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Abstract

Information technology simultaneously drives and facilitates global business. The World Wide Web (WWW) represents a paradigm shift of comparable significance to that of the printing press due to its capability of broadcasting not only the written word (static information) but also entire software applications (dynamic information). The WWW surfaces a new level of power and effectiveness for the Internet-Intranet-Extranet (Net) enabled organization similar to the benefits brought about by the three-tier/hyper-tier structure in the client-server computing model. The Internet acts as a natural extension of the intranet and the extranet, since the underlying technologies (e.g., TCP/IP, HTML, HTTP, CGI, URL) are continuous with one another. This enables global access to applications such as data warehousing, on-line analytical processing (OLAP), data mining and data visualization, thus contributing to the productivity of millions of knowledge workers across the globe. This also enables organizations to allow access outside of their own employee base to customers, partners, suppliers, and investors.

Introduction

A global electronic information system is achieved through the synergistic efforts of many people. Its characteristics are manifold interconnections among networks, heterogeneity, a melange of public and private services, widely distributed network management, and architectural structures to achieve a sensitive balance among cost, reliability, and performance. The focus of this paper is to discuss the Internet-Intranet-Extranet connection issues and propose a hyper-tier architecture model that will make multi-tier architectures and Internet/Web access transparent to users. Its purpose is twofold, one to help corporations take a "big picture" look at their investments in Net technologies; and two to suggest a practical approach to managing the need for information, before it becomes unmanageable. First, the common Web-enabling technologies are defined, followed by the discussion of the three wave evolution of the World Wide Web (WWW). Next, a hyper-tier model is proposed as a strategic approach to managing complexity of three-tier and multi-tier applications. In particular, it is posited that information technology be both the product of human action as well as a medium for human action. The paper concludes with a discussion of some important emerging technologies and some implications for management of the global enterprise.

Overview And Background Of Web-Enabling Technologies

Intranet (previously called the enterprise network) is defined as a dedicated-access information network based on open Internet technologies (such as Transmission Control Protocol/Internet Protocol (TCP/IP) *(a set of network protocols, at the transport and network layers of the network model*), Hypertext Transfer Protocol (HTTP) (*a TCP/IP based "connectionless" communication protocol used by the Web that stores state information in a temporary server on the HTTP server or on a hypertext markup language (HTML) (a language in which pages for the WWW are written, characterized by explicit tags, containing formatting and structure information and supporting the ability to "jump" to other document addresses from embedded hot spots))* and others), designed to meet the communication needs; and support a variety of enterprise-wide applications, connecting distributed locations of a particular organization. The Internet is a robust collection of multiple, interconnected public and private computer networks across the globe, linked together by the international telephone system. With the advent of the World Wide Web (WWW) (*a system that organizes information on the Internet and was developed to be a pool of human knowledge, which would allow collaborators in remote sites to share their ideas and all aspects of a common*

The Three Waves Of Evolution

There have already been three waves of development for the World Wide Web according to Vinton Cerf, commonly regarded as the Father of the Internet for his role as a problem solver, aggregator, and a leader for two decades after co-authoring TCP/IP. In the first wave (prior to late 1994), emphasis was on the presentation of text and graphical information, primarily by the research community. In the second wave, starting in 1994, Web browsers and Hypertext Markup Language (HTML) were enhanced to enable the presentation of many different types of information, including forms and tables. Multimedia applications, such as sound and graphics could be developed and downloaded through a Common Gateway Interface (*CGI, which is a standard for passing data from a client application through an hypertext transfer protocol (HTTP) server to a back-end database or application server, specifically the layer between the HTTP server and the back-end*) using either a scripting language such as Perl or a traditional programming language such as C or C++. Although conceptually these applications had similar properties to the non-Web client-server applications, they differed in one main aspect of client platform independence, i.e., the client could be any browser running on any computer supporting that browser. The third wave of applications began with the introduction of the Java programming language and the Java Virtual Machine in May 1995. These developments enabled the processing of complex operations written as Java applications (applets) on the a variety of computing platforms. Simultaneously, companies were moving from using the Web as an externally directed marketing tool to using it as an internally directed communications mechanism, i.e., intranets.

Database access from a Web browser is effectively achieved through the Internet Server Application Programming Interface (ISAPI), which allows applications to maintain state information. Additionally, Open Database Connectivity (ODBC) allows access to relational and object-oriented databases. Similarly, databases may be used from Java with a Java Database Connectivity (JDBC) connection. Although companies such as Federal Express and Charles Schwab have implemented mission-critical Web-based applications in the last year, application development for the World Wide Web is in its infancy. There are several key areas such as testing, metrics, and tools for version control and configuration management on the Web-based applications for which additional R&D is needed. This network-centric computing and communications architecture will trigger a period of great innovation and change. The Internet, by extending people's reach and making communication so much easier, has the power to radically impact business in a non-linear way. General Electric (GE), the world's biggest user of the Electronic Commerce wants the Web to permeate its dealings with suppliers and customers as it drives down costs and improves efficiencies to continue its rapid earnings growth. GE attributes its 1996 earnings of $7.28 billion on sales of $79.2 billion to information technology (IT) and electronic commerce initiatives that have made the conglomerate more efficient in purchasing, manufacturing, bringing products to market, and designing services.

