

Chapter 5

Information Technology Infrastructure

Overview

Information technology is the application of computers and telecommunication equipments to store, retrieve, transmit and manipulate data, often in the context of a business or other enterprise. The term is commonly used as a synonym for computers and computer networks, but it also encompasses other information distribution technologies such as television and telephones. Humans have been storing, retrieving, manipulating and communicating information since the Sumerians in Mesopotamia developed writing in about 3000 BC, but the term *information technology* in its modern sense first appeared in a 1958 article published in the Harvard Business Review; authors Harold J. Leavitt and Thomas L.

As information becomes a valuable resource of a digital firm, the infrastructure used to care for it is also considered as valuable resource of an organization. This Chapter will examine all of the components that comprise today's and tomorrow's IT infrastructure and how it can be managed in best way.

What is IT Infrastructure?

IT infrastructure refers to the composite hardware, software, network resources and services required for the existence, operation and management of an enterprise IT environment. It allows an organization to deliver IT solutions and services to its employees, partners and customers and is usually internal to an organization and deployed within owned facilities. Typically, a standard IT infrastructure consists of the following components:

- **Hardware:** Servers, computers, data centers, switches, hubs and routers, etc.
- **Software:** Enterprise resource planning (ERP), customer relationship management (CRM), productivity applications and more.
- **Network:** Network enablement, Internet connectivity, firewall and security.
- **Persware:** Human users, such as network administrators, developers, designers and generic end users with access to any IT appliance or service are also part of an IT infrastructure, specifically with the advent of user-centric IT service development.

To round out the list of IT infrastructure components we need to add the following services to computing hardware and software:

- Computing services: Provide platforms that ensure a coherent digital environment
- Telecommunications services: Determine appropriate data, voice, and video that connect employees, customers, and suppliers
- Data management services: Not just store, but manage massive amounts of corporate data and make it available for users to analyze
- Application software services: Enterprise resource planning, customer relationship management, supply chain management and knowledge management systems
- Physical facilities management services: Physical installation of computing, telecommunications, and data management services
- IT management services: Plan and develop infrastructures, coordinate IT services among business units, account for IT expenditure, and provide project management services
- IT standards services: Develop policies that ensure interoperability of all IT infrastructure components
- IT education services: Train employees to properly use IT investments and educate managers about planning for and managing the investments
- IT research and development services: Research future IT projects and investments

