Chapter 5

IT Infrastructure and Emerging Technologies

Learning Objectives

5.1 Discuss IT infrastructure and its evolution.

5.2 Describe the components of IT infrastructure.

5.3 Discuss the mobile platform, apps, and BYOD.

5.4 Discuss quantum computing and green computing.

5.5 Discuss virtualization and cloud computing.

5.6 Describe contemporary software platforms.

5.7 Discuss alternative way of obtaining software.

5.8 Describe IT infrastructure for AI.

5.9 Discuss IT infrastructure management challenges.

5.8 Understand how the information in this chapter can help your career.

Video Cases

Case 1: Rockwell Automation Fuels the Oil and Gas Industry with the Internet of Things (IoT)

https://www.youtube.com/watch?v=eg8URrKkf7Y

Case 2: ESPN.com: The Future of Sports Broadcasting in the Cloud
https://www.youtube.com/watch?v=zv7q1Wx_QHw

Case 3: Netflix: Building a Business in the Cloud
https://www.youtube.com/watch?v=XrWII4ewrXA

Southeast Asia's Grab Leverages Information Technology to Enhance Its Services

- Problem
- Solutions
  - scalable services, GrabMaps
- Illustrates use of cloud computing to improve effectiveness and control costs.

5.1 Discuss IT infrastructure and its evolution?

Defining IT Infrastructure

$5.06 trillion industry in 2024

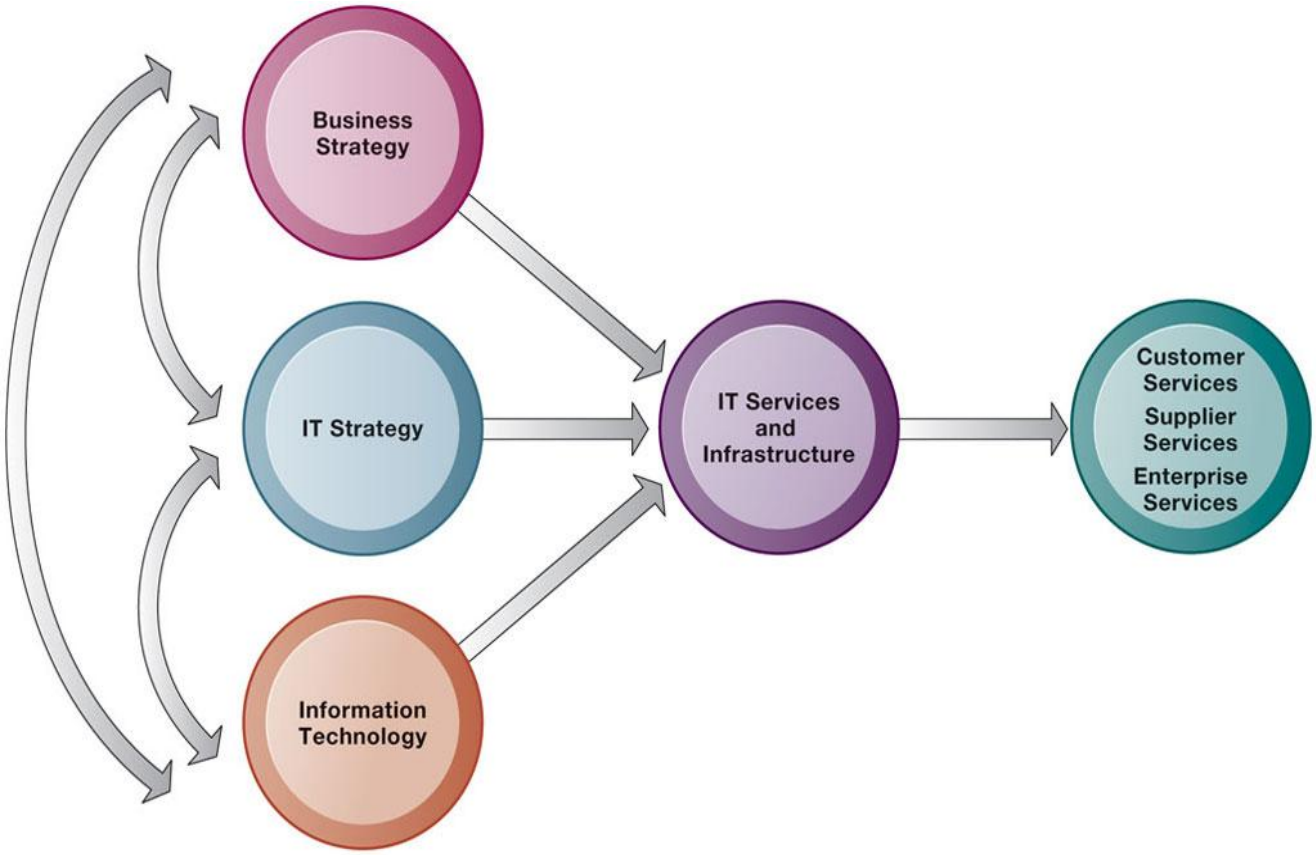
- Investments in infrastructure account for 25-50% of IT expenditures in large firms.

- **IT infrastructure:**
  - **Set of physical devices and software applications required to operate the entire enterprise**
  - **Set of firmwide services including:**
    - Computing platforms providing computing services
    - Telecommunications services
    - Data management services
    - Application software services: providing ERP, CRM, SCM, KMS
    - Physical facilities management services
    - IT management, standards, education, R&D, and other services
  - **"Service platform" perspective**
    - A more accurate view of (business) value of investments

It refers to analyzing the actual services enabled by new technology tools. For example, a new PC might save an employee one hour per day in wait time for information, dramatically increasing his/her value to the firm.

Figure 5.1 Connection Between the Firm, IT Infrastructure, and Business Capabilities

The point of this slide is to illustrate the centrality of IT infrastructure and services to the achievement of firm success. Ultimately, what the firm delivers to customers, its quality, is a direct function of the power of its infrastructure. e.g.) Amazon is routinely cited as the most popular online shopping site and receives high praise from customers for the quality of its service and speed of execution. There is a reason for this: Amazon has one of the world's largest computing infrastructures numbering several hundred thousand processors to provide these services.

