CITRIX®

Application Serving White Paper

Meeting Enterprise Needs for Ubiquitous Application Access in the Digital Economy

In today's fast-paced global marketplace, the ability to provide employees, partners and other users with access to the right applications and data – whenever and wherever they are needed – is crucial to a competitive edge. However, application delivery has grown increasingly complicated and expensive, thanks to increasing worker mobility, corporate expansion worldwide, the trend toward mergers and acquisitions, an ongoing shortage of IT professionals, greater choice of computing devices, and the rise of the Internet.

Here are some of the facts behind the high cost and complexity of application delivery:

- The Internet user community worldwide topped 276 million in 1999, and is expected to exceed 375 million in 2000*.
- Companies can choose from an ever-widening range of devices, including PCs, terminals, and information appliances such as cellular phones, to deliver the Internet and networked applications.
- Users in record numbers are working remotely – from hotel rooms, conferences, customer sites, branch offices and homes around the globe.
- The trend toward mergers and acquisitions has created a need to integrate and roll out multiple systems and applications, and provide application access to large groups of new users.
- The computer industry is currently the fastest-growing sector in the U.S. economy**. This rapid growth has led to shortages of qualified IT workers, especially those proficient in several different operating systems and applications. An estimated 850,000 information technology jobs are expected to go unfilled in 2000.

** eTForecasts report, "Internet users by countries" 5/1/00*

***Wall St. Journal, 5/2/00*

Challenges of Enterprise-Wide Application Delivery

In the Digital Economy, where line of business and productivity applications have become the premier competitive weapons, businesses are caught between the need to provide workers the latest, most powerful solutions and the pressure to keep costs down. The traditional client/server computing model is expensive and complicated to support and administer. It also limits the ability of an enterprise to add new users, provide high-level application performance, ensure security of information, and take advantage of new, "thin" client devices. Enterprises seek a new approach to computing that can deliver expanded application reach, high performance, security and cost-effectiveness:

Reach. Organizations today compete in more places and countries than ever before, serving an increasingly extended workforce that requires 24X7 access to the same set of applications that are available at headquarters. Multiple types of devices, operating platforms and connections must be supported. Additionally, IT organizations are under pressure to meet strategic business mandates and Internet imperatives, including e-commerce, customer care and supply chain integration. To conduct business faster and stay abreast or ahead of the competition, organizations must provide their partners, vendors and customers – as well as all their employees – with reliable, secure, high-performance application access.

Speed. The time required to deploy an application determines how quickly the organization can benefit from it. Unfortunately, large, complex implementations or repeated upgrades can take months or years to complete, especially when IT professionals are in short supply, users are scattered around the world, and new business units or acquisitions must be brought online. Organizations are finding they cannot install/upgrade and support applications at the desktop fast enough to keep pace with technology change. Further, such time-consuming administrative chores take up valuable IT staff time that could be devoted to strategic projects.

Security. Transmitting applications and data over a network increases the risk of unauthorized access. Traditional client/server computing architectures call for applications to be executed on both the server and client devices. The increasing use of the Internet as a delivery network has added to enterprise concerns about security of sensitive information.

Cost. Enterprises are often caught between conflicting demands to acquire the latest technology and to control costs. Constant technology churn often forces organizations to make major upgrades to hardware, software and networks so they can keep pace with competitors. Day to day, a client/server computing environment requires significant expenditures for support, administration and training at each user desktop that contribute to the Total Cost of Ownership (TCO). The Tolly Group, an independent consulting organization, estimated in its white paper entitled, "Total Cost of Application Ownership (TCA)," that the initial and recurring costs of application access can exceed $10,000 per user annually. Acquisitions and business growth that add new groups of users and new locations can further drive up administrative costs.

Application Delivery Strategies

Currently, there are several options available to enterprises in delivering applications to their users. These include the traditional client/server architecture, distributed or network computing, and server-based computing. These options differ in their processing model as well as the type of hardware required. A client/server architecture centers processing around local execution using "fat," powerful client devices and "fat," expensive pipes that can accommodate high-speed transport of bandwidth-intensive applications. In distributed or network computing, components are dynamically downloaded from the network to the client for execution. This model also requires a "fat" client for processing. In contrast, a server-based architecture keeps application execution 100 percent on the server, enabling the use of virtually any device. It also provides considerable TCA savings through centralized application management, the ability to leverage the existing computer infrastructure, and the option to use inexpensive, thin clients and narrow bandwidth connections. The key differences among the three architectures are presented in the chart below.

