

DATA NETWORKING DIRECTIONS

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Today's corporations are using information movement and management to gain strategic advantage in the increasingly competitive business world. They are putting new processing power in departments and on desk tops, while using centralized systems to handle corporate data. Their challenge is to find ways to obtain the cost benefits of new technology without disrupting current operations and systems. This paper describes networked computing—AT&T's response to this challenge. This solution combines standard, digital network transport, open connectivity, a uniform computing environment, and unified network management. It permits customers to integrate their current networks with a single network with centralized network management, and to add new applications as needed. We also give examples of banking and airline industry applications of AT&T's solution.

Introduction

In today's increasingly competitive business world, corporations have discovered that information movement and management (IM&M) can provide a key to gaining strategic advantages over competitors. Thus, productive use of information has become a high priority at many companies. Current trends in technology, including the decreasing cost of processing and bandwidth, have made it cost-effective to install new processing power in departments and on desk tops, while much of the corporation's data still resides on centralized systems. The challenge to corporate management is to find ways to obtain the cost benefits of new technology without disrupting current operations and systems. (Panel 1 defines terms and acronyms used in this paper.)

AT&T's response to this challenge is networked computing, which combines:

- Standard, digital network transport using the Integrated Services Digital Network (ISDN).

Panel 1. Acronyms and Terms in This Paper

802.3	IEEE link-level standard for CSMA/CD LANs	MCS	multifunction communication system
802.5	IEEE link-level standard for token-ring LANs	MIS	management information systems
802.6	IEEE link-level standard for MANs	MIT	Massachusetts Institute of Technology
ACD	automatic call distributor	NE	network element
ANSI	American National Standards Institute	NMP	AT&T's specification for a network-management protocol
AOE	application operating environment	OAG	Official Airline Guide
ATM	automated-teller machine	OIS	office information systems
CCITT	International Telegraph and Telephone Consultative Committee	OSI	Open Systems Interconnection
CIO	chief information officer	PBX	private-branch exchange
CPU	central-processing unit	PC	personal computer
CSMA/CD	carrier-sense multiple access with collision detection	POS	point of sale
DOS	disk operating system	Posix	an IEEE standard for portable operating-system interfaces (based on the UNIX operating system)
FDDI	fiber distributed data interface	PRI	primary-rate interface
FEP	front-end processor	RISC	reduced instruction-set computing
IEEE	Institute of Electrical and Electronics Engineers	StarLAN	AT&T's star technology local-area network
IM&M	information movement and management	SQL	structured query language
ISDN	Integrated Services Digital Network	TP	transaction processor
ISO	International Organization for Standardization	TTY	teletype
LAN	local-area network	UNMA	Unified Network Management Architecture
LAPD	link-access procedures for D channel	VAN	value-added network
MAN	metropolitan area network	VCS	virtual-circuit switch
		WAN	wide-area network

- Open connectivity based on the Open Systems Interconnection (OSI) standards. [These standards are being issued jointly by the International Organization for Standardization (ISO) and the International Telegraph and Telephone Consultative Committee (CCITT).]
- A uniform computer execution environment that uses AT&T's UNIX[®] operating system and application operating environment (AOE).
- Unified network management through AT&T's Unified Network Management Architecture (UNMA).

These provide an integration capability that allows new applications to be built in an open environment, while supporting interaction and data exchange with existing systems.

AT&T's approach gives customers an opportunity to integrate their current networks into a single corporate-utility network with centralized network management and add new applications as necessary. It allows a customer to meet the goals of connectivity, integration, management, and investment protection and to continue to meet those

goals as advances in technology cause further disruption in the underlying communications and computing hardware.

To illustrate AT&T's solution, we give examples of its application to the banking and airline industries.

Customer Needs

Businesses today are facing an extremely complex environment, driven by competition, technological innovation, and structural cost cutting. Increasingly, executives of successful businesses view information as a strategic resource and the computing and network facilities that process and transport information as key components of their business operations. These executives want an edge in their markets and are seeking ways to meet competitive threats, contain costs, generate new markets, maintain flexibility, and integrate their applications across their business operations. Business plans to meet these goals—such as acquisition, divestiture, international expansion, or movement to a more decentralized organizational structure—all lead the business executive to demand corresponding changes in the role and scope of the corporate network.

Disparate systems, incompatible vendor products, applications backlogs, or disruptions in network operations can adversely affect a corporation's ability to make full use of its information resources. More frequently, the well-informed business executive is holding the telecommunications manager, management information systems (MIS) director, or chief information officer (CIO) accountable for realizing the strategic benefits of data networking.

