Chapter 5

IT Infrastructure and Emerging Technologies

LEARNING OBJECTIVES

- What is IT infrastructure and what are the stages and drivers of IT infrastructure evolution?
- What are the components of IT infrastructure?
- What are the current trends in computer hardware platforms?
- What are the current trends in computer software platforms?
- What are the challenges of managing IT infrastructure and management solutions?

Toyota Motor Europe Makes with the Cloud

- **Problem:** Providing a consistent maintenance service to millions of customers
- **Solution:** Cloud-based computing service that manages onboard computers in Toyota vehicles
- Demonstrates IT's role in reducing costs and improving security and customer service

IT Infrastructure

- **IT infrastructure:**
  - **Set of physical devices and software required to operate enterprise**
  - **Set of firmwide services including:**
    - Computing platforms providing computing services
    - Telecommunications services
    - Data management services
    - Application software services
    - Physical facilities management services
    - IT management, education, and other services
  - **"Service platform" perspective**
    - More accurate view of value of investments

CONNECTION BETWEEN THE FIRM, IT INFRASTRUCTURE, AND BUSINESS CAPABILITIES

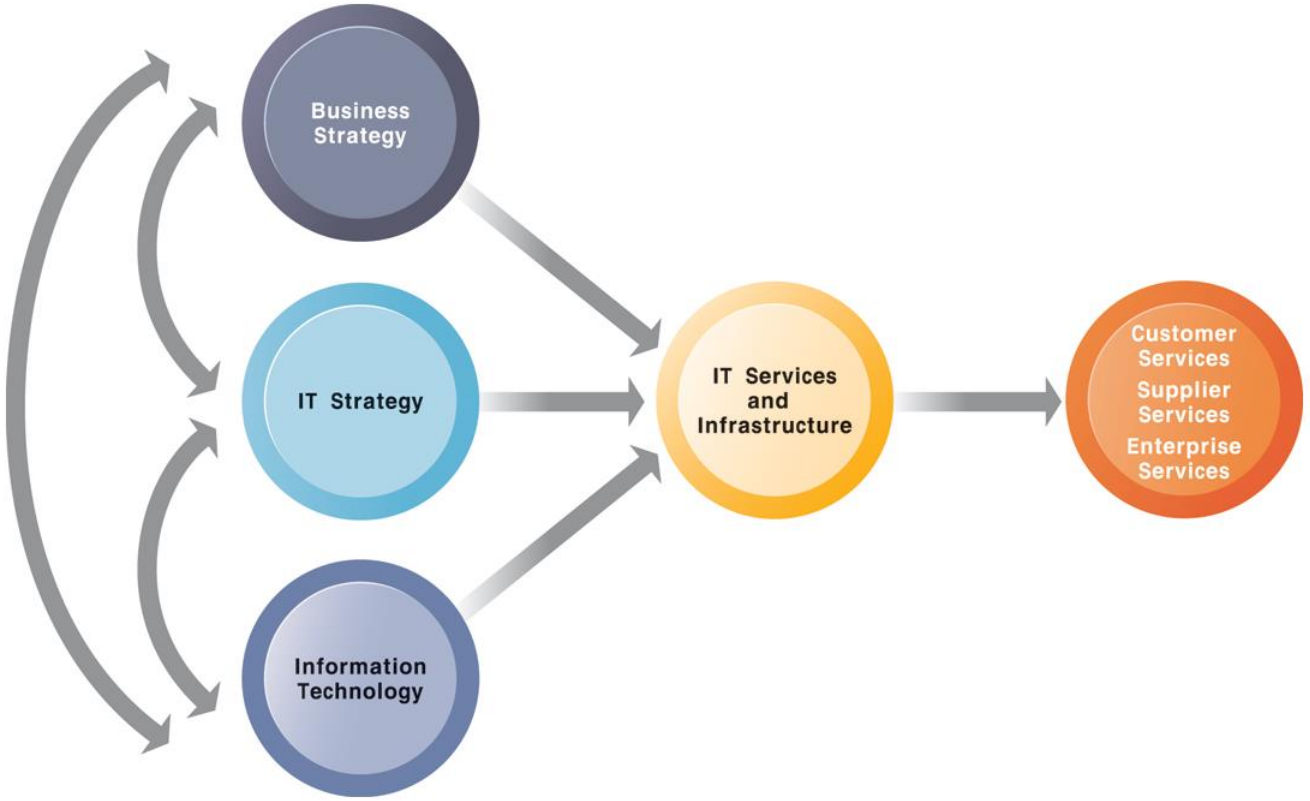


FIGURE 5-1 The services a firm is capable of providing to its customers, suppliers, and employees are a direct function of its IT infrastructure. Ideally, this infrastructure should support the firm's business and information systems strategy. New information technologies have a powerful impact on business and IT strategies, as well as the services that can be provided to customers.

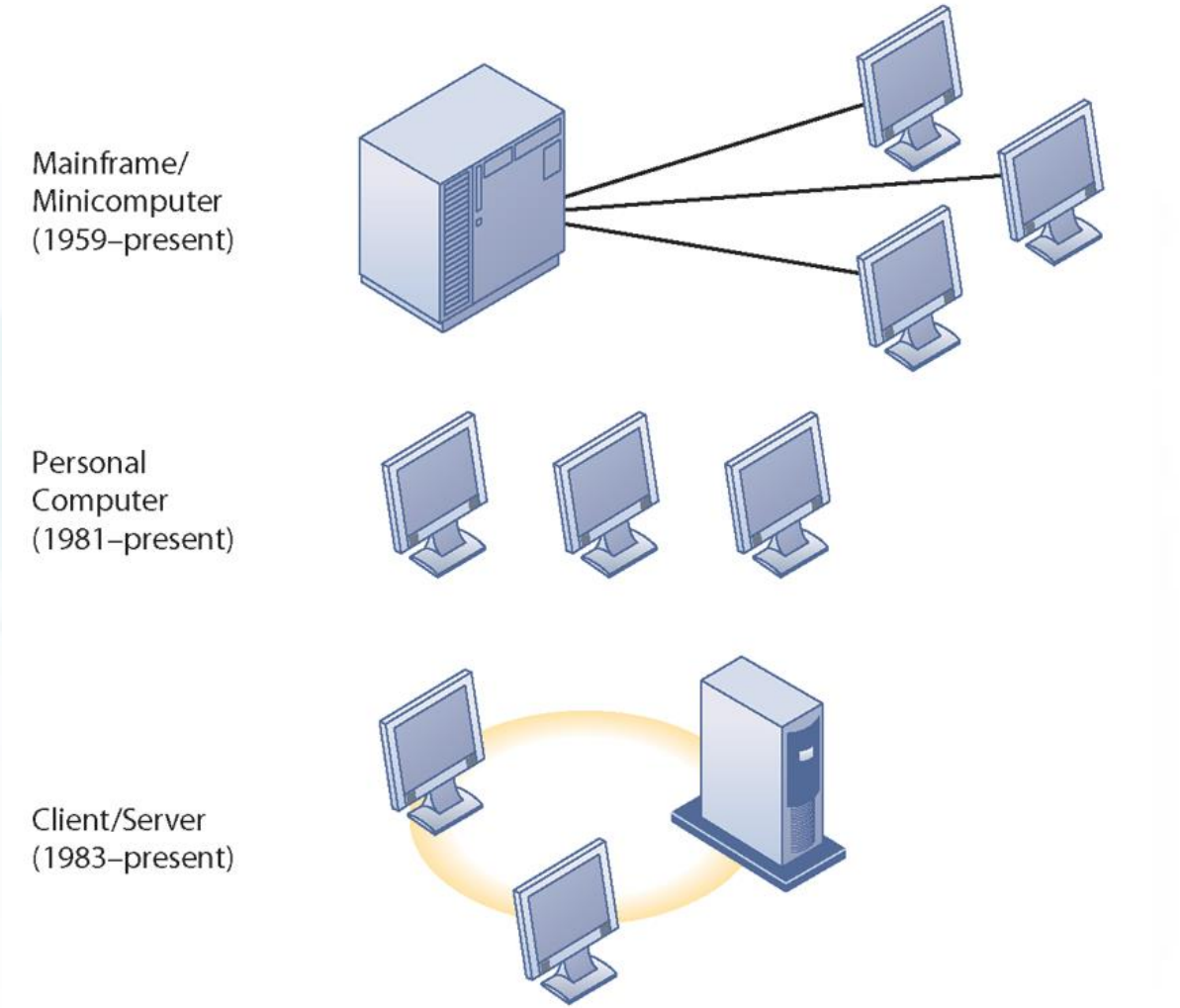
- **Evolution of IT infrastructure**
  - **General-purpose mainframe and minicomputer era: 1959 to present**
    - 1958: IBM first mainframes introduced
    - 1965: Less expensive DEC minicomputers introduced
  - **Personal computer era: 1981 to present**
    - 1981: Introduction of IBM PC
    - Proliferation 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
  - **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