Computing Architecture	Server-based Computing	Network Computing/Web	Traditional Client/Server
Processing Model	100% Server Execution	Download and Execute	Local Execution
Hardware Footprint	Thin or Fat	Fat	Fat
Application Architecture	Monolithic, Component or 2- or 3-Tier Client/Server	Component	2- or 3-Tier Client/Server
Native Device	Variable or Fixed Function (PC, NPC, NC, WBT, UNIX)	Variable Function (NC)	Variable Function (PC)
Native Application Type	Windows, UNIX or Java	Java	Windows
Application Richness	Full	Limited	Full

Application Server Architecture Comparison

Application server computing has been widely adopted by the corporate mainstream as the most efficient, flexible and cost-effective system for application delivery and administration. It addresses the enterprise challenges of optimizing application reach, speed and security, and reducing computing costs. Where alternatives require an additional server as a middle tier between the application server and the client, Citrix Systems, Inc., installs software directly on top of the application server. Following is a comparison of these approaches.

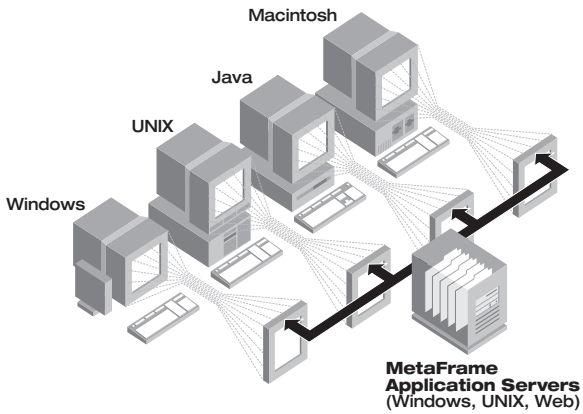
- The "additional server" architecture uses a dedicated server and accompanying technology as an intermediary, or middle tier, between Microsoft® Windows® 2000 Terminal Services/NT 4.0 TSE or UNIX® servers and a Windows or Java™ client device. This dedicated server translates the respective Windows or UNIX protocol (RDP or X.11) into a proprietary protocol that can deliver application access to the client.
- The architecture provided by Citrix uses proprietary software that is installed on top of Microsoft Windows 2000 Terminal Services/NT 4.0 TSE or a Sun Solaris™, IBM AIX® or HP-UX® server. The Citrix ICA protocol delivers low-bandwidth connectivity to virtually any client, without translation.

The Citrix architecture offers a number of advantages, which stem primarily from its greater simplicity and direct connection between application server and client:

Less complexity/lower cost: adding another server to the architecture adds a layer of complexity, cost and a single point of failure to the system. Citrix's model simplifies the delivery of applications by eliminating the need for a middle tier.

Improved performance: the need to translate protocols can degrade application performance. Using a single protocol to connect the application server and client, as Citrix does, enhances performance.

Centralized management: With Citrix, application management and support remain on the application server; all users, applications, and even Web deployment are administered from the same server or server farm. The "additional server" option divides administration between the application server and the middle tier, thus diluting the benefits of centralized management.



Citrix's architecture allows application server software to run on the existing server over a wide variety of connections to any platform without translations.

In summary, the best way to realize maximum business benefits from an application server computing system is to keep it simple. Citrix not only provides a streamlined server architecture, but also increases user productivity and reduces complexity on the client side by supporting virtually every type of device natively.

Application Serving Components

Corporate Portals

Mass adoption of the Internet and broad use of Web browsers have encouraged software developers to use the Web to deliver applications to users. However, this scenario presents a number of challenges. The HTTP protocol and HTML — the associated language for describing how Web pages should look — were designed for publishing static material. User interaction is strictly limited in order to publish information to large numbers of people with the appearance of simultaneous access.