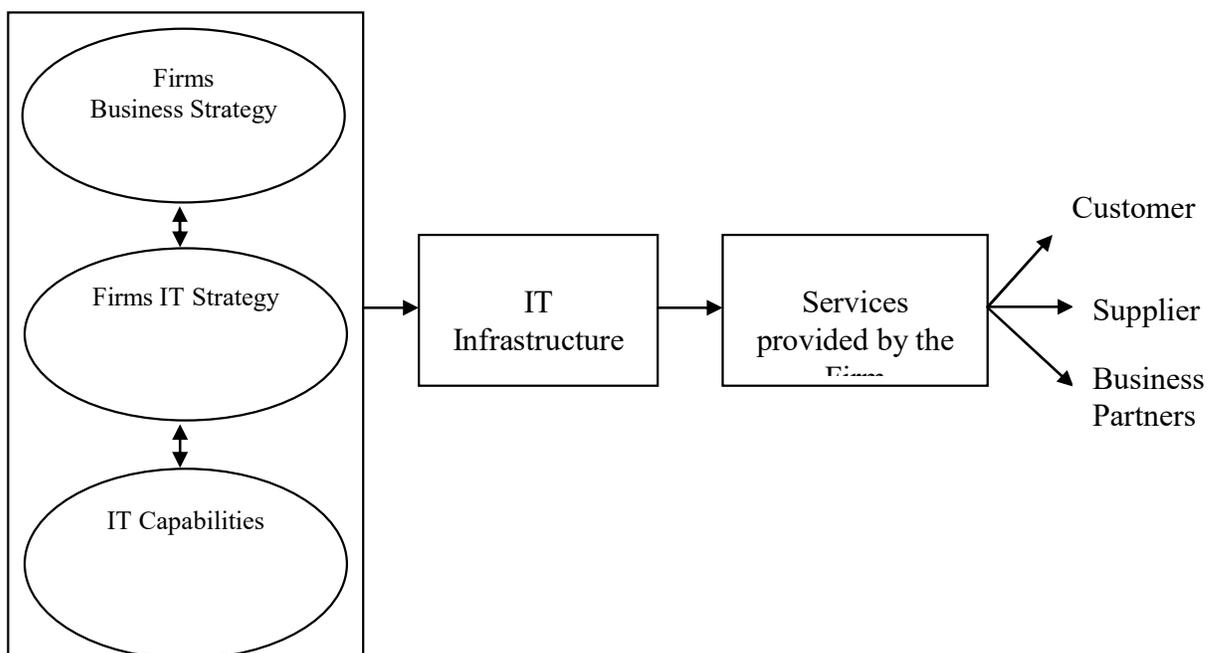


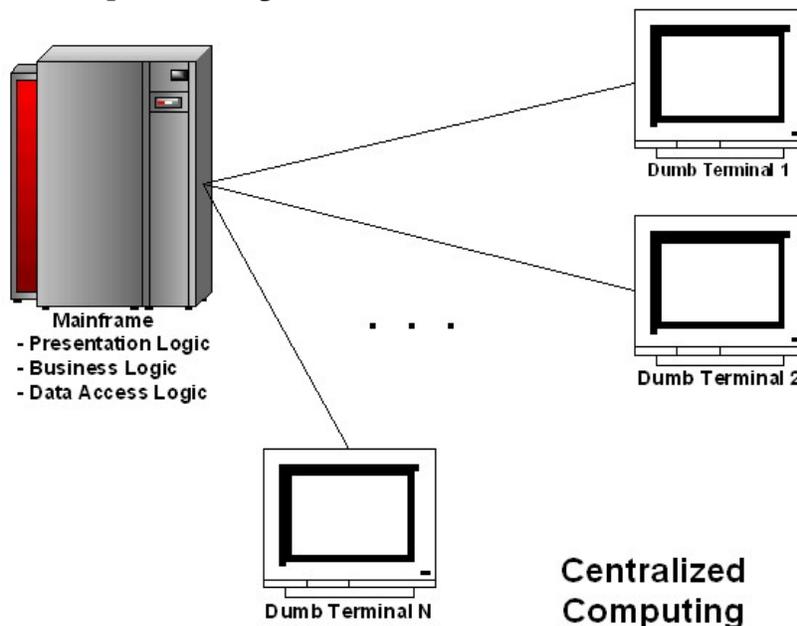
Fig: Connection between Firm, IT Infrastructure and Business Capabilities

Evolution of IT Infrastructure

Reviewing the evolution of corporate IT infrastructure offers some insight into where we may be headed. Five stages in the evolution of IT infrastructure can be identified. Which are described below:

General-purpose mainframe and minicomputer era (1959 to present)

The introduction and continued use of mainframes. Mainframes were the first powerful computers that could provide time sharing, multi tasking, and virtual memory, and became powerful enough to support thousands of remote terminals. The mainframe era was a period of highly centralized computing controlled by programmers and system operators. In this era dumb terminals were normally connected with centralized computing facilities. Minicomputers are, powerful yet less expensive computers, began to change this pattern, allowing decentralized computing customizable to individual departments or business units. It's interesting to note that IBM began this era and remains the sole supplier of mainframe computing. Although the experts and pundits predicted the death of mainframes in the mid-1980s, they have evolved and remain a strong, viable component in many IT infrastructures because of their ability to store and process huge amounts of data and transmissions



Personal computer era (1981 to present)

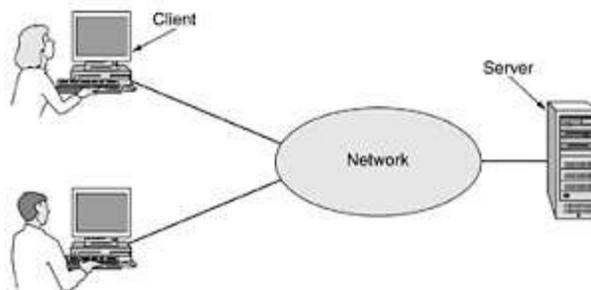
The appearance of the IBM PC in 1981 is usually considered the beginning of the PC era. Advances developed for personal computers in the home have given rise to much of the advances in corporate computing in the last 25 years. As the home

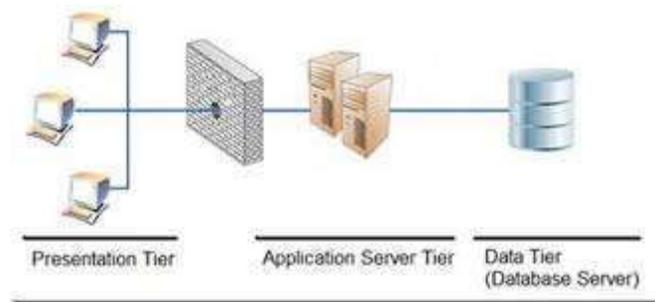
user became more comfortable with using computers, and more applications were developed for personal computers, employees demanded increased use of computers in the workplace. While the **Wintel PC** standard has dominated this era, open-source software is starting to put a big dent into that stronghold.



