model

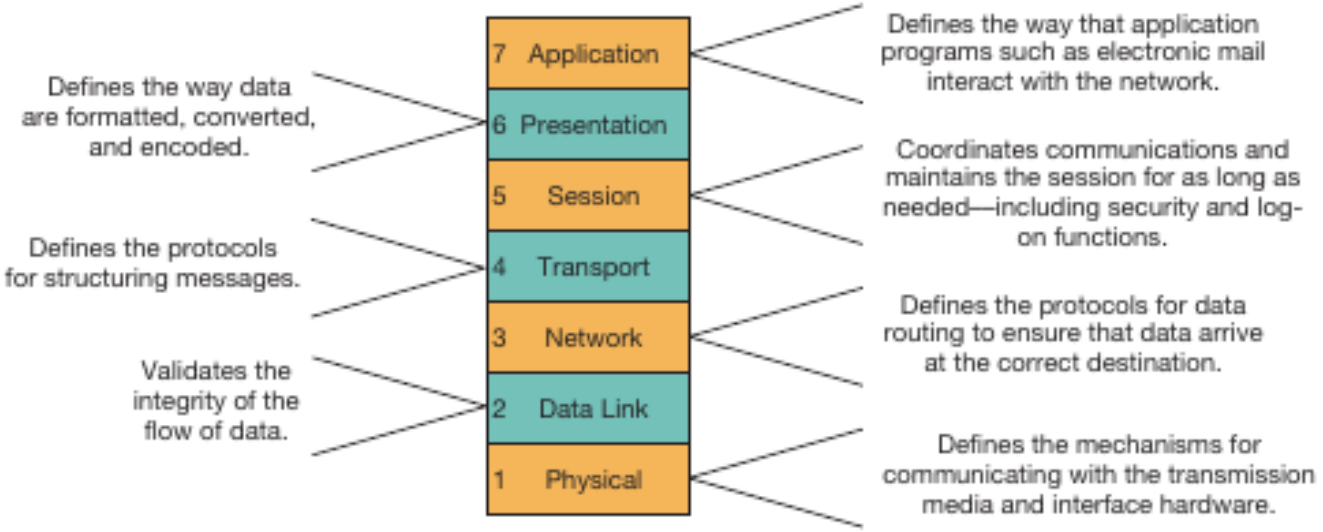


FIGURE TB17

The OSI model has seven layers and provides a framework for connecting different computers with different operating systems to a network.

Networks

- The OSI model

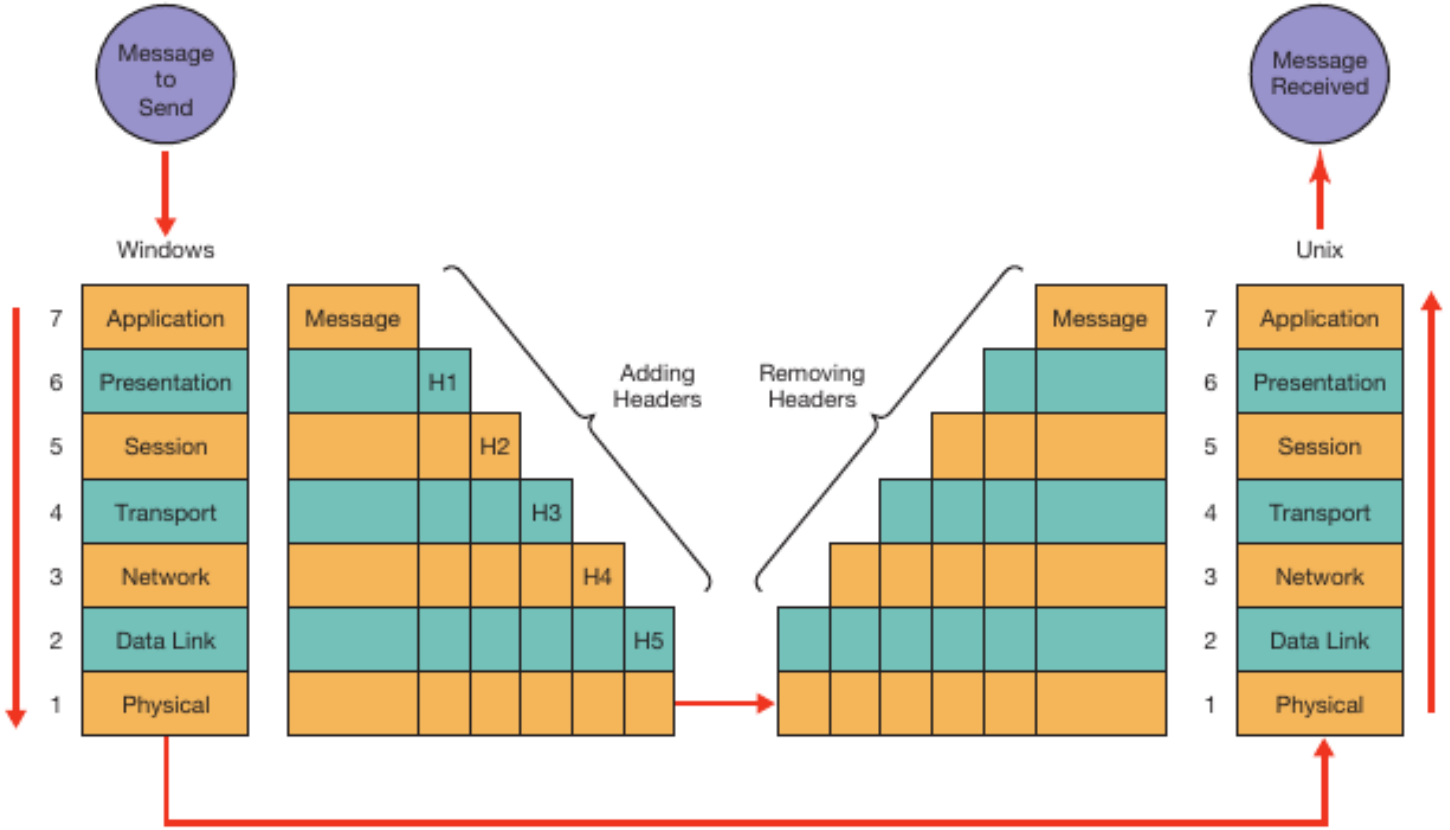


FIGURE TB18

Message passing between two different computers.

