

Chapter 5



IT Infrastructure and Emerging Technologies

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Chapter 5 IT Infrastructure and Emerging Technologies

LEARNING OBJECTIVES

- **Define IT infrastructure and describe its components.**
- **Identify and describe the stages of IT infrastructure evolution.**
- **Identify and describe the technology drivers of IT infrastructure evolution.**
- **Assess contemporary computer hardware platform trends.**
- **Assess contemporary software platform trends.**
- **Evaluate the challenges of managing IT infrastructure and management solutions.**

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IRCTC – Balancing the Infrastructure with the Load

- **IR moves the entire population of Australia DAILY**
- **Around 7000 Stations**
- **Around 8500 Trains**
- **Around Million passengers have reservations**
 - **Can select their Berths also**
 - **Can also select type of food if available.**
- **Need to balance availability, reach and performance over Ticket-booths, Webbased terminals and smart phones.**

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IRCTC – Balancing the Infrastructure with the Load

- **Selected Infrastructure needs to cater to**
 - **Large data capture and storage**
 - **Large data processing and retrieval and retention**
 - **Security**
 - **High Availability**
 - **Performance**

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IT Infrastructure

- **Defining IT infrastructure:**
 - **Set of physical devices and software required to operate enterprise**
 - **Set of firmwide services including:**
 - Computing platform providing computing services
 - Telecommunications services
 - Data management services
 - Application software services
 - Physical facilities management services
 - IT management, education, research and development services
 - **“IT as services” perspective more accurate view of value of investments**

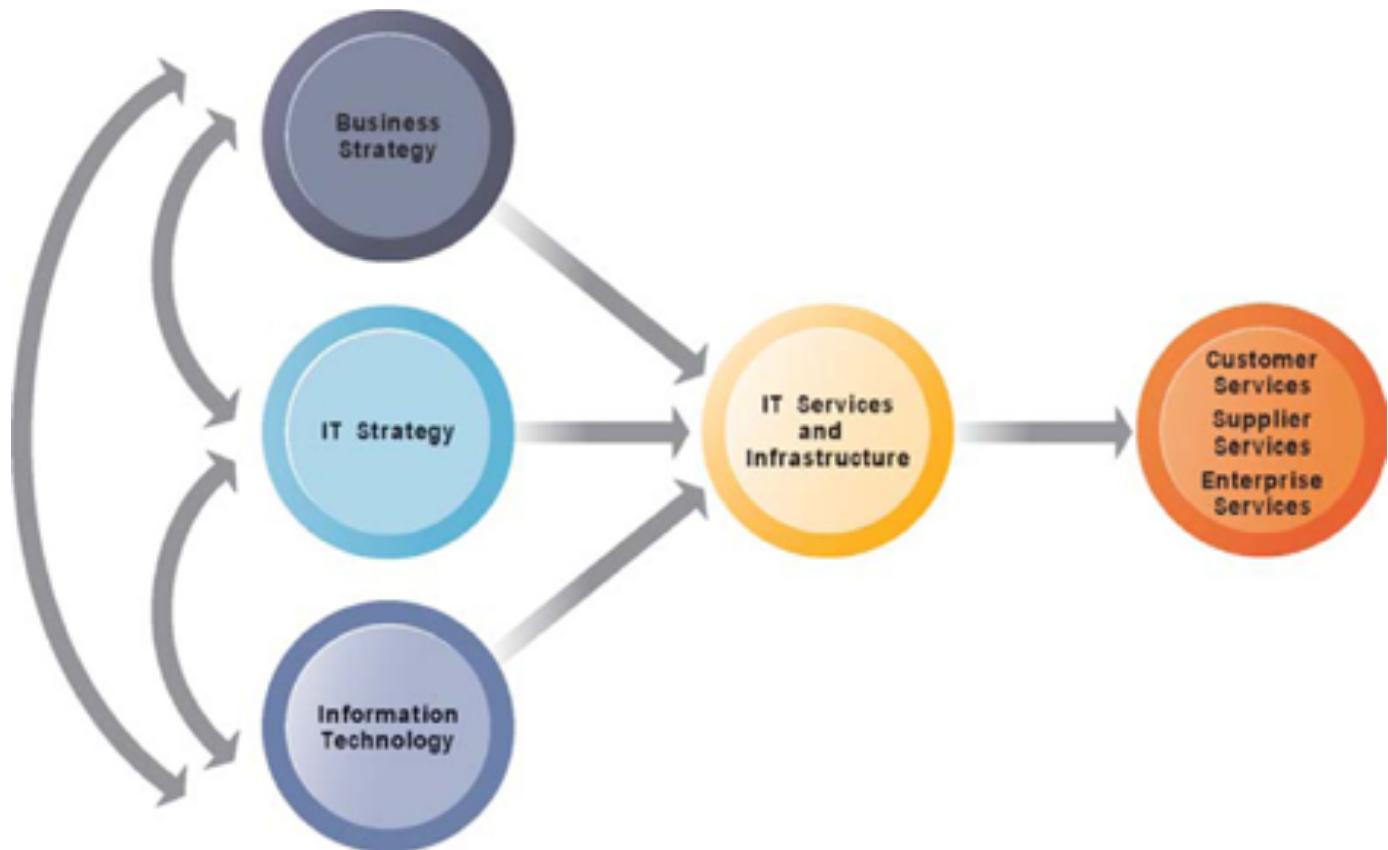
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IT Infrastructure

Connection Between the Firm, IT Infrastructure, and Business Capabilities

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.



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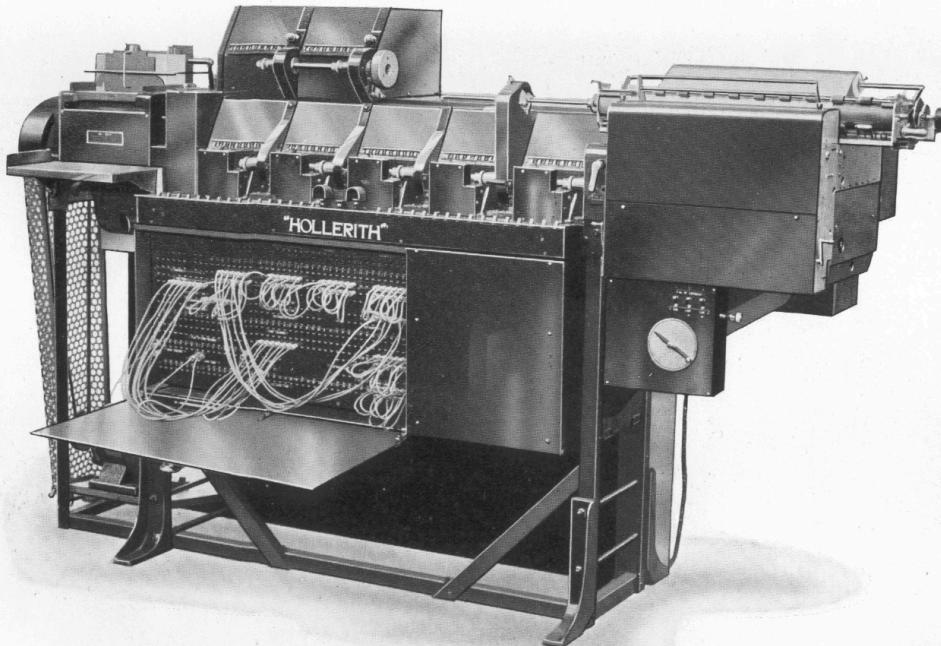
- **Evolution of IT infrastructure: 1950-2007**
 - **Electronic accounting machine era: 1930-1950**
 - Specialized machines sorting computer cards, accumulating totals, printing reports
 - **General-purpose mainframe and minicomputer era: 1959 to present**
 - 1958 IBM first mainframes introduced, eventually used to support thousands of online remote terminals
 - 1965 less expensive DEC minicomputers introduced, allowing decentralized computing