STAGES IN IT INFRASTRUCTURE EVOLUTION

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

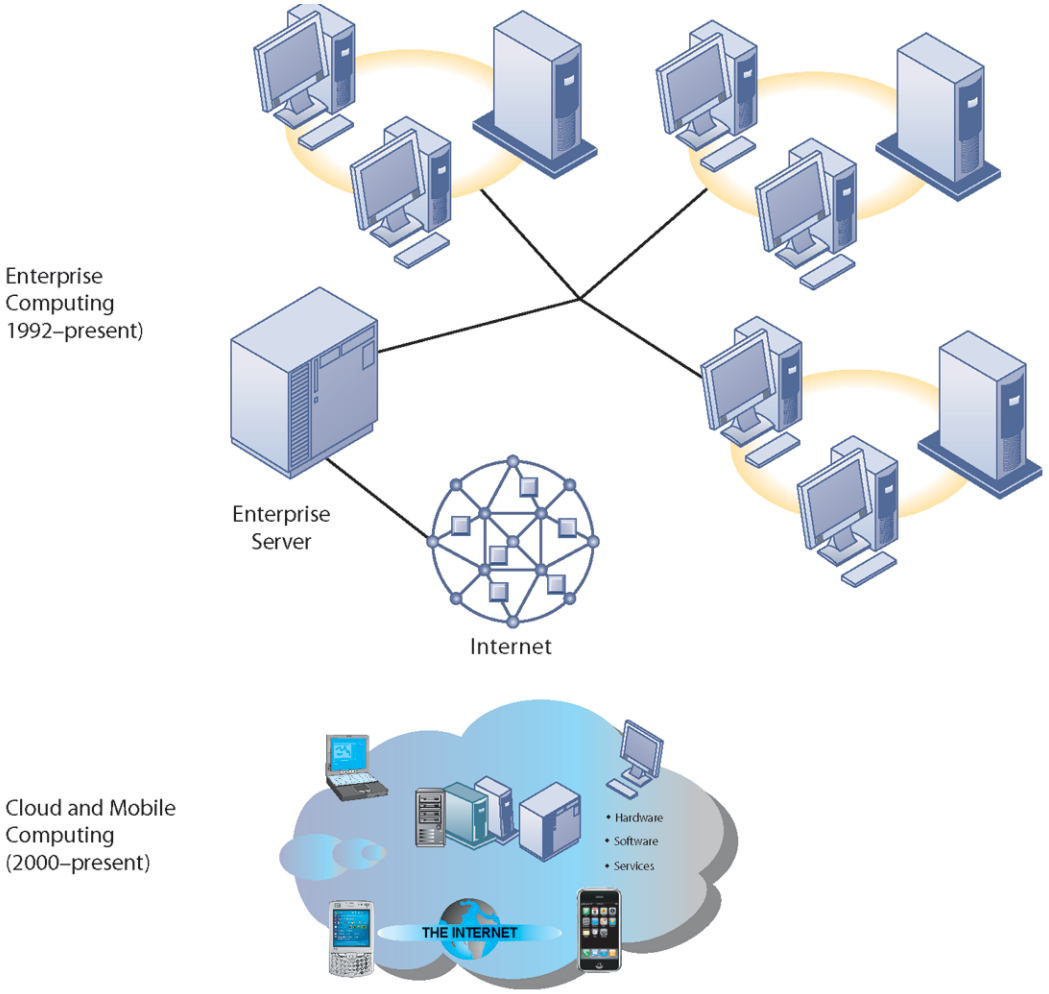
FIGURE 5-2



STAGES IN IT INFRASTRUCTURE EVOLUTION (cont.)

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

FIGURE 5-2



A MULTITIERED CLIENT/SERVER NETWORK (N-TIER)

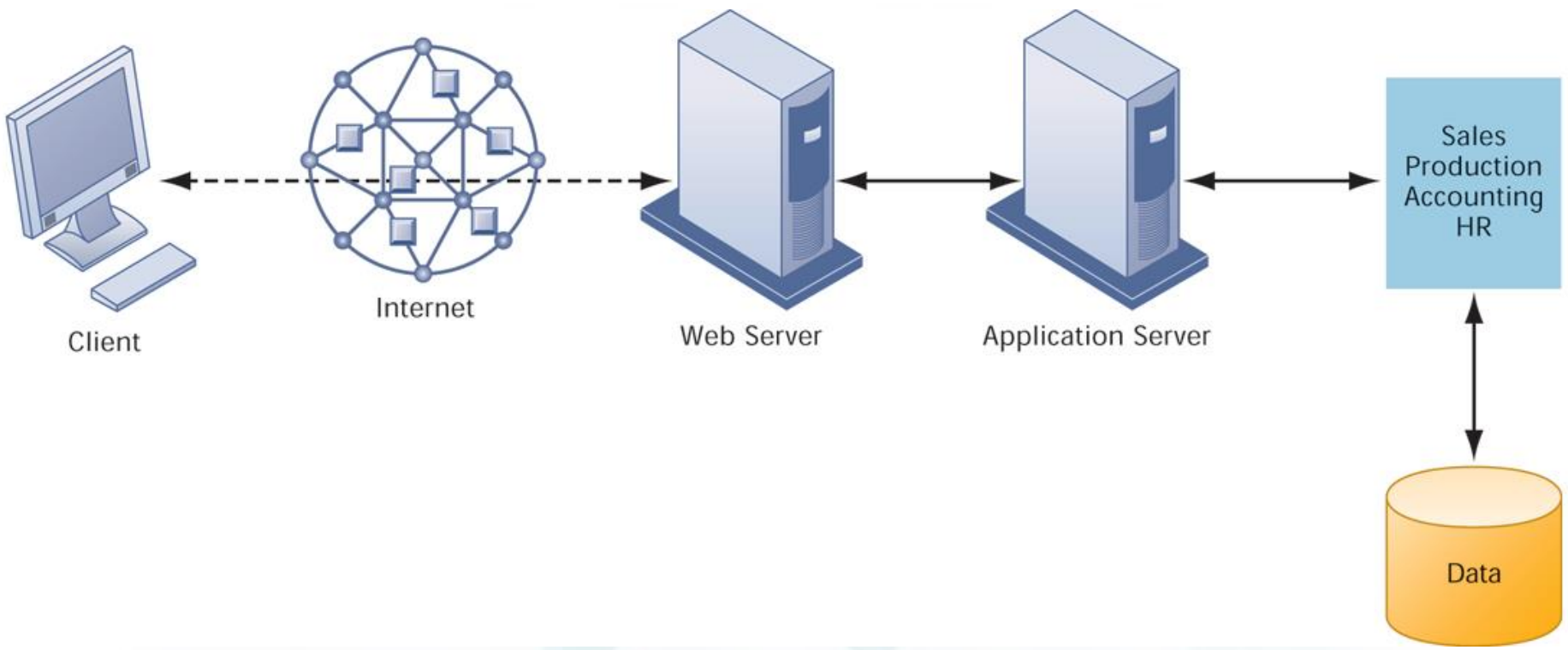


FIGURE 5-3 In a multitiered client/server network, client requests for service are handled by different levels of servers.

