IT Roadmap for Today's Transactional Worker

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Summary

Managers in the information technologies group within most organizations are facing difficult decisions about the platforms for their client applications and server applications. Old friends appear to run out of steam and fall out of favor. Making investments in information technology pay over the long haul is a significant challenge. Organizations are seeking technology that offers the promise of reduced cost and increased simplicity while still offering power and flexibility.

Most organizations have both transactional and knowledge workers. Members of each group have different computing styles and needs. An organization's information technology plans must take both types of users into account.

This paper will consider today's environment, issues faced by organizations in today's environment and discuss some potential solutions.

Today's Environment

All of the end-user surveys that IDC has conducted show that the average organization has many different client environments and many different server environments. This diversity offers a great deal of flexibility but it also imposes higher administration, support, and development costs than one that is more uniform. Organizations are really looking for a way to reduce their overall costs while still maintaining the flexibility of their heterogeneous environments.

New Solutions Are Built Upon Existing Investments

Computing solutions have evolved through three waves of computing-automating the back office, automating the front office, and automating remote field representatives. A new wave of reaching out to consumers and partners is approaching.

New systems (hardware and software) are added to enhance the capabilities of those already installed. As new solutions are installed, organizations expect back office solutions to communicate with front office solutions. Front office solutions were expected to interoperate with

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mobile and handheld computer systems carried by remote sales and support representatives. As organizations reach out to the new wired marketplace via the Web, they expect all of these installed computing solutions to be able to communicate with the personal computers and network computing devices installed in the homes of consumers' and partners' offices.

The Environment Grows Ever More Complex

Each wave of computing brings increasing complexity into the workplace. Today, workplace-computing solutions must support dumb terminals, personal computers; and new computing devices, such as personal organizers, Web telephones and Web televisions.

Although some suppliers of operating environment software would like to convince the world that they have won and that all others have died an ignominious death, IDC's supply-side and demand-side research tells a different story. Server Operating Environments, Client Operating Environments, Applications, and Management Environments all will be examined in turn.

A View of Today's Computing Environment

A computing environment is made up of many elements including, server environments, client environments, application software, and management tools.

Server Operating Environments

IDC's supply-side research shows that organizations adopt a broad range of server operating environments. Although the "shrink-wrapped" operating systems enjoyed the largest volume, single-vendor, high-performance operating systems also saw continued support (See Appendix, Figure 1, Worldwide Server Operating Environment Software License Shipments).

From a server (hardware) point of view, organizations are found to have heterogeneous environments. This is especially true at sites reporting the presence of an IBM S/390 or AS/400 server where the mean number of server platforms present is 5.0 (See Appendix, Figure 2, Mean Number of Different Server Platforms in Environment.)

Organizations employing heterogeneous server environments are often challenged with the following critical problems:

- Developing and deploying common applications
- Implementing robust integrated system management services
- Implementing common/consistent database tools
- Managing costs, evaluating new system purchases, etc.

Multiuser systems vendor revenues derived from vertical markets are distributed across different platforms: Netware, NT, UNIX, OS/400, OS/390, OS/2, etc. There is clearly no vertical industry that consolidates spending around 1 or 2 platforms (See Appendix, Table 1, Vertical Market Segmentation of the U.S. Multiuser Systems Market).

Client Operating Environments

Likewise, IDC's supply-side research on client operating environments shows that a diverse set of desktop/client environments are common. (See Appendix, Figure 3, Worldwide PC/Client Operating Environment Software License Shipments).

Issues With Today's Environment

Developers of computing solutions now face the enormous problem of how to develop software for all systems commonly found in organizations. Each of these systems is likely to be running a different operating system and based upon different processor architectures. None will be discarded in favor of another. The server environment evolves relatively slowly compared to the client environment. Most of the operating environment complexity and change that organizations currently face can be attributed to the client environment.

Client Complexity

IDC's Windows NT Server Adoption Survey 1997 examined the complexity of the organizational development environment. Many different types of devices are in use including terminals connected to host computers, X-Windows Terminals, Network Computing Devices; personal computers (running MacOS, OS/2, Windows 3.x, and Windows 95, or Windows NT), Workstation, NetWare servers, and Unix Workstations.

Although Windows 95 and Windows NT Workstation/Intel are receiving the highest level of developer use, OS/2, NetWare, Windows 3.x/DOS, Hosts via terminal, Unix workstations, Windows NT Workstation on RISC processors, Macintosh systems, X-Windows Terminals and Network Computing Devices are all seeing some use. This implies that these desktop devices are also in use by end users once the application is deployed.

Constant Change

Personal computer-based desktops are experiencing an unprecedented rate of change. In the past, it was not uncommon for a given configuration to be available for several years. This is no longer the case. Hardware and software are now on 6-12 month product life cycles.