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Eras in IT Infrastructure Evolution



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- **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)
- **Enterprise Internet computing era: 1992 to present**
 - Move toward integrating disparate networks, applications using Internet standards and enterprise applications
- **Cloud Computing Era (2000 to Present)**

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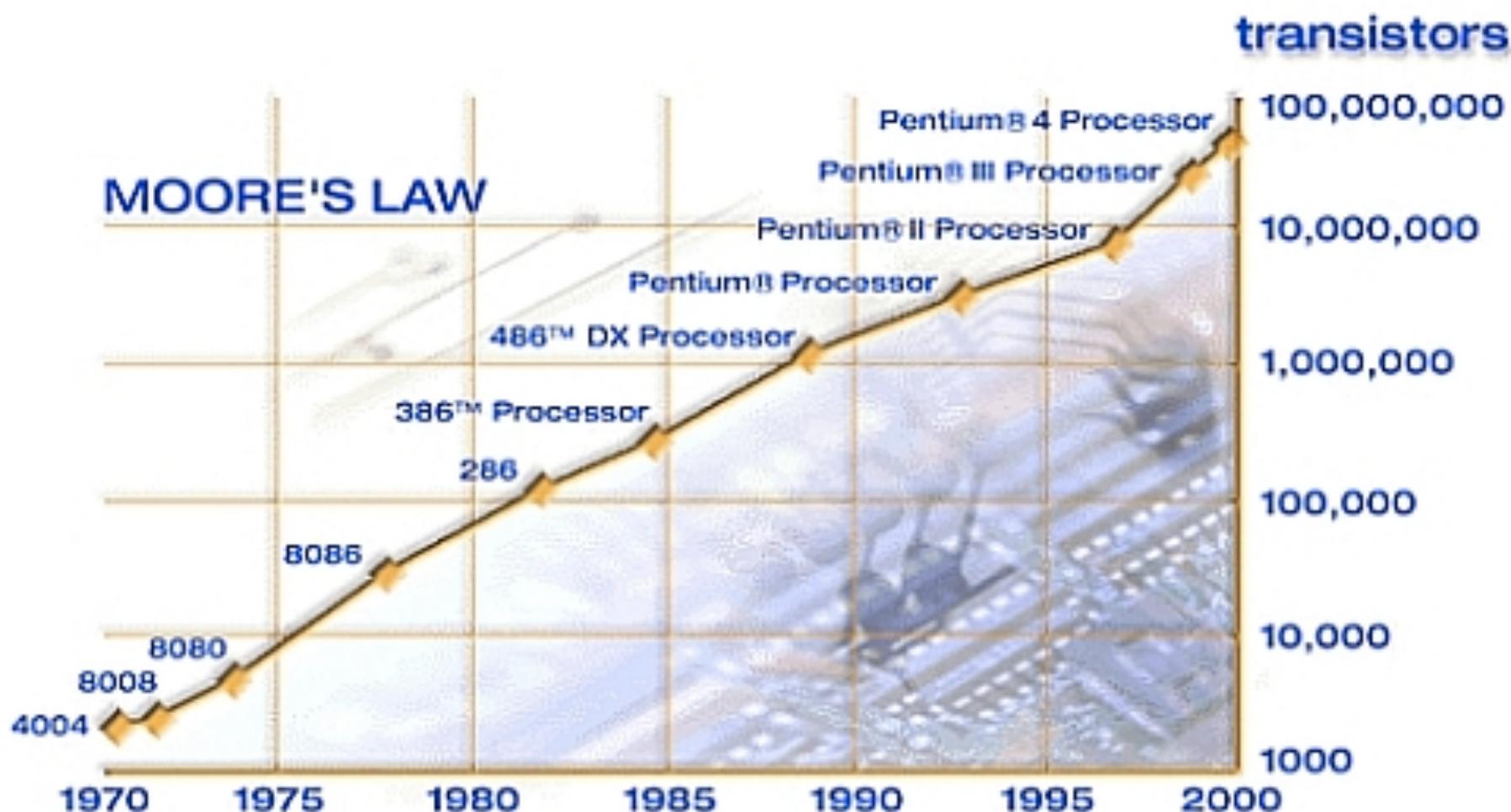
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- **Technology drivers of infrastructure evolution**
 - **Moore's law and microprocessing power**
 - Computing power doubles every 18 months
 - Nanotechnology: May shrink size of transistors to width of several atoms
 - Contrary factors: Heat dissipation needs, power consumption concerns
 - **Law of Mass Digital Storage**
 - The amount of data being stored each year doubles

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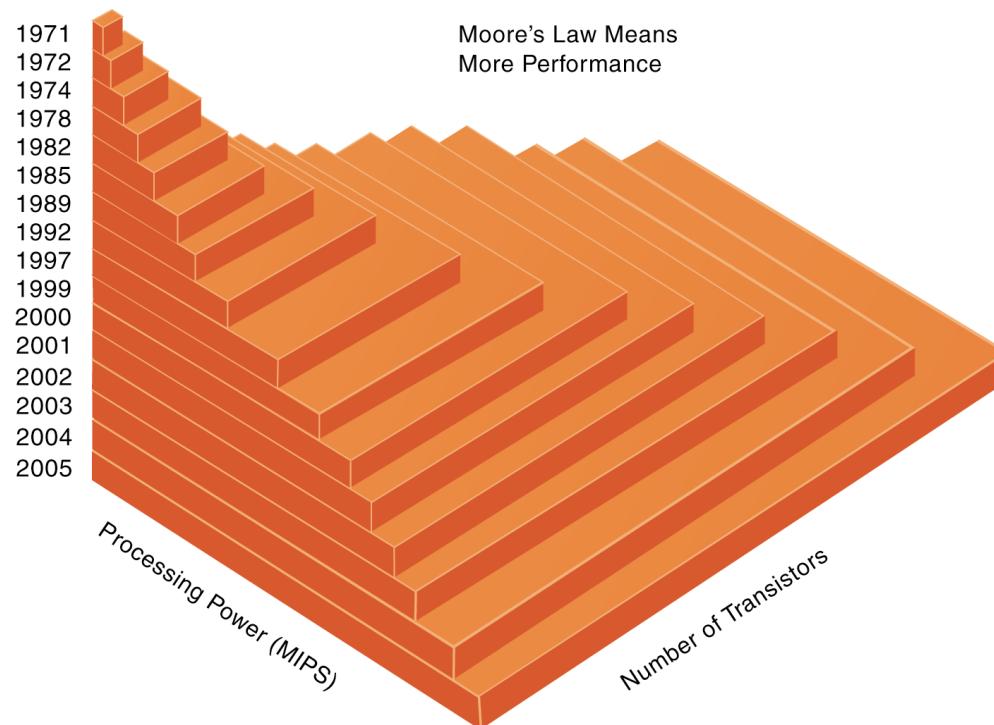


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Moore's Law and Microprocessor Performance



Packing more transistors into a tiny microprocessor has exponentially increased processing power.