Client/server era (1983 to present)

In client/server computing, desktop or laptop computers called clients are networked to server computers that provide the clients with 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 typically 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. In two-tiered client/server architecture, a client computer is networked to a server with processing split between the two. In multi-tiered (N-tier) client/server architecture, the work of the entire network is balanced over several different levels of servers. Distributing work across a number of smaller inexpensive machines cost much less than minicomputers or mainframes.





Enterprise computing era (1992 to present)

The Internet networking technology Transmission Control Protocol/Internet Protocol (TCP/IP) suite enables enterprises to link disparate devices and local area networks (LANs) into single enterprise-wide networks. Integrated computing environments allows for much faster and seamless gathering and distribution of data. Perhaps no other era has seen the explosive growth in functionality and popularity as this era. The problems created by proprietary, closed systems are being solved by the standards and open-source software created in this era.

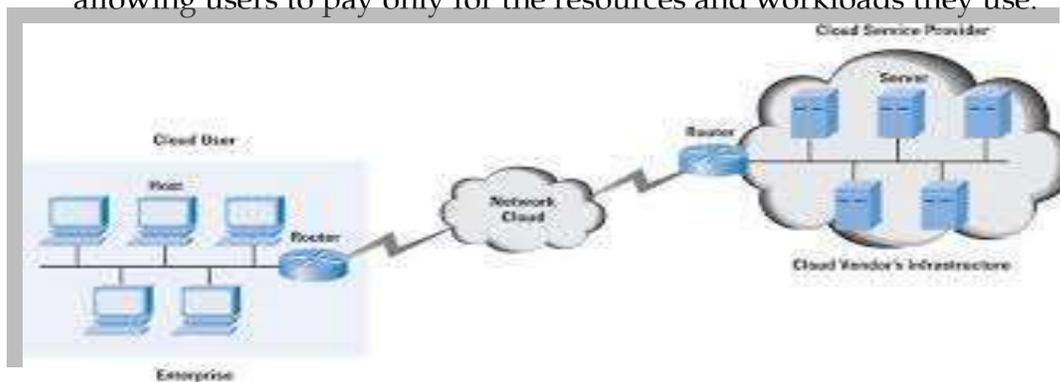


Cloud and mobile computing era (2000 to Present)

Cloud computing is defined as a type of computing that relies on sharing computing resources rather than having local servers or personal devices to handle applications. Cloud computing enables companies to consume compute

resources as a utility -- just like electricity -- rather than having to build and maintain computing infrastructures in-house. Cloud computing promises several attractive benefits for businesses and end users. Three of the main benefits of cloud computing includes:

- **Self-service Provisioning:** End users can spin up computing resources for almost any type of workload on-demand.
- **Elasticity:** Companies can scale up as computing needs increase and then scale down again as demands decrease.
- **Pay per use:** Computing resources are measured at a granular level, allowing users to pay only for the resources and workloads they use.



Technology Drivers of Infrastructure Evolution

There are five important features or characteristics of information technology today that act as drivers toward the expansion and further development of technology. These include:

Moore's Law and Microprocessing Power

Moore's Law states that microprocessing power doubles in every two years. Variations of this law assert that

- Microprocessing power doubles in every 18 months
- Computer power doubles in every 18 months
- The price of computing falls by half in every 18 months.

Perhaps no other law holds as much weight in the evolution of computers as Moore's Law. Microprocessor chips using transistors have helped increase computing power exponentially. At the same time 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® processors 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.

Nanotechnology uses individual atoms and molecules to create computer chips thousands of times smaller than current technologies permit. Nanotubes have potential uses as minuscule wires or in ultrasmall electronic devices. Other technologies promise to further miniaturize transistors and improve chip technology.

The Law of Mass Digital Storage

The Law of Mass Digital Storage states that while the amount of digital information produced worldwide doubles every year, the cost of storing digital information is falling at an exponential rate. In the early evolution of computing, storage needs were based on written text. Now we need the extra storage for photos, music, and video. 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.