Networks

- The OSI model

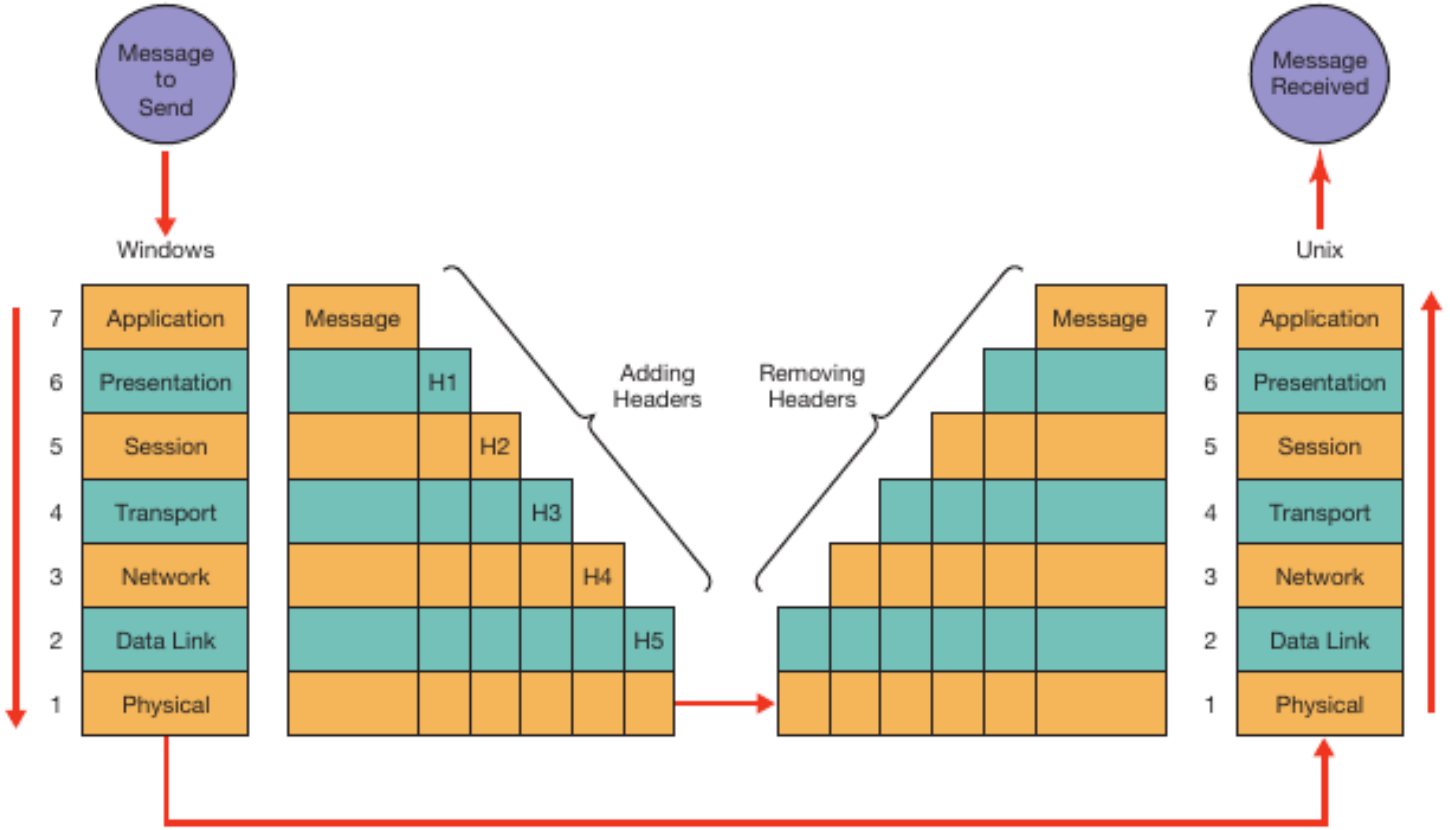


FIGURE TB18

Message passing between two different computers.

Networks

- Topology

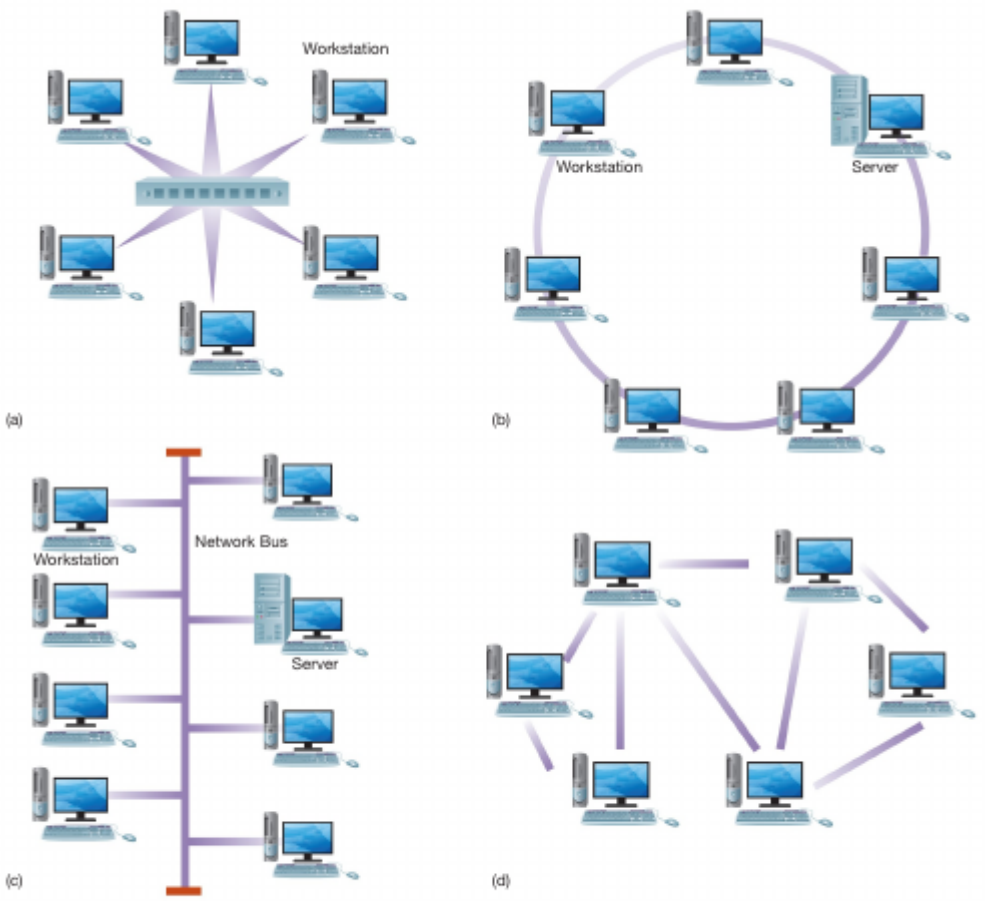


FIGURE TB19

(a) The star network has several workstations connected to a central hub. (b) The ring network is configured in a closed loop, with each workstation connected to another workstation. (c) The bus network is configured in the shape of an open-ended line where each workstation receives the same message simultaneously. (d) The mesh network consists of computers and other devices that are either fully or partially connected to each other.