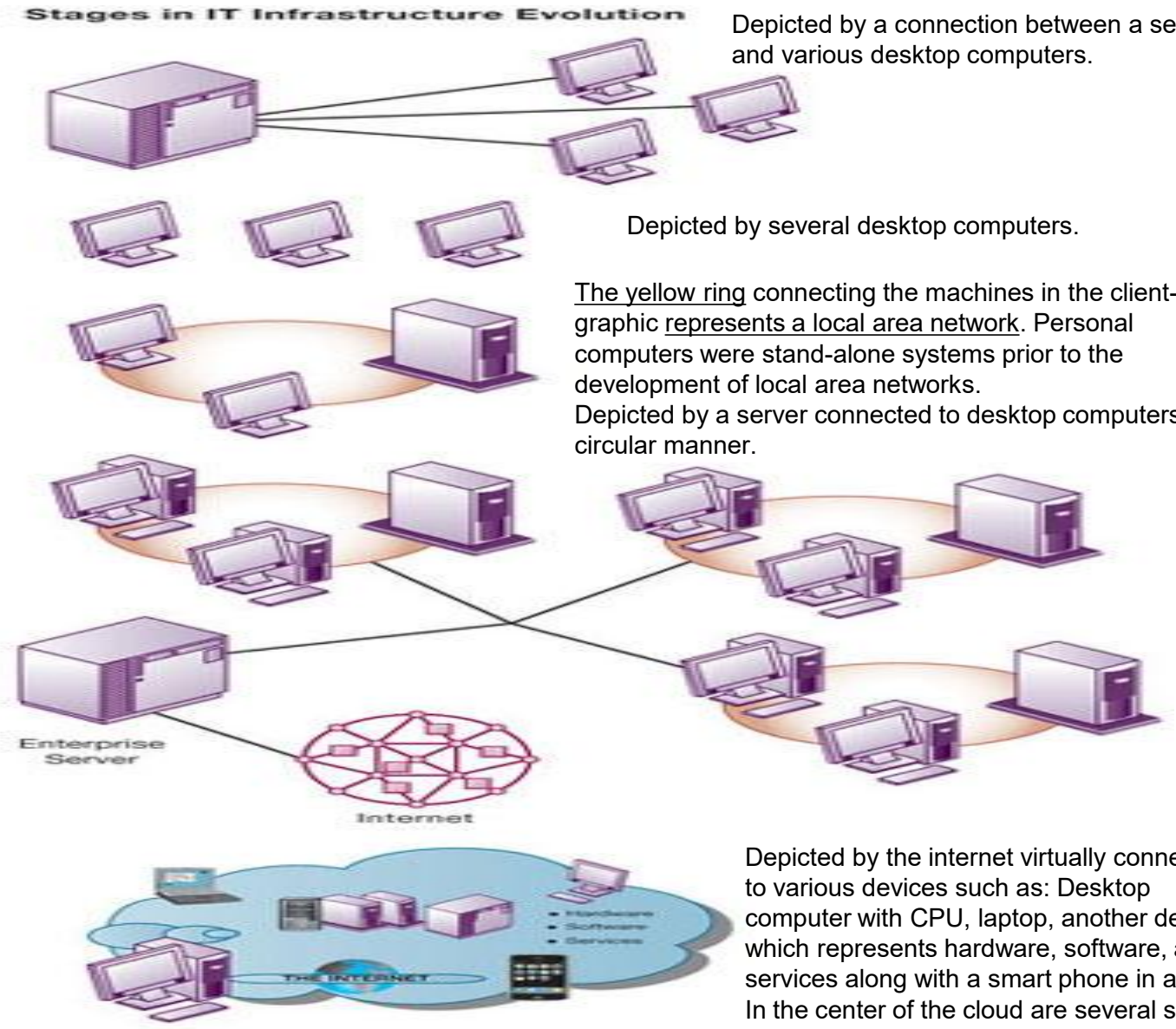


The services a firm is capable of providing to its customers, suppliers, and employees are a direct function of its IT infrastructure. Ideally, this infrastructure should support the firm's business and information systems strategy. New information technologies have a powerful impact on business and IT strategies, as well as the services that can be provided to customers.

Evolution of IT Infrastructure

- Mainframe and minicomputer era: 1959 to present
- Personal computer era: 1981 to present
- Client/server era: 1983 to present
- Enterprise computing era: 1992 to present
- Cloud and mobile computing: 2000 to present

Figure 5.2 Stages in IT Infrastructure Evolution



Depicted by a connection between a server and various desktop computers.

Depicted by several desktop computers.

The yellow ring connecting the machines in the client-server graphic represents a local area network. Personal computers were stand-alone systems prior to the development of local area networks.
Depicted by a server connected to desktop computers in a circular manner.

Depicted by network of various servers connected to several desktop computers with CPU in a circular manner to one enterprise server. The enterprise server is connected to the internet.

Depicted by the internet virtually connected to various devices such as: Desktop computer with CPU, laptop, another desktop which represents hardware, software, and services along with a smart phone in a cloud. In the center of the cloud are several servers, including the enterprise server.

IT Infrastructure

The concept of mainframe computers: Think the difference in size (much larger) and computing capacity (much smaller) from today's computers to get a sense of perspective regarding how far the computing industry has gone in 70 years. However, modern-day mainframes (IBM z-Series), are extremely powerful servers used for large Fortune 1000 enterprise networks and corporate Web sites. The mainframe is not dead, in other words and still represents a large revenue stream for IBM.

- **Evolution of IT infrastructure**

  *** effects**

  - **General-purpose mainframe and minicomputer era: 1959 to present**
    - 1958: IBM first mainframes introduced
    - 1965: Less expensive DEC minicomputers introduced * IBM 360 series
  - **Personal computer era: 1981 to present**
    - 1981: Introduction of IBM PC * Wintel PC
    - Proliferation in 80s, 90s resulted in growth of personal software
  - **Client/server era: 1983 to present**
    - Desktop clients networked to servers, with processing work split between clients and servers
    - Network may be two-tiered or multitiered (N-tiered)
    - Various types of servers (network, application, Web)

- **Evolution of IT infrastructure (cont.)**
  - **Enterprise computing era: 1992 to present**
    - Move toward integrating disparate networks, applications using Internet standards and enterprise applications