Metcalf's Law and Network Economics

Metcalf's Law described the value of a network grows exponentially with each increase in membership to the network. Demand for information technology has been driven by the social and business value of digital networks, which rapidly multiply the number of actual and potential links among network members. If you build a network for ten users, you'll spend the necessary money for the basic equipment. If you already have the equipment in place, you can add one more user at nominal costs. However, the additional user will bring value to the network far beyond what it costs to add him/her.

Declining Communications Costs and the Internet

One of the biggest drivers in the exploding use of computers is directly attributable to the Internet. It's getting cheaper every day to connect to the Internet because of declining communication costs. As more and more users connect to the Internet, businesses must find ways to meet the expectations and demands of users, especially in the area of mobile computing devices.

The rapid decline of communication costs and the exponential growth in size of

Standards and Network Effects

Technology Standards and specifications 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 products built to a certain standard. Some of the important standards that have shaped IT infrastructure include ASCII, UNIX, TCP/IP, Ethernet, the IBM/Microsoft/Intel Personal Computer, and the World Wide Web.

ASCII stands for American standard code for information interchange and made it possible to exchange data among computers developed by different manufacturers. **UNIX** is an open source multitasking operating system that is used by variety by computers developed by different manufacturers. **TCP/IP** stands for transmission control protocol/internet protocol and is a suit of communication protocols that defines common language for establishing communication between different computers attached in a network. Ethernet enables desktop computers to local area networks. IBM/Microsoft/Intel Personal Computer is the standard Wintel design for personal computers based on Intel processors and other devices and Microsoft Windows operating systems.