Many applications, such as those used in everyday enterprise computing, require a level of interaction that is beyond the capability of HTML. Although attempts have been made to extend the protocol to deliver application richness, the results have either compromised the application's performance or reduced its functionality.

Application server computing offers a new approach to this dilemma, enabling enterprises to deliver the full richness and interactivity of client/server applications over the Web, while ensuring a thin-client footprint. This technology also eliminates the need to rebuild the user interface with HTML, Java or customized programming.

The emergence of corporate portals — where users can access selected content, applications and data — is increasing demand for Web-enabled applications that can be published to individuals and groups based on their identity and role in the organization. There is technology available today that allows publishing of existing applications to a corporate portal without the need for rewriting.

Application Servers

The keystone of an application server environment is technology that allows an organization to base the processing and deployment of its business-critical applications 100 percent on a server. However, many companies have developed a heterogeneous computing system that comprises more than one server platform, including the Web, to deliver the range of applications required by their user base. A typical scenario might include Windows servers for office and productivity applications, and UNIX servers for engineering software.

Application server software needs to be flexible enough to support a mix of platforms within an organization and deliver a variety of applications seamlessly to users via a single device. Server-based computing offerings should have the ability to enable seamless deployment of Windows, Java and UNIX applications from central servers to users on virtually any device, including Web browsers. This flexibility allows companies to select best-of-breed solutions, regardless of platform, yet deliver convenient, single-point application access to users.

Service Management

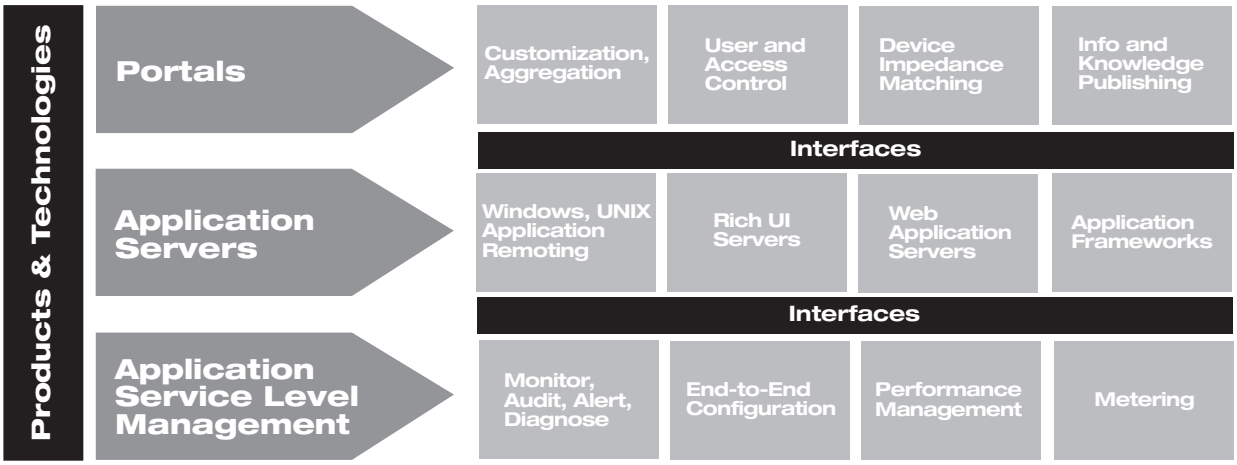
While server software provides the foundation for an application server computing system, additional management capabilities are needed to measure, monitor and control the quality of user interaction with server-based applications. These capabilities include system, application and user management, and are provided via:

- ***Load balancing*** among servers in a group, or farm, to ensure users are routed to the least-busy unit. Load balancing is transparent to the user but is a key factor in delivering high performance and availability of applications. Dynamic routing of users also makes it easier and faster for administrators to scale up the server farm to accommodate new groups of users.

- ***Installation management*** of applications across a server farm through replication. Automated installation allows administrators to quickly deploy new or updated software to large server farms.
- ***Resource management*** to track and analyze server performance. Through data collection processes, administrators can anticipate and correct performance problems.
- ***Security*** measures, particularly encryption and authentication to verify user and resource access, that protect information being sent between the server and client.