- **Technology drivers of infrastructure evolution**
  - **Moore's law and microprocessing power**
    - Computing power doubles every 18 months
    - Nanotechnology:
      - Shrinks size of transistors to size comparable to size of a virus
  - **Law of Mass Digital Storage**
    - The amount of data being stored each year doubles

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 200,000 MIPS (2.6 billion instructions per second).

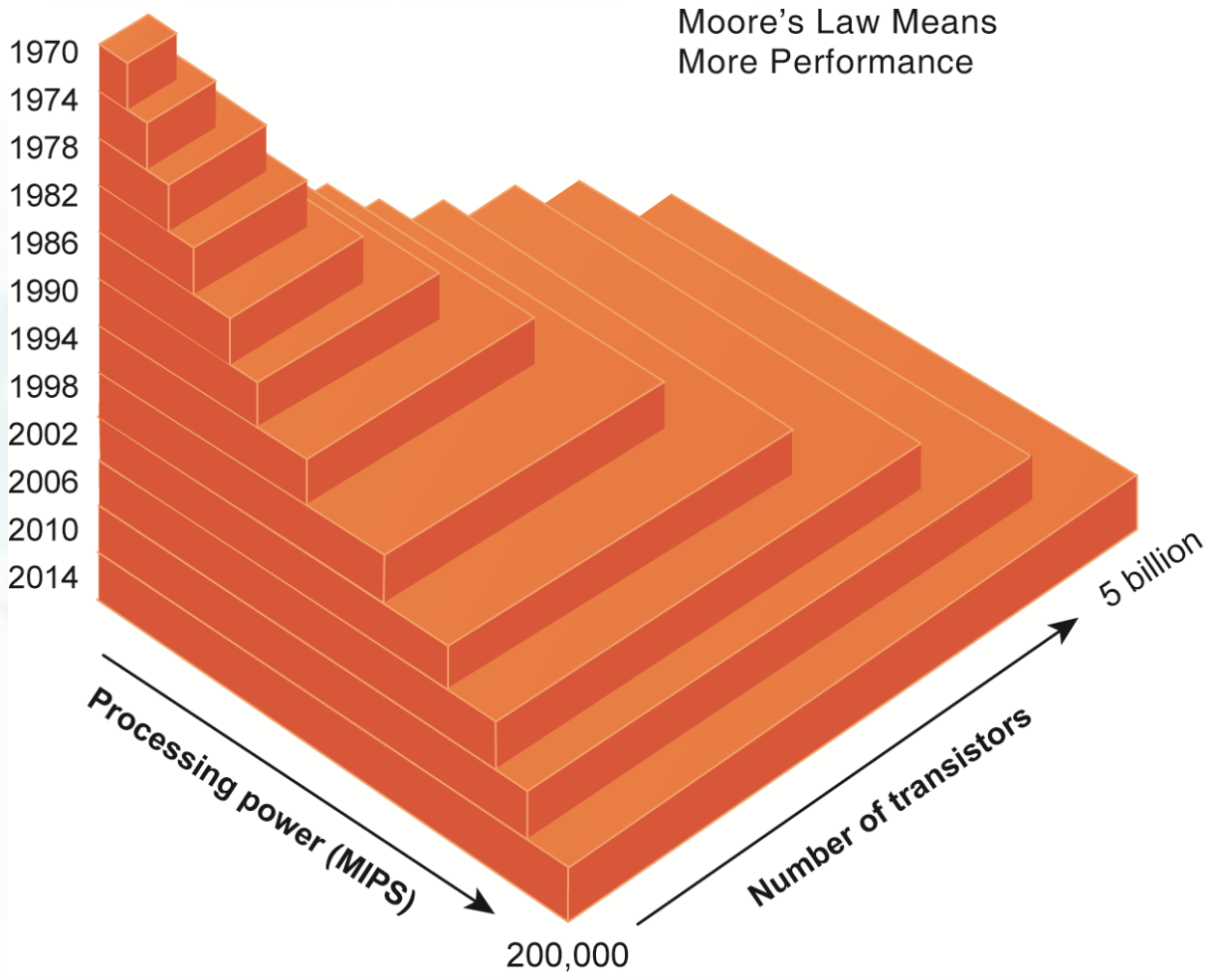
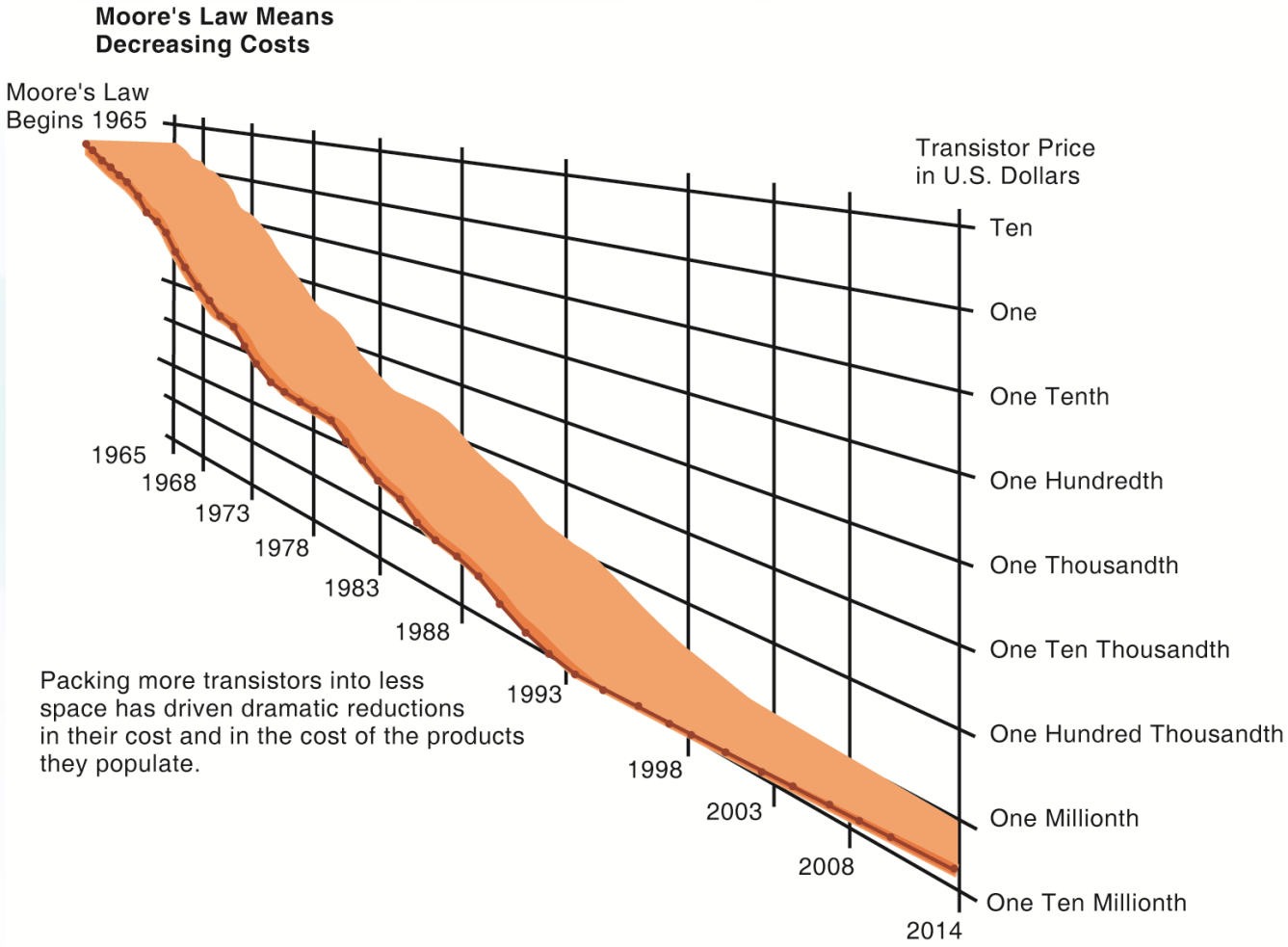


FIGURE 5-4

FALLING COST OF CHIPS

Packing more transistors into less space has driven down transistor cost dramatically as well as the cost of the products in which they are used.