Source: 2004 Intel Corporation; updated by the authors.

Figure 5-4

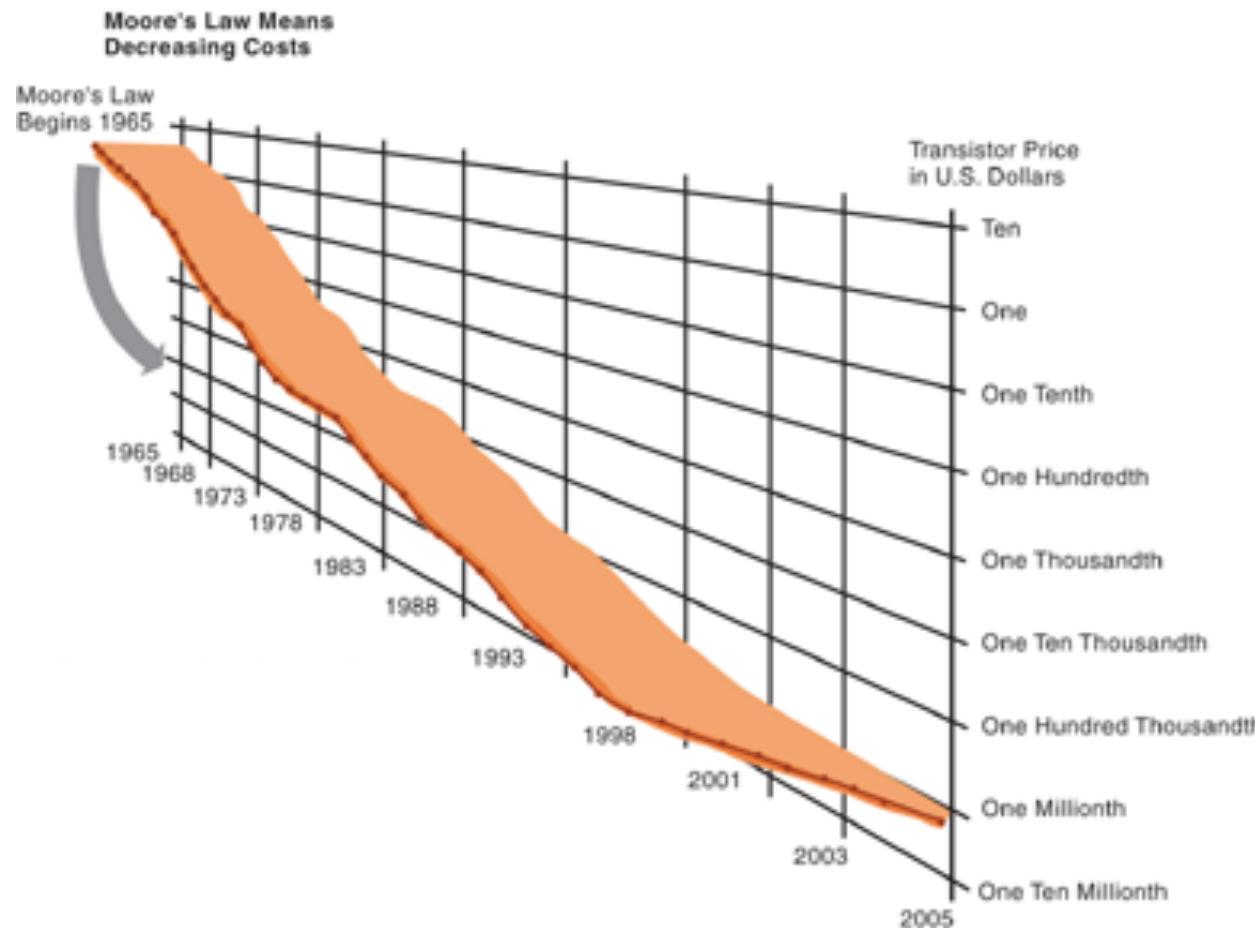
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Falling Cost of Chips

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. An Intel® processor today can contain as many as 1 billion transistors, run at 3.2 GHz and higher, deliver over 10,000 MIPS, and can be manufactured in high volumes with transistors that cost less than 1/10,000th of a cent. That's a little less than the cost of one printed character in this book.