As we will see, today's IM&M technology can help provide a quality response to these needs. Trends in data networking products and services can provide the basis for common platforms that support corporate demands for access to and management of corporate data. By leveraging these trends, the astute chief information officer has the opportunity to provide information as a strategic resource and effectively offer the business innovative ways to increase competitiveness and improve its strategic position within its industry.

But the corporate pressures placed on the chief information officer can be intense. The CIO must address such issues as multivendor connectivity, investment protection and price versus performance constraints, applications backlog and programmer productivity, data security, and cost allocations. Often, new technology can be adopted only if it retains compatibility with an embedded base of equipment and facilities, avoids disrupting normal business operations, and can be implemented on a declining budget.

A corporation's end users present other constraints. As we will see in the next section, end users have installed ad hoc responses to meet individual, group, or department needs for access to a myriad of data and systems applications. Individual purchases have resulted in a proliferation of unmanaged and often redundant local communications solutions. Out of frustration, end users are calling on the CIO to support their need for user-friendly, corporate-wide access to data and computing resources to improve their departments' productivity.

Environmental Trends

The CIO's response is to seek ways to:

- Provide processing power on the users' desks.
 - Interconnect a department's systems and connect individual users to corporate systems, enabling all users to share information.
 - Transfer data among systems at higher speeds.
 - Manage all networked systems and applications.
- Often, the answer is a corporate utility network.

Intelligence on the Desk Top. While the price-performance ratio has consistently shrunk [more CPU (central-processing unit) power per dollar], major disruptions in the underlying technology have made new options available to customers.¹ First minicomputers, then microprocessors (in several different families), and now reduced-instruction-set-computing (RISC) technology have provided price-performance advantages for smaller systems over traditional mainframes. This trend has pushed processing power onto the desk top, as demonstrated by

continuing growth in the installed base of personal computers (PCs).

International Data Corporation forecasts² a near doubling (from 65,758,000 to 125,570,000) in the worldwide installed base of PCs between 1988 and 1992 in all application segments, with the U.S. business-professional segment more than doubling (from 22,130,000 to 47,561,000). For the same period, Dataquest forecasts³ similar growth (from 19,200,000 to 36,700,000) in the U.S. business environment. While there are some differences between these two reports, both show a substantial increase in intelligence at the desk top.

At the same time, corporate databases and applications on centralized mainframe computers have continued to grow because of the investment already made in these systems. The mainframe systems are commonly accessed from "dumb" terminals, using circuit-switched networks [e.g., private-branch exchange (PBX) or public network] or private-line networks. More recently, the explosion of PCs and departmental minicomputers in the work place has established the importance of local-area networks (LANs) and the need to network those LANs.

LANs allow PCs and minicomputers to "talk" to each other at megabit-per-second (Mb/s) rates—far greater than the speeds normally associated with the links between dumb terminals and their host computers. The bandwidth and response time that LANs provide, coupled with the movement of processing power onto the desk top and a continuing reduction in LAN connection costs, has fostered the growth of new types of applications—e.g., file and peripheral sharing across departments. (The Gartner Group projects⁴ a 1991 cost of \$200 per connection, down from the 1987 cost of from \$600 to \$800.) As a result, the LAN has become a vital part of the state-of-the-art computing environment—networked computing. (Dataquest estimates³ that 19 percent of all PCs will be connected to LANs by the end of 1988, increasing to 50 percent in 1991 and 58 percent in 1992.)

Many of these departmental LANs have grown informally on an ad hoc basis and now need to communi-

cate with each other. Indeed, some departments that need to exchange large amounts of data have already connected their LANs, using bridges and routers as needed.

End users have become accustomed to easily manipulating data with their PCs, and want fast access to data from other departments and from up-to-date corporate mainframe databases. At the same time, corporate headquarters is realizing that many individual departments have valuable data that could be integrated to provide benefits across the corporation.

This need for data at the desk top will increase local- and wide-area communications requirements at the department, campus, and corporate or enterprise levels. Networked computing will require the high-speed interconnection of existing workstations and LANs using bridges, routers, and gateways, both locally and through wide-area networks (WANs). What will aid the WAN evolution are continued reductions in T1 transport costs and advanced voice-data switches with T1 interfaces.

Thus, a major new growth area for WAN services will be to interconnect LANs on a wide-area basis, allowing intelligent workstations to access distributed databases for multiple applications. Today's hierarchical, point-to-point topologies are common to both data processing and telephony networks. In the future, they will evolve to distributed, peer-to-peer configurations that support distributed databases and networked computing. Continued increases in desktop intelligence, a need for more distributed database access, and the emergence of application platforms that support loosely coupled processing will hasten the development of networked computing. Further, new applications will be built from the start to operate in a distributed, client-server environment.