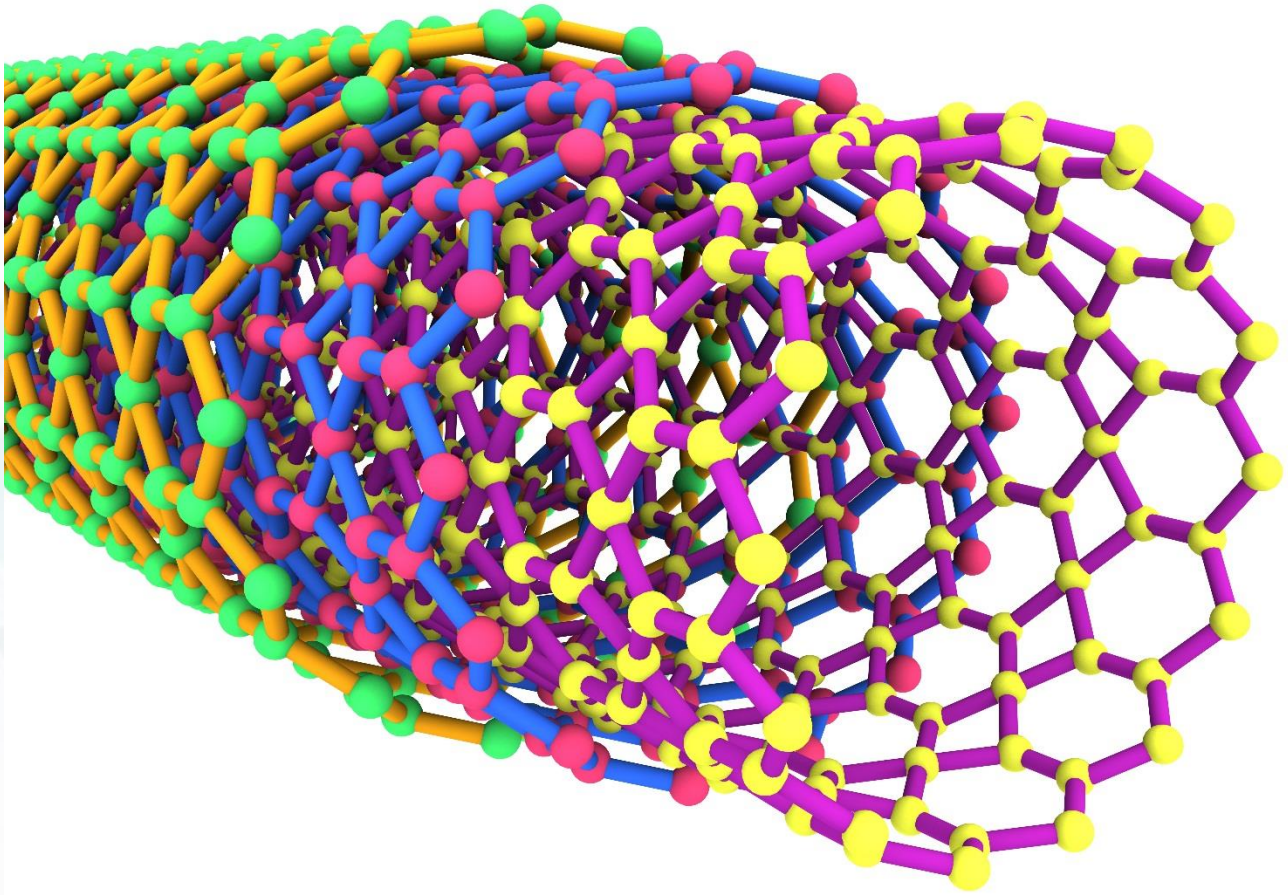
FIGURE 5-5



EXAMPLES OF NANOTUBES

Nanotubes are tiny tubes about 10,000 times thinner than a human hair. They consist of rolled up sheets of carbon hexagons and have the potential uses as minuscule wires or in ultrasmall electronic devices and are very powerful conductors of electrical current.

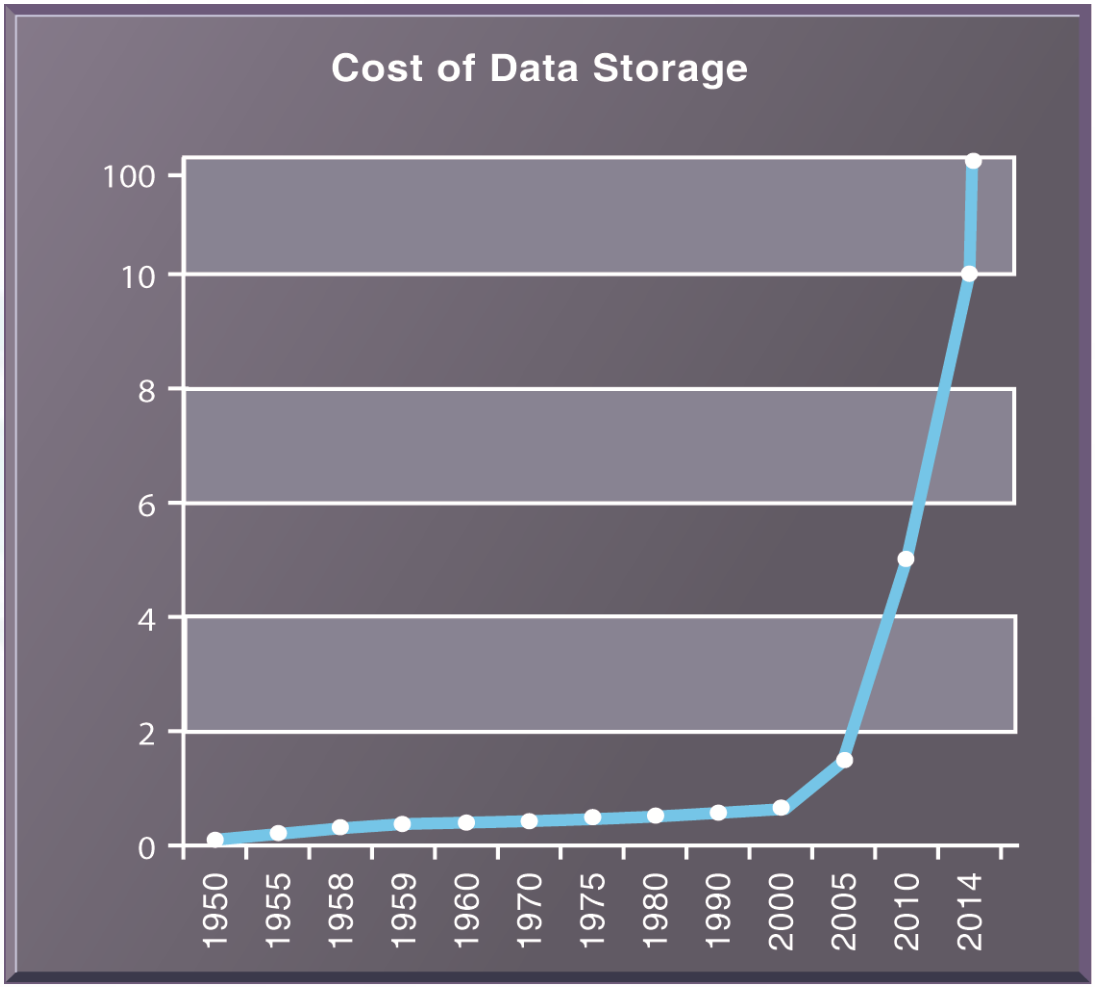
FIGURE 5-6



THE COST OF STORING DATA DECLINES EXPONENTIALLY 1950–2012

Since the first magnetic storage device was used in 1955, the cost of storing a kilobyte of data has fallen exponentially, doubling the amount of digital storage for each dollar expended every 15 months on average. Cloud storage services provide 100 gigabytes of storage for about $1.00.