TCP/IP

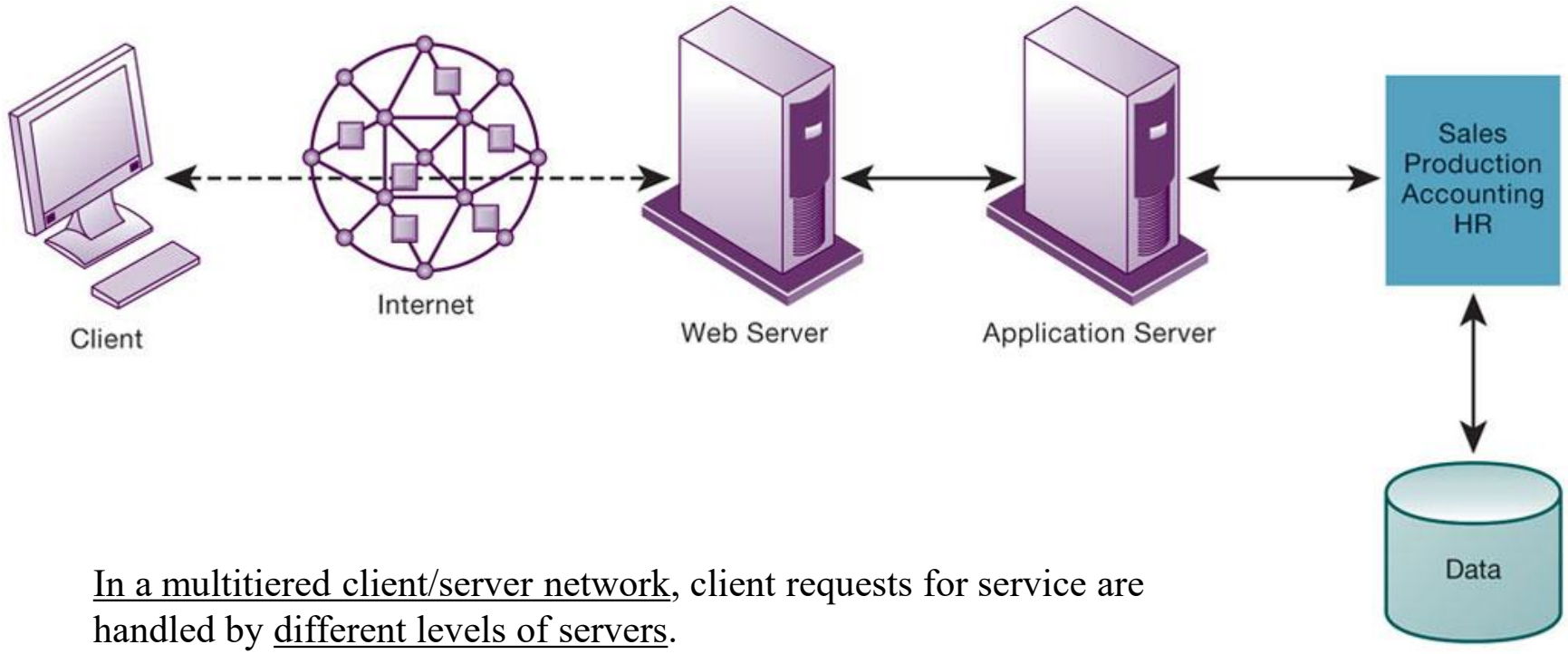
-> information can flow freely across the org. and between the firm and other org.

  - **Cloud and mobile computing: 2000 to present**
    - Cloud computing: computing power and software applications supplied over the Internet or other network
      - Fastest growing form of computing

Driver: the growing bandwidth power of the Internet

- Examples of the use of cloud computing are Google Apps, Google's suite of software applications that rivals Microsoft's Office applications at a fraction of the cost, and Salesforce.com's CRM management software, delivered over the Internet. Most large Fortune 500 firms have some applications that run in the cloud.
- Most of these same corporations do not put their strategic or critical systems on the cloud just yet because of lingering concerns about reliability and security.

Figure 5.3 A Multitiered (N-Tier) Client/Server Network



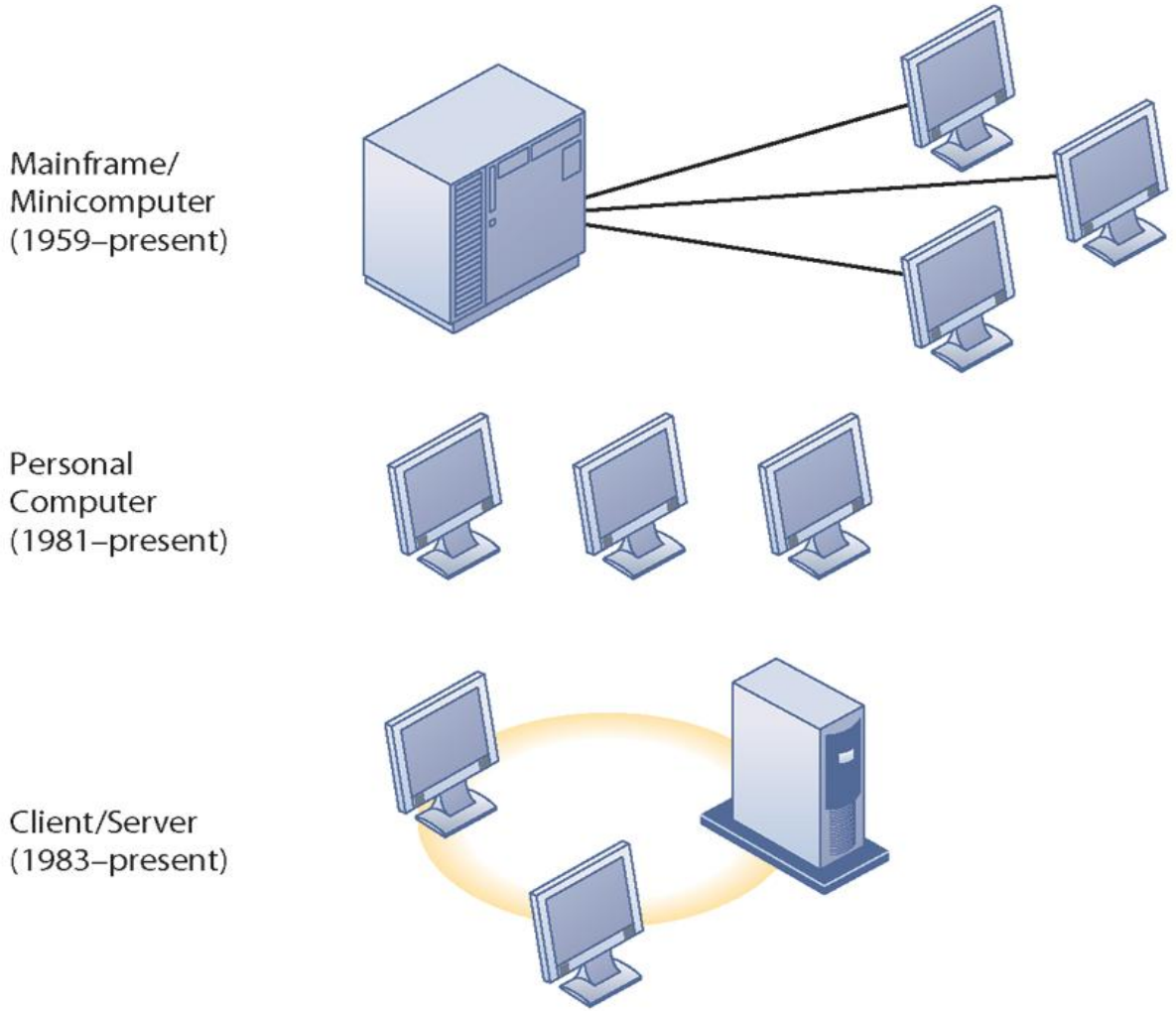
In a multitiered client/server network, client requests for service are handled by different levels of servers.

- The distribution of computing power across smaller, less expensive machines enabled by client/server computing is in part responsible for the drastic increase in computing power and applications throughout the firm.
- Prior to small, less expensive server computers, computing power had to purchased in large blocks at great expense. With client/server computing, you can grow your firm's inventory of computers gradually, over time, to meet current demand.

STAGES IN IT INFRASTRUCTURE EVOLUTION

Illustrated here are the typical computing configurations characterizing each of the five eras of IT infrastructure evolution.