Open Connectivity. The networked computing environment requires the capability to interconnect LANs across a broad array of business locations of varied size and function, while supporting multiple networks with different application and protocol characteristics. For example, the user interfaces and data-exchange protocols used to serve the factory, sales office, engineering, and

headquarters offices are naturally different and often incompatible. Typical connectivity solutions today use *bridges* to extend and link LANs and *routers* to interconnect different types of LANs [e.g., connect a token-ring network (802.5) to an Ethernet™ network or an AT&T StarLAN network (802.3)]. (Ethernet is a trademark of Xerox Corporation. The numbers 802.3 and 802.5 refer to IEEE link-level standards for LANs.) This arrangement is satisfactory to support a range of performance requirements and functionality in the short term.

However, even with the next generation of bridge router connectivity products, the operation, administration, and management of all end points on the network will become cumbersome and unwieldy. This is especially true as networks grow and are interconnected over time. In addition, name servers in today's connectivity solutions are frequently decentralized and not synchronized. (A *name server* is an automated directory system for a computer network.) Corporate-wide LAN directories are needed to realize the benefits of ubiquitous connectivity.

Business' growing need to move and manage data traffic between these diverse environments and among the total universe of end points calls for evolution to longer-term solutions. Such a solution would embrace centralized name servers, protocol permissiveness, and consistent user-network interfaces; avoid ad hoc implementations; and conform to standards. Such solutions will provide customers with reduced costs, improved network management, and greater flexibility to respond to the needs of their business. Clearly, today's competitive business environment calls for networked computing—no LAN is an “isLAND.”

Further, the sheer combinatorial nature of today's ad hoc approach to LAN and WAN connectivity makes readily apparent the need to replace multivendor protocols with standard, open-connectivity solutions. Standards-based protocols (e.g., OSI, ISDN⁵) more capably support the multivendor environment on an end-to-end basis than proprietary protocols. Standards give companies freedom of choice to mix and match vendor offerings, while also

decreasing the cost and complexity of network design, configuration planning, and operational support.

Customers understand this problem and are adopting standards as a solution. In a survey conducted in January 1987, Forrester Research found⁶ that 33 percent of Fortune 1000 companies had plans to migrate to OSI standards and 40 percent had plans to migrate to ISDN. The Gartner Group surveyed Fortune 500 customers at their 1987 OIS Conference, and found 49 percent expected OSI would be part of their strategic plan by 1991.⁷

Open connectivity through standards enables information to flow freely throughout the corporation and beyond, to the corporation's suppliers and customers throughout the world (e.g., electronic data interchange). AT&T's tradition of support for open standards will enable customers to realize seamless connectivity more quickly on a wide-area basis.

Demand for Greater Bandwidth. Another observable trend in data transport is the continuing need for greater bandwidth. In the time-sharing, terminal-to-host environment of the 1970s, asynchronous 300-b/s (bits per second) modems gave way to modems with 1200-b/s rates. Now, these are being replaced by 2400 and even 9600-b/s modems as the price per unit continues to decrease. Synchronous terminals have followed a similar trend.

In the 1980s, the use of PCs and the availability of LAN speeds made the server concept feasible. (The *server concept* allows several PCs, *clients*, to share files and peripherals on centralized machines, *servers*. The cost of expensive peripherals may then be shared over a wider group of users.) Today, costs continue to fall, stimulating continued demands for higher bandwidth. (See reference 1 for a summary of price-performance trends in communications.)

For example, the increase in workstation intelligence and the reduction in data-storage costs have made it commonplace for users to transmit large files containing data, images, and graphics. Soon, we may even see the integration of *scanner servers* on LANs⁴ to support the increased use of facsimile in business communications.

The use of high-resolution color graphics, advances in optical disk technology, and demand for image processing (e.g., desktop publishing) have advanced the concept of file and print servers, thereby increasing bandwidth and network performance requirements. (Gonze provides additional examples.⁸)

Users expect response times for these new applications in the multimedia environment to be the same (or better) than today's LAN environment, so there is an increasing need for bandwidth between the servers and the clients. This need for greater bandwidth applies both to the LAN level—where demand is first made—and then to the WAN level—when LANs are interconnected as part of a corporate utility network. Today, direct digital access to high-capacity facilities and the use of intelligent, high-speed (T1) multiplexers have made low-cost, high-speed, wide-area transmission capacity readily available. Within 5 years, the fiber-optic communications market is expected to quadruple.^{9,10} The emergence of even higher speed standards [such as the Fiber Distributed Data Interface (FDDI) and metropolitan area network (MAN; 802.6)] suggest that LAN speeds will soon exceed 100 Mb/s. (FDDI is an ANSI standard, and 802.6 is the IEEE standard for MANs.) WAN bandwidth demands will surely follow; and LAPD frame-relay networks, which minimize protocol processing at intermediate nodes, promise¹¹ to provide high-quality, high-speed bandwidth over a wide area. (LAPD is the link-access procedures for D channel.)