FIGURE 5-7



- *Technology drivers of infrastructure evolution (cont.)*
  - **Metcalfe's Law and network economics**
    - Value or power of a network grows exponentially as a function of the number of network members.
    - As network members increase, more people want to use it (demand for network access increases).

- *Technology drivers of infrastructure evolution (cont.)*
  - **Declining communication costs and the Internet**
    - An estimated 3 billion people worldwide have Internet access.
    - As communication costs fall toward a very small number and approach zero, utilization of communication and computing facilities explodes.

EXPONENTIAL DECLINES IN INTERNET COMMUNICATIONS COSTS

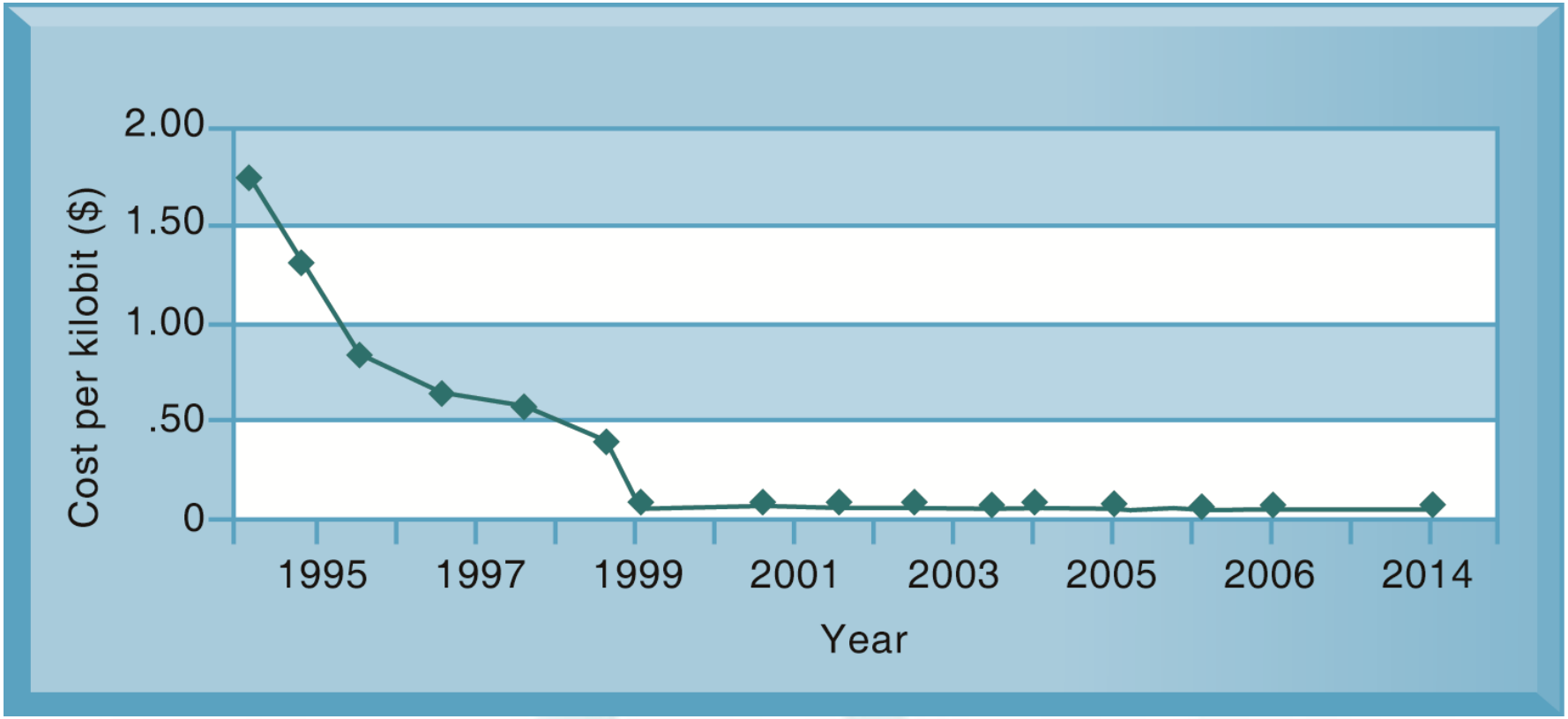


FIGURE 5-8 One reason for the growth in the Internet population is the rapid decline in Internet connection and overall communication costs. The cost per kilobit of Internet access has fallen exponentially since 1995. Digital subscriber line (DSL) and cable modems now deliver a kilobit of communication for a retail price of less than one penny.

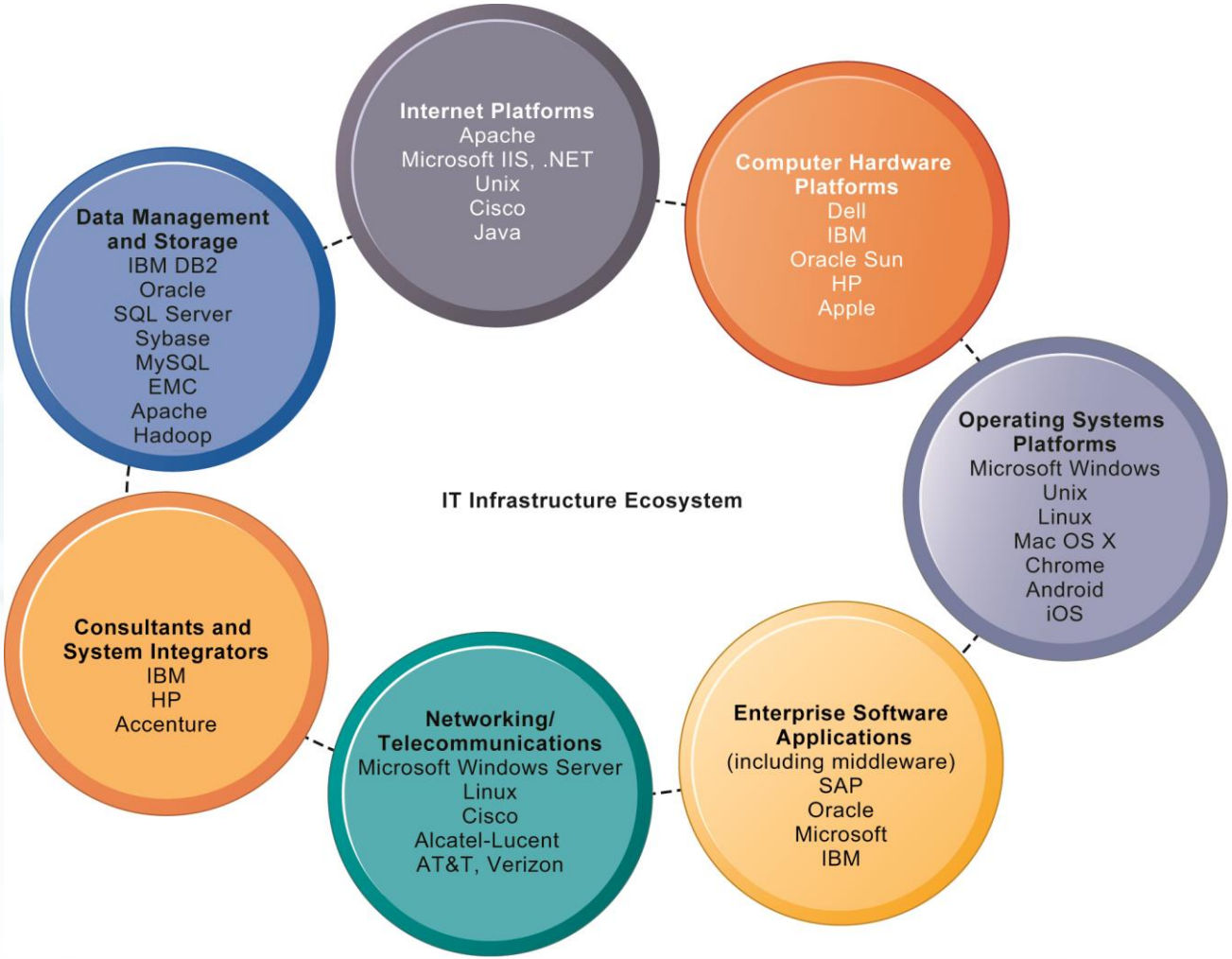
- **Technology drivers of infrastructure evolution (cont.)**
  - **Standards and network effects**
    - Technology standards:
      - Specifications that establish the compatibility of products and the ability to communicate in a network
      - Unleash powerful economies of scale and result in price declines as manufacturers focus on the products built to a single standard