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Examples of Nanotubes

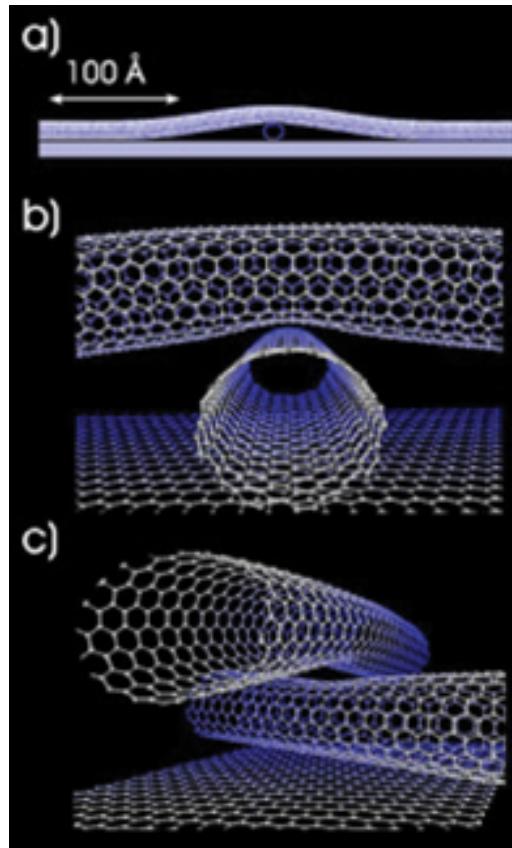


Figure 5-6

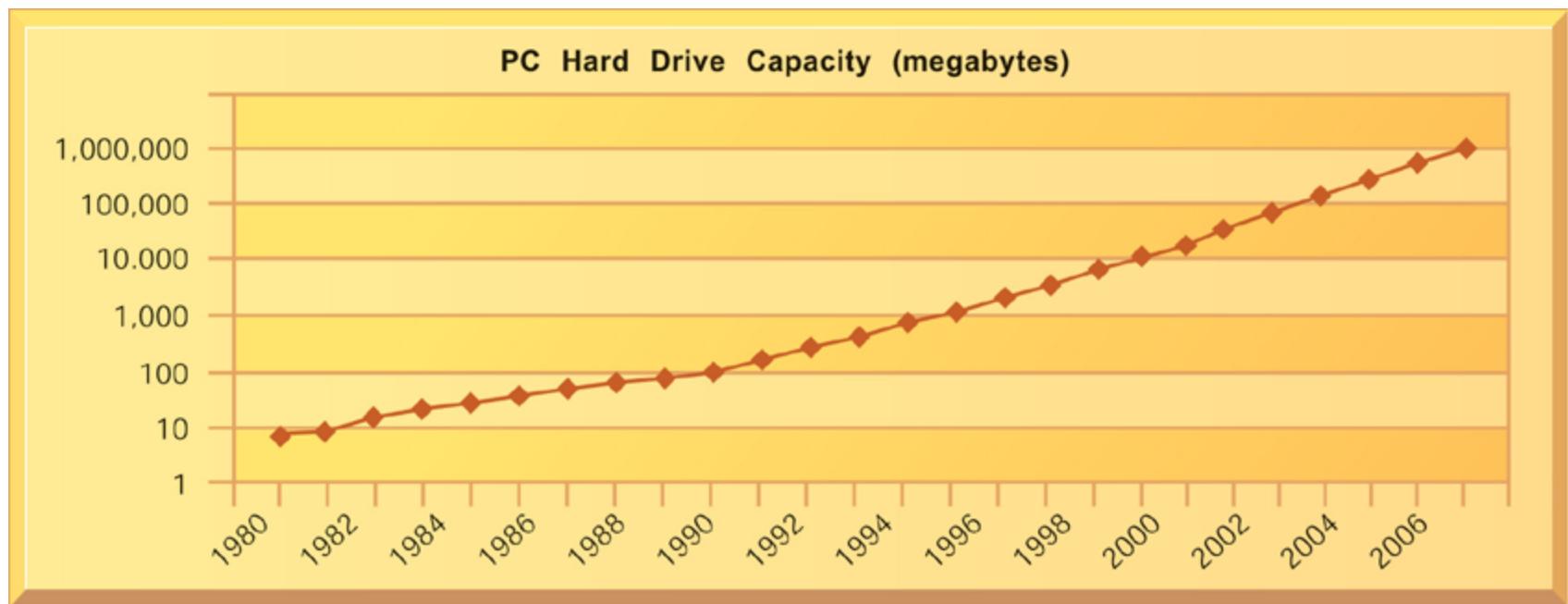
Nanotubes are tiny tubes about 10,000 times thinner than a human hair. They consist of rolled up sheets of carbon hexagons. Discovered in 1991 by researchers at NEC, they have the potential uses as minuscule wires or in ultrasmall electronic devices and are very powerful conductors of electrical current.

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The Capacity of Hard Drives Grows Exponentially 1980-2007



From 1980 to 1990, hard disk drive capacities for PCs grew at the rate of 25 percent annual compound growth, but after 1990, growth accelerated to more than 65 percent each year.

Figure 5-7

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The Cost of Storing Data Declines Exponentially 1950-2005

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.

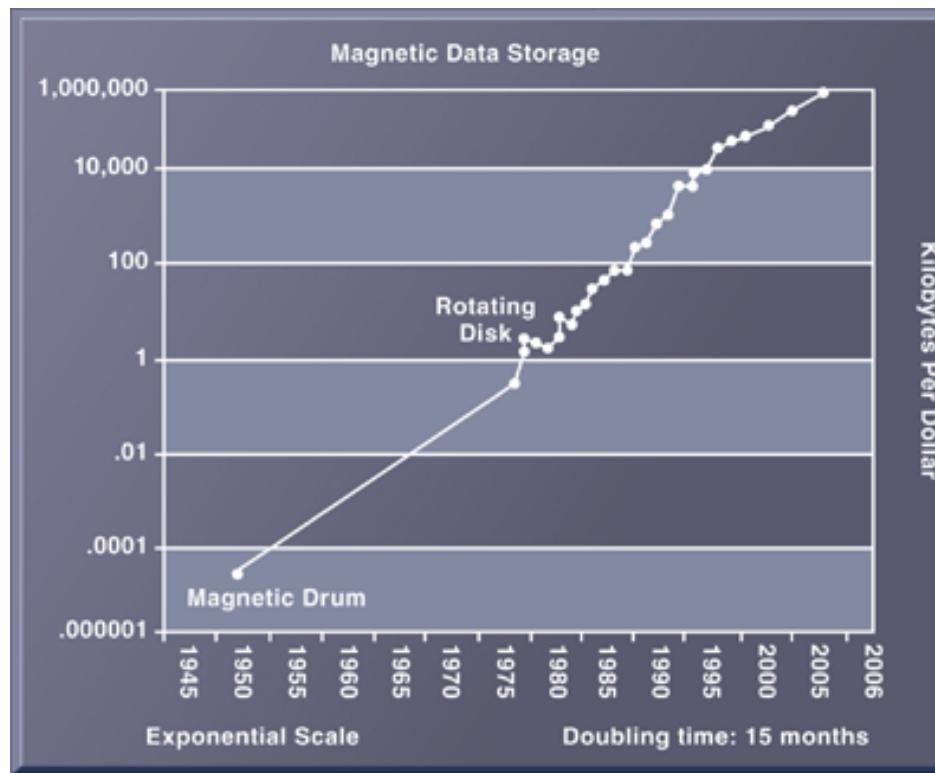


Figure 5-8

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- **Technology drivers of infrastructure evolution (cont.)**
 - **Metcalf'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).

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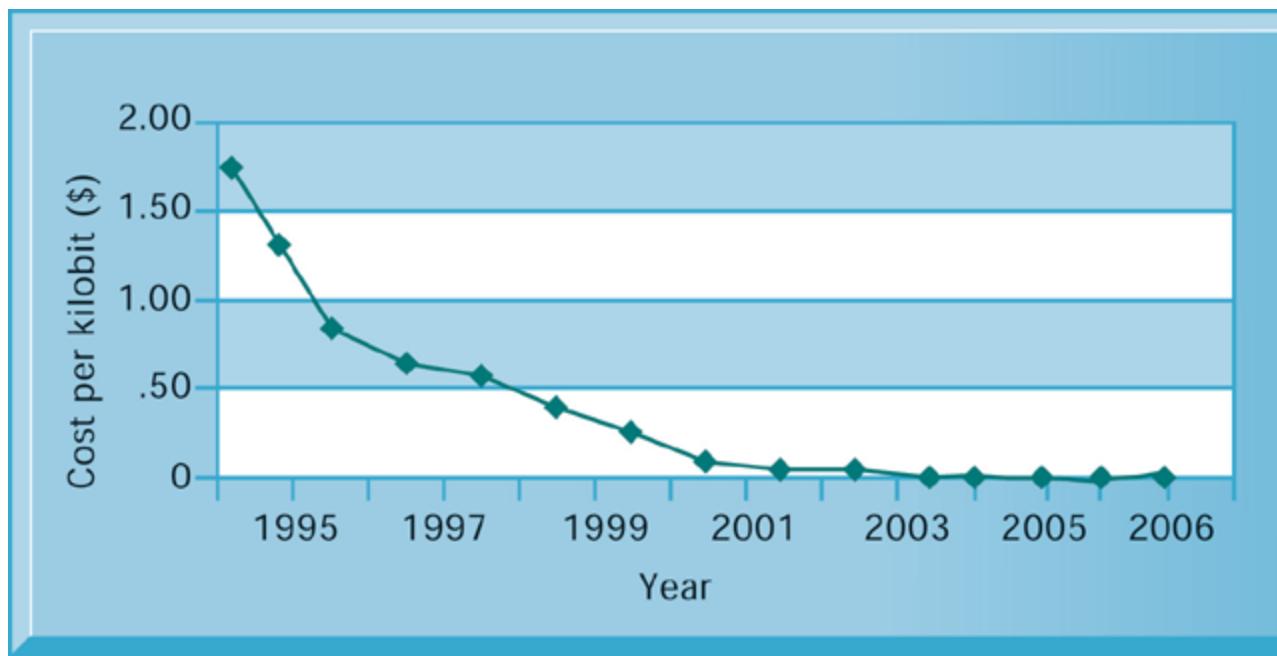
- **Declining communication costs and the Internet**
 - An estimated 1.1 billion people worldwide have Internet access
 - As communication costs fall toward a very small number and approach 0, utilization of communication and computing facilities explodes.