Managing the life cycle of business applications is an ongoing process that includes initial deployment, updates, user configuration, help desk support, security, performance tuning, capacity planning and system management. An application serving solution requires an array of robust tools to optimize system resources and bandwidth, monitor system health, and install and replicate applications across the enterprise.

This chart shows the components that should be included in an application serving environment.



Citrix Application Server Computing

A Better Approach

Citrix is the pioneer and market leader in application server computing, a model that centralizes the execution and administration of applications on a server, and allows multiple users to access them over a network. Citrix software enables enterprises to achieve Digital Independence™, the ability to run any application on any device with any connection, wireless to Web. Citrix technology allows companies to leverage virtually everything in their computing environments to reach more users in more locations with more applications — and do it at record speed.

Citrix technology delivers a comprehensive application server solution that comprises application portals, application servers and supporting services. Citrix enables creation of an Internet portal through which users can subscribe to and receive applications based on organizational policies. Citrix application servers support many platforms, including the Web, UNIX, and Windows 2000, to give organizations flexibility in a mixed computing environment. Underlying Citrix solutions are robust management services, such as load balancing and security, that ensure a high-quality experience for users and administrators.

The many business benefits of application server computing, including scalability, cost-effectiveness, flexibility and ease of use, have led to its adoption by the corporate mainstream. In fact, the entire Fortune 100 and 80 percent of the Fortune 500 use Citrix application server software. Citrix application server technology has become a standard in enterprise computing, supporting more than 24 million users. According to Giga Information Group, a survey of clients indicated most planned to double the number of users supported through server-based computing environments within 12 months.

Giga's survey also found there are several application deployment scenarios for which Citrix software is being used. These include delivering complex vertical applications that are difficult and expensive to support in remote locations; deploying modules of PeopleSoft and other ERP software; and delivering Microsoft Office and other productivity applications. Giga also indicated that graphically intensive applications are beginning to be more widely deployed in an application server environment because they are so bandwidth-hungry.

Features and Benefits

Application server computing is a proven approach to solving the critical business issue of fast, simple, cost-effective application access. This architecture enables enterprises to provide users the fullest range of applications — from Windows to Web — under a variety of scenarios. For example, Citrix application server software allows users to access Windows, Java and UNIX applications from Web pages through a wide range of client devices. Remote users can access server-based applications over dial-up connections without the traditional drawbacks of slow performance and uncertain security. Companies with branch offices can connect workers via the corporate WAN to applications running on Citrix servers in headquarters. And they can choose from the latest thin devices, such as Windows-based terminals, wireless LAN devices, intelligent keyboards and palm-size devices, as well as traditional client hardware, for greater flexibility and cost savings.

In addition to its adaptability to different corporate organizations and infrastructures, application server computing offers business benefits in four key areas:

- Enterprise-class management for end-to-end command and control
- Flexibility to leverage any application, device or connection
- "Webability" to run any application via the Web through a standard browser
- Seamless integration with existing systems without impacting performance

Enterprise-Class Management

One of the major benefits of application server computing is centralized application management. The ability to install, upgrade, support and manage applications from a central location helps enterprises increase administrative efficiency, reduce IT costs, make the best use of scarce IT resources, and ensure faster time-to-value for new and upgraded solutions. Further, security is enhanced by keeping application processing 100 percent on the server.

Under this model, users enjoy fast, high-performance access to the applications they need, while administrators maintain control over the desktop.

Flexibility

In today's enterprises, success hinges on providing users the applications and data they need to conduct business more effectively than the competition. Windows, UNIX and Java applications must be deployed to users around the world on a variety of devices, including information appliances, wireless devices, X-devices, UNIX and Linux® workstations, Windows-based terminals and PCs, and over many types of network connections, such as WAN and LAN links, the Internet, dial-up and wireless.