Integrated Network Management. The use of data networking as a strategic business resource is a double-edged sword. It provides powerful competitive advantages, but carries with it an acute need for real-time control and monitoring capabilities. Future data networks will be very large, highly distributed, and enormously complex. The trend toward networked computing will increase the need for manageable, self-healing, and intelligent networks.

Many customers, especially large ones, support multivendor environments and use a variety of communications and computer equipment and network facilities. They need help in identifying the source and nature of problems

from a centralized location in an environment of multi-vendor equipment, complex protocols, and geographically dispersed networks. Also, there is an urgent need for tools to aid network design, configuration planning, provisioning, inventory and directory management, and network security. Customers and vendors have approached this need for more effective network management in two ways: a standard architecture and integrated service and support.

As Figure 1 shows, some customers are adopting a standard network-management architecture. It serves as a framework for end-to-end management solutions in a multivendor environment, and is integrated across both the communications and computing environments. By supporting standard communications-interface specifications that are based on the OSI reference model and protocols (e.g., NMP, AT&T's specification for a network management protocol), AT&T's UNMA¹² ensures that products from multiple vendors can be managed together. Such systems bring together, in a single place, network management information from existing element management systems. Users of UNMA can then view their networks graphically or, with the help of expert systems, analyze alarms and status information to manage and control their networks more effectively.

A second approach is found among some companies that seek to "get back to basics" and refocus their efforts on their own core or strategic business operations. They are looking to their network supplier to offer integrated network management service and support. Not surprising, the difficulties in staffing, training, and retaining key personnel often emerge as the single biggest risk to a company in the use of data networking for strategic advantage. Customers have observed that an experienced data-networking supplier, with a large pool of skilled and motivated people, can offer the customer a complete solution that encompasses operations, security, and reliability.

Corporate Utility Networks. History shows that any emerging technology guarantees relentless change, yet brings with it new opportunities. Companies that can successfully manage data across their networks and use it in

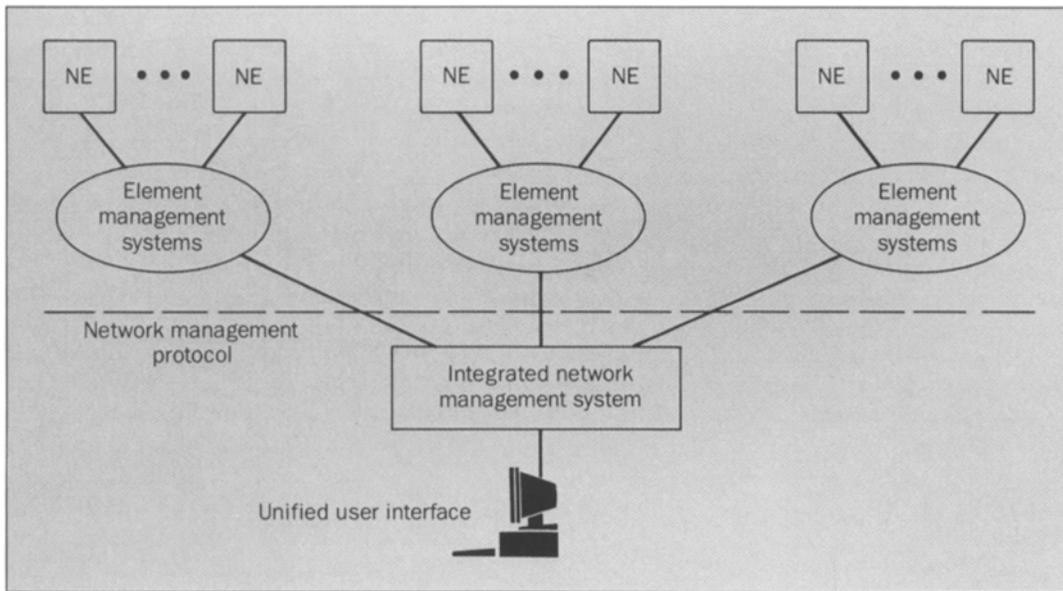


Figure 1. Generic architecture of AT&T's unified network management architecture. NE identifies a network element.

their business operations will have an advantage in the increasingly competitive global economy. To achieve this goal, leading companies have been integrating their networks.