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Exponential Declines in Internet Communication Costs



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 2 cents.

Figure 5-9

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- **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.

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Infrastructure Components

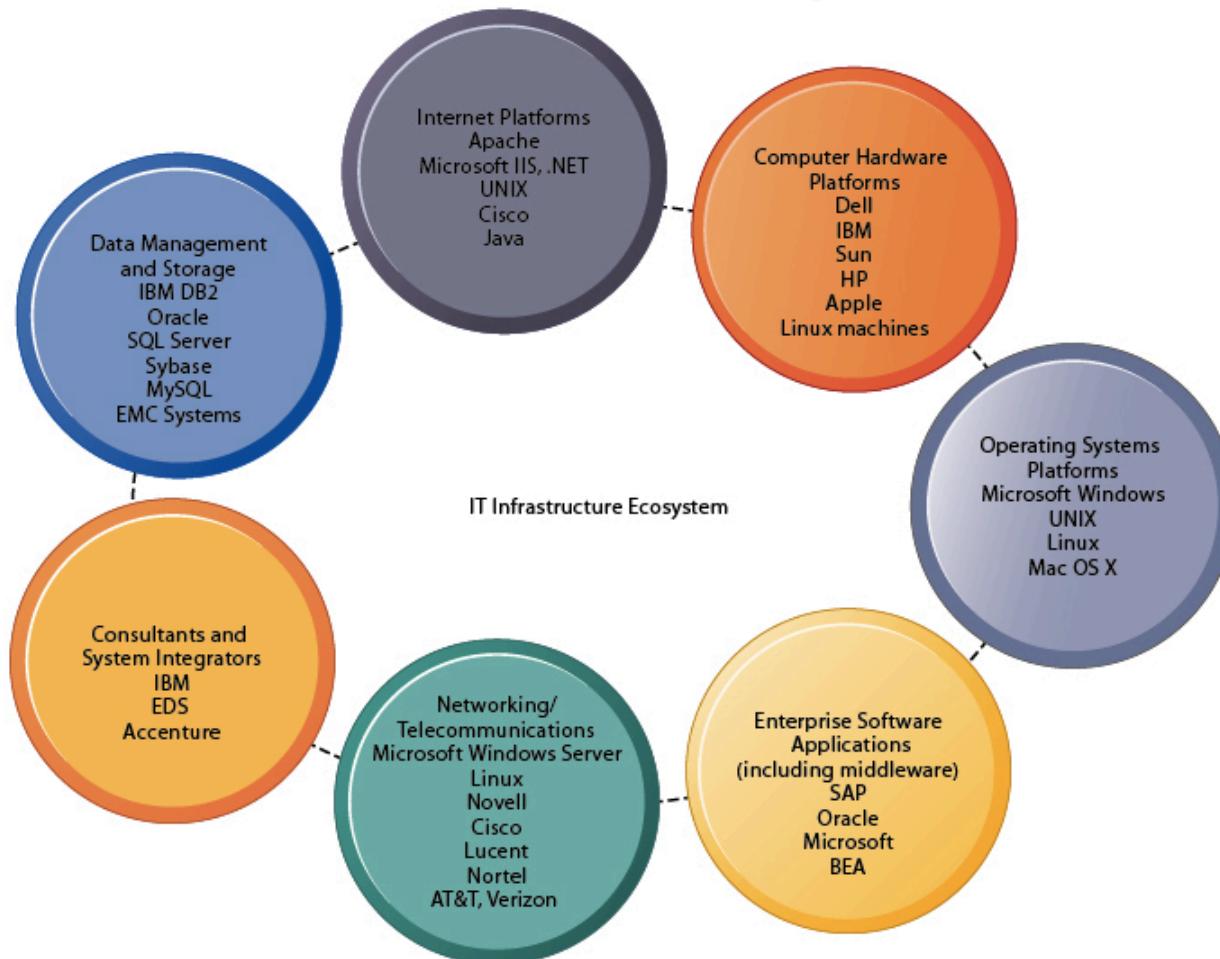
- **IT Infrastructure has 7 main components**
 - Computer hardware platforms (9%)
 - Enterprise and other IT software applications (19%)
 - Operating system platforms (7%)
 - Database management and storage (3%)
 - Networking and telecommunications equipment and services (50% of U.S. expenditures)
 - Internet platforms (2%)
 - Consulting services and system integrators (9%)

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Infrastructure Components

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.

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Infrastructure Components

- **Computer hardware platforms**
 - Client machines
 - Desktop PCs, mobile computing devices – PDAs, laptops
 - Servers
 - Blade servers: ultrathin computers stored in racks
 - Mainframes:
 - IBM mainframe equivalent to thousands of blade servers
 - Top chip producers: AMD, Intel, IBM
 - Top firms: IBM, HP, Dell, Sun Microsystems

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Infrastructure Components

- **Computer software platforms**
 - Operating systems
 - Client level: 95% run Microsoft Windows (XP, 2000, CE, etc.)
 - Server level: 85% run Unix or Linux
 - Enterprise software applications
 - Enterprise application providers: SAP and Oracle
 - Middleware providers: BEA

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Infrastructure Components

- **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, Maxtor, Western Digital
 - Storage area networks: connect multiple storage devices on dedicated network

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Infrastructure Components

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

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Infrastructure Components

- **Internet platforms**

- Hardware, software, management services to support company Web sites, (including Web hosting services) intranets, extranets
- Internet hardware server market: Dell, HP/Compaq, IBM
- Web development tools/suites: Microsoft (FrontPage, .NET) IBM (WebSphere) Sun (Java), independent software developers: Macromedia/Adobe, RealMedia

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Infrastructure Components

- **Consulting and system integration services**
 - Even large firms do not have resources for full range of support for new, complex infrastructure
 - 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
 - Accenture, PwC Consulting

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Hardware Platform Trends and Emerging Technologies