New Hardware

Intel has brought out new processors and processor variations at an ever-increasing pace. The personal computer suppliers built many different systems based upon each microprocessor (See Appendix, Table 2, Intel Microprocessors).

Organizations have frequently been faced with the difficult task of selecting the proper configuration for their application requirements. Intel

often had several different processors and several different variations of each processor available at a given point in time. If an organization had three vendors on its approved list, there were five different Intel processors available at a given moment, and each vendor had three different system configurations to be evaluated. An organization would have to test 45 different hardware configurations each time it wished to purchase a system.

Organizations often found that after they selected a system configuration, tested their application software and embarked on a sensible upgrade process, that the selected system configuration had become obsolete and, thus, unavailable before the procedure could be completed. To avoid this problem, organizations would be forced to purchase all of the systems they required for a rollout up front rather than staging hardware purchases. This approach imposed the requirement that organizations store all of the systems and hope they wouldn't be damaged in transit once it had become time to deploy them.

New Software

Microsoft also upgrades operating system software, application software, and development tools software rapidly. Furthermore, the upgrades are not always synchronized with one another. A configuration purchased to support Windows 95 and Office 95 may not have enough memory or storage to support Windows 95 and Office 97 (See Appendix, Table 3, Chronology of Microsoft Operating Systems, which demonstrates the history of Microsoft operating environments and their ever-growing requirements for processor power, memory and storage).

Upgrade Issues

Each release of Microsoft's Windows operating system has required more memory, more processor power, and more storage. Applications designed for one release of Microsoft's Windows often required some level of enhancement to run optimally on the next release.

Since end users often want to use the most current version of the operating environment and personal productivity software, organizations have faced a constant stream of changes. Each new piece of software may require a hardware update. Some required the replacement of the entire desktop configuration.

Information technologies departments of many organizations feel that they have been forced to ride an expensive merry-go-round. By the time new technology is deployed, it is out of date and the process must begin again.

A New View of Desktop Requirements

Some suppliers build their software on the assumption that everyone who uses a computer to perform their job is a knowledge worker and that they are very much like computer hobbyists who want the ability to manipulate every function of the operating environment at a very low level. IDC believes that an organization has at least two categories of computer users — the knowledge worker and the transactional worker. IDC characterizes these groups as follows.

- Knowledge workers are individuals who collect and analyze data, synthesize information, write about or present this information, and make decisions using this information. These workers are quite willing and able to write custom functions to facilitate some custom, highly specialized analysis of the data. These workers are the first to require newer, more flexible and capable applications, and more powerful system software. They often have the training and expertise to utilize new software without requiring the intervention of their organization's IT department.
- Transactional workers use computers to execute a basically non-computer-oriented function. While some of these workers use computers to facilitate functions like order entry, manufacturing, health care provision, etc., many others who fall into this category are senior executives, attorneys, doctors, and the like. Transactional workers typically make more use of packaged or custom business support applications than sophisticated data collection, data analysis, writing or presentation software. Forcing these workers to adopt new desktop software and hardware usually requires a significant investment in retraining and help-desk support.

IDC believes the desktop requirements of these two groups differ. It is important to consider the needs of both types of workers during the platform selection process. An organization may realize some reduced cost and increased simplicity by selecting a different desktop environment for each group of workers rather than choosing a standard for everyone.

Selecting two different platforms can increase costs in some areas. This increased level of costs can be minimized by an IT architecture which provides support for file sharing, electronic mail, and access to common workplace applications for both types of workers.

Platform Selection for the Knowledge Worker

Knowledge workers often require the newest, most powerful and, unfortunately, most complex application software. The availability of leading edge personal productivity tools, development tools, and other packaged software products are usually driving forces behind the selection of a desktop environment.

When Win32-based Applications Have Become the Key Decision Criteria

It is clear to IDC that the Microsoft Win32 API is the interface being utilized for a significant number of the new applications and tools that are of interest to knowledge workers. If these applications are the foundation of an organization's computer usage, the options boil down to which Microsoft desktop environment is the best. In this case, Windows NT Workstation is likely to be the best choice if security, robust multitasking, and support of complex, network-based applications are requirements. Windows 95 and its successors (Windows 98), on the other hand, are likely to be the best when support of mobile computers, smaller hardware configurations, or special purpose hardware devices are key requirements.

Microsoft has pointed out that it plans to eventually move Windows 9X onto the Windows NT kernel. It may be wise for organizations to consider a move to Windows NT Workstation now, where appropriate, rather than be forced to upgrade from Windows 3.1 to Windows 95 to Windows 98 to Windows 9X.

When Non-Win32-based Applications are the Key Decision Criteria

Organizations whose knowledge workers primarily use custom or packaged applications on MacOS, Caldera Software's OpenDOS, IBM's PC-DOS or OS/2, MS-DOS, or Unix may be best advised to continue to use these platforms. Each of these desktop environments has strengths that may be crucial to an organization's success.