FIGURE 5-2

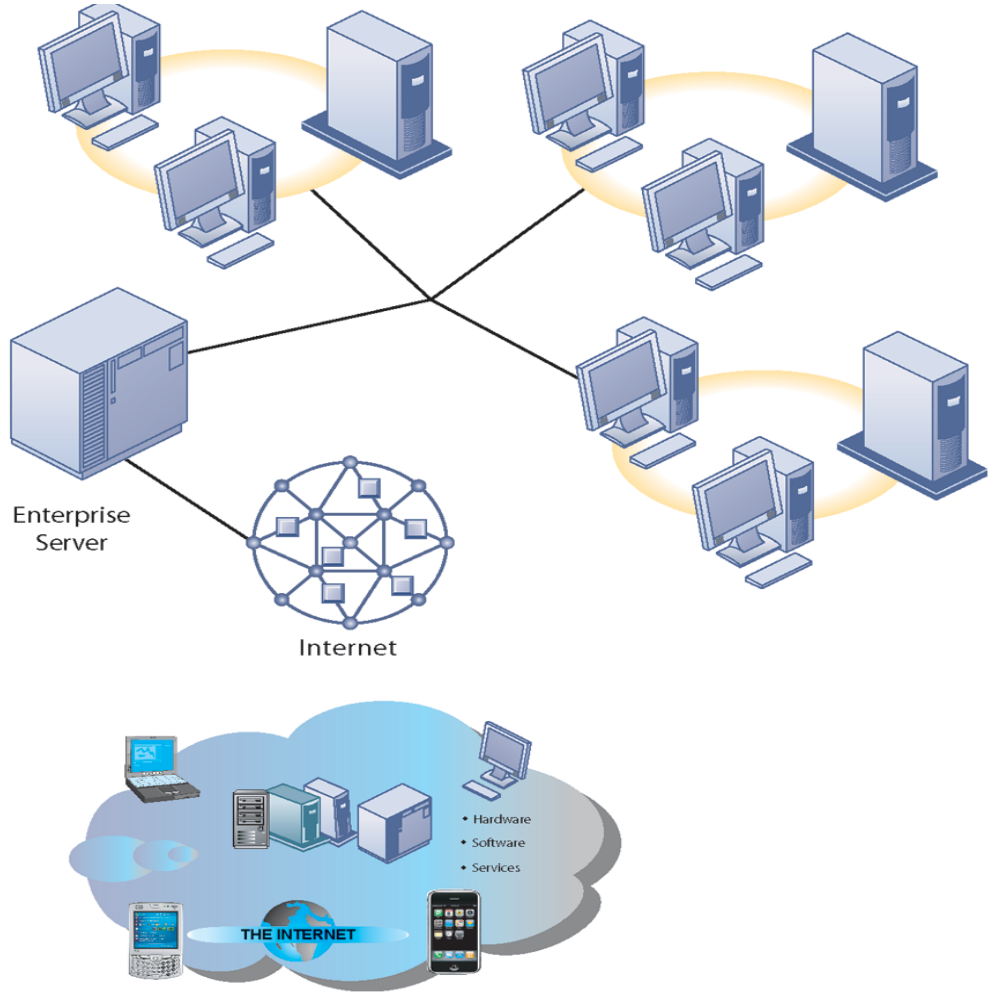


* The yellow ring connecting the machines in the client-server graphic represents a local area network (LAN). Personal computers were stand-alone systems prior to the development of local area networks (LANs).

STAGES IN IT INFRASTRUCTURE EVOLUTION (cont.)

FIGURE 5-2

The enterprise Internet graphic represents several individual networks linked together into an enterprise-wide network. The cloud computing graph represents several types of technology that are capable of connecting to the Internet and accessing applications and services through a cloud.



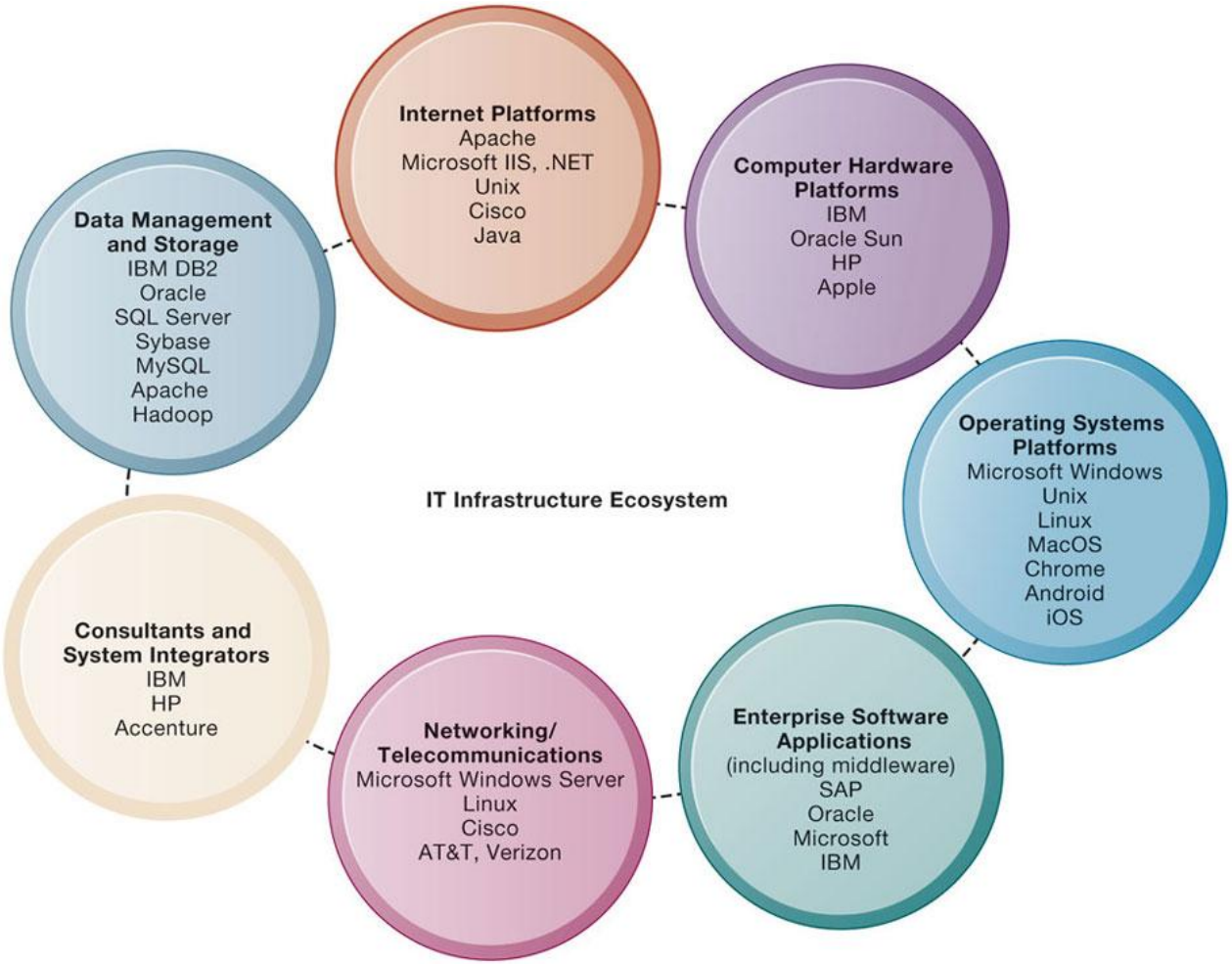
5.2 Describe the Components of IT Infrastructure?

seven main components

1. Computer hardware platforms
2. Operating system platforms
3. Enterprise software applications
4. Data management and storage
5. Networking/telecommunications platforms
6. Internet platforms
7. Consulting system integration services

Figure 5.4 IT Infrastructure Components

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.