Over time, customers have been faced with supporting dynamic business needs by applying currently available and evolving technology. It is not surprising, therefore, to witness the growth of multiple and parallel voice and data networks, each designed for a different application, purpose, or locally optimized need. And, as LANs have become simpler to install, use, and maintain, they have proliferated within the departments of a corporation. International Data Corporation shows¹³ that the installed base of LANs has increased from just under 100,000 in 1985 to over 800,000 today. This base is projected to grow to 3.6 million by 1992—a compound annual growth rate of 69 percent. The number of devices attached to LANs will grow from 6 to 8 million today to about 35 million in 1992.^{3,13}

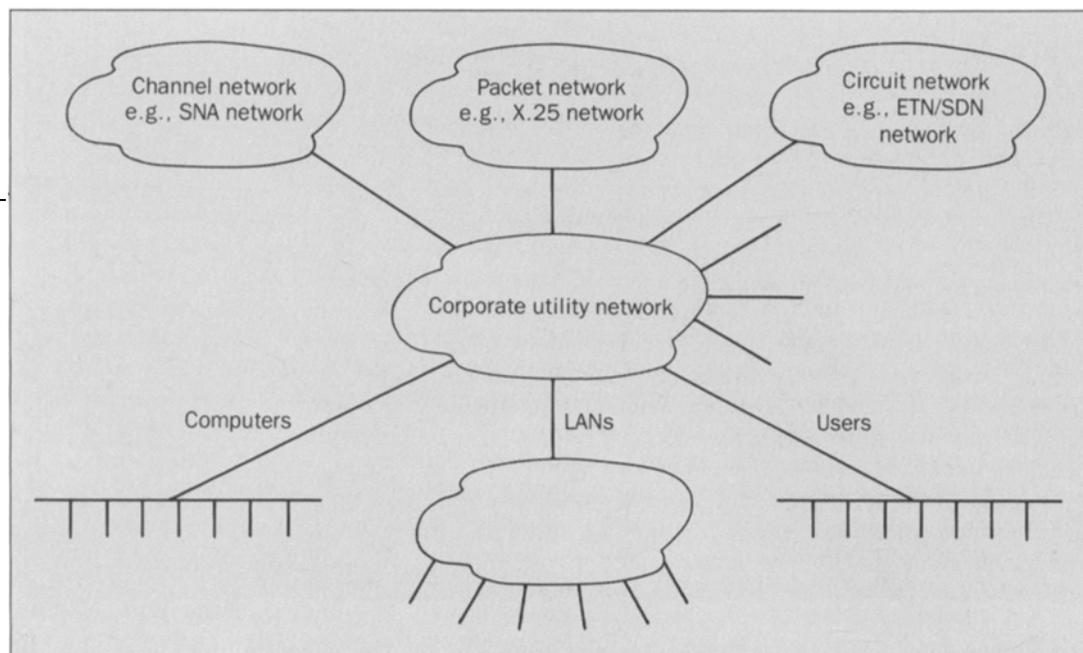
There is an emerging need for inter-LAN connectivity to support networked computing that will quickly and accurately carry the information needed to conduct business throughout the world. To satisfy this need, corporations are “inventing” the corporate utility network (Figure 2) to provide networking connectivity for all applications and users. Central MIS or telecommunications organizations have become increasingly responsible for developing the technical strategies, designing the network architecture, and coordinating implementation of

the corporate utility backbone. While policies, plans, and standardization of the corporate utility network are centrally controlled, end users are free to implement local network solutions that optimally meet their needs. This “loose-tight” joint responsibility is an elegant way for companies to manage this strategic resource.

Another major benefit of this utility network approach is its inherent flexibility to allow new applications to be developed more quickly and enable new locations to be connected more quickly. To realize these benefits, some companies are increasingly basing their corporate utility network on virtual circuits, instead of dedicated links. Virtual circuits have proven to be an effective and economically advantageous alternative to dedicated private lines for many of today's networks.¹⁴ This approach makes it possible to consolidate multiple networks into a central utility network that provides wide-area connectivity and compatibility with a variety of end-point protocols.