A great deal has already been written about the requirements of the knowledge worker and how to supply the needed computing solutions. The rest of this paper will focus on the needs of the transactional worker.

Platform Selection for the Transactional Worker

Transactional workers have different requirements than those of knowledge workers. The former primarily use packaged or custom applications to improve their productivity doing basically non-computer-oriented tasks.

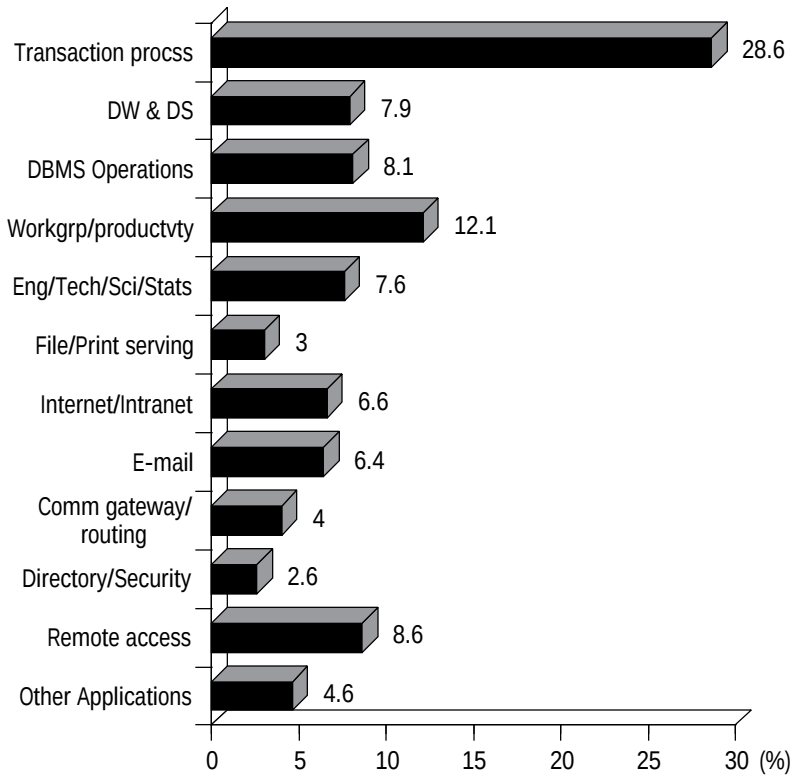
Transactional workers, as a general rule, have little requirements for sophisticated data collection, analysis, or synthesis tools other than those provided by the packaged or custom business applications used by their organization. While it is very likely that these workers will need the ability to create and manipulate documents, their need for advanced writing and presentation tools is limited. The same can be said for the transactional worker's use of spreadsheet and personal database products. A stable, robust, and manageable environment is more important for these workers than one that is rapidly changing and highly adaptable.

Today, many of these workers are using transactional software hosted on mainframes, single vendor minicomputers, e.g. Digital OpenVMS, HP MPE/ix, or IBM OS/400, or Unix systems. They typically are accessing these applications through non-intelligent terminals or through a personal computer running terminal emulation software.

Figure 4 shows the breakdown of various computing activities running on servers. The leading activity is transaction process. This means that transactional activities at companies are demanding more computing resources than the others shown.

Figure 5 shows the percentage of computing resources dedicated to transaction processing (across all platforms) by vertical industry. This data shows that financial services, insurance, other services (personal, auto repair, recreation, etc.), and process manufacturing are the industries with the most computing resources dedicated to transaction processing.

Figure 4
Resource Allocation for Various Computing Activities, by Mean (%)