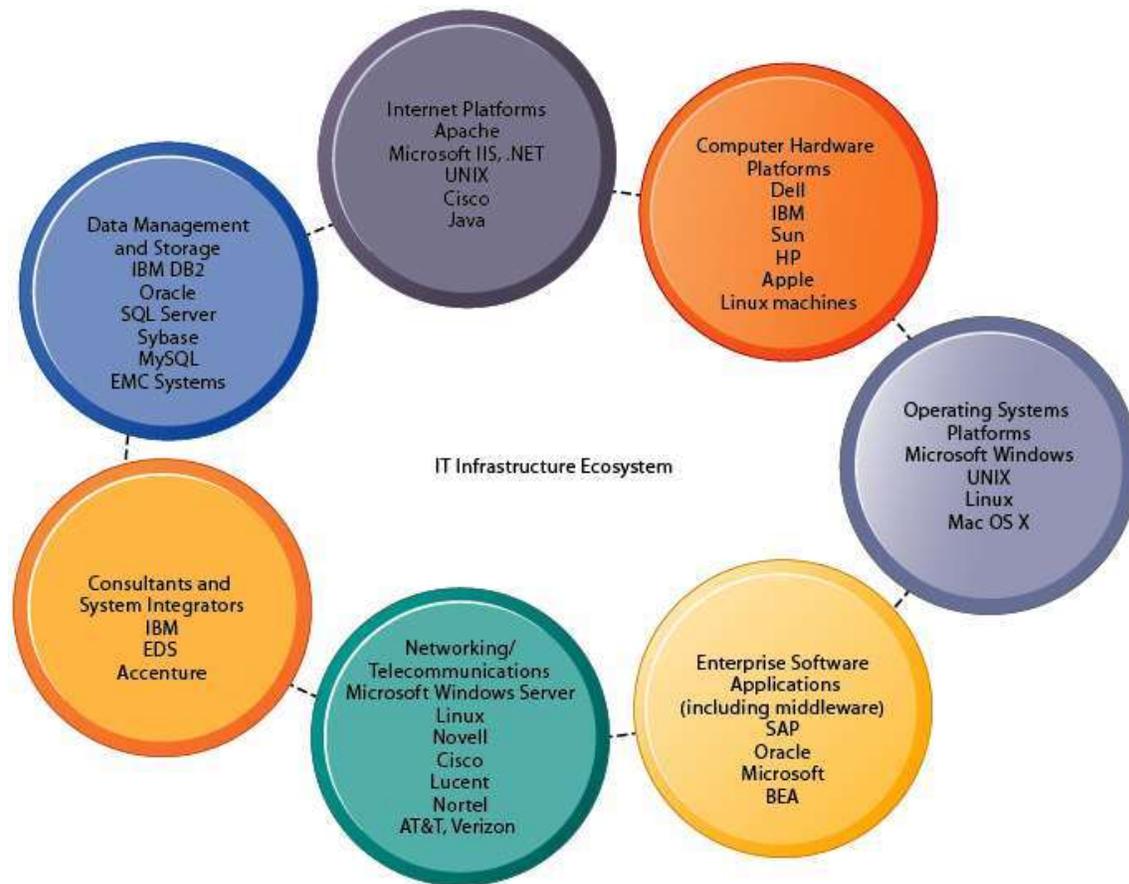
Infrastructure Components

In the early days of personal computers, the printer you had your eye on may not have worked with your brand of computers. You had to buy a scanner built specifically for your computer. You couldn't connect to the Internet unless you had the correct modem for your Internet Service Provider. The evolution we are now experiencing is aiming to fix these problems and make computing ubiquitous anytime, anywhere. IT infrastructure is composed of seven major components that aim to achieve above mentioned goal.

1. **Computer Hardware Platforms:** It includes client machines and server machines, as well as modern main frames produced by IBM. Blade Servers are ultrathin servers, intended for a single dedicated application, and are mounted in space-saving racks.
2. **Operating System Platforms:** It includes platforms for client computers, dominated by Windows operating systems, and servers, dominated by the various forms of the UNIX operating system or Linux. Operating

Systems are software that manage the resources and activities of the computer and act as an interface for the user.

3. **Enterprise and Other Software Applications:** It includes SAP, Oracle, and PeopleSoft, and middleware software that are used to link a firm's existing application systems.
4. **Data Management and Storage:** It is handled by database management software and storage devices include traditional storage methods, such as disk arrays and tape libraries, and newer network-based storage technologies such as storage area networks (SANs). It is the network that connects multiple storage devices on dedicated high-speed networks.
5. **Networking and Telecommunications Platforms:** It includes Windows server operating systems, Novell, Linux, and UNIX. Nearly all LANs and many wide area networks (WANs) use the TCP/IP standards for networking.
6. **Internet Platforms:** It overlaps with, and must relate to, the firm's general networking infrastructure and hardware and software platforms. Internet-related infrastructure includes the hardware, software and services to maintain corporate Web sites, intranets, and extranets, including Web hosting services and Web software application development tools. A Web hosting service maintains a large Web server, or series of servers, and provides fee-paying subscribers with space to maintain their Web sites.
7. **Consulting and System Integration Services:** These are relied on for integrating a firm's legacy systems with new technology and infrastructure and providing expertise in implementing new infrastructure along with relevant changes in business processes, training, and software integration. Legacy systems are generally older transaction processing systems created for mainframe computers that continue to be used to avoid the high cost of replacing or redesigning them.



Hardware Platforms and Emerging Technologies

If some of these IT infrastructure components like storage and telecommunications have gotten so cheap, why does it seem like companies are spending more and more money on information technology? This is because users are demanding better, faster, and easier ways to use computers and more ways to communicate with others. Let's discuss some of these hardware technologies that are helping companies meet the growing technology demand of employees, customers, suppliers, and business partners.

The Emerging Mobile Digital Platform

Anytime, anywhere, 24/7, 365. That's what computer users now expect. Technology manufacturers are meeting the demand with a host of new communication devices like cell phones and smartphones. The newest gadgets

on the market are **tablets** and e-book readers like the Kindle from Amazon.com or Barnes & Noble's Nook reader. Smartphones are getting – well – smarter, and proving more reasons for users to migrate away from traditional desktop PC computing.. Tablets are miniaturized subnotebooks that are built specifically for wireless communications and Internet access. Even though they may be small in size, they still pack a lot of computing power.

Grid Computing

Take a moment and think about how much time you *don't* use your personal computer. It's actually quite a lot. In fact, most computers are idle more time than not. What if you could combine all the idle time of hundreds or thousands of computers into a continuous, connected computing capacity to capture, process, manage, store, and retrieve data? You wouldn't have to purchase mammoth, super computers to realize this capability and capacity.