Networks

- Hardware

TABLE TB9 Networking Hardware

Networking Hardware	Description
Switch	A **switch** is used to connect multiple computers, servers, or printers to create a network. Switches typically inspect data packets received and forward them to the correct addressee.
Router	A router is an intelligent device used to connect two or more different networks. When a router receives a data packet, it looks at the network address and passes the packet on to the appropriate network. Routers are commonly used to connect a LAN to a WAN, such as the Internet.
Wireless access point	A **wireless access point** transmits and receives wireless (Wi-Fi) signals to allow wireless devices to connect to the network.
Wireless controller	A **wireless controller** manages multiple access points and can be used to manage transmission power and channel allocation to establish desired coverage throughout a building and minimize interference between individual access points. Further, wireless controllers can be used to manage authentication and other security features.

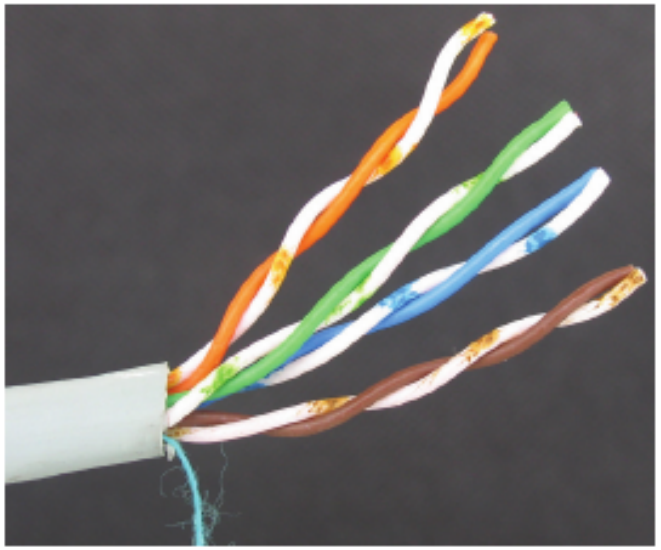
Networks

- Cables

FIGURE TB20

(a) A cable spliced open showing several twisted pairs. (b) A sample network installation that utilizes many TP cables at once.
Sources: (a) Georgios Alexandris/Shutterstock; (b) Inara Prusakova/Shutterstock.

(a)



(b)

Networks

- Coaxial and Fiber

FIGURE TB21

These coaxial cables are ready to be connected to a computer or other device.

Source: Kasia/Shutterstock.

FIGURE TB22

Fiber-optic cable consists of a light-conducting glass or plastic core, surrounded by more glass, called cladding, and a tough outer sheath.

Source: Goodshoot/Getty Images Plus/ Getty Images.

Networks

- Wireless media
  - **Infrared** sight of light
  - High frequency radio, **cellular phone**, **WiFI**
  - Microwave transmission

Networks

- Cellular network

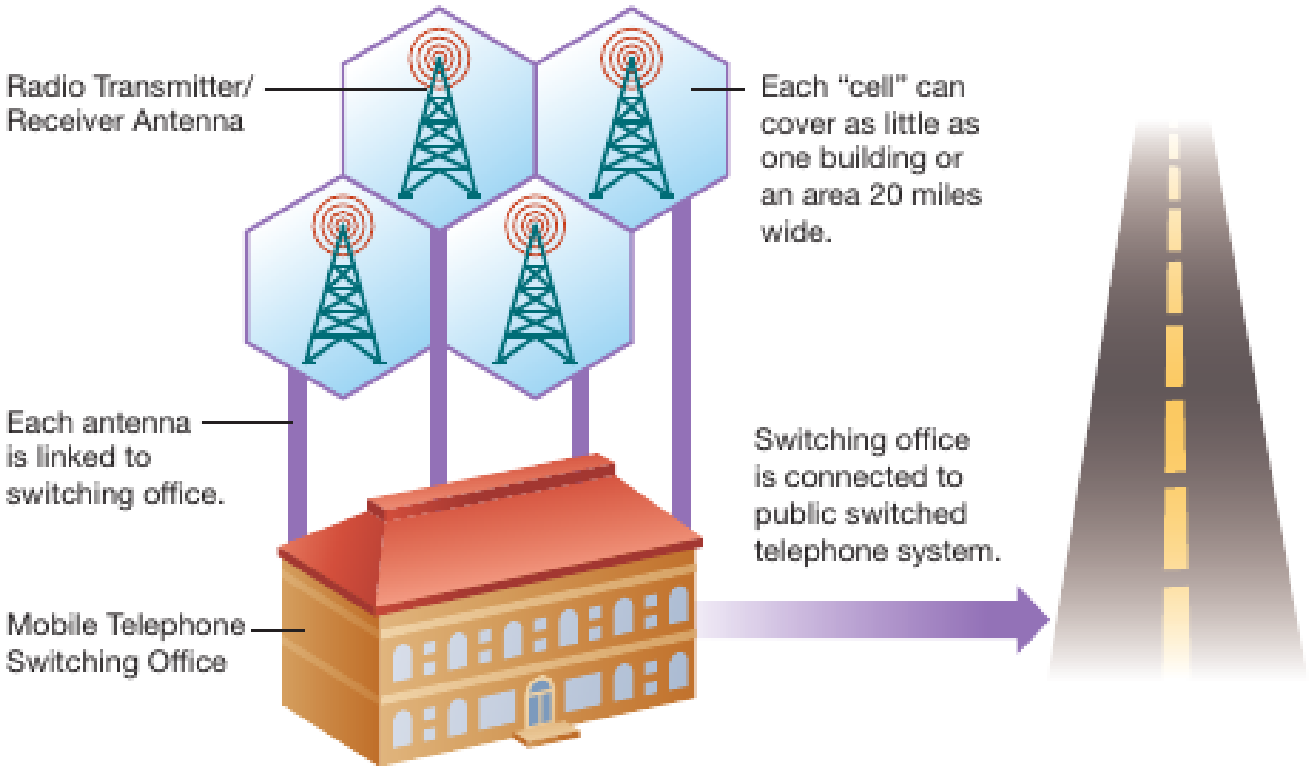


FIGURE TB23

A cellular network divides a geographic region into cells.

Networks

TABLE TB10 Evolution of Cell Phone Technology

Generation	Description	Data Transfer	Advantages
0G	Preceded modern cellular mobile telephony and was usually mounted in cars or trucks; it was a closed circuit, so you could call only other radio telephone users.	Analog	Enabled communicating on the go.
1G	This technology, introduced in the 1980s, used circuit switching; it had poor voice quality, unreliable handoffs between towers, and nonexistent security.	Analog	Enabled users to communicate with other cell phones and land lines.
2G	The first all-digital signal that was divided into TDMA and CDMA standards. Allowed for SMS (text) messaging and e-mails to be sent/received.	Digital (up to 9.6 Kbps transfer)	Lower-powered radio signals allowed for longer battery life. Digital format allowed for clearer signal and reduced signal noise.
2.5G	Allows for faster data transmission via a packet-switched domain in addition to the circuit-switched domain.	Digital (up to 115 Kbps transfer)	Higher data speeds allowed for more complex data to be transmitted (e.g., sports scores and news stories).
3G	Even faster. Requires a new cellular network, different from that already available in 2G systems.	Digital (minimum of 384 Kbps when moving and 2 Mbps when stationary)	Transfer full video and audio.
4G	Set of standards for high-speed mobile connectivity. Different standards on different networks and locations.	Digital (up to 100 Mbps when moving and 1 Gbps when stationary)	Data speeds similar to wired networks.

