

Chapter 4

IT Infrastructure: Hardware and Software

LEARNING TRACK 5: THE EVOLUTION OF IT INFRASTRUCTURE

Evolution of IT Infrastructure: 1950–2005

The IT infrastructure in organizations today is an outgrowth of over 50 years of evolution in computing platforms. We have identified five stages in this evolution, each representing a different configuration of computing power and infrastructure elements (see Figure 4-1). The five eras are automated special-purpose machines, general-purpose mainframe and minicomputer computing, personal computers, client/server networks, and enterprise and Internet computing.

These eras do not necessarily end for all organizations at the same time, and the technologies that characterize one era may also be used in another time period for other purposes. For example, some companies still run traditional mainframe or minicomputer systems. Mainframe computers today are used as massive servers supporting large Web sites and corporate enterprise applications. More detail on infrastructure history can be found on the Laudon Web site for Chapter 6.

ELECTRONIC ACCOUNTING MACHINE ERA: 1930–1950

The first era of business computing used specialized machines that could sort computer cards into bins, accumulate totals, and print reports (DaCruz, 2004). Although the electronic accounting machine was an efficient processor of accounting tasks, the machines were large and cumbersome. Software programs were hardwired into circuit boards, and they could be changed by altering the wired connections on a patch board. There were no programmers, and a human machine operator was the operating system, controlling all system resources.

GENERAL-PURPOSE MAINFRAME AND MINICOMPUTER ERA: 1959 TO PRESENT

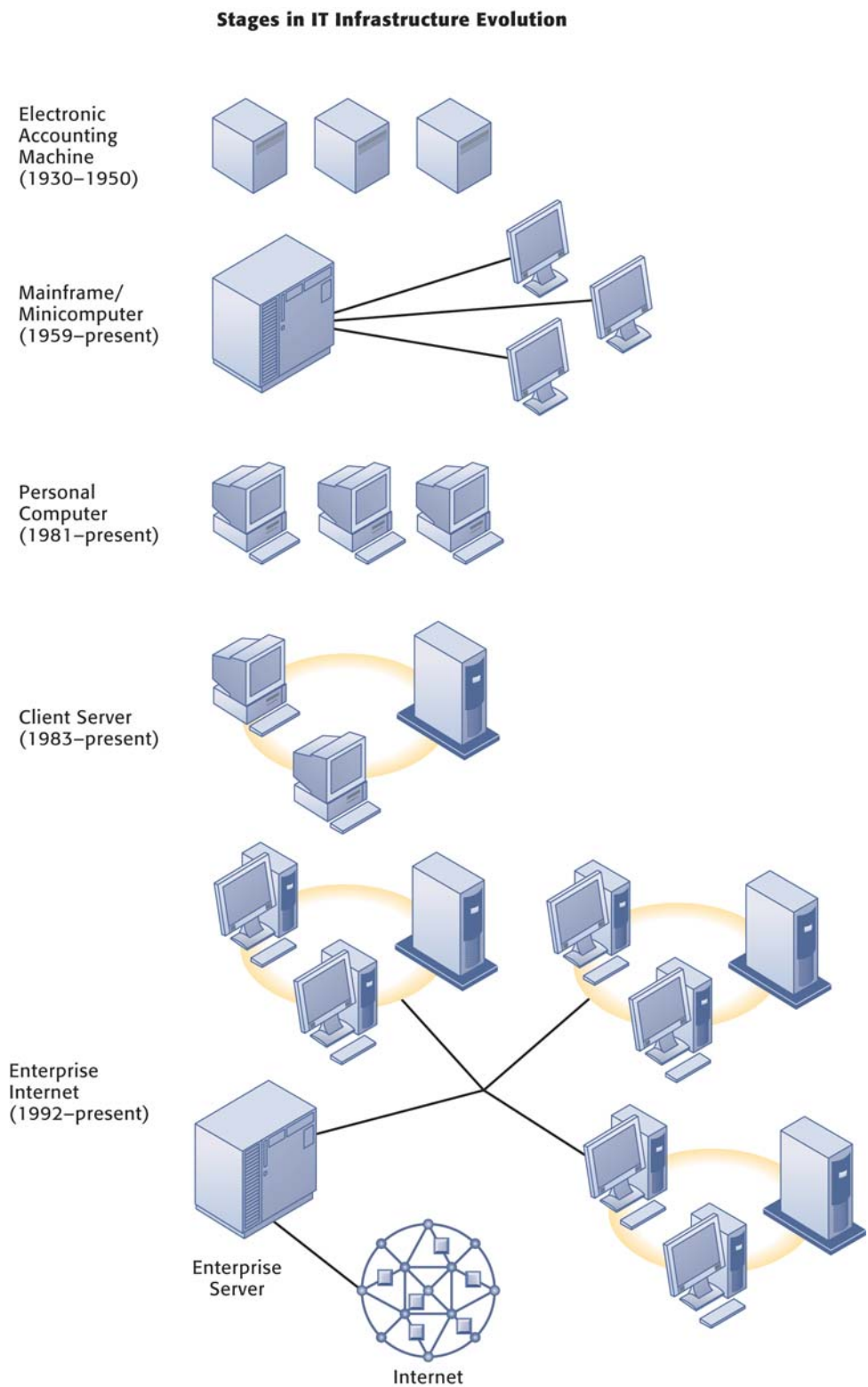
The first commercial all-electronic vacuum tube computers appeared in the early 1950s with the introduction of the UNIVAC computers and the IBM 700 Series. Not until 1959 with the introduction of the IBM 1401 and 7090 transistorized machines did widespread commercial use of mainframe computers begin in earnest. In 1965, the general-purpose commercial mainframe computer truly came into its own with the introduction of the IBM 360 series. The 360 was the first commercial computer with a powerful operating system that could provide time sharing, multitasking, and virtual memory in more advanced models.