The corporate utility network may also be characterized as a hybrid network that integrates public and private facilities, channelized and packetized transport, and voice and data traffic. Typically, the best economic solution for most customers is a combination of private and public networks. This also provides flexibility to distribute network intelligence among the customer's premises, local-exchange carrier, and AT&T service node. The channelized-packet hybrid enables a customer to put a packetized data stream onto a few channels of a channe-

Figure 2. Architecture of a corporate utility network. ETN is electronic tandem networking; LANs are local-area networks; SDN is software defined network. (SNA is a trademark of IBM Corporation.)



lized backbone network, typically used for voice.

Although a strong demand for separate voice and data networks will remain into the 1990s, there is a significant trend for existing networks to evolve to integrated voice and data networks. According to the Yankee Group,¹⁵ "In today's age of building enterprise networks, the top issues consistently are data and voice integration and network management." As voice encoding technology advances so that "everything is digital," the combination of voice and data traffic provides the opportunity to realize engineering efficiencies. The widespread availability of ISDN capabilities will offer a customer additional flexibility, improved performance, and new functionality to support the needs of its business. For example, we may view the joint effort of AT&T, Illinois Bell Telephone Company, and McDonald's Corporation¹⁶ as one step in the evolution to a corporate utility network.

Computing Trends and Applications Portability. The corporate utility network described above supports the embedded base of existing corporate applications and provides a communications platform for the cost-effective and timely implementation of new applications. Networked computing relies on processing as well as communications, and we will now look at some trends in this area.

Changes in processor technology (from minicomputer to PC, and then changes in PC technology) have led to compatibility problems in the processing arena:

- Rapid obsolescence of software as the hardware architecture changes. Some familiar "old" programs are not available on RISC workstations.
- Rapid obsolescence of hardware as the software grows in complexity to use the features available on newer hardware. New versions of popular applications will not fit within the memory and performance constraints of "old" PCs.

Thus, the dilemma: If the hardware is upgraded, much of the old software cannot be reused. But if the hardware is not upgraded, new software with improved functionality cannot be used, and potential performance gains from new hardware cannot be realized.

To reduce this problem, computer vendors typically develop new processors that are upward compatible with existing systems. However, some new technologies (e.g., RISC) make upward compatibility with existing instruction-set architectures difficult or impossible. Indeed, the Yankee Group has noted:¹⁷ "The implementation of RISC (reduced instruction set computing) microprocessors in desktop systems could make all current desktop systems obsolete."

Formal standards have long been used to address compatibility problems in the communications world, and the processing world is beginning to standardize as well. Standards in this area can improve an application's portability, allowing it to be moved easily to new machines in a

multivendor network. By using these standards, we can ease the transition from current systems to new RISC-based workstations. Standards can also prepare the way for easier transitions when future technology again causes significant changes in the hardware environment.

Some examples here include IEEE's Posix™ standard for operating system interfaces, the X.11 standards for program interfaces to graphical terminals (which are based on the X-Window System™ standard), and the SQL (structured query language) standard for relational database queries. (The Posix standard defines a portable operating system interface and is based on AT&T's UNIX operating system. X-Window System is an MIT trademark.) While these processing standards have not yet reached the level of acceptance of some of the well-known communications standards, the trend is clear: Standards will be increasingly important in the computing world. (AT&T's UNIX System V operating system will conform to the Posix specifications, and AT&T's AOE¹⁸ includes several standard interfaces for programmers, e.g., X.11 and SQL.)

AT&T's Solution

So far, the discussion has concentrated on the trends that are operating in the marketplace. Here, we present a way to segment the market based on those trends, and then show how AT&T expects to address our customers' problems.

AT&T's goal is to understand the customer needs and technology trends discussed in the previous section, classify them, and then develop specific market-segment responses. Because customer needs and market trends are continually evolving, our efforts to understand and meet those needs must evolve as well.

AT&T's goal is to provide solutions for our customers' IM&M problems. Some of these solutions will address general problems that are common to many different parts of the market, and others will be market-segment specific. In both cases, the market needs will evolve over time, and the solutions must evolve with the needs. Because models can help us understand this evolu-

tion, we now examine one such model.

A Model of the Environment. Business computing environments and the data networks that support them will continue to be diverse. Figure 3 shows one way to classify these environments by dividing them into categories based on the scope of the system (wide-area corporate-intercorporate systems, or local department-campus systems) and the technology on the typical user's desk top (terminal, PC, or workstation).