Networks

- Wireless network
  - WLANs
  - 802.11 protocols
  - Up to 450 Mbit/sec (802.11n standard)

Networks

- Microwave, terrestrial

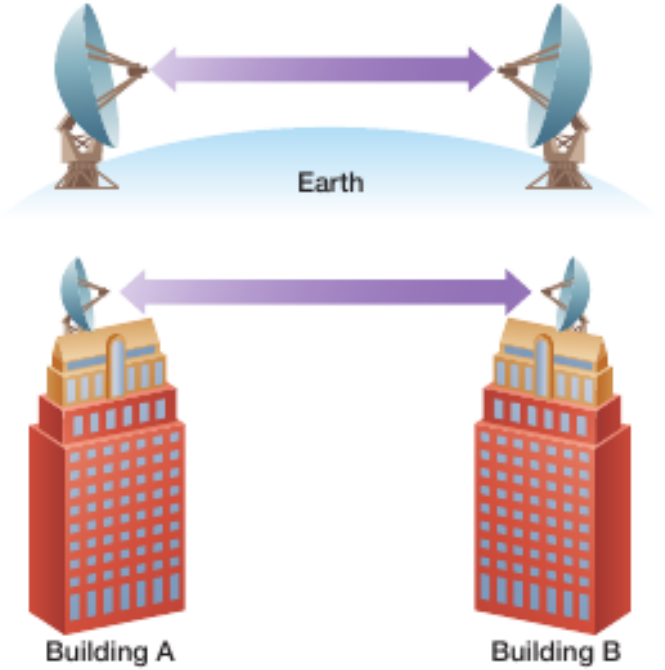


FIGURE TB24

Terrestrial microwave requires a line-of-sight path between a sender and a receiver.

Networks

- Microwave, satellites

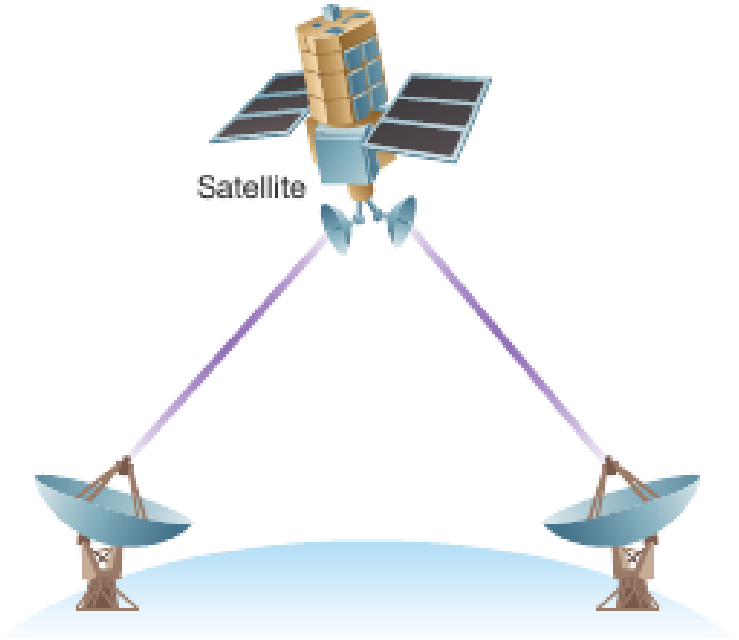


FIGURE TB25

Communications satellites are relay stations that receive signals from one earth station and rebroadcast them to another.

Networks

- Microwave, satellites

TABLE TB11 Characteristics of Satellites with Different Orbits

Name	Distance from Earth	Characteristics/Common Application
Low Earth Orbit (LEO) Satellite	400–1,000 miles	■ Not fixed in space in relation to the rotation of the earth; circles the earth several times per day. ■ Photography for mapping and locating mineral deposits; monitoring ice caps, coastlines, volcanoes, and rain forests; researching plant and crop changes; monitoring wildlife habitats and changes; search and rescue for downed aircraft or ships that are in trouble; research projects in astronomy and physics.
Medium Earth Orbit (MEO)	1,000–22,300 miles	■ Not fixed in space in relation to the rotation of the earth; circles the earth more than one time per day. ■ Primarily used in geographical positioning systems (such as GPS) for navigation of ships at sea, spacecraft, airplanes, automobiles, and military weapons.
Geosynchronous Earth Orbit (GEO)	22,300 miles	■ Fixed in space in relation to the rotation of the earth; circles the earth one time per day. ■ Because it is fixed in relation to the earth, transmission is simplified. ■ Transmission of high-speed data for television, weather information, remote Internet connections, digital satellite radio, and telecommunications (satellite phones).