Grid computing is the technique that utilizes the idle computational resources of separate, geographically remote computers to create a single virtual supercomputer. In this process, a server computer breaks data and applications into discrete chunks that are parceled out to the grid's machines. Three reasons why grid computing is appealing to companies include:

- Cost savings
- Computational speed
- Computational agility

Virtualization and Multicore Processors

Virtualization is the process of presenting a set of computing resources (such as computing power or data storage) so that they can all be accessed in ways that are not restricted by physical configuration or geographic location. Server virtualization enables companies to run more than one operating system at the same time on a single machine. Most servers run at just 10 to 15 percent of capacity, and virtualization can boost utilization server utilization rates to 70 percent or higher. Here's a list of the benefits businesses enjoy from using virtualization:

- Increase equipment utilization rates
- Conserve data center space and energy usage
- Require fewer computers and servers
- Combine legacy applications with newer applications
- Facilitate centralization and consolidation of hardware administration

A Multicore processor is an integrated circuit that contains two or more processors. This technology enables two or more processing engines with reduced power requirements and heat dissipation to perform tasks faster than a resource-hungry chip with a single processing core.

Cloud Computing and the Computing Utility

Cloud computing is already defined in this chapter. Basically, **cloud computing** is defined by five characteristics:

- **On-demand self-service:** Users can access computing capabilities whenever and wherever they are.
- **Ubiquitous network access:** No special devices are necessary for accessing data or services.
- **Location independent resource pooling:** Users don't need to be concerned about where the data are stored.
- **Rapid elasticity:** Computing resources expand and contract as necessary to serve users.
- **Measured service:** Users pay only for the computing capabilities actually used.

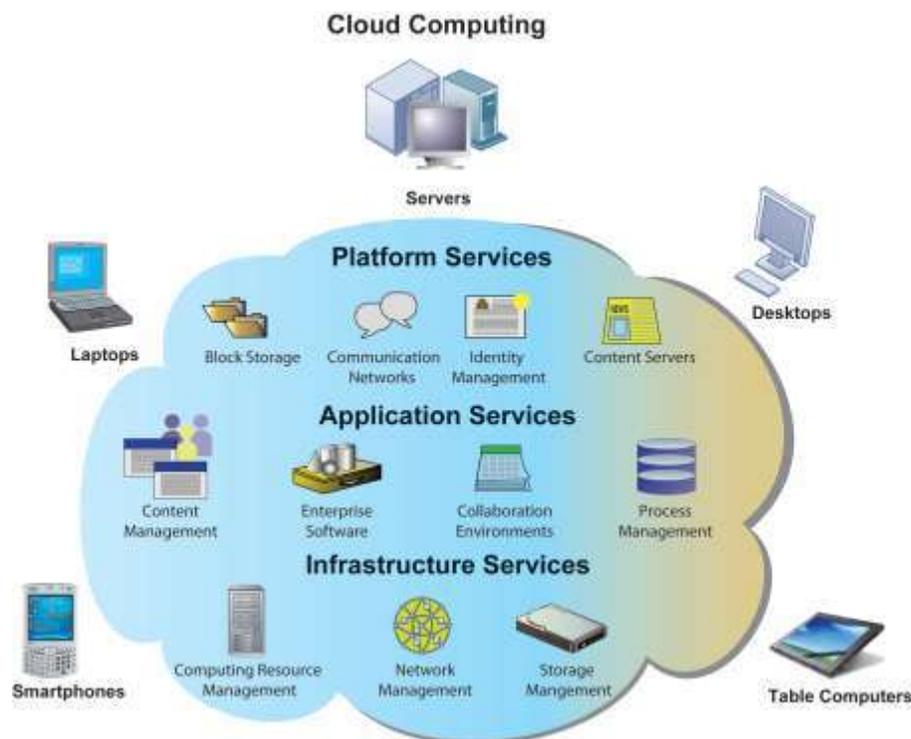


Figure 5-10 Cloud Computing Platform

Almost any type of computing device can access data and applications from these clouds through three types of services:

- **Cloud infrastructure as a service:** Allows customers to process and store data, and use networking and other resources available from the cloud.
- **Cloud platform as a service:** The service provider offers infrastructure and programming tools to customers so they can develop and test applications.
- **Cloud software as a service:** The vendor provides software programs on a subscription fee basis.