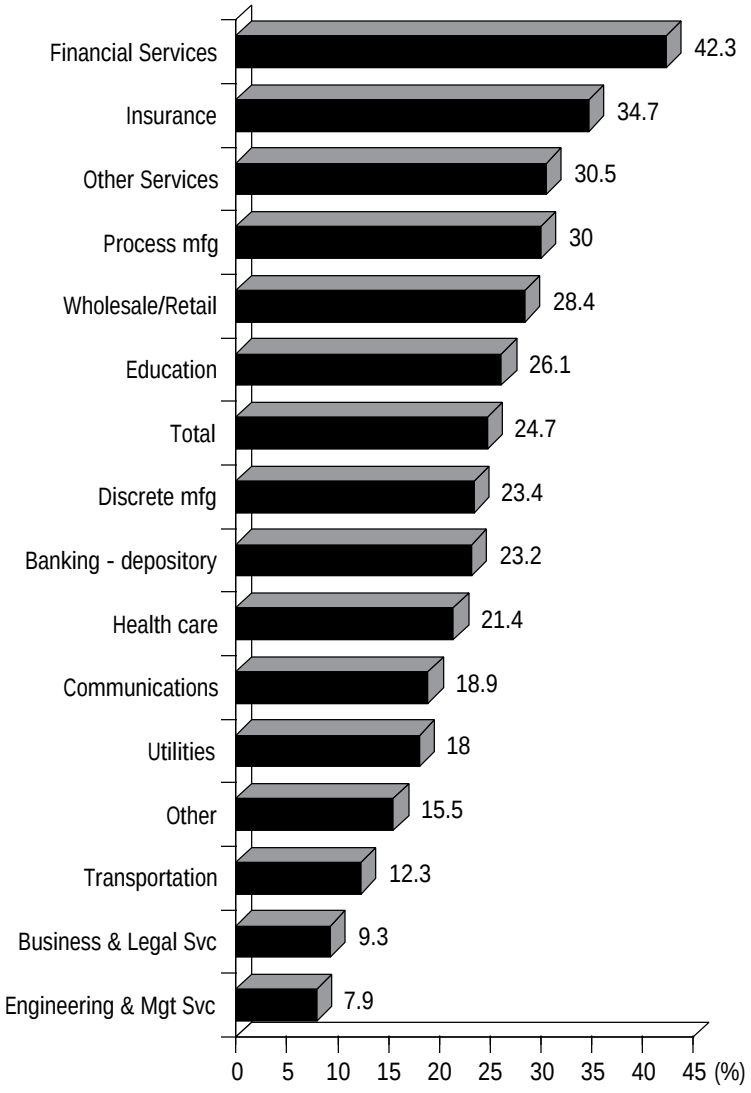
Source: International Data Corporation, © 1998

Some organizations, understanding the need of their transactional workers to access graphical applications without being forced to become "PC hobbyists, provided X-Windows terminals rather than character cell terminals. IDC recalls that, at one point in time, this approach appeared poised to succeed the character cell terminal in many organizations. The lack of personal productivity applications and the initial requirement for high-speed or LAN connections, however, reduced the market's enthusiasm for X-Terminal-based solutions. The providers of these devices and software have never stopped expounding the value proposition of their products and technology: simplicity, manageability, and low cost.

Although any of the desktop operating environments can certainly be the platform for these applications, IDC believes it would be wise for organizations to contemplate adopting Web technologies as they reconsider the platform for their custom or packaged transactional applications.

Web browsers and Java virtual machines have become available on just about every desktop or mobile configuration, regardless of the microprocessor and operating system. The benefit of this approach is that organizations can extend the life of currently installed systems which are too slow, have too little memory, or too little storage capacity to run current personal productivity applications.

Figure 5
Computing Resources Dedicated to Transaction Processing by Vertical Industry (%)



Source: International Data Corporation, © 1998

Since most organizations expect desktop operating environments to support various types of distributed application architectures, it is important to consider these distributed application architectures and the workloads they impose on the desktop device.

Client/Server Evolves to Encompass the World Wide Web

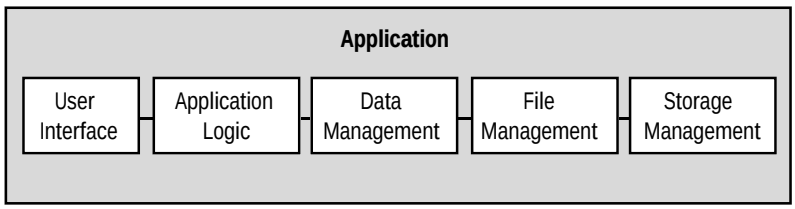
A major force behind the desktop operating environment dilemma is the introduction of the Web-based application architecture. Organizational management may not understand what the World Wide Web will do for their organization, but they are absolutely certain that they need to

adopt Web technologies immediately. Since these managers are not technologists, IDC is often asked questions such as, Is client/server computing really dead? or Should I stop focusing on my ongoing adoption of client/server computing to focus on building my intranet?

Distributed Computing Architectures

All applications, which communicate with a user, have the following components (See Figure 6): user interface, application logic, data management, file management, and storage management. Applications that do not require user communication, such as background or batch applications, have only application logic, data management, and storage management components.

Figure 6
Application Components



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Traditional, host-based computing architectures have all of these components linked together into one binary image. The application runs on a single computer.

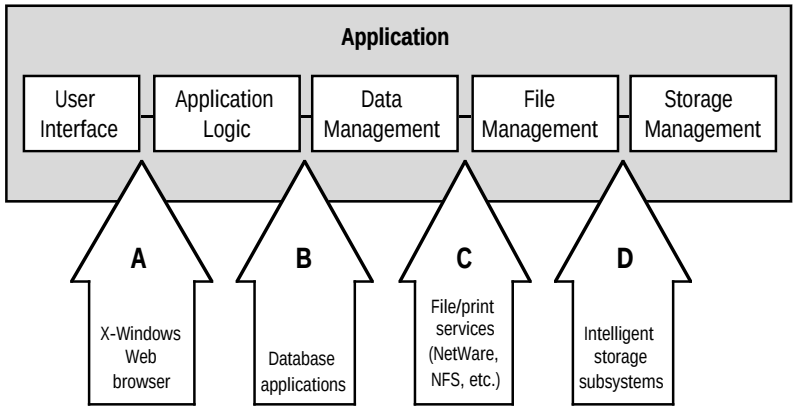
Distributed applications still have the same components as are shown in Figure 6. The difference is that networking technology has been inserted between one or more of these application components to create one or more application partitions (See Figure 7). These partitions can then all be run on the same system or could be distributed throughout a network.