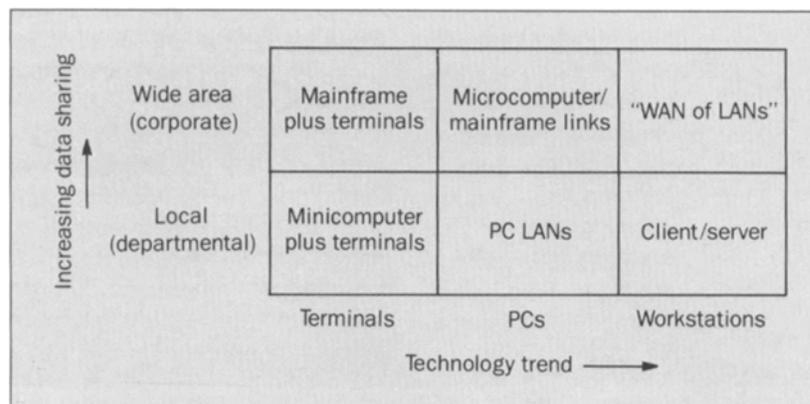
The left column of the chart shows computing based on terminals and central computing facilities, i.e., mainframes for the corporate data center and minicomputers for departmental systems. A variety of network technologies support the departmental case: circuit switching over public and private telephone networks (i.e., PBX, Centrex), data switches, or direct connections over in-house wiring. There may also be provisions for remote access via the public switched network or X.25 value-added networks (VANs). All these solutions typically ride on existing voice network facilities.

The corporate case, while also sharing telephony's facility infrastructure, is the domain of host-centered networking, which typically is based on IBM's SNA™ network architecture. (SNA is a trademark of IBM Corporation.) These are hierarchical networks. Terminals are connected to local controllers, which are then connected to the host by private-line facilities.

The middle column of Figure 3 shows the changes that are occurring because of the wide availability and use of PCs. In the local case, the availability of high-speed local communications that use the family of 802.x LANs allows for new types of support and cooperation among group or departmental sized entities. Although the PCs still do much of their work in a stand-alone environment, the LAN opens up opportunities to share data and expensive peripherals. This makes the network integral to the environment, and devices are referred to as servers: print, file, mail, etc.

This environment is particularly important, because it predicts future environments as greater dis-

Figure 3. Model of the environment. PC is a personal computer, LAN is a local-area network, and WAN is a wide-area network. A "client" is a PC or terminal, and a "server" provides a function such as printing, file access, or mail.



tance is traversed (i.e., LANs → campus → MANs → WANs) and corporate utility networks are established. With declining transport and computing costs, two things are driving the motivation for sharing:

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- The cost of administration (e.g., administering a single database server versus administering and coordinating many personal databases)
- The ability to introduce new technologies cost-effectively (e.g., a shared laser printer versus many personal dot-matrix printers).

The rightmost column in Figure 3 shows an environment where workstations and servers are designed from the beginning to work together. Here, the network that connects them is an essential part of the computing environment. End users are connected in a transparent and seamless fashion to information in distributed databases and do not need to know where the information is actually stored. A user logs on and, if authorized, is routed automatically to the appropriate database, locally or distantly, based on his or her request.

In the wide-area case, these connections are made through a WAN that provides high-speed connections between LANs at many different locations. In the local case, the workstation and server are on the same LAN.

The trend to the right in Figure 3 is not inevitable, nor will all parts of a corporation move at the same

rate. Despite advances in distributed database and transaction processing technology, many applications will continue to use centralized mainframe solutions where consistency and currency are both required. Similarly, LAN costs will likely continue to be less than MAN or WAN costs for a given bandwidth and throughput, so there will continue to be reasons to keep some applications in a single, local environment. Thus, it seems both unlikely and unnecessary that all applications will arrive at the last column of Figure 3.

Certainly, many customers currently have both PC- and terminal-based systems in place, and connections among these systems are needed to protect these equipment investments. Thus, networks will grow increasingly heterogeneous and complex over time because all the environments shown in Figure 3 need to work with each other.

The coexistence of all these environments reemphasizes the importance to customers of company-wide connectivity and the corporate utility network described earlier.

AT&T's Response. AT&T's response to marketplace needs is to use our existing capabilities and develop or acquire new capabilities to let us offer customers a software-definable networked-computing capability that gives them the ability to manage and control their own networks. To help our customers address their business

problems, we will provide total application and networking responses.

To achieve this goal, we must proceed along three separate but linked paths:

- Design standard platforms.
- Develop components that can be integrated.
- Evolve an integration capability.