- **While cost of computing is lower, infrastructure costs have expanded**
 - More computing, more sophisticated computing, increased consumer expectations, need for security
- **Integration of computing and telecommunications platforms**
 - Client level convergence: Handhelds/Cell phones
 - Server, network level convergence: Internet telephony
 - Cloud Computing :Network becoming source of computing power

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Hardware Platform Trends and Emerging Technologies

- **Grid computing**
 - Connects geographically remote computers into a single network to combine processing power and create virtual supercomputer
 - Provides cost savings, speed, agility
- **On-demand computing (utility computing)**
 - Off-loading peak demand for computing power to remote, large-scale data processing centers
 - Lowers cost, risks of hardware investment, provides agility
- **Edge computing**
 - Multitier, load-balancing for Web-based applications
 - Significant parts of processing performed by less expensive servers located near the source of the Data.
 - Increases response time and lowers technology costs
 - Akamai: Internet edge provider

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Hardware Platform Trends and Emerging Technologies

- **Autonomic computing**

- Industry-wide effort to develop systems that can configure, optimize themselves, heal themselves when broken, and protect themselves from outside intruders
- Similar to self-updating antivirus software; Apple and Microsoft both use automatic updates

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Infrastructure Components

Edge Computing Platform

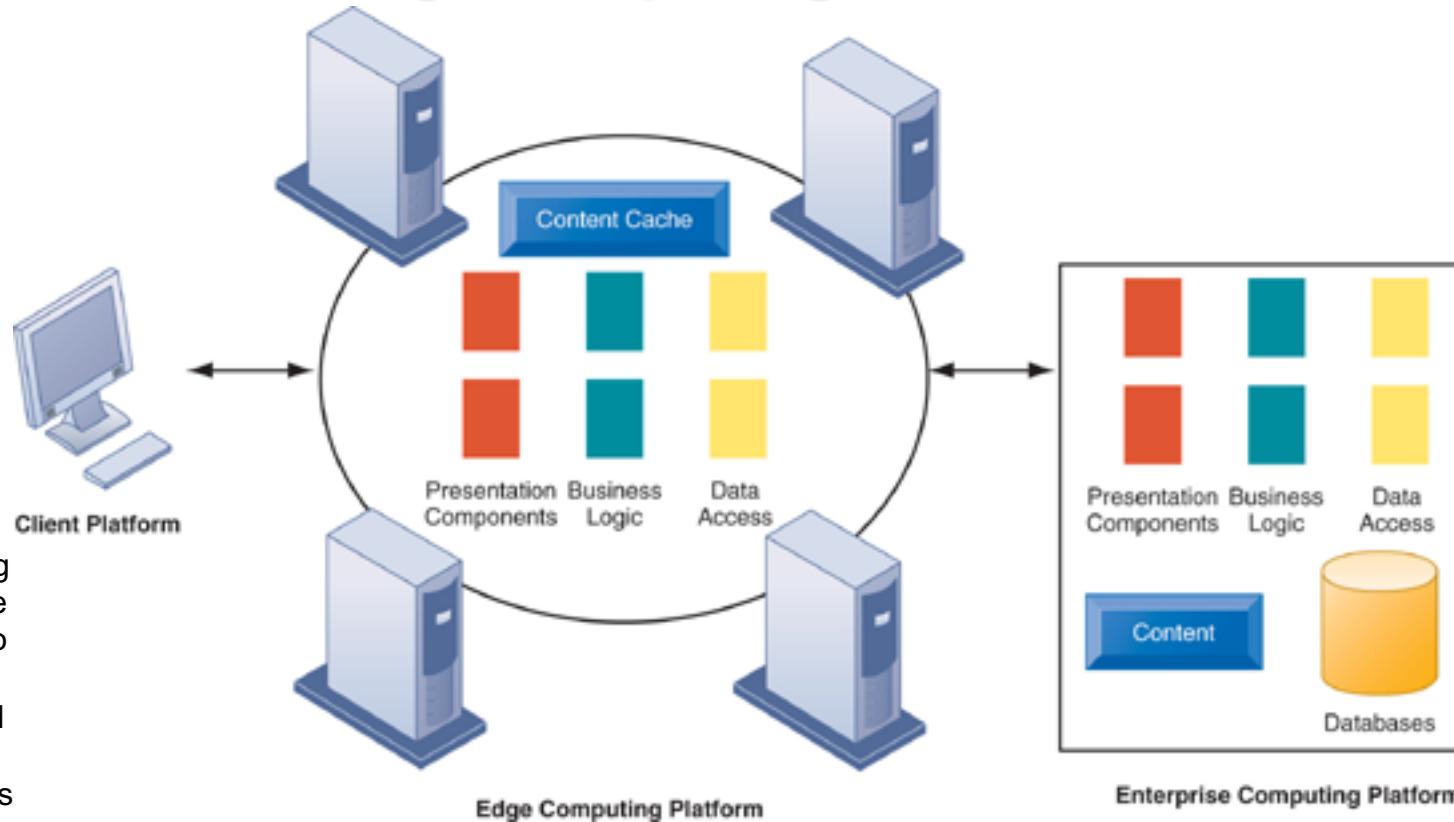


Figure 5-11

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Hardware Platform Trends and Emerging Technologies

- **Virtualization**

- Presenting set of computing resources (such as computing power or data storage) so they can be accessed in ways not restricted by physical configuration or geographic location.
- Server virtualization: Running more than one operating system at same time on single machine.
- Fewer computers required to process same work

- **Multicore processors**

- Integrated circuit with two or more processors
- Reduces power requirements and heat

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Software Platform Trends and Emerging Technologies

- **Linux and open-source software**
 - Open-source software: Produced by community of programmers, free and modifiable by user
 - Linux: Open-source software OS
 - 6% new PCs in 2005 were Linux (U.S.)
 - 23% market share as LAN server (U.S.)
- **Java**
 - Object-oriented programming language (Sun Microsystems)
 - Operating system, processor-independent (Java Virtual Machine)
 - Leading programming environment for Web
 - Applets
 - E-commerce applications

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Software Platform Trends and Emerging Technologies