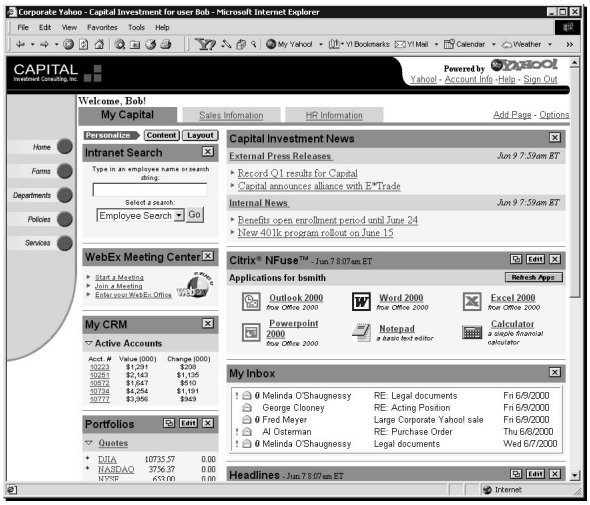
Flexibility in devices and connections means fewer hardware roadblocks, greater user satisfaction and more effective use of existing networks. No longer do users need multiple desktops or software emulation packages to access multiple platforms.

Citrix technology supports virtually every type of client device, allowing users a choice

Webability

The Internet has changed the way the world conducts business. As more users turn to the Web as their preferred means of accessing information, enterprises are under pressure to deliver applications and data via standard browsers. Citrix application server software provides a fast, simple way to integrate and publish existing, interactive applications into a Web browser. Using Citrix NFuse™ technology, enterprises simply create application portals and define the application(s) specific to each user or group. After accessing the portal from a Web browser, the user opens the desired application and works with it as if it were running locally. An example of NFuse application publishing capability is Corporate Yahoo!™, a customized enterprise information portal based on the widely adopted My Yahoo! interface. With Citrix NFuse technology, Corporate Yahoo! users can benefit from integrating

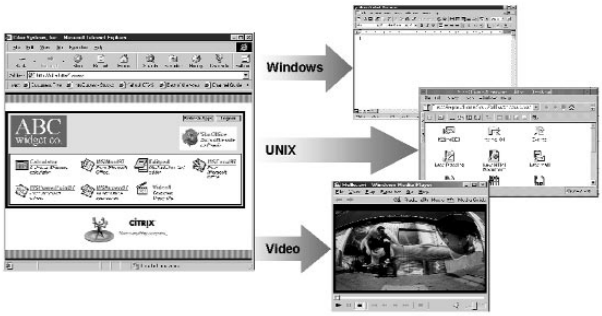
existing server-based applications into the portal simply by clicking a link or icon.



Citrix NFuse enables Corporate Yahoo! to integrate existing and new server-based applications into the portal

Seamless Systems Integration

Many enterprises have made significant, ongoing investments in computing infrastructure over time. As they strive to expand the reach and performance of their applications, these organizations want to continue using their existing hardware, networks and software as much as possible. Citrix application server computing allows organizations to leverage their entire technology infrastructure while delivering LAN-like application access to their users. Citrix enables the integration of different platforms, such as Microsoft Windows NT 4.0 TSE and Windows 2000, Sun Solaris, IBM AIX and HP-UX, as well as many different types of clients, networks and applications.



Through a single browser, users can access applications running on different platforms

How Does it Work?

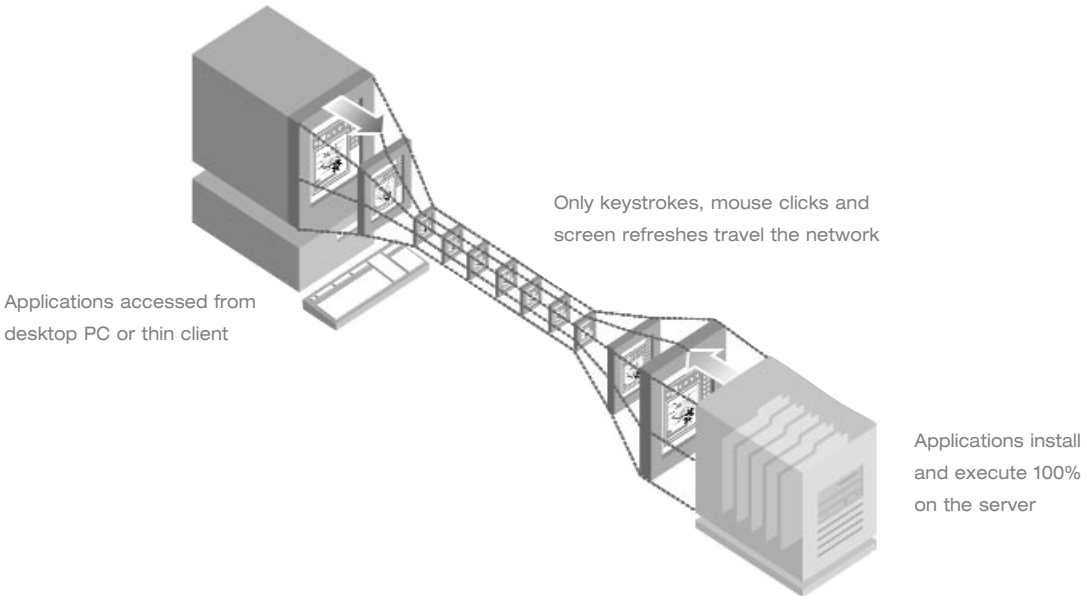
The core technology for Citrix application server computing is Independent Computing Architecture (ICA®), a remote presentation services protocol that provides the foundation for turning any client device — thin or fat — into the ultimate thin client. ICA technology includes a server software component, a network protocol component, and a client software component.