The Internet-intranet connection provides a more cost-effective solution to businesses than dedicated lines and allows remote or mobile users in multiple countries, Internet access to specialized information deep within the intranet. The typical Intranet-Internet "boundary" consists of one or two boxes--a firewall and a proxy server. Firewalls filter the traffic crossing the boundary, the simplest being a filter on IP addresses and TCP socket numbers to reject unwanted traffic. A proxy server is a node or software program that provides services such as authentication, proxy, replication, and access to the client(s). Unfortunately, these security measures are not scaleable to support an extension of the reach of the boundary because as the number of edge points increases, the firewall's filter tables become too complex. However, many of today's concerns about security, reliability, remote management and uniformity of Web presence will be solved by emerging Web-security technologies such as transaction/digital cash processing servers.

The simple Intranet-Internet boundary expands to meet the diverse requirements of users who need access to the Internet from their intranets, to include both a "leading" and "trailing" edge. At the leading edge, an enterprise extends its presence closer to its customers in order to improve response time and to provide more meaningful content. Fewer network hops and shorter (network) distance between the Web server site and the customer means quicker response time. Second, from a global information systems perspective, targeted content can serve users better by including important cultural and language differences that are simply lost in uniform content and a single language. Even within a single country, organizations may want to separately target subsets of users--industrial clients and consumers, for example--with different content.

At the trailing edge are the servers that are closer to the information sources within the enterprise in order to meet the need for internal, real-time processing of information during a user's session and a fine- grained demand for some narrow target audience(s). Generally, the closer users are to the content, the better the performance, but as the number of sites increases this general rule follows the law of diminishing returns, although theoretically the value of the sites accessible to the Internet-intranet users constantly increases, if the added content were always useful and accessible. Pragmatically, the business value flattens and then diminishes as more sites are added.

The proactive process to face the new IS challenges that are brought about by the task of building a "true" intranet--i.e., one that connects to the Internet is a complex and difficult one, to not only plan but also manage. First, the issue of advocacy dictates that IS must fight managerial fear of staff surfing and promote cost-cutting potential and revenue opportunities. Second, up-front planning requires that security must go in before the Web site goes up. Third, the technological change requires constant software updates that overwhelm the support staff. Fourth, the infrastructure connectivity challenge stems from the fact that the local area networks (LANs) and wide area networks (WANs) were not built for the kind and volume of traffic triggered by the Web users. Fifth and last, but not the least, tremendous skill set changes are required due to the introduction of a decade of new technology in less than two years, including Java, ActiveX, HTML, and browsers.

The Hyper-Tier Architecture Model

Many organizations are establishing WWW sites--the ultimate wide area client-server network solution--to post basic information about their business. With the access to the Internet and the WWW being taken into account, "hyper-tier" architectures will make multi-tier architectures and Internet/Web access transparent to the users. The Web accelerates the use of thin clients in a network-centric computing architecture. Hyper-tiers is a concept in which a number of tiers or logical software layers an application requires appears as a series of services available on the network to the users.

Since the Web is a multi-tiered architecture, it exploits all the performance and reliability benefits of partitioned systems. The GUI can be on one computer, the application on another computer and the database on a third computer. This partitioning of function takes maximum advantage of client-server computing. In certain applications, multi-tiered partitioning allows users to deploy "thin" (i.e. inexpensive) clients, letting the server handle the bulk of the work. "Thin client" translates into delivering information to a broader audience that has neither expensive client hardware and software nor extensive computer literacy. Additionally, a centralization of application maintenance and deployment is provided. Due to the complexity of three-tier and multi-tier applications, a middleware layer is required to manage them. Common systems management tasks such as software updates can be accomplished more easily in a three-tier architecture than with two-tiers since the application is more modular and logically isolated. However two-tier and three-tier configurations are complementary, not competitive and exclusionary.

Dedicated servers such as the on-line database connectivity (ODBC)/ Java Database Connectivity (JDBC) middleware, proprietary APIs, and transaction processors that provides access to multiple databases are the hyper-tiers on a departmental scale. The key Internet technologies connect directly to the definition of client-server architecture in that the web browser is at the front-end, the HTTP protocol layer is the middle layer, and the CGI is at the back-end. In a global information systems application, the Internet and the Web lead the way to this concept of hyper-tiers, since users typically have to access several servers before reaching their destination.

Conclusion

The functional and/or data needs of the application such as the number of users, the number of applications, or the volume of transactions will determine the number of tiers necessary in the IT architecture of the Intranet-Internet empowered organization. Cohen and Levinthal (1994) argue that a firm's absorptive capacity (which is its ability to exploit new technological developments) not only enables a firm to exploit

new extramural knowledge, but also to predict more accurately the nature of future technological advances. Martin (1996) predicts that most corporations of the future "cybercorps" will not be purely virtual or non-virtual; they will have elements of virtualness which are primarily of two types. The first relates to virtual space where employees in the same company may be scattered geographically but linked with electronics as though they were in the same building. The second relates to virtual business where employees in different companies may be linked as though they were in the same company. This ever-shifting dynamic groupings of pre-qualified partners can be assembled and disassembled rapidly based on the strategic needs of the organization. It is from enterprise efficiency and effectiveness and enterprise transformation that higher payoffs of information technology are derived.

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References available upon request from the author.