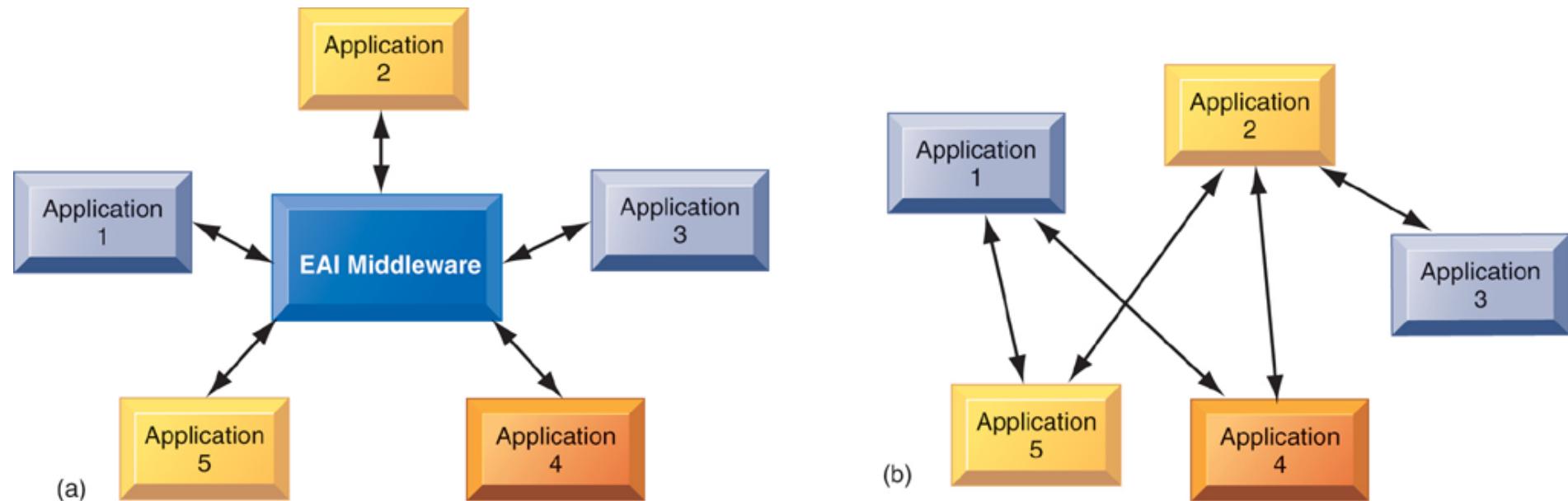
- **Software for enterprise integration**
 - Integration of legacy software an urgent software priority for U.S. firms
 - Middleware: Software that connects two separate applications
 - Enterprise application integration (EAI) software: Enables multiple systems to exchange data using single software hub

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Infrastructure Components

Enterprise Application Integration (EAI) Software Versus Traditional Integration



EAI software (a) uses special middleware that creates a common platform with which all applications can freely communicate with each other. EAI requires much less programming than traditional point-to-point integration (b).

Figure 5-12

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Software Platform Trends and Emerging Technologies

- **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
- **SOAP:** Simple Object Access Protocol
 - Rules for structuring messages enabling applications to pass data and instructions
- **WSDL:** Web Services Description Language
 - Framework for describing Web service and capabilities
- **UDDI:** Universal Description, Discovery, and Integration
 - Directory for locating Web services

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Software Platform Trends and Emerging Technologies

- **SOA: Service-oriented architecture**
 - Set of self-contained services that communicate with each other to create a working software application
 - Software developers reuse these services in other combinations to assemble other applications as needed.
 - E.g. an “invoice service” to serve whole firm for calculating and sending printed invoices
 - Amazon.com:
 - Direct result of SOA services for interfaces, billing, third-party providers; Amazon’s Merchant Services
 - Dollar Rent A Car
 - Uses Web services to link online booking system with Southwest Airlines’ Web site

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Management Issues

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.

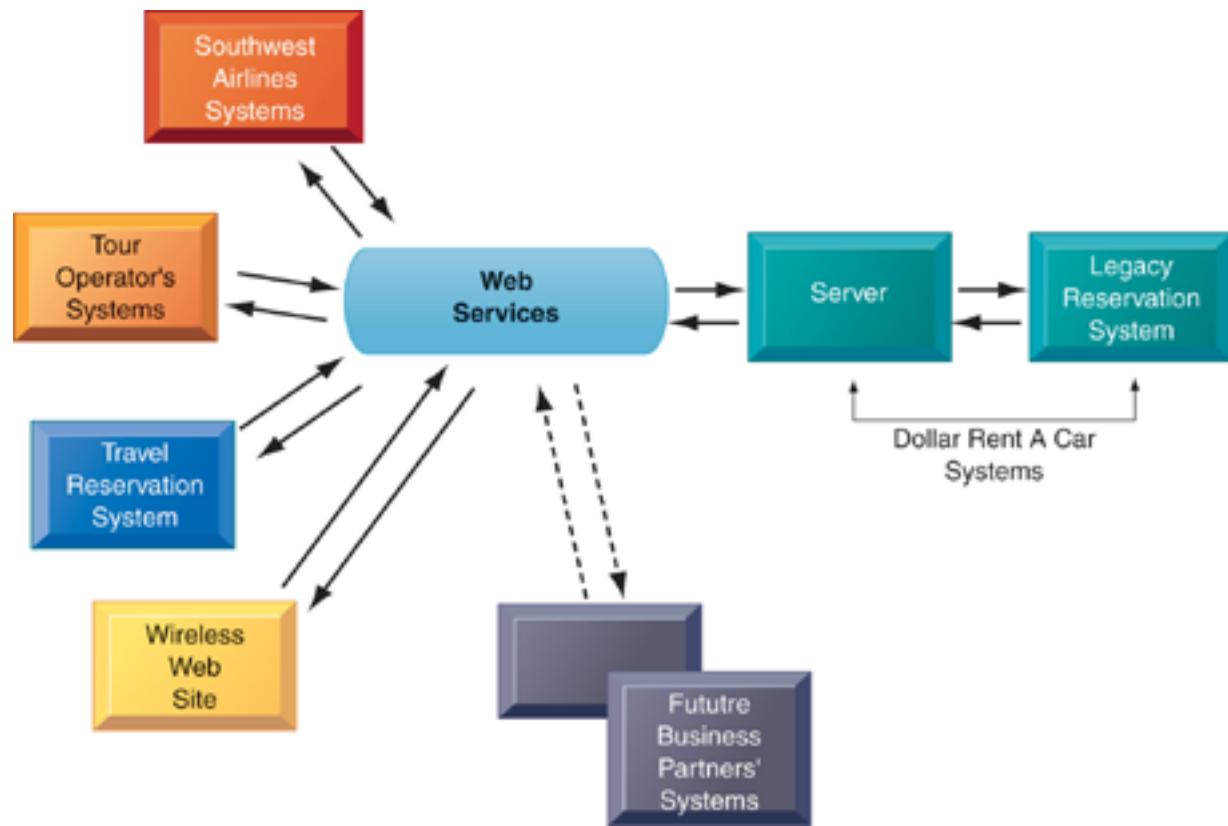


Figure 5-13

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Software Platform Trends and Emerging Technologies

- **Ajax**
 - Software technique for allowing client and server to hold conversation in background, so browser page does not need to be fully reloaded. Google Maps.
- **Web-based software tools**
 - Google's online spreadsheet and word processing
- **Mashups**
 - Combinations of two or more online applications; e.g. combining mapping software (Google Maps) with local content

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Software Platform Trends and Emerging Technologies

- **Web 2.0 key concepts**

- Web becoming collection of capabilities, rather than pages
- Services
- Control over unique data sources
- Users as co-developers
- Harnessing collective intelligence
- Leveraging “long tail” through customer self-service
- Software above level of single device
- Lightweight user interfaces, development models, and business models

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Software Platform Trends and Emerging Technologies

- **Changing sources of software:**
 - Software packages and suites
 - Complex, enterprise software systems
 - Application service providers (ASPs)
 - Business that delivers and manages applications and computer services from remote computer centers to multiple users using the Internet or a private network
 - Outsourcing
 - Domestic or offshore
 - Today, 1/3 U.S. firms outsource software development