The Internet

- Foundation topics in **Internet management**

The Internet

- Use of routers

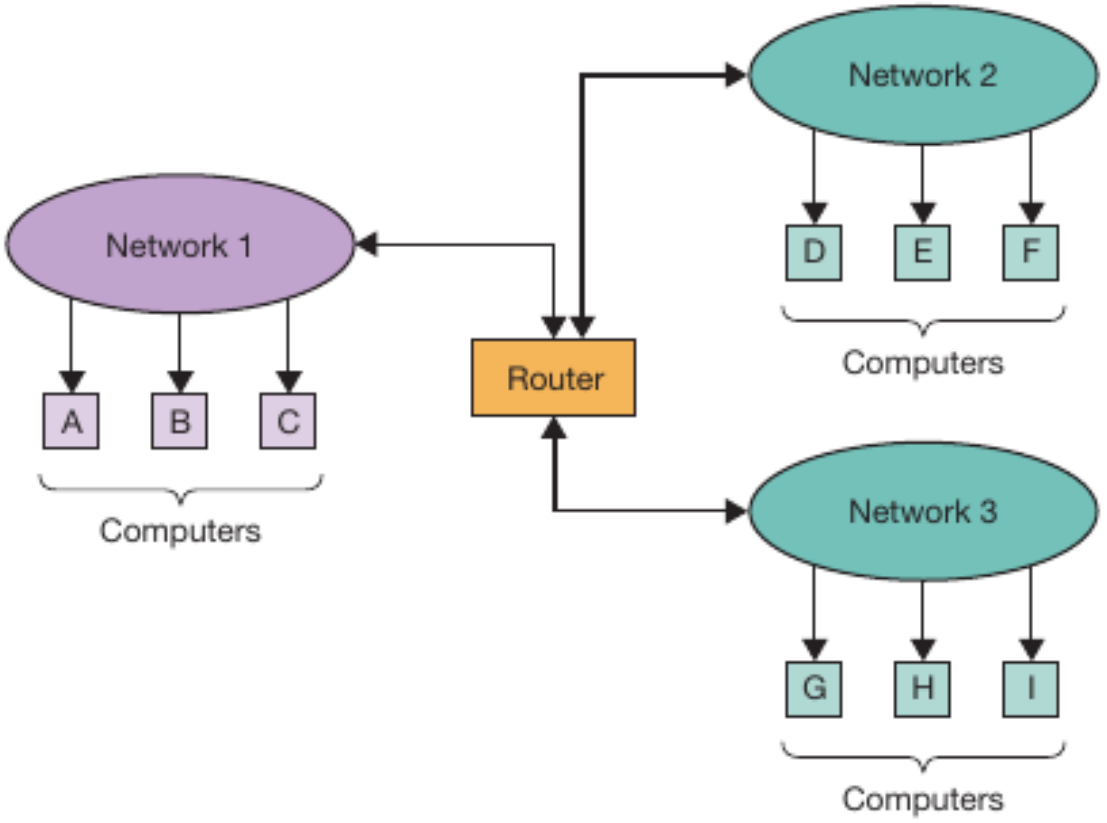


FIGURE TB26

Routers connect independent networks.

The Internet

- Connecting LANs to WAN backbones

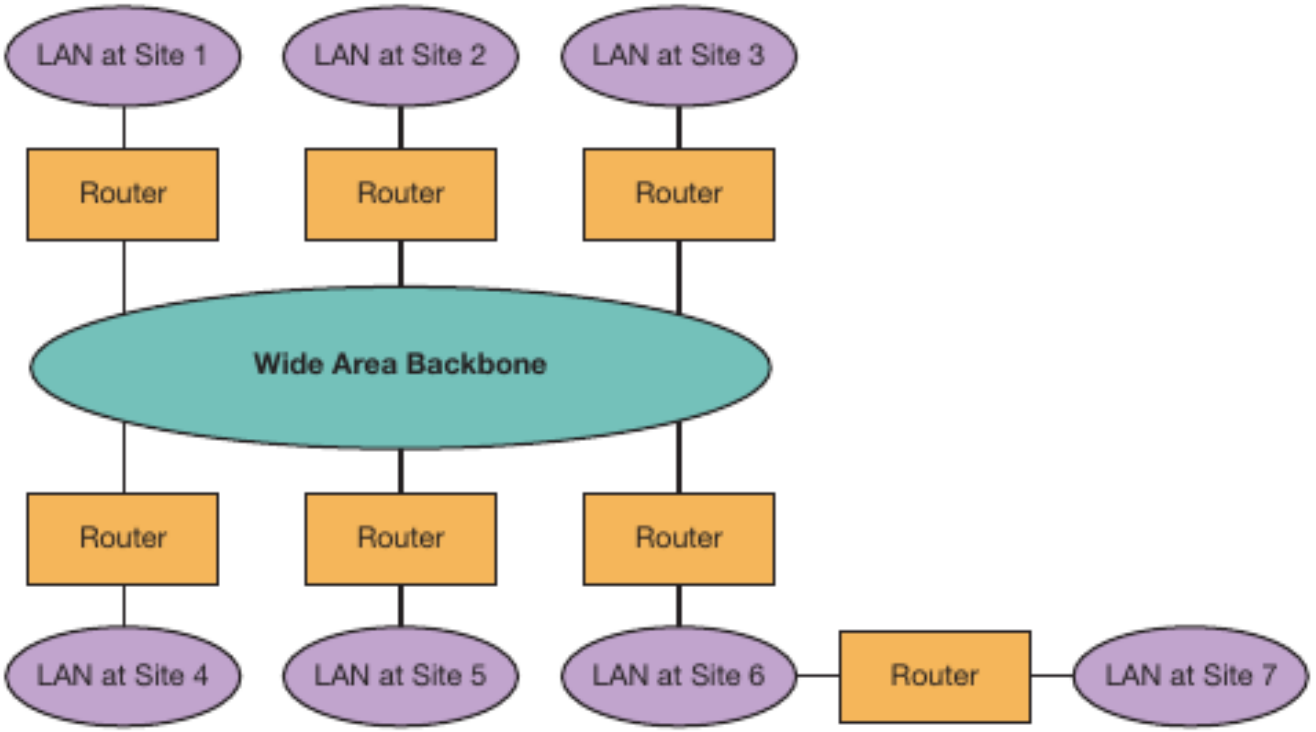


FIGURE TB27

LANs connect to wide area backbones.

The Internet

- Who manages the Internet?
-

The Internet

- How to connect to the Internet?
  - Internet Service Providers (ISPs)
  - Internet eXchange Points (IXPs)
  - Internet Backbone

The Internet

TABLE TB13 Methods for Connecting to the Internet

Service	Current Status and Future Outlook	Typical Bandwidth
Dial-up	Although still used in the United States, there are very few new dial-up customers. This market should dry up as broadband moves to rural areas and developing nations.	52 Kbps
Integrated Services Digital Network	This technology has limited market share because of its expense. Typically, these connections are more expensive than broadband connections, although they offer less bandwidth.	128 Kbps
Cable	Coaxial cable used for cable TV provides much greater bandwidth than telephone lines and therefore is the market leader in broadband use for home users. Overselling of bandwidth that causes slower-than-average speeds tends to be a major problem for home users.	Upload: up to 31 Mbps Download: up to 43 Mbps
DSL	DSL technology has gained market share from cable. With many companies offering higher speeds at lower cost, DSL should continue to cut into cable's market share.	Upload: up to 16 Mbps Download: 1.5–50 Mbps
Satellite	Although satellite connectivity had a promising future, many users are moving away from this expensive technology in favor of faster and cheaper cable or DSL connections.	Upload: 50 Kbps Download: 5 Mbps
Wireless broadband	Wireless broadband offers the most promise of any of the current technologies, as the speeds are increasing while the coverage areas continue to grow.	Up to 1 Gbps
Fiber to the home	Fiber to the home has been adopted by several major players in the ISP industry. Although the technology typically can be placed only in new developments, the demand for fast connections is helping make this a significant technology for ISPs.	At least 100 Mbps, up to 1000 Mbps