Mainframe computers eventually became powerful enough to support thousands of online remote terminals connected to a centralized mainframe using proprietary communication protocols and proprietary data lines. The first airline reservation systems appeared in 1959 and became the prototypical online, real-time interactive computing system that could scale to the size of an entire nation.

IBM dominated mainframe computing from 1965 onward and still dominates this \$27 billion global market in 2004. Today IBM mainframe systems can work with a wide variety of different manufacturers' computers and multiple operating systems on client/server networks and networks based on Internet technology standards.

FIGURE 4-1 Eras in IT infrastructure evolution.

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



The mainframe era was a period of highly centralized computing under the control of professional programmers and systems operators (usually in a corporate data center), with most elements of infrastructure provided by a single vendor, the manufacturer of the hardware and the software. This pattern began to change with the introduction of minicomputers produced by Digital Equipment Corporation (DEC) in 1965. DEC minicomputers (PDP-11 and later the VAX machines) offered powerful machines at far lower prices than IBM mainframes, making possible decentralized computing, customized to the specific needs of individual departments or business units rather than time sharing on a single huge mainframe.

PERSONAL COMPUTER ERA: (1981 TO PRESENT)

Although the first truly personal computers (PCs) appeared in the 1970s (the Xerox Alto, MIT's Altair, and the Apple I and II, to name a few), these machines had only limited distribution to computer enthusiasts. The appearance of the IBM PC in 1981 is usually credited as the beginning of the PC era because this machine was the first to become widely adopted in American businesses. At first using the DOS operating system, a text-based command language, and later the Microsoft Windows operating system, the Wintel PC computer (Windows operating system software on a computer with an Intel microprocessor) became the standard desktop personal computer. Today, 95 percent of the world's estimated 1 billion computers use the Wintel standard.

Proliferation of PCs in the 1980s and early 1990s launched a spate of personal desktop productivity software tools—word processors, spreadsheets, electronic presentation software, and small data management programs—that were very valuable to both home and corporate users. These PCs were standalone systems until PC operating system software in the 1990s made it possible to link them into networks.