Distributed User Interface

The partitioning scheme labeled A in Figure 7 shows how X-Windows and simple Web browser-based applications are partitioned. X-Windows Terminals, workstations, or personal computers running an X-Windows server receive and execute X-Windows commands sent via the X-Windows protocol from the server. User input is sent back to the server. This approach typically requires relatively high performance networking connections, making remote application usage problematic.

Simple browser-based applications are partitioned similarly. Workstations, personal computers, network computers, or network PCs run a Web browser. HTML pages with embedded graphic images, sounds, video clips, or other complex, non-structured data is sent from the

Figure 7
Common Points of Application Partitioning



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server to the client using the HTTP protocol. The client then renders the page on the screen.

Since HTML is a text-based, page definition language rather than a low level, graphics-oriented protocol, text-based pages can be transferred over relatively low speed network connections and still provide adequate application performance. As page developers add greater amounts of non-text data, this approach requires progressively higher network bandwidth.

Applications that are heavily graphics oriented, such as electronic computer-aided design, perform poorly when partitioned this way.

Distributed Storage Management

The application partitioning scheme labeled "D" in Figure 7 shows how applications using the storage services provided by an intelligent storage subsystem, such as those offered by EMC, Seagate, StorageTek and others. This application architecture places the user interface, the application logic, and the data management components either on the client or on second- or third-tier servers. This approach is selected to minimize storage management costs in applications requiring very large databases. Since applications using this approach are almost always data intensive, high to very high performance network connections are absolutely required.

Distributed File Management

The application partitioning scheme labeled "C" in Figure 7 shows how applications using the file services provided by flat file software such as Btrieve from Pervasive Software, running on LAN environments such as the NetWare family or Windows NT Server. This application architecture places the user interface, the application logic, and the data management components on the client.

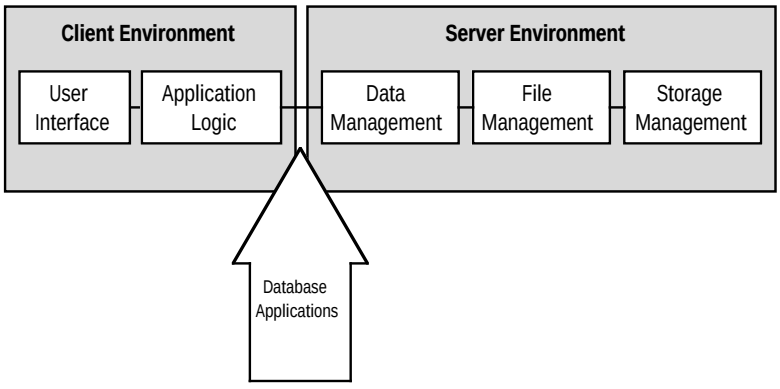
While this approach is quite workable for simple applications, large database applications would transfer enormous amounts of information back and forth across the network, resulting in poor performance.

The next application partitioning scheme, distributed data management, is coming to the forefront as developers move to using database and the data access software provided by suppliers such as Oracle, Informix, Sybase, etc. There are two different forms of distributed data management schemes-client/server style and the new Web-based style.

Distributed Data Management — Client/Server Style

Figure 8 shows how applications using the development tools, data access software, and database engine software provided by database suppliers, such as Oracle, Informix, Sybase, etc., are partitioned. This architecture places the user interface and the application logic components on the client. The data management, file management, and storage management components are placed on the server. Complex applications require both the client and the server to be heavily configured. If the application is designed properly, this approach can work on network connections ranging from low to high performance.