The Internet

- Visualization of the Internet Backbone

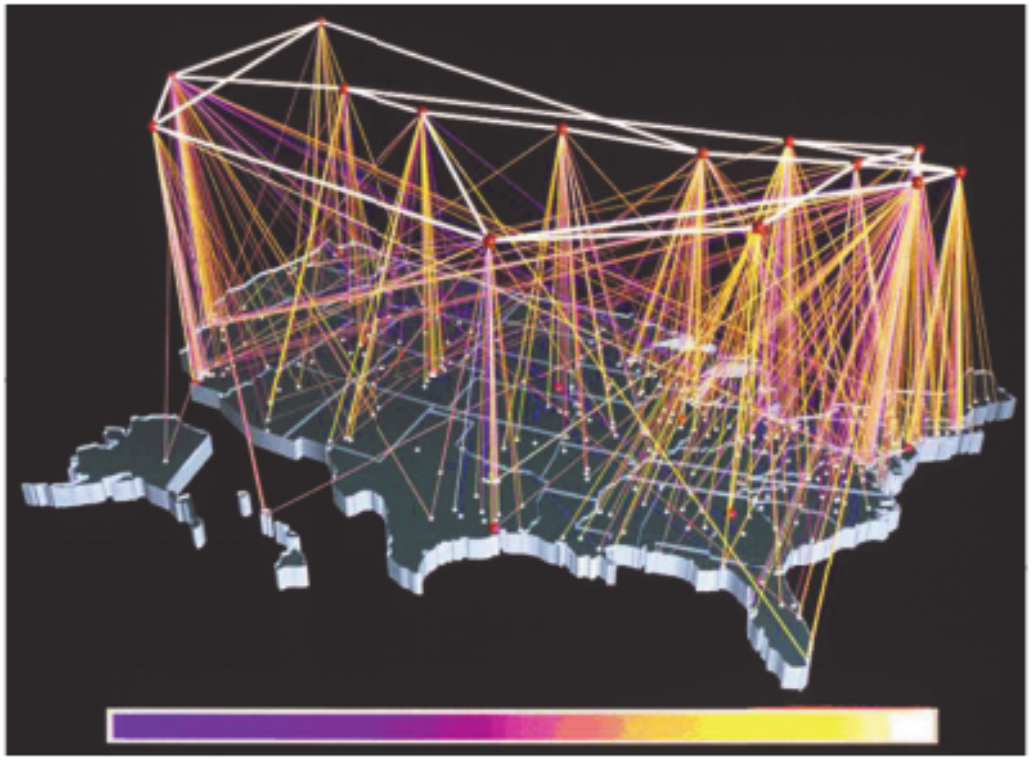


FIGURE TB28

The Internet backbone.

The Internet

- Business connection
  - Leased Lines T1, T3
  - Fiber optics
  - …

TABLE TB14 Capacity of Telecommunication Lines

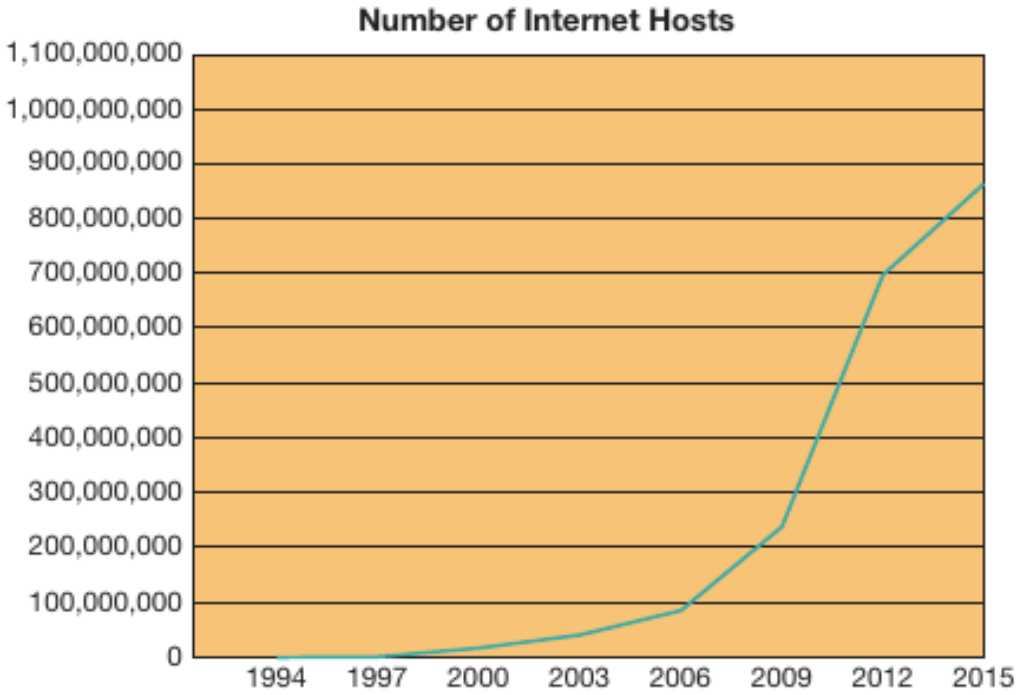
Type of Line	Data Rate
T1	1.544 Mbps
T3	44.736 Mbps
OC-1	51.85 Mbps
OC-3	155.52 Mbps
OC-12	622.08 Mbps
OC-24	1.244 Gbps
OC-48	2.488 Gbps

The Internet

- Current state of Internet usage
  http://www.internetlivestats.com/total-number-of-websites/

FIGURE TB30

Growth in Internet servers (hosts).
Source: Based on http://www.internetlivestats.com/total-number-of-websites.

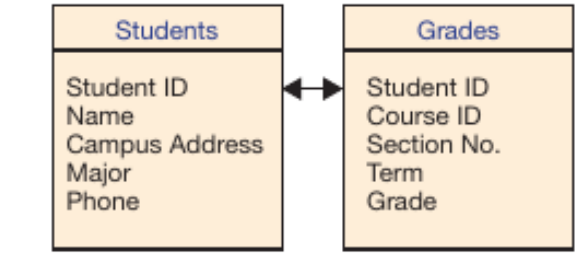


Databases

- Foundation topics in **database management**

Databases

- Relational database design



Students

Student ID	Name	Campus Address	Major	Phone
555-39-3232	Joe Jones	123 Any Avenue	Finance	335-2211
289-42-8776	Sally Carter	1200 Wolf Street #12	Marketing	335-8702

Grades

Student ID	Course ID	Section No.	Term	Grade
555-39-3232	MIS 250	2	F'15	D+
555-39-3232	MIS 250	1	F'16	A–
289-42-8776	MIS 250	3	S'17	B+

FIGURE TB31

The attributes for and links between two entities—students and grades.