Server. ICA has the unique ability to separate an application's logic from its user interface. The application executes 100 percent on the server, and only the user interface is actually transmitted to users. For this reason, application serving is able to centralize all system, application and user management on the server for greater efficiency and lower cost of ownership.

Network. ICA enables an application's user interface, as well as keystrokes and mouse movements, to be transported to and from the client over standard network protocols — TCP/IP, PPP, IPX, SPX, and NetBEUI — and over popular network connections — asynchronous, dial-up, ISDN, Frame Relay and ATM. With a server-based architecture, applications require only a fraction of the network bandwidth of a client/server model. Therefore, ICA allows the latest, most powerful applications to be transmitted rapidly over standard networks.

Client. By centralizing application processing on the server, ICA turns any device into a thin client that only needs to be able to display and manipulate the user interface. The specific memory, features and brand of the device are irrelevant. ICA supports a wide array of devices, including the latest information appliances as well as traditional PCs and workstations.

Citrix ICA and MetaFrame Application Serving in action.

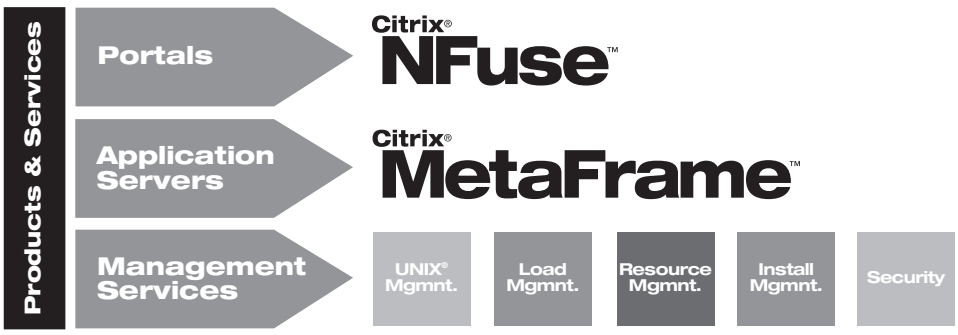


Delivering Digital Independence

The high cost and growing complexity of today's computing systems have forced many enterprises to make painful choices — between the competitive advantage of new solutions and the need for cost reduction, for example, or between individual user preferences and a standardized technology environment. Application server computing can free organizations from these dilemmas by delivering a host of business and IT benefits without the traditional drawbacks. Giga Information Group reported, "...based on anecdotal information (primarily from discussions with clients), interest in server-based computing technology is doing anything but slowing down."

This computing approach reduces costs while allowing organizations to provide high-performance, worldwide access to the latest applications. It permits workers to use the devices and connections they need or prefer, while eliminating the complexity of desktop-based support and administration. Perhaps most important, application server computing gives enterprises key strategic advantages — rapid system scalability, Web-based application deployment, and fast time-to-value for new solutions — that can help them meet or surpass the competition.

Citrix's comprehensive application serving offering includes portal, server and management software.



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