- IT Infrastructure has 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

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.

FIGURE 5-9



- **Computer hardware platforms**
  - **Client machines**
    - Desktop PCs, laptops
    - Mobile computing: smartphones, tablets
  - **Servers**
    - Blade servers: ultrathin computers stored in racks
  - **Mainframes:**
    - IBM mainframe equivalent to thousands of blade servers
  - **Top chip producers: Intel, AMD**

- **Operating system platforms**
  - **Operating systems**
    - Server level: 65% run Unix or Linux; 35% run Windows
    - Client level:
      - 90% run Microsoft Windows (Windows 8, Windows 7, etc.)
      - Mobile/multitouch (Android, iOS)
      - Cloud computing (Google's Chrome OS)
- **Enterprise software applications**
  - **Enterprise application providers: SAP and Oracle**
  - **Middleware providers: IBM, Oracle**

- **Data management and storage**
  - **Database software:**
    - IBM (DB2), Oracle, Microsoft (SQL Server), Sybase (Adaptive Server Enterprise), MySQL
  - **Physical data storage:**
    - EMC Corp (large-scale systems), Seagate, Western Digital
  - **Storage area networks (SANs):**
    - Connect multiple storage devices on dedicated network

- **Networking/telecommunications platforms**
  - **Telecommunication services**
    - Telecommunications, cable, telephone company charges for voice lines and Internet access
    - AT&T, Verizon
  - **Network operating systems:**
    - Windows Server, Linux, Unix
  - **Network hardware providers:**
    - Cisco, Alcatel-Lucent, \Juniper Networks

- Internet platforms
  - Hardware, software, management services to support company Web sites (including Web-hosting services), intranets, extranets
  - Internet hardware server market: IBM, Dell, Sun (Oracle), HP
  - Web development tools/suites: Microsoft (Visual Studio and .NET), Oracle-Sun (Java), Adobe, Real Networks

- 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, HP, Infosys, Wipro Technologies
  - Software integration: ensuring new infrastructure works with legacy systems
  - Legacy systems: older TPS created for mainframes that would be too costly to replace or redesign

- **The mobile digital platform**
  - **Smartphones (iPhone, Android, and Blackberry)**
    - Data transmission, Web surfing, e-mail, and IM
  - **Netbooks:**
    - Small lightweight notebooks optimized for wireless communication and core tasks
  - **Tablets (iPad)**
  - **Networked e-readers (Kindle and Nook)**
  - **Wearable devices (smart watches, smart glasses)**

Interactive Session: Management

THE GREENING OF THE DATA CENTER

Read the Interactive Session and discuss the following questions

- What business and social problems does data center power consumption cause?
- What solutions are available for these problems? Are they management, organizational, or technology solutions? Explain your answer.
- What are the business benefits and costs of these solutions?
- Should all firms move toward green computing? Why or why not?

- BYOD (Bring your own device)
  - Allowing employees to use personal mobile devices in workplace
- Consumerization of IT
  - New information technology emerges in consumer markets first and spreads to business organizations
  - Forces businesses and IT departments to rethink how IT equipment and services are acquired and managed

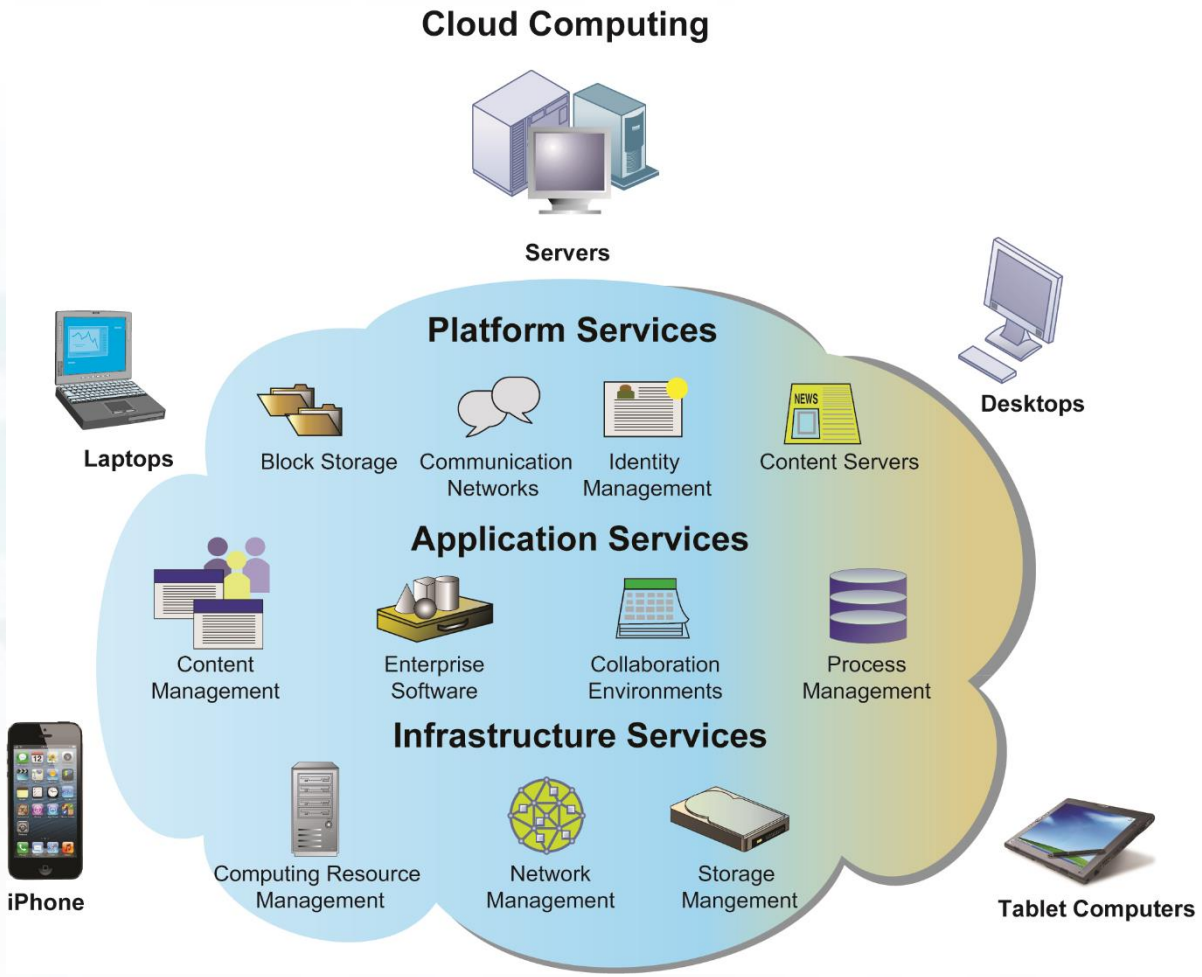
- **Quantum computing**
  - Uses quantum physics to represent and operate on data
  - Dramatic increases in computing speed
- **Virtualization**
  - Allows single physical resource to act as multiple resources (i.e., run multiple instances of OS)
  - Reduces hardware and power expenditures
  - Facilitates hardware centralization