Figure 8
Distributed Data Management

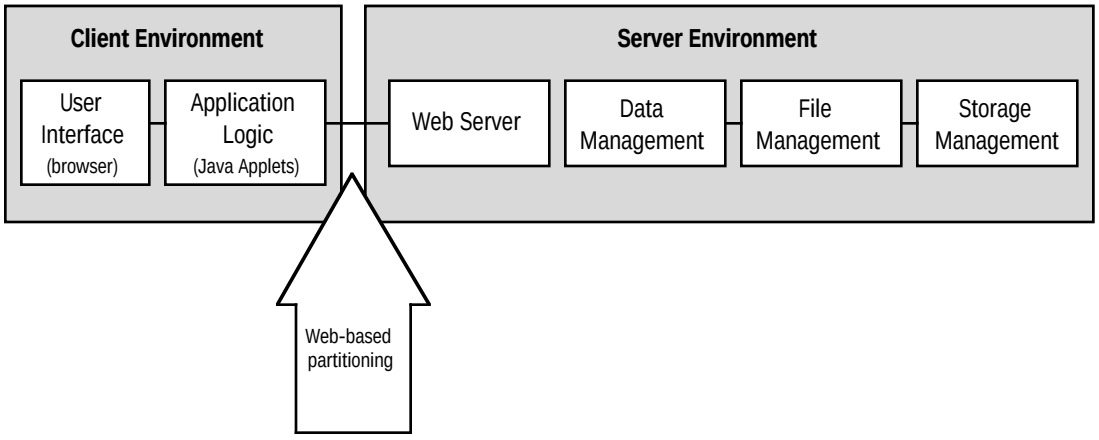


Source: International Data Corporation, © 1998

Distributed Data Management — Web-Based Style

Figure 9 shows how applications using the new Web-based application architecture would use the services of both Web server and database server software. This architecture places the user interface and the application logic components on the client. In this case, the user interface is a Web browser and the application logic is implemented as Java applets. The Web server, data management, file management, and storage management components are placed on the server. Complex applications require both the client and the server to be heavily configured. If the

Figure 9
Web-based Applications



Source: International Data Corporation, © 1998

application is designed properly, this approach can work on network connections ranging from low to high performance.

Database suppliers, such as Oracle, Informix, Sybase, Computer Associates, and IBM, when working with suppliers of Web server software, such as Netscape, Microsoft and Lotus are beginning to propose this approach when developing the Web-based application. In this case, HTTP is the primary protocol rather than some data access protocol.

The Rapid Adoption of Web Technologies

Operating System Suppliers Adopt Web-based Architectures

Web browsers and Java virtual machines are rapidly becoming available on all graphically-based desktop operating environments including MacOS, OS/2 Warp Client, Windows 95, Windows NT Workstation and Unix. They will also be a standard part of network computers and network PCs. This means that organizations that have adopted web-based application architectures will be free to select the most cost-effective client regardless of its operating environment, its microprocessor, or its form factor.

This choice, incidentally, also means that older Intel 486 systems that will no longer run Microsoft's newest operating systems effectively, and are still not fully amortized, could become useful once again! Adding the right operating system, a Web browser, and a Java virtual machine to these older systems would, in essence, make them network computers and would give them another life.

Middleware Suppliers Adopt Web-based Architectures

The major transaction-oriented middleware products, such as IBM's CICS, NCR's Top End, Transarc's Encina, and BEA's Tuxedo, all have

enhanced versions that support Web-based clients. Applications based upon these software platforms can be easily adapted to working with Web-based clients.

Development Tools Suppliers Adopt Web-based Architectures

The major suppliers of database and client/server application development software have enhanced their tools to build Web-based applications as just another build-time option. Some examples of such products are Oracle's Developer/2000 and Sybase's Dynamo. Applications built using development tools such as these can also be easily adapted to working with Web-based clients.

Tools for the Transition

In most organizations, the transactional workers are using different computing tools to facilitate their work. Some of the typical approaches follow.

- Using character or block mode terminals supported by host-based, transactional software
- Accessing host-based, transactional software using a terminal emulation package on a personal computer
- Using personal productivity software on a personal computer while accessing host-based, transactional software using a terminal emulation package
- Using personal productivity software on a personal computer

Several suppliers have demonstrated software that may be used to support one or more of these approaches. IBM's WorkSpace On-Demand is the first that has gone beyond the demonstration phase and has actually become available as a product. IDC expects others to follow shortly with their products.

Recommended Approach

The requirements of the organization's knowledge workers are best fulfilled by providing them with the highest performance personal computer and the personal productivity applications and tools they need. Since all of the popular operating environments, Windows 95, Windows NT Workstation, OS/2 Warp, and MacOS all come with Web browsers and Java Virtual Machines, these platforms will also support Web-based applications. Transactional workers, on the other hand, pose an interesting challenge.

Before rushing into the process of moving employees to network computing devices and adopting Web-based application architectures, organizations should consider the needs of each of the different categories of transactional workers and develop a deliberate, step-by-step plan. Table 4 shows some of these different transactional worker categories and their needs.