Cloud computing is becoming popular because customers only pay for the computing infrastructure that they actually use. In many cases users experience lower IT costs than if they had to buy all the equipment, hire the technical staff to run it and maintain it, and purchase software applications. This type of **on-demand computing** is beneficial to small and medium-size companies since they can easily scale up and down their IT requirements as the pace of their business demands it. Larger organizations however, may not want their most sensitive data stored on servers which they don't control. System reliability is also a special concern to all businesses. The unavailability of business data and applications for even a few hours may be unacceptable. Three kinds of clouds are available:

- **Public cloud:** A public cloud is basically the internet. Service providers use the internet to make resources, such as applications and storage, available to the general public. Examples of public clouds include Amazon Elastic Compute Cloud (EC2), IBM's Blue Cloud, Sun Cloud, Google AppEngine and Windows Azure Services Platform.
- **Private cloud:** These clouds are data center architectures owned by a single company that provides flexibility, scalability, provisioning, automation and monitoring. The goal of a private cloud is not sell "as-a-service" offerings to external customers but instead to gain the benefits of cloud architecture without giving up the control of maintaining your own data center.
- **Hybrid cloud:** By using a Hybrid cloud, companies can maintain control of an internally managed private cloud while relying on the public cloud as needed. For instance during peak periods individual applications, or portions of applications can be migrated to the Public Cloud.

Autonomic Computing

Autonomic computing is a step toward creating an IT infrastructure that is able to diagnose and fix problems with very little human intervention. It is an industry-wide effort to develop systems that can configure, optimize, repair, and protect themselves against intruders and viruses, in an effort to free system administrators from routine system management, reduce costly system crashes. Today's virus software with automatic virus updates is one example of autonomic computing. Thus autonomic computing features systems that can:

- Configure themselves
- Optimize and tune themselves
- Heal themselves when broken
- Protect themselves from intruders and self-destruction

Although this type of computing is still rather new, it promises to relieve the burden many companies experience in trying to maintain massive, complex IT infrastructures.

Software Platform Trends and Emerging Technologies

You can have all the computer hardware money can buy, but if you don't have the right software, you can't do very much with the hardware and you've wasted a lot of money. There are five major themes in contemporary software platform evolution:

1. Linux and open-source software
2. Java
3. Enterprise software
4. Web services and service-oriented architecture
5. Software outsourcing

Linux and Open-Source Software

Open-Source software is software produced by a community of several hundred thousands of programmers around the world, and is available free of charge to be modified by users, with minimal restrictions. The premise that open-source software is superior to commercial software is based on the ability of thousands of programmers modifying and improving the software at a much faster rate. In return for their work, programmers receive prestige and access to a network of other programmers, and additional for-pay work opportunities. The process of

improving open source software is monitored by self-organized, professional programming communities. Thousands of open-source programs, ranging from operating systems to office suites, are available from hundreds of Web sites.

Linux is an operating system related to UNIX, is one of the most well-known open-source software, and is the world's fastest growing client and server operating system, along with related Linux applications. The rise of open-source software, particularly Linux and the applications it supports, has profound implications for corporate software platforms: cost reduction, reliability and resilience, and integration, because Linux works on all the major hardware platforms from mainframes to servers to clients. Because of its reliability, low cost, and integration features, Linux has the potential to break Microsoft's monopoly of the desktop.

Open-source software isn't limited to Linux but includes applications such as Mozilla Firefox Web browser and free office suite software such as OpenOffice. OpenOffice.org is the result of over twenty years' software engineering. Designed from the start as a single piece of software, it has a consistency other products cannot match.

Software for the Web: Java, AJAX, and HTML

Java is an operating system-independent, object-oriented programming language, has become the leading programming environment for the Web, and its use has migrated into cellular phones, cars, music players, and more. For each of the computing environments in which Java is used, Sun has created a Java Virtual Machine that interprets Java programming code for that machine. In this manner, the code is written once and can be used on any machine for which there exists a Java Virtual Machine. A Macintosh PC, an IBM PC running Windows, a Sun server running UNIX, and even a smart cellular phone or personal digital assistant can share the same Java application.

AJAX stands for **A**synchronous **J**avaScript and **X**ML. AJAX is a new technique for creating better, faster, and more interactive web applications with the help of XML, HTML, CSS, and Java Script. Conventional web applications transmit information to and from the sever using synchronous requests. It means you fill out a form, hit submit, and get directed to a new page with new information from the server. With AJAX, when you hit submit, JavaScript will make a request to the server, interpret the results, and update the current screen. In the purest

sense, the user would never know that anything was even transmitted to the server. Simply we can say that AJAX is about updating parts of a web page, without reloading the whole page.

Hypertext markup language (HTML) is the language that used for creating web pages. The original version of HTML was created when the Web was first borne. It never took into account that eventually people would want to incorporate audio, video, and pictures within a Web page. More importantly, the authors of basic HTML language never envisioned that people would want to access the Web through small handheld devices, smartphones, tablets, and notebooks. As our computing hardware has evolved, so too must the software that provides information to all those devices. The next evolution of HTML is **HTML5**.