Databases

- Identifiers
  - Primary key, unique ID
  - Combination primary key
  - Attributes sometimes used as Secondary key

Databases

- Associations, Relations

TABLE TB15 **Rules for Expressing Relationships Among Entities and Their Corresponding Data Structures**

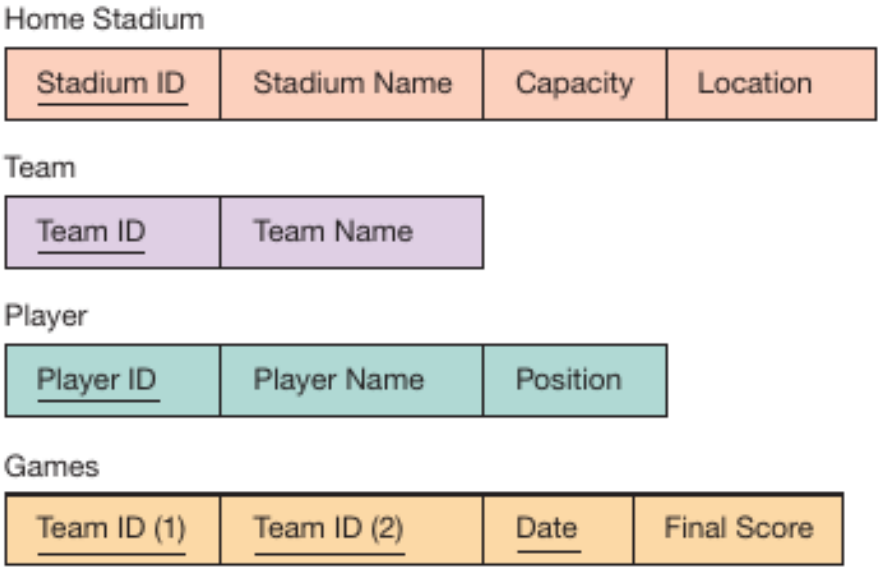
Relationship	Example	Instructions
One-to-one	Each team has only one home stadium, and each home stadium has only one team.	Place the primary key from one table (e.g., Stadium) into the other (e.g., Team) as a foreign key.
One-to-many	Each player is on only one team, but each team has many players.	Place the primary key from the table on the "one" side of the relationship (e.g., Team) as a foreign key in the table on the "many" side of the relationship (e.g., Player).
Many-to-many	Each player participates in many games, and each game has many players.	Create a third table (e.g., Player Statistics) and place the primary keys from each of the original tables (e.g., Player and Team) together in the third as a combination primary key.

Databases

- Can we identify relationship here?

FIGURE TB32

Tables used for storing information about several basketball teams, with no foreign key attributes added; thus, associations cannot be made.



Databases

- Use of foreign keys for associations

FIGURE TB33

Tables used for storing information about several basketball teams, with foreign key attributes added in order to make associations.

A. One-to-one relationship: Each team has only one home stadium, and each home stadium has only one team.

Team

Team ID	Team Name	*Stadium ID*

B. One-to-many relationship: Each player is on only one team, but each team has many players.

Player

Player ID	Player Name	Position	*Team ID*

C. Many-to-many relationship: Each player participates in many games, and each game has many players.

Player Statistics

Team 1	*Team 2*	*Date*	*Player ID*	Points	Minutes	Fouls

Databases

- Entity relationship diagrams

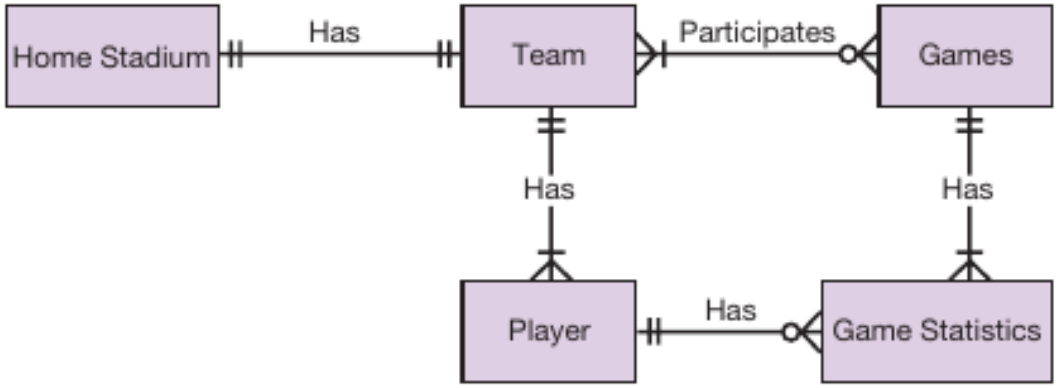


FIGURE TB34

An entity-relationship diagram showing the relationships between entities in a basketball league database.

Databases

- Representing relations

FIGURE TB35

With the relational model, we represent these two entities, department and instructor, as two separate tables and capture the relationship between them with a common column in each table.

Department Records

Dept No	Dept Name	Location	Dean
Dept A			
Dept B			
Dept C			

Instructor Records

Instructor No	Inst Name	Title	Salary	Dept No
Inst 1				
Inst 2				
Inst 3				
Inst 4				

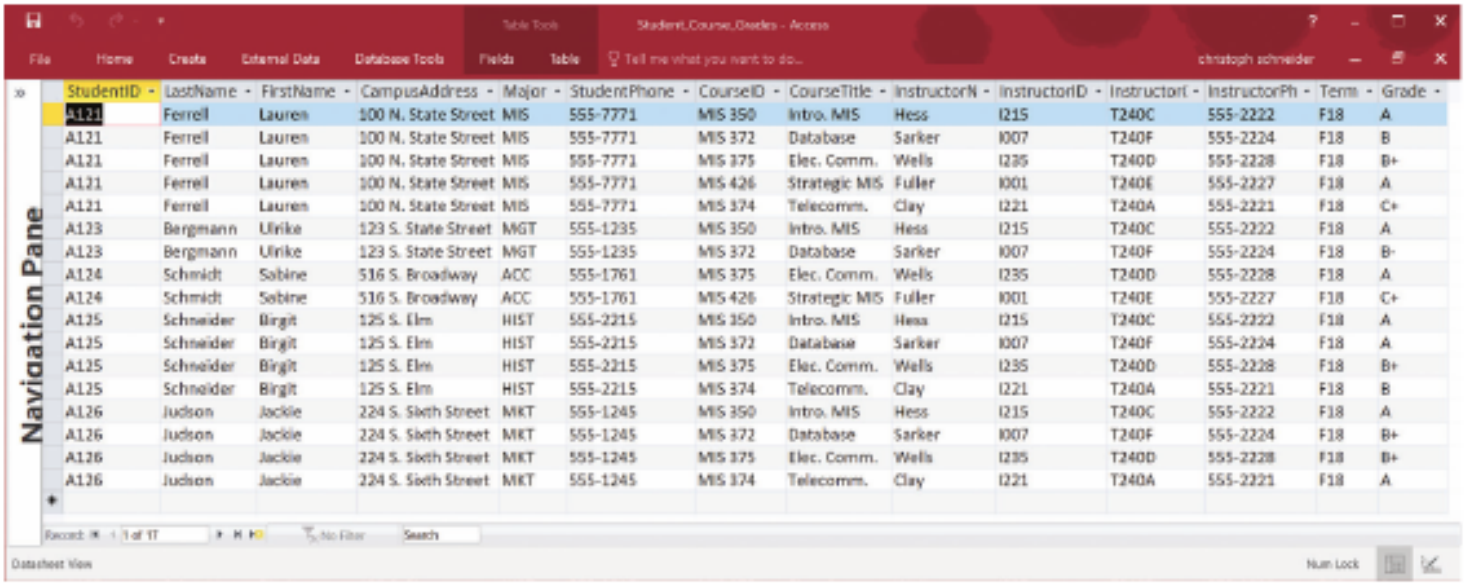
Databases

- Normalization, removing redundancy

FIGURE TB36

Database of students, courses, instructors, and grades with redundant data.