Take a look at the example companies that appear under each heading. What companies appear repeatedly? How many items are unfamiliar?

Computer Hardware Platforms

- Client machines
  - Desktop PCs, laptops
  - Mobile computing: smartphones, tablets (worldwide, over 7 billion people use smartphones)
  - Desktop chips vs. mobile chips NVIDIA
- Mainframes
  - IBM mainframe (equivalent to thousands of blade servers)
  - Digital workhorse for banking and telecommunications networks
  - Mainframes have not disappeared

To think the size of the market for computer hardware and devices, in 2020, firms worldwide will spend around $688 billion on computer hardware, from mainframes to tablets and smartphones.

Operating System Platforms

- The system S/W that manages and controls the activities of a computer-> over 68% of desktop and tablets use some form of the Microsoft Windows OS Chrome OS, Android, iOS (features a multitouch interface)
- Corporate servers
  - Microsoft Windows Server
  - Unix
  - Linux: 90% of the world's cloud computing infra. runs on Linux
- Client level
  - Microsoft Windows
  - Android, iOS, Windows 10 (mobile/multitouch)
  - Google's Chrome OS (cloud computing)

Enterprise Software Applications

- In 2020, firms are expected to spend over $500 billion on software for enterprise applications
- Largest providers: SAP and Oracle
- Middleware providers: IBM, Oracle

- These applications are considered to be part of IT infrastructure. Traditionally, large firms were the most prominent users of enterprise software, but firms such as Microsoft have moved into the market of small- and medium-size businesses that can benefit from enterprise software.

Data Management and Storage

- Database software providers
  - IBM (Db2)
  - Oracle
  - Microsoft (SQL Server)
  - SAP (HANA)
  - My SQL
  - Apache Hadoop: is an open source S/W framework for managing very large data sets

The amount of new information in the world is doubling every three years, driving the need for more efficient data management and storage.

Networking/Telecommunications Platforms

- Network operating system software (NOS software)
  - Windows Server, Linux, Unix
- Network equipment providers
  - Huawei, Nokia, Ericsson, Cisco Systems
- Telecommunication services
  - Telecommunications/telephone services companies that offer voice and data connectivity, WAN, wireless services and Internet access
  - AT&T, Verizon

Companies worldwide are expected to spend $1.5 trillion for telecommunications services in 2020.

Internet Platforms

- Hardware, software, and services to support company websites, intranets
  - Web-hosting services: maintain websites for fee-paying clients
  - Routers
  - Cabling or wireless equipment
- Internet hardware server market (has become concentrated in the hands of)
  - Dell, Cisco, HPE, IBM, and Oracle
- Web and app SW application development tools/suites
  - Microsoft (Visual Studio and Microsoft .NET development platform), Oracle, and a host of independent software developers

Consulting and System Integration Services

- Even large firms do not have resources for full range of support for new, complex infrastructure
- Leading consulting firms: Accenture, IBM Global Services, HPE, Infosys, and Wipro
- Software integration: ensuring new infrastructure works with older legacy systems and ensuring the new elements of the infra work with one another
- Legacy systems: an older system (TPS created for mainframes) that continues to be used to avoid the high cost of replacing or redesigning it
- Another big change: companies are moving more of their IT infrastructure to the cloud or to outside services

5.3 Discuss the Mobile Platform, Apps, and BYOD

- The mobile platform
  - Smartphones (iPhone, Android): Data transmission, Web surfing, e-mail, and IM
  - Netbooks: Small lightweight subnotebooks optimized for wireless communication and core tasks
  - Tablet computers
  - Digital e-book readers and apps (Kindle)
  - Wearable computing devices include smartwatches, smart glasses, smart badges, activity trackers

Apps-> switching costs high

- **Consumerization of IT and BYOD** (bring your own device)
  - Forces businesses and IT departments to rethink how IT equipment and services are acquired and managed

Business computing is increasingly moving from PCs and desktops to mobile devices, and managers are increasingly using these to coordinate work and communicate with employees and customers.

In the past, IT departments in large firms dictated to their employees what kinds of devices they could use, both on site and off site while traveling. Increasingly, employees are telling the IT department what tools they want to use and demanding that IT support these tools.

- **BYOD (Bring your own device)**
  - **Allowing employees to use personal mobile devices in the workplace** * BYOD is one aspect of the consumerization of IT. -> IT departments risk losing control over the h/w-> More vulneabilities
- **Consumerization of IT**
  - **New information technology originating <u>in the consumer markets first</u> and spreads to <u>business</u> organizations**
  - Forces businesses and IT departments to rethink how IT equipment and services are acquired and managed

- It Includes mobile personal devices + business uses of software services that originated in the consumer marketplace as well, such as Google Search, Gmail, Google Maps, Dropbox, Facebook and TikTok

5.4 Discuss Quantum Computing and Green Computing

Quantum computing is still experimental but has the potential to revolutionize computing speeds and power. **Virtualization** allows organizations to optimize their use of resources in new ways and to take advantage of spare computing power by allowing a single resource to act as multiple resources.

- Quantum computing
  - Uses quantum physics to represent and operate on data
  - Dramatic increases in computing speed/power
  - Leading company: IBM, Microsoft Azure, Google (Cirq)
  - Benefits and Limitations
- Green computing (Green IT)
  - Practices and technologies for designing, manufacturing, using, disposing of computers and other IT equipment to minimize impact on the environment
  - Reducing computing power consumption-> a high priority
  - Green data center-> 1.5% energy use in the world
  - **E-wate** (electronic waste) consists of all types of end-discarded electronic equipment

5.5 Discuss Virtualization and Cloud Computing

- **Virtualization**

  * **VMware:** leading vendor

  - A method of presenting a set of computing resources so that they can be accessed in ways that are not restricted by physical configuration or geographic location
  - Allows single physical resource to act as multiple logical resources (i.e., run multiple instances of OS); also enables multiple physical resources (such as storage devices) to appear as a single logical resource (such as in software-defined storage (SDS))
  - Reduces hardware and power expenditures * server vir.
  - Facilitates centralization and consolidation of h/w administration
  - **Software-defined storage** (SDS): storage architecture that separates the s/w for managing data storage from the physical storage h/w

    -> It enables firms to replace expensive storage h/w with lower-cost commodity h/w and cloud storage h/w

(15-20%-> virtualization boost to 70% server utilization rates)

5.5 Discuss Virtualization and Cloud Computing

Cloud computing allows organizations to avoid the expenses of maintaining their own hardware and software, relying on the cloud instead. Virtualization plays a critical role in cloud computing.