Web Services and Service-Oriented Architecture

Web services are XML-based information exchange systems that use the Internet for direct application-to-application interaction. These systems can include programs, objects, messages, or documents. Software applications written in various programming languages and running on various platforms can use web services to exchange data over computer networks like the Internet in a manner similar to inter-process communication on a single computer. This interoperability (e.g., between Java and Python, or Windows and Linux applications) is due to the use of open standards. Four software standards and communication protocols provide easy access to data and information via Web services:

- **XML** – eXtensible Markup Language: Describes data in Web pages and databases.
- **SOAP** – Simple Object Access Protocol: Allows applications to exchange data and instructions.
- **WSDL** – Web Services Description Language: Describes a Web service so that other applications can use it.
- **UDDI** – Universal Description, Discovery, and Integration: Lists Web services in a directory so users can find them.

A **service-oriented architecture (SOA)** is architecture in computer software design in which application components provide services to other components via a communication protocol, typically over a network. The principles of service-orientation are independent of any vendor, product or technology.

Software Outsourcing and Cloud Services

Like businesses were going to outside vendors to meet their hardware needs, Organizations are now doing much the same for their software needs. Three external sources for software outsourcing are: Software packages from a commercial vendor, cloud-based software services and tools, and outsourcing custom application development

- **Software Packages and Enterprise Software:** A commercial software package is a prewritten set of software programs for certain functions, eliminating the need for a firm to write its own software program. Rather than design, write, test, and maintain legacy systems, many organizations choose to purchase software packages from other companies that specialize in certain programs. Enterprise software is large and complex software that includes content, collaboration, and communication software. These systems are so complex that few corporations have the expertise to develop these in house. Vendors such as SAP and PeopleSoft have developed powerful software packages that can support business processes such as customer relationship management, supply chain management, human resource management.
- **Software Outsourcing:** Outsourcing is a mechanism in which a firm contracts custom software development or maintenance to outside firms, normally to the firms operating in low-wage areas of the world. With the growing sophistication and experience of offshore firms, more and more new-program development is outsourced. The Internet has made this option more viable than it ever was. Companies primarily outsource to reduce certain costs – such as peripheral or "non-core" business expenses, high taxes, high energy costs, excessive government regulation/mandates, production and/or labor costs. The incentive to outsource may be greater for U.S. companies due to unusually high corporate taxes and mandated benefits, like social security, Medicare, and safety protection
- **Cloud-based Software Services and Tools:** Small and mid-size companies in need of sophisticated software can rent only what they need and can afford through online software as a service (SaaS) providers. For instance, Right Now Technologies provides applications services via the Internet for customer service and marketing programs. Because these

services are Web-based, data are accessible from virtually any computer connected to the Internet. Workers can collaborate with others in distant offices through a Web-based SaaS, and no one has to worry about their files being compatible with others. There is some danger to outsourcing your information resources to this kind of service. Remember, all your data are stored on another company's server computers and you have little control of it. What happens if the service provider goes out of business? How secure are data stored on the servers? These are just some of the issues managers must address when they consider using SaaS providers versus in-house technology support. Businesses must exercise caution when using software outsourcing or SaaS providers. Service level agreements (SLA) help protect both customers and the service providers.

Mashups and Apps

The term mash-up refers to a new breed of Web-based applications created by programmers to mix at least two different services from disparate, and even competing, Web sites. The term mash-up comes from the hip-hop music practice of mixing two or more songs. Mash-ups are often created by using a development approach called Ajax . Here's a sampling of mash-up Web sites:

- Panoramio : a mash-up of Google Maps and geopositioned photographs of locations
- Hiking Outpost : a mash-up of Amazon and online hiking information resources
- HousingMaps : a mash-up of Google Maps and Craigslist rental ads that displays geographical information for rental properties.

App is an abbreviated form of the word application, and are very small programs that perform one particular task. They can be loaded to your hand-held computing device, including smartphones, e-book readers (in some cases) or tablet computers like the iPad. It's worth noting that most apps are developed for a specific device or devices from a specific company. Apps that are written for the Apple company will run on any Apple device. However, apps written for an Apple device will generally not run on a device manufactured or sold by Samsung or a BlackBerry. More and more apps are being created for the business user that lets her access server documents, call up sales data from the corporate database, or schedule meetings with colleagues or customers.