- **Cloud computing**
  - **On-demand (utility) computing services obtained over network**
    - Infrastructure as a service (IaaS)
    - Platform as a service (PaaS)
    - Software as a service (SaaS)
  - **Cloud can be public or private**
  - **Allows companies to minimize IT investments**
  - **Drawbacks: Concerns of security, reliability**
  - **Hybrid cloud computing model**

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.

Figure 5-10



IS IT TIME FOR CLOUD COMPUTING?

Read the Interactive Session and discuss the following questions

- What business benefits do cloud computing services provide? What problems do they solve?
- What are the disadvantages of cloud computing?
- How do the concepts of capacity planning, scalability, and TCO apply to this case? Apply these concepts both to Amazon and to subscribers of its services.
- What kinds of businesses are most likely to benefit from using cloud computing? Why?

Current Trends in Hardware Platforms

- **Green computing (Green IT)**
  - Practices and technologies for manufacturing, using, disposing of computing and networking hardware
  - Reducing power consumption a high priority
  - IT responsible for 2% U.S. power demand
- **High performance, power-saving processors**
  - Multi-core processors
  - Power-efficient microprocessors

Current Trends in Software Platforms

- **Open-source software:**
  - Produced by community of programmers
  - Free and modifiable by user
  - Examples: Apache web server, Mozilla Firefox browser, OpenOffice
- **Linux**
  - Open-source OS used in high-performance computing
  - Used in mobile devices, local area networks, Web servers, Android OS

- **Software for the Web**
  - **Java:**
    - Object-oriented programming language
    - Operating system, processor-independent
  - **HTML/HTML5**
    - Web page description language
    - HTML5 is latest evolution
      - Embeds media, animation
      - Supports cross-platform apps, offline data storage
  - **Ruby and Python**

- **Web Services**
  - **Software components that exchange information using Web standards and languages**
  - **XML: Extensible Markup Language**
    - More powerful and flexible than HTML
    - Tagging allows computers to process data automatically

- **SOA: Service-oriented architecture**
  - **Set of self-contained services that communicate with one another to create a working software application**
  - **Software developers reuse these services in other combinations to assemble other applications as needed**
    - Example: an "invoice service" to serve whole firm for calculating and sending printed invoices
  - **Dollar Rent A Car**
    - Uses Web services to link online booking system with Southwest Airlines' Web site

HOW DOLLAR RENT A CAR USES WEB SERVICES

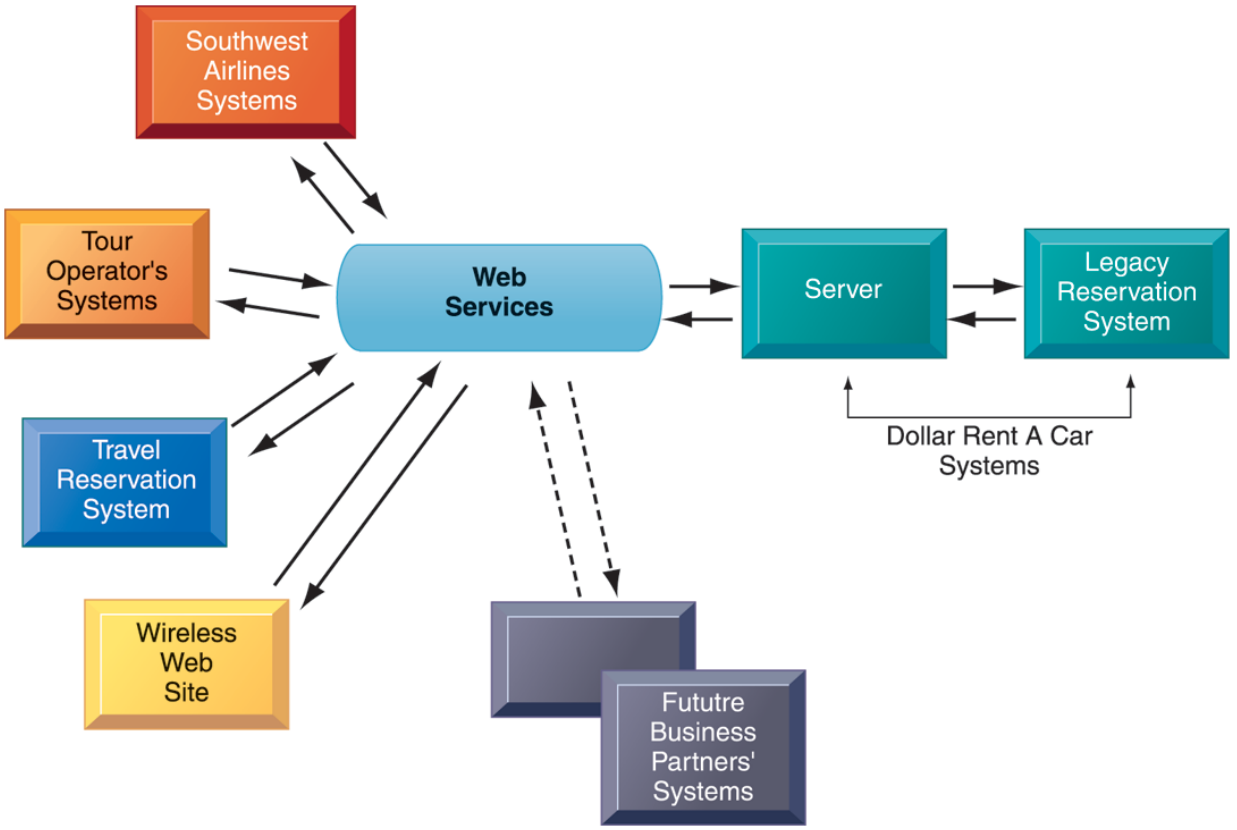


FIGURE 5-11 Dollar Rent A Car uses Web services to provide a standard intermediate layer of software to "talk" to other companies' information systems. Dollar Rent A Car can use this set of Web services to link to other companies' information systems without having to build a separate link to each firm's systems.