The next step in the process of selecting the appropriate group to move to the network computing approach is to determine which group will

Table 4
Categorizing an Organization's Employees

Employee Type	Category	Typical Workload	Network Computing Candidate?
Administrative	Transactional	• Creation of documents and presentations	Yes
		• Electronic mail	
Analysts	Knowledge	• Creation of documents and presentations	
		• Data analysis	
		• Data collection via Web and other sources	
		• Electronic mail	
		• Planning	
		• Presentations	No
Customer Service	Transactional	• Electronic mail	
		• Transactional applications	Yes
Executives	Transactional	• Ad hoc query	
		• Creation of documents and presentations	
		• Data analysis	
		• Data collection via Web and other sources	
		• Electronic mail	
		• Planning	
		• Presentations	
		• Transactional applications	Yes
Professional (doctor, attorney)	Transactional	• Creation of documents and presentations	
		• Data analysis	
		• Data collection via Web and other sources	
		• Electronic mail	
		• Planning	
		• Presentations	Yes
Programmers	Knowledge	• Creation of documents and presentations	
		• Data analysis	
		• Data collection via Web and other sources	
		• Electronic mail	
		• Presentations	
		• Software development	No
Sales	Transactional	• Creation of documents and presentations	
		• Data analysis	
		• Data collection via Web and other sources	
		• Electronic mail	
		• Planning	
		• Presentations	
		• Transactional applications	Yes

Source: International Data Corporation, © 1998

find the move the least problematic and will offer the organization the greatest cost reduction. It would be wise to select a small, centralized group as a "proof of concept" and then move on to other groups once the original group is successfully using this approach.

A product such as IBM's Workplace on Demand, would be an ideal tool to assist organizations in this process.

Conclusion

IDC recommends that organizations consider the requirements of both their knowledge and transactional workers when making the selection of a desktop operating environment. If the worker is using custom or packaged applications, the application developer may have already made the selection of desktop environment.

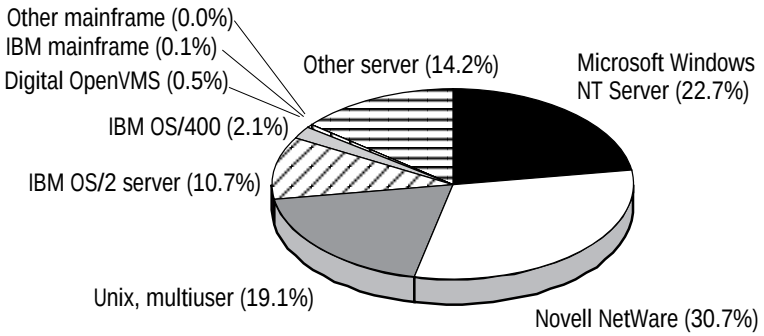
If the worker — typically a knowledge worker — requires a highly flexible, customizable environment, a desktop operating environment, such as MacOS, OS/2, or Windows makes sense. The platform supporting the organization's choice of applications should be selected.

If the worker, typically a transactional worker, requires a stable, manageable environment, a network computer or network PC may be the best choice.

Return on investment is a key issue. Upgrading for no other reason than to keep pace with a software supplier's version releases may not be in the best interest of the organization.

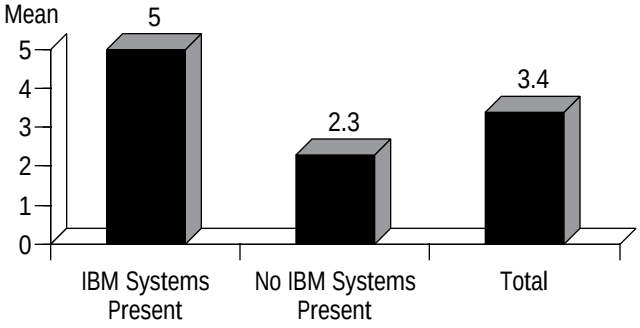
Appendix

Figure 1
Worldwide Server Operating Environment
Software License Shipments, 1996



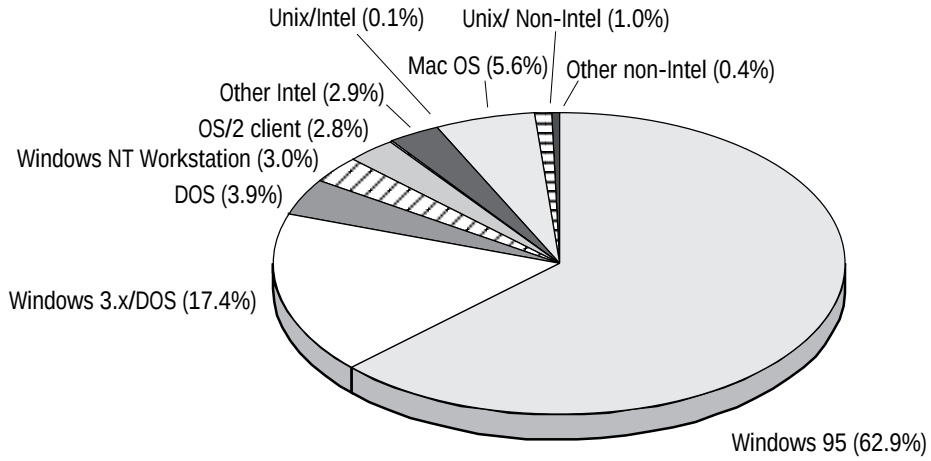
n=3,231
Source: International Data Corporation, © 1998