Source: Access 2016, Windows 10, Microsoft Corporation.



StudentID	LastName	FirstName	CampusAddress	Major	StudentPhone	CourseID	CourseTitle	InstructorN	InstructorID	InstructorI	InstructorPh	Term	Grade
A121	Ferrell	Lauren	100 N. State Street	MIS	555-7771	MIS 350	Intro. MIS	Hess	I215	T240C	555-2222	F18	A
A121	Ferrell	Lauren	100 N. State Street	MIS	555-7771	MIS 372	Database	Sarker	I007	T240F	555-2224	F18	B
A121	Ferrell	Lauren	100 N. State Street	MIS	555-7771	MIS 375	Elec. Comm.	Wells	I235	T240D	555-2228	F18	B+
A121	Ferrell	Lauren	100 N. State Street	MIS	555-7771	MIS 426	Strategic MIS	Fuller	I001	T240E	555-2227	F18	A
A121	Ferrell	Lauren	100 N. State Street	MIS	555-7771	MIS 374	Telecomm.	Clay	I221	T240A	555-2221	F18	C+
A123	Bergmann	Ulrike	123 S. State Street	MGT	555-1235	MIS 350	Intro. MIS	Hess	I215	T240C	555-2222	F18	A
A123	Bergmann	Ulrike	123 S. State Street	MGT	555-1235	MIS 372	Database	Sarker	I007	T240F	555-2224	F18	B-
A124	Schmidt	Sabine	516 S. Broadway	ACC	555-1761	MIS 375	Elec. Comm.	Wells	I235	T240D	555-2228	F18	A
A124	Schmidt	Sabine	516 S. Broadway	ACC	555-1761	MIS 426	Strategic MIS	Fuller	I001	T240E	555-2227	F18	C+
A125	Schneider	Birgit	125 S. Elm	HIST	555-2215	MIS 350	Intro. MIS	Hess	I215	T240C	555-2222	F18	A
A125	Schneider	Birgit	125 S. Elm	HIST	555-2215	MIS 372	Database	Sarker	I007	T240F	555-2224	F18	A
A125	Schneider	Birgit	125 S. Elm	HIST	555-2215	MIS 375	Elec. Comm.	Wells	I235	T240D	555-2228	F18	B+
A125	Schneider	Birgit	125 S. Elm	HIST	555-2215	MIS 374	Telecomm.	Clay	I221	T240A	555-2221	F18	B
A126	Judson	Jackie	224 S. Sixth Street	MKT	555-1245	MIS 350	Intro. MIS	Hess	I215	T240C	555-2222	F18	A
A126	Judson	Jackie	224 S. Sixth Street	MKT	555-1245	MIS 372	Database	Sarker	I007	T240F	555-2224	F18	B+
A126	Judson	Jackie	224 S. Sixth Street	MKT	555-1245	MIS 375	Elec. Comm.	Wells	I235	T240D	555-2228	F18	B+
A126	Judson	Jackie	224 S. Sixth Street	MKT	555-1245	MIS 374	Telecomm.	Clay	I221	T240A	555-2221	F18	A

Databases

- Normalization, removing redundancy

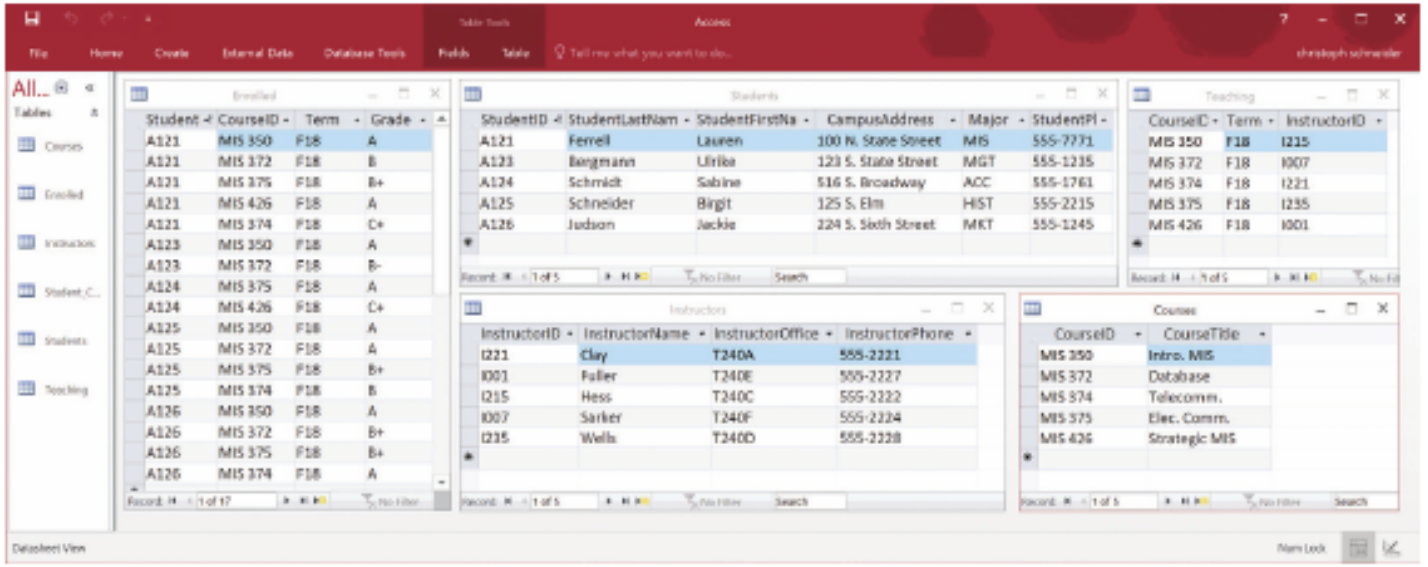


FIGURE TB37

Organization of information on students, courses, instructors, and grades after normalization.

Source: Access 2016, Windows 10, Microsoft Corporation.

Databases

- Advanced database models
  - Relational databases very **good** for **highly structured** data
  - Unstructured data not suitable for relational models
  - **Unstructured** data **heavy on text**, media, etc.
  - Use of **NoSQL** databases

Databases

- NoSQL databases
  - NoSQL suitable for **Big Data** systems
  - Example of NoSQL database system is **Hadoop**
  - Use of **computer clusters** for Hadoop installations
  - Other **NoSQL database systems** are:
    - Cassandra
    - Hypertable
    - DynamoDB
    - IBM Informix
  - **NoSQL** is used in **Web 2.0** and in most **social media** platforms.

Key Points

- IS hardware concepts
- IS software concepts
- Networks and Internet
- Databases

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