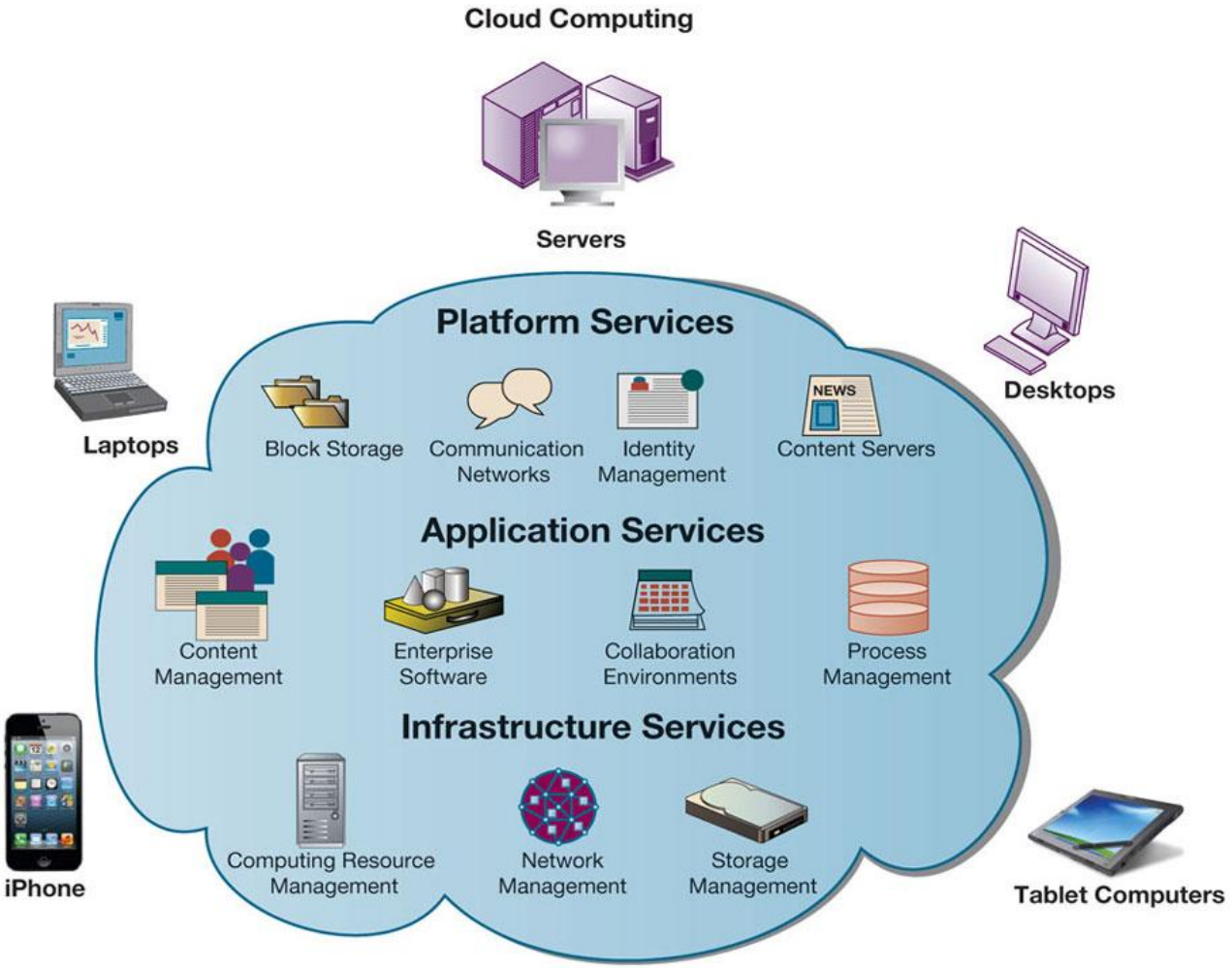
- As-needed basis
- **Essential characteristics (p.189)**

- **Cloud computing**
  - **On-demand (utility) computing services obtained over a network** On-demand or utility computing describes a payment structure in which use is dependent upon actual time or power used.
    - Infrastructure as a service (IaaS) to run users' IS
    - Platform as a service (PaaS) to develop users' own applications
    - Software as a service (SaaS) e.g. Google Workspace, salesfoce.com
  - **Cloud can be public or private** **<- p.191**
  - **Allows companies to minimize IT investments**
  - **Drawbacks: Concerns of security, reliability**
  - **Hybrid cloud computing model**

- Large firms are most likely to adopt it where they use their own infrastructure for their most essential core activities and adopt public cloud computing for less-critical systems or for additional processing capacity during peak business periods.

Figure 5.5 Cloud Computing Platform

In cloud computing, hardware and software capabilities are a pool of virtualized resources provided over a network, often the Internet. Businesses and employees have access to applications and IT infrastructure anywhere, at any time, and on any device.



- **Industry cloud platform**: a model in which specialized cloud services are provided to meet the specific requirements of a particular industry such as healthcare, finance. Aka. known as a **vertical cloud platform**

- Cloud AI Services: AWS, M/S Azure, GCP, Salesforce

Figure 5.6 Amazon Web Services

- Amazon Web Services (AWS) is a collection of web services that Amazon provides to users of its cloud platform.
- AWS is the largest provider of cloud computing services In the United States.



5.5 Discuss Virtualization and Cloud Computing

- **Edge computing**
  - A method of optimizing cloud computing systems by performing some data processing on a set of linked servers at the edge of the n/w, near the source of the data.
  - Servers at the edge of the Internet
  - Reducing latency, and network traffic

- Edge computing is needed to provide efficient service to consumers located across the country.
- It works by reducing the distance between local computers and web resources and sharing the total load across many regional computing facilities.
- It also reduces delay in transmitting and processing large quantities of data needed for AI applications.

5.6 Describe Contemporary Software Platforms?

* 3 major themes in contemporary software platform evolution

- **Open-source software**
  - Produced by community of programmers
  - Free and modifiable by user
  - Examples: Apache HTTP web server, Mozilla Firefox web browser, Apache OpenOffice desktop productivity suite
  - Linux

    Linux plays a major role in the administration of local area networks.