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Management Issues

The Changing Sources of Software

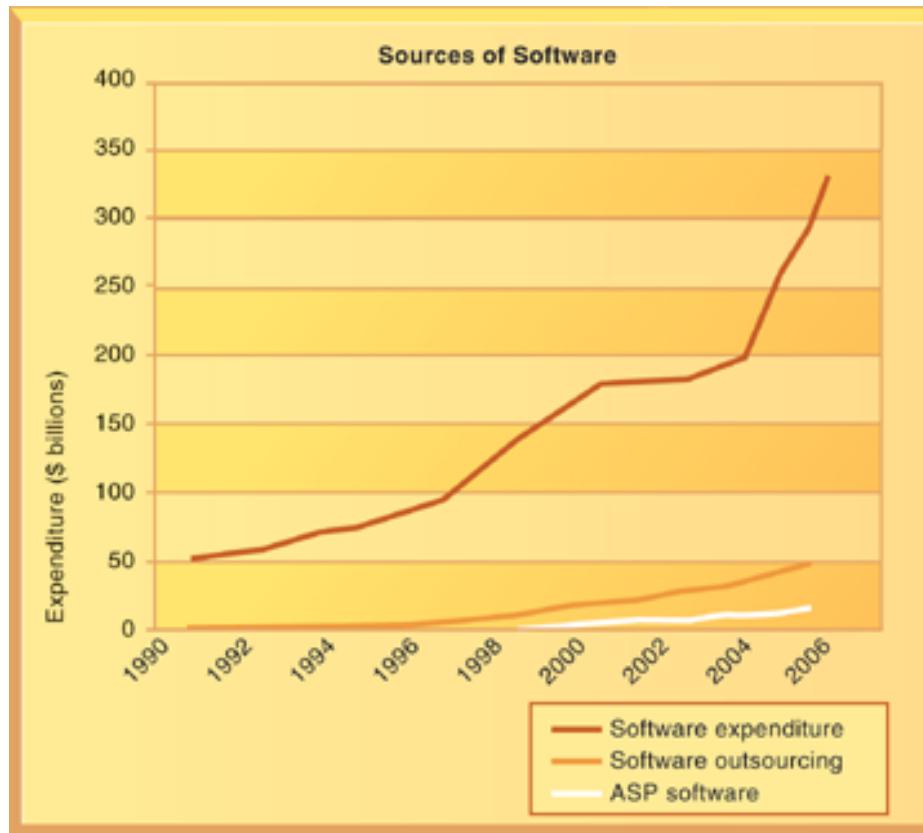


Figure 5-14

U.S. firms will spend nearly \$340 billion on software in 2006. Over 30 percent of that software will come from outsourcing its development and operation to outside firms, and another 15 percent will come from purchasing the service from application service providers either on the Web or through traditional channels.

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Management Issues

- **Dealing with scalability and change**
 - As firms shrink or grow, IT needs to be flexible and scalable. Easier said than done.
 - How does firm remain flexible and still make long term investments?
 - Scalability: Ability to expand to serve larger number of users

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Management Issues

- **Management and governance**
 - Who controls IT infrastructure
 - Centralized/decentralized
 - How are costs allocated between divisions, departments?

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Management Issues

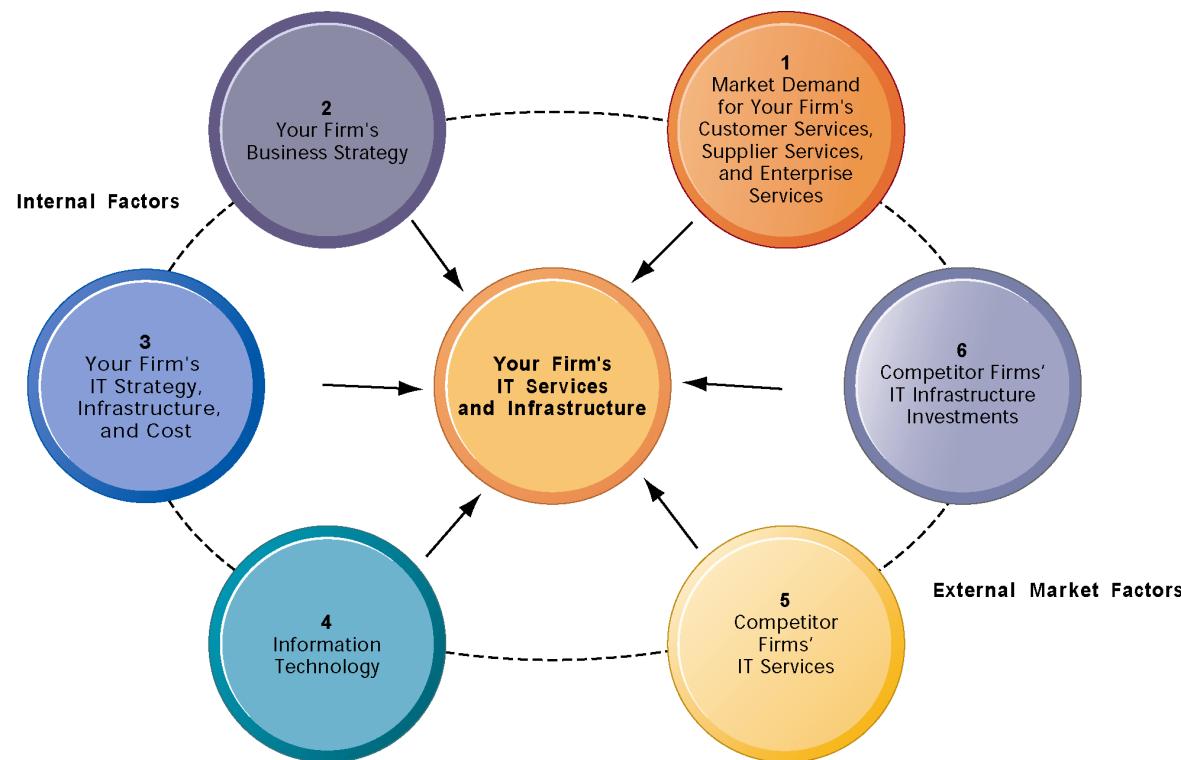
- **Making wise infrastructure investments**
 - Amount to spend on IT is complex question
 - Rent vs. buy, outsourcing
- **Competitive forces model for IT infrastructure investment**
 - Market demand for firm's services
 - Firm's business strategy
 - Firm's IT strategy, infrastructure, and cost
 - Information technology assessment
 - Competitor firm services
 - Competitor firm IT infrastructure investments

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Management Issues

Competitive Forces Model for IT Infrastructure



There are six factors you can use to answer the question, “How much should our firm spend on IT infrastructure?”

Figure 5-15

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Management Issues

- **Total Cost of Ownership of Technology Assets**
 - **TCO model:** Used to analyze direct and indirect costs of systems
 - Hardware, software account for only about 20% of TCO
 - Other costs include: Installation, training, support, maintenance, infrastructure, downtime, space and energy
 - TCO can be reduced through greater centralization and standardization of hardware and software resources