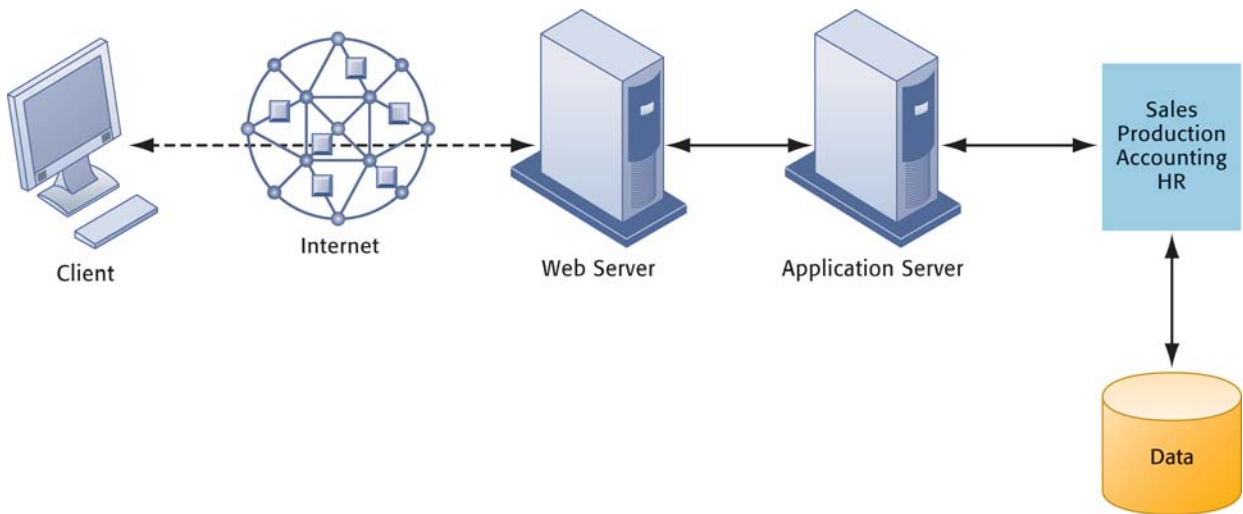
CLIENT/SERVER ERA (1983 TO PRESENT)

In client/server computing, desktop or laptop computers called clients are networked to server computers that provide the client computers with a variety of services and capabilities. Computer processing work is split between these two types of machines. The client is the user point of entry, whereas the server provides communication among the clients, processes and stores shared data, serves up Web pages, or manages network activities. The term server refers to both the software application and the physical computer on which the network software runs. The server could be a mainframe, but today server computers typically are more powerful versions of personal computers, based on inexpensive Intel chips and often using multiple processors in a single computer box.

The simplest client/server network consists of a client computer networked to a server computer, with processing split between the two types of machines. This is called a two-tiered client/server architecture. Whereas simple client/server networks can be found in small businesses, most corporations have more complex, multitiered (often called N-tier) client/server architectures in which the work of the entire network is balanced over several different levels of servers, depending on the kind of service being requested (see Figure 4-2).

For instance, at the first level a Web server will serve a Web page to a client in response for a request for service. Web server software is responsible for locating and managing stored Web pages. If the client requests access to a corporate system (a product list or price information, for instance), the request is passed along to an application server. Application server software handles all application operations between a user and an organization's back-end business systems. The application server may reside on the same computer as the Web server or on its own dedicated computer.

Client/server computing enables businesses to distribute computing work across a number of smaller, inexpensive machines that cost much less than minicomputers or centralized mainframe systems. The result is an explosion in computing power and applications throughout the firm.

FIGURE 4-2 A multitiered client/server network (N-tier).

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

Novell Netware was the leading technology for client/server networking at the beginning of the client/server era. Today Microsoft is the market leader, with its Windows operating systems (Windows Server, Windows XP, Windows 2000), controlling 78 percent of the local area network market.

ENTERPRISE INTERNET COMPUTING ERA (1992 TO PRESENT)

The success of the client/server model posed a new set of problems for corporations. Many large firms found it difficult to integrate all of their local area networks (LANs) into a single, coherent corporate computing environment. Applications developed by local departments and divisions in a firm, or in different geographic areas, could not communicate easily with one another and share data.