    - Open-source OS used in high-performance computing
    - Used in mobile devices, local area networks, Web servers, Android OS
- **Software for the web: Java, HTML, and HTML5**
  - Java Virtual Machine
  - Web browsers
  - HTMLand HTML5
  - Ruby and Python

5.6 Describe Contemporary Software Platforms?

- Software for the web: Java, HTML, and HTML5
  - **Java:** Java is designed to run on any computing device by use of the Java Virtual Machine. This includes mobile devices such as smartphones.
    - Object-oriented programming language
    - Operating system, processor-independent
  - **HTML/HTML5**
    - Web page description language
    - HTML5 is latest evolution
      - Embeds media, animation directly into a document without processor-intensive add-ons
      - Supports cross-platform apps, offline data storage

    HTML is a markup/formatting tool that creates Web pages that all browsers can interpret and display regardless of the type or manufacture of the computer being used.
  - **Ruby and Python** are popular programming tools for web applications

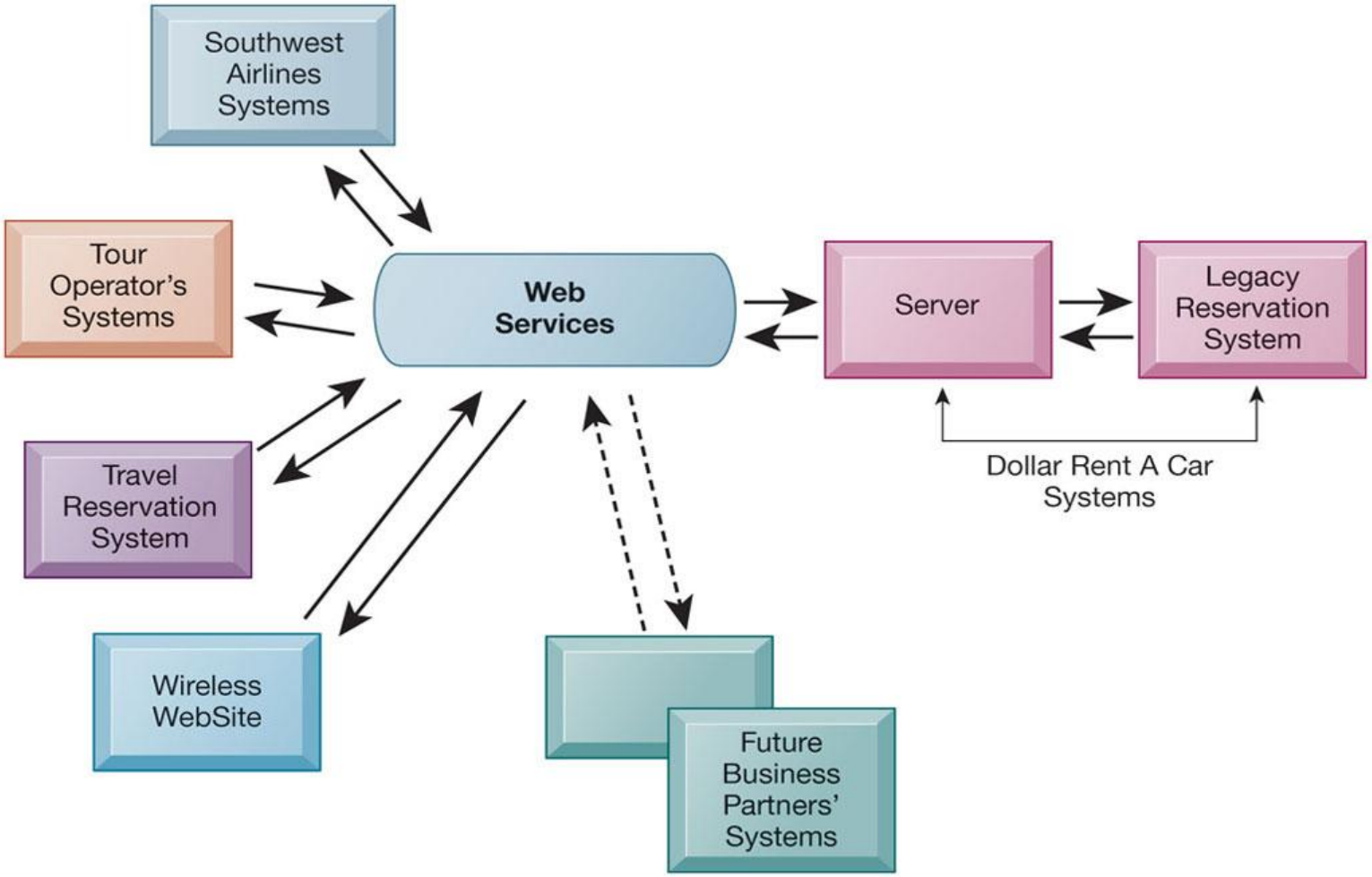
5.6 Describe Contemporary Software Platforms?

- **Web services**
  - Web services: Software components that exchange information using Web standards and languages
  - XML: Extensible Markup Language**<-the foundation technology for Web services**
    - A more powerful and flexible markup language than HTML
    - Tagging allows computers to process data automatically

Firms are collections of thousands of computer programs and systems built over many years. In general, these systems cannot "talk" with one another, and sharing information among them is very expensive. One way to get to work together is to build software links among them. This is the Web services approach. You can compare it to the Web: any computer with a browser can access billions of Web pages and draw down the information or download PDF files that work on all computers that have a version of Adobe acrobat installed. In a business firm, you want a similar environment: any computer program can get data from any other computer program. Web services makes this possible.

Ensure that you are able to explain the difference between XML and HTML (in other words, the additional features XML has compared to HTML). These include classifying, presenting, communicating, and storing data, as opposed to HTML being able to merely present data. These features also allow computers to manipulate documents written in XML automatically. Does this remind you of autonomic computing?

Figure 5.7 How Dollar Rent A Car Uses Web Services



- Dollar Rent A Car uses Web services to provide a standard intermediate layer of software to "talk" to other companies' information systems.
- Dollar Rent A Car can use this set of Web services to link to other companies' information systems without having to build a separate link to each firm's systems.

5.7 Discuss Alternative Ways of Obtaining Software

*** Three external sources for SW**

- Software outsourcing and cloud services
  - Software packages and software services
  - Software outsourcing: Contracting custom s/w development or maintenance to an outside firm * Offshore s/w outsourcing e.g., People.ai
  - Cloud-based software services
    - Software as a service (SaaS) Salesforce.com
    - Accessed with Web browser over Internet
    - Service Level Agreements (SLAs): formal contract between customers and their service providers that defines the specific responsibilities of the service provider and the level of service expected by the customer

- **Software outsourcing and cloud services** (cont.)
  - **Mashups**
    - Combinations of two or more online applications, such as combining mapping software (Google Maps) with local content
  - **Apps**
    - Small pieces of software that run on the Internet, on your computer, or on mobile device
    - Refer commonly to mobile applications
      - iPhone, Android
    - Tie user to platform

- Apps for business users; e-commerce apps

5.8 Describe IT Infrastructure for AI

- **AI and Edge Computing**
  - Edge artificial intelligence (Edge AI): the deployment of AI algorithms and models directly on local edge devices such as smartphones, sensors, or IoT devices
  - AI H/W Components: CPU, GPU, TPU, RAM, Data Storage and Management
  - AI S/W Components: OS, AI Frameworks and Libraries (TensorFlow, PyTorch, Keras), Version control (GitHub platform), Cloud services

5.9 Discuss IT Infrastructure Management Challenges

Dealing with Platform and Infrastructure Change

- **As firms shrink or grow, IT needs to be flexible and scalable**
- **Scalability:** The ability of a computer, product, or system to expand to serve a larger number of users without breaking down
- **For mobile computing and cloud computing**
  - New policies and procedures for managing these new platforms
  - **Mobile device management** (**MDM**): s/w that monitors, manages, and secures mobile devices that are deployed across multiple mobile O/Ss used in the organization
  - Firms using cloud computing and SasS will need to make new contractual agreements with firms running clouds and distributing software required

How can IT be flexible and still make long-term investments in hardware and software? **SaaS** may solve some problems. Envision some of the pitfalls of working with an external hardware or software vendor such as Google or Salesforce.com. What are some nightmare scenarios that companies must guard against? For instance, the vendor fails to make critical applications available when needed, poor customer service, and so on, or the vendor fails to upgrade equipment in order to save investment monies.