Figure 2
Mean Number of Different Server Platforms in Environment



Source: International Data Corporation, © 1998

Figure 3
Worldwide PC/Client Operating Environment Software License Shipments, 1996



n=77,396
Source: International Data Corporation, © 1998

Table 1
Vertical Market Segmentation of the U.S. Multiuser Systems Market, 1996
Percentage of Vertical Industry Revenues

IDC Vertical Markets	Multiuser Systems Spending ($M)	(%)
Manufacturing	4,658	24.2
Financial (Banking, Financial Svc, Insur)	3,251	16.9
Services (Business/Legal, Mngmt, Other)	3,033	15.8
Wholesale/Retail	1,630	8.5
Government	1,613	8.4
Communications (telco, broadcast)	1,224	6.4
Education	1,188	6.2
Health Care	1,016	5.3
Other	1,615	8.4
Total	**19,226**	**100.0**

Source: IDC's Corporate Computing: Vertical Views Program, IT Market Segmentation Series, 1998

Table 2
Intel Microprocessors

Year	Microprocessor	Date Announced	"Technology Pace"
1971	4004	November, 1971	
1972	8008	April,1972	70s
1974	8080	April,1974	Release Rate = 1 every 14 months
1976	8085	March, 1976	
1978	8086	June, 1978	Total Releases = 6
1979	8080	June, 1979	
1982	80286	February, 1982	80s
1985	I386 16MHz	October, 1985	Release Rate = 1 every 12 months
1987	I386 20MHz	February, 1987	
1988	I386 25MHz I386 33MHz	April,1988	Total Releases = 6
1989	I486 DX 25MHz	April,1989	
1990	I486 DX 33MHz	May 1990	
1991	I486 DX 50MHz	June, 1991	
1992	I486 DX2 50MHzI 486 DX2 66MHz	March, 1992 August, 1992	
1993	Pentium 60MHz Pentium 66MHz	March, 1993	
1994	I486 DX4 75 MHz I486 DX4 100MHz Pentium 90MHz Pentium 100MHz	March, 1994	90s
	Pentium 75MHz	October, 1994	
1995	Pentium 120MHz Pentium 133MHz	March, 1995 June, 1995	Release Rate = 1 every 3.2 months
	Pentium 150MHz Pentium 166MHz Pentium 180 MHz Pentium 200 MHz	November, 1995	Total Releases = 26
1996	Pentium 150MHz Pentium 166MHz	January, 1996	
	Pentium 200MHz	June 1996	
1997	Pentium II 233MHz Pentium II 266MHz Pentium II 300MHz	May, 1997	
	Pentium MMX 166 MHz Pentium MMX 200 MHz	January, 1997	
	Pentium MMX 300 MHz	June 1997	

Source: International Data Corporation, © 1998

Table 3
Chronology of Microsoft Operating Systems

Date	Operating System	DOS	Memory	Requirements Storage	Other
November, 1985	Windows 1.01	MS-DOS V2.0	256 KB	double-sided floppy diskettes or hard disk	graphics card
August, 1986	Windows 1.03	MS-DOS V2.0	320 KB	double-sided floppy diskettes or hard disk	graphics card
November, 1987	Windows 2.03	MS-DOS V3.0	512 KB	double-sided floppy diskettes or hard disk	graphics card
May, 1988	Windows 2.10	MS-DOS V3.0	512 KB	double-sided floppy diskettes *and* hard disk	graphics card
March, 1989	Windows 2.11	MS-DOS V3.0	512 KB	double-sided floppy diskettes *and* hard disk	graphics card
March, 1990	Windows 3.0	MS-DOS V3.1	640 KB 256 KB extended	double-sided floppy diskettes *and* hard disk	graphics card 80286 or higher (80386 recommended)
April, 1992	Windows 3.10	MS-DOS V3.1	896 KB (1024 KB recommended)	double-sided floppy diskettes *and* 6 MB hard disk (10 MB recommended)	graphics card 80286 or higher (80386 recommended)
December, 1993	Windows 3.11	MS-DOS V3.1	896KB (1024 KB recommended)	double-sided floppy diskettes *and* 6 MB hard disk (10 MB recommended)	graphics card 80286 or higher (80386 recommended)
December, 1995	Windows 95	-	4 MB memory (8 MB recommended)	40-45 MB hard disk	80486/25 MHz or higher VGA or higher resolution graphics adapter
2H 1998?	Windows 98	-	16 MB (24 MB or more to be recommended)	150-160 MB hard disk	Pentium VGA or higher resolution graphics adapter

Source: Microsoft, 1998

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