In the early 1990s, firms turned to networking standards and software tools that could integrate disparate networks and applications throughout the firm into an enterprise-wide infrastructure. As the Internet developed into a trusted communications environment after 1995, business firms began using the Transmission Control Protocol/ Internet Protocol (TCP/IP) networking standard to tie their disparate networks together.

The resulting IT infrastructure links different types and brands of computer hardware and smaller networks into an enterprise-wide network so that information can flow freely across the organization and between the firm and other organizations. Enterprise networks link mainframes, servers, PCs, mobile phones, and other handheld devices, and connect to public infrastructures such as the telephone system, the Internet, and public network services.

The enterprise infrastructure employs software that can link disparate applications and enable data to flow freely among different parts of the business. Other solutions for enterprise integration include enterprise application integration software, Web services, and outsourcing to external vendors that provide hardware and software for a comprehensive enterprise infrastructure.

The enterprise era promises to bring about a truly integrated computing and IT services platform for the management of global enterprises. The hope is to deliver critical business information painlessly and seamlessly to decision makers when and where they need it to create customer value. This could be everything from getting inventory data to the mobile salesperson in the customer's office, to helping a customer at a call center

with a problem customer, or providing managers with precise up-to-the-minute information on company performance.

That is the promise, but the reality is wrenchingly difficult and awesomely expensive. Most large firms have a huge, tangled web of hardware systems and software applications inherited from the past. This makes achieving this level of enterprise integration a difficult, long-term process that can last perhaps as long as a decade and cost large companies hundreds of millions of dollars. Table 4-1 compares each era on the infrastructure dimensions discussed above.

TABLE 4-1 Stages in the IT Infrastructure Evolution

Infrastructure Dimension	Electronic Accounting Machine Era (1930–1950)	Mainframe Era (1959 to Present)	PC Era (1981 to Present)	Client/Server Era (1983 to Present)	Enterprise Era (1992 to Present)
Signature Firm(s)	IBM Burroughs NCR	IBM	Microsoft/Intel Dell HP IBM	Novell Microsoft	SAP Oracle PeopleSoft
Hardware Platform	Programmable card sorters	Centralized mainframe	Wintel computers	Wintel computers	Multiple: <ul style="list-style-type: none"> • Mainframe • Server • Client
Operating System	Human operators	IBM 360 IBM 370 Unix	DOS/Windows Linux IBM 390	Windows 3.1 Windows Server Linux	Multiple: <ul style="list-style-type: none"> • Unix/Linux • OS 390 • Windows Server
Application and Enterprise Software	None; application software created by technicians	Few enterprise-wide applications; departmental applications created by in-house programmers	No enterprise connectivity; boxed software	Few enterprise-wide applications; boxed software applications for workgroups and departments	Enterprise-wide applications linked to desktop and departmental applications: <ul style="list-style-type: none"> • mySAP • Oracle E-Business Suite • PeopleSoft Enterprise One
Networking/Telecommunications	None	Vendor-provided: <ul style="list-style-type: none"> • Systems Network Architecture (IBM) • DECNET (Digital) • AT&T voice 	None or limited	Novell NetWare Windows 2003 Linux AT&T voice	LAN Enterprise-wide area network (WAN) TCP/IP Internet standards-enabled
System Integration	Vendor-provided	Vendor-provided	None	Accounting and consulting firms Service firms	Software manufacturer Accounting and consulting firms System integration firms Service firms

Data Storage and Database Management	Physical card management	Magnetic storage Flat files Relational databases	DBase II and III Access	Multiple database servers with optical and magnetic storage	Enterprise database servers
Internet Platforms	None	Poor to none	None at first Later browser-enabled clients	None at first Later: <ul style="list-style-type: none">• Apache server• Microsoft IIS	None in the early years Later: <ul style="list-style-type: none">• Intranet- and Internet-delivered enterprise services• Large server farms