- **Software outsourcing and cloud services**
  - **Three external sources for software:**
    - Software packages and enterprise software
    - Software outsourcing
      - Contracting outside firms to develop software
    - Cloud-based software services
      - Software as a service (SaaS)
      - Accessed with Web browser over Internet
      - Service Level Agreements (SLAs): formal agreement with service providers

CHANGING SOURCES OF FIRM SOFTWARE

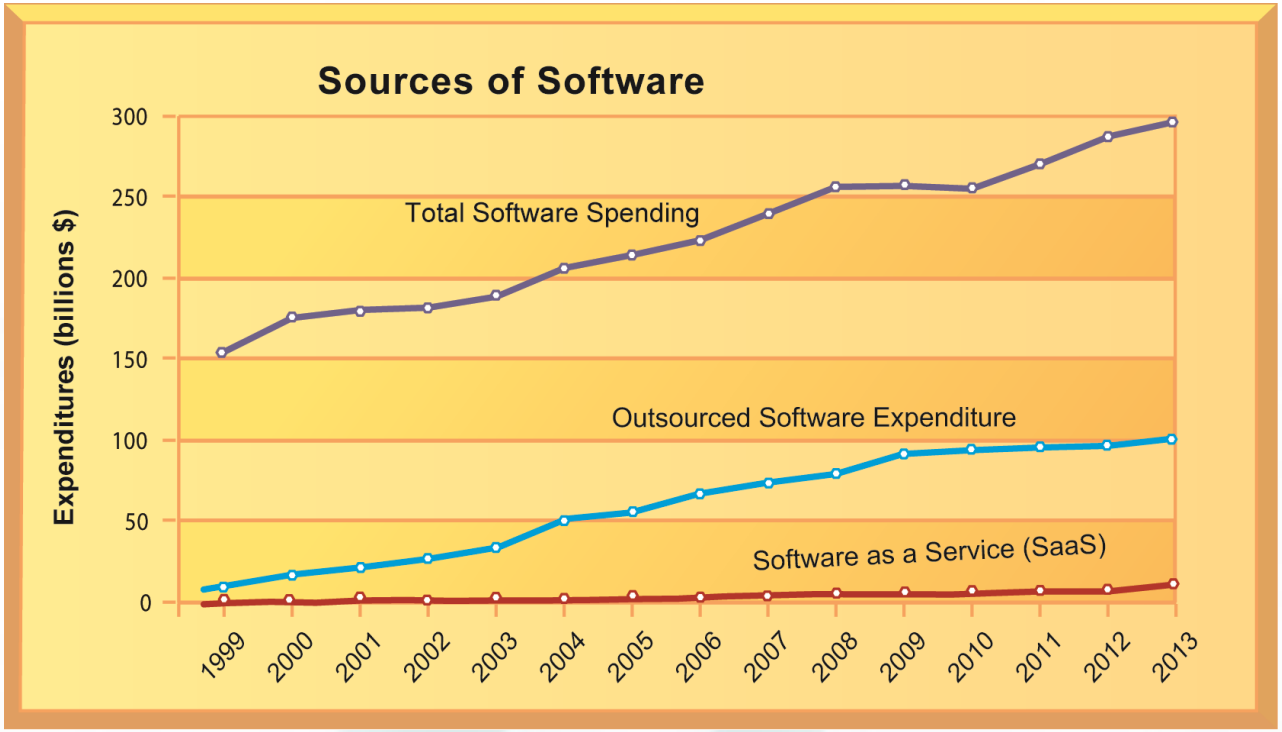


Figure 5-12 In 2014, U.S. firms will spend more than $279 billion on software. About 35 percent of that will originate outside the firm, either from enterprise software vendors selling firm-wide applications or individual application service providers leasing or selling software modules. Another 4 percent ($11 billion) will be provided by SaaS vendors as an online cloud-based service.

- **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

- **Dealing with platform and infrastructure change**
  - **As firms shrink or grow, IT needs to be flexible and scalable**
  - **Scalability:**
    - Ability to expand to serve larger number of users
  - **For mobile computing and cloud computing**
    - New policies and procedures for managing these new platforms
    - Contractual agreements with firms running clouds and distributing software required

- **Management and governance**
  - **Who controls 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?**

Challenges of Managing IT Infrastructure

- **Making wise infrastructure investments**
  - **Amount to spend on IT is complex question**
    - Rent vs. buy, cloud computing
    - Outsourcing
  - **Total cost of ownership (TCO) model**
    - Analyzes 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

Challenges of Managing IT Infrastructure

- **Competitive forces model for IT infrastructure investment**
  1. Market demand for firm's services
  2. Firm's business strategy
  3. Firm's IT strategy, infrastructure, and cost
  4. Information technology assessment
  5. Competitor firm services
  6. Competitor firm IT infrastructure investments

COMPETITIVE FORCES MODEL FOR IT INFRASTRUCTURE

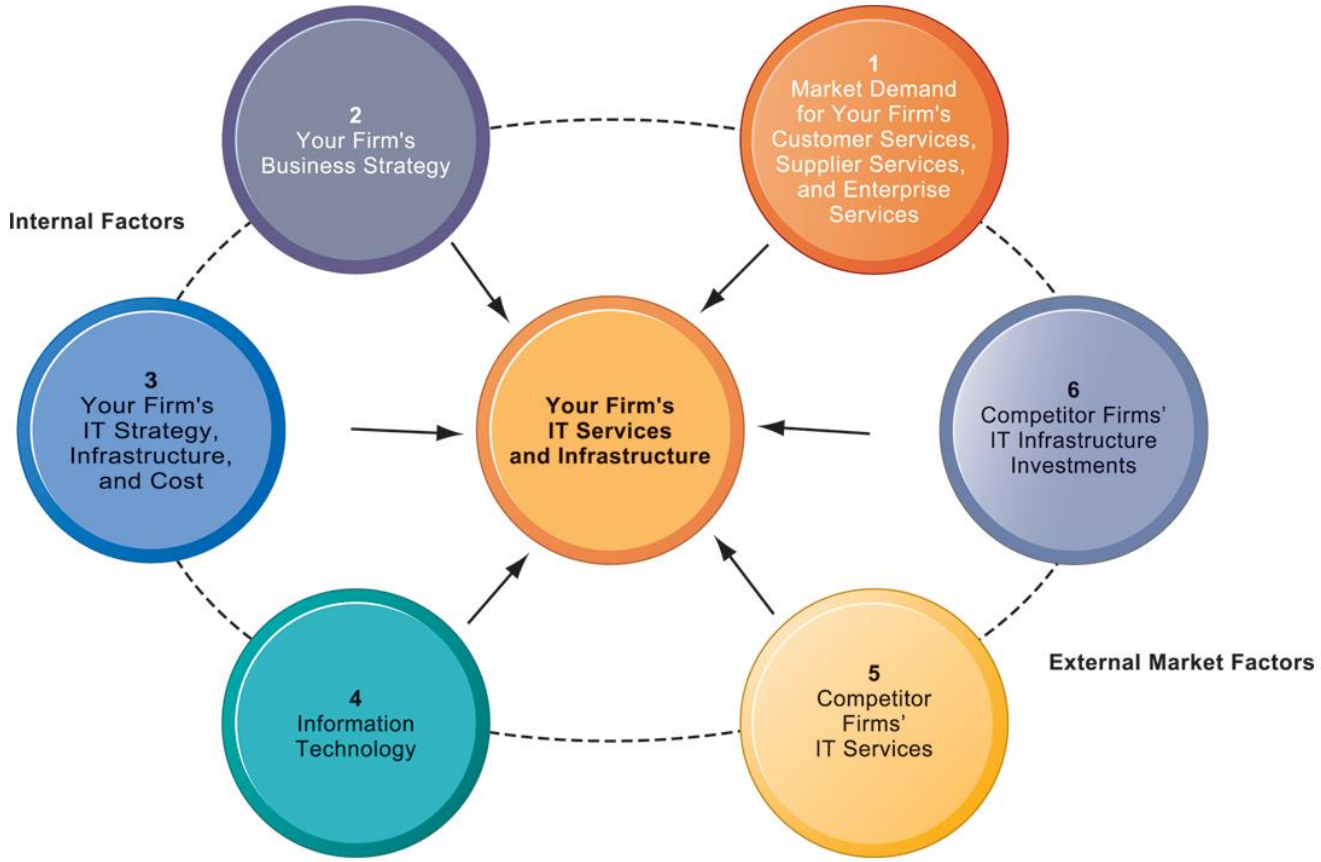


FIGURE 5-13 There are six factors you can use to answer the question, "How much should our firm spend on IT infrastructure?"