Management and Governance

- IT Governance
- Who will control and manage a firm's IT infrastructure?
- How should IT department be organized?
  - Centralized
    - Central IT department makes decisions
  - Decentralized
    - Business unit IT departments make own decisions
- How are costs allocated between divisions, departments?

What are the ramifications of poor IT governance at a firm? For example, if a company does not clearly define what departments have the responsibility to make their own IT decisions, what could be the consequences? Some potential consequences are data mismanagement, poor communication, and slower response times to crises.

Making Wise Infrastructure Investments

- The amount to spend on IT is a complex question
- Under-investment and over-investment can hamper firm performance
- Rent-versus-buy decision
- Cloud computing
  - Security requirements
  - Impact on business processes and workflow
- Outsourcing

What types of companies should opt to rent as opposed to buy software? Possibly, companies with seasonal employees or semi-annual workloads.

Total Cost of Ownership (TCO) Model

- The actual total cost of owning technology resources, including the initial cost of acquiring and installing h/w and s/w, as well as ongoing administration costs for h/w and s/w upgrades, maintenance, technical support, training and even utility and real estate costs for running and housing the technology - TCO is a way of quantifying some of the hidden costs of hardware.
- Used to analyze direct and indirect costs
- Hardware, software account for only about 20% of TCO
- Other costs: Installation, training, support, maintenance, infrastructure, downtime, space, and energy
- **TCO can be reduced**
  - Use of cloud services, greater centralization and standardization of hardware and software resources

Competitive Forces Model for IT Infrastructure Investment

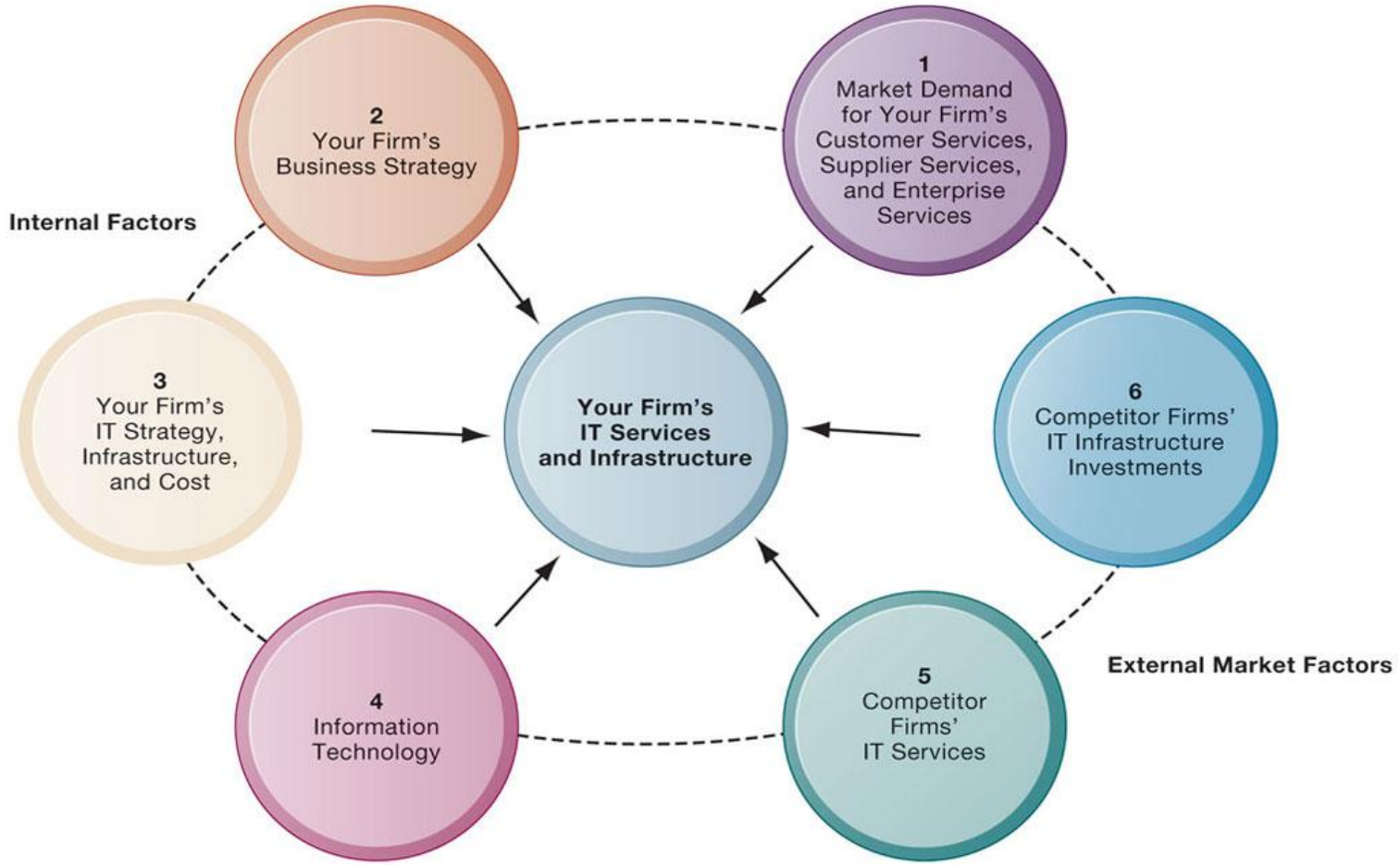
- To address the question of how much your firm should spend on IT infra and how the investment should be spent-> **Six factors to consider**

- Market demand for firm's services
- Firm's business strategy
- Firm's IT strategy, infrastructure, and cost
- Information technology assessment
- Competitor firm services
- Competitor firm IT infrastructure investments

How great of an impact do competitors' services and investments have on a firm's IT services and infrastructure? Is it wise to rely on those factors alone to determine what kind of services your firm provides?
For instance, your competitors may not be the industry's best example of how to develop IT services. In fact, your entire industry might be technological laggards. In this case, it might be better to look at best practices in other industries which have a reputation for superior IT services and capabilities.

Figure 5.8 Competitive Forces Model for IT Infrastructure

- To the left of the radial diagram are the internal forces
- To the right of the radial diagram are the external market forces



- You can also use this diagram as a framework for understanding why some firms fail to develop a workable, powerful IT infrastructure.