Standard platforms. To support a world-wide, intelligent, open, and easy-to-use network computing environment, the AT&T solution set centers around an open, uniform architecture for applications, networking, transport, and management. In each area, AT&T is pursuing an open strategy based on standards that provide a unique customer benefit (Figure 4):

- Applications—UNIX System V software and AOE standards protect investments in applications via hardware portability.
- Networks—OSI standards provide connectivity in multivendor networks.
- Transport—ISDN standards, especially ISDN frame relay, are the basis for AT&T's integrated data architecture,¹¹ which will provide high-performance networking capability for the applications environment.
- Management—UNMA standards provide manageability with broad unified scope.

AT&T platforms will be built around these standards and, as Figure 4 shows, will be integrated with other environments. However, this does not imply the exclusive support of *only* these standards. AT&T will also support interfaces to other de facto or de jure standards that have significant market presence.

For example, a distributed UNIX system environment may be well suited for a mortgage system, but existing customer records may reside in a centralized mainframe system. Here, the distributed mortgage system might use OSI and ISDN internally, but would have SNA network gateways for interchange of data with existing mainframe applications. The standards provide enabling technology for integration and interworking, but we are ready to interact with our customers' existing systems and

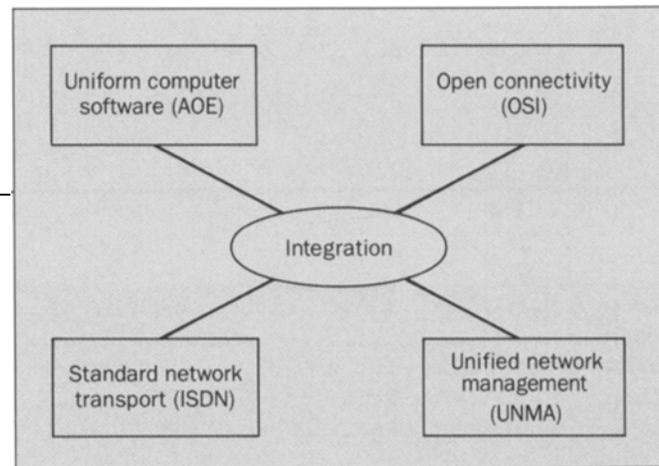


Figure 4. AT&T's approach to open networking integrates four "standards": AT&T's application operating environment (AOE), which includes the UNIX system; Open Systems Interconnection (OSI); Integrated Services Digital Network (ISDN); and AT&T's Unified Network Management Architecture (UNMA).

meet their specific needs.

Integratable components. AT&T already has a wide range of products and services, from computers to PBXs, from Megacom[®] telecommunications services to Accunet[®] packet service. Each product and service is designed to meet the needs of our customers and provide them benefits. But there may be additional benefits when these products and services are offered as parts of integrated solutions.

For example, by integrating AT&T PCs with the UNIX operating system, StarLAN network, and server capabilities, we can provide a work group that allows MS-DOS[®] and UNIX software applications to operate simultaneously and communicate, thus multiplying the resources available to a single PC user. (MS-DOS is a trademark of Microsoft, Inc.; DOS means disk operating system.) By linking processors with PBXs, we can provide integrated messaging systems and message center services. Processors, PBXs, ISDN primary-rate interface (PRI) service, and the AT&T 6500 multifunction communication system (MCS) can be integrated with specialized application software to provide a telemarketing service customized for the needs of a particular business. (The 6500 MCS is compatible with IBM's 3270 synchronous terminal/cluster controller.)

Integration capability. As noted above, AT&T has a

set of existing products and services that can meet many customer needs. However, specific customers have needs unique to their industry or company, and AT&T must be ready to work with these customers to meet those needs.

This requires an integration capability—to build, test, and support specific configurations from our set of components or build new applications using our standard platforms. It also implies a wide range of support activities, from training to operations, for custom solutions as they are built and as they evolve with a customer's changing environment.

Customer Application Examples

We have already given an overview of AT&T's response to our customers' business needs and the general technology trends. Here are some specific examples of the application of this response to real industry needs.

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Banking Industry. In recent years, the banking industry has gone through a revolution spurred by deregulation. In turn, deregulation has stimulated significant competition from both traditional banks (e.g., the introduction of new financial products) and nontraditional competitors (e.g., retailers, brokerage houses, automobile manufacturers). In addition, deregulation has given banks the freedom to become regional and interstate, thus spawning numerous mergers and acquisitions.

Banks have always been among the leading-edge users of data networking. In general, a successful bank realizes that its communications networks and data processing systems *are* its business. They do not lend dollars; they move and manage bits and bytes. Therefore, a bank's information systems and data networks are its delivery vehicle to obtain competitive advantage. They enable a bank to provide new applications and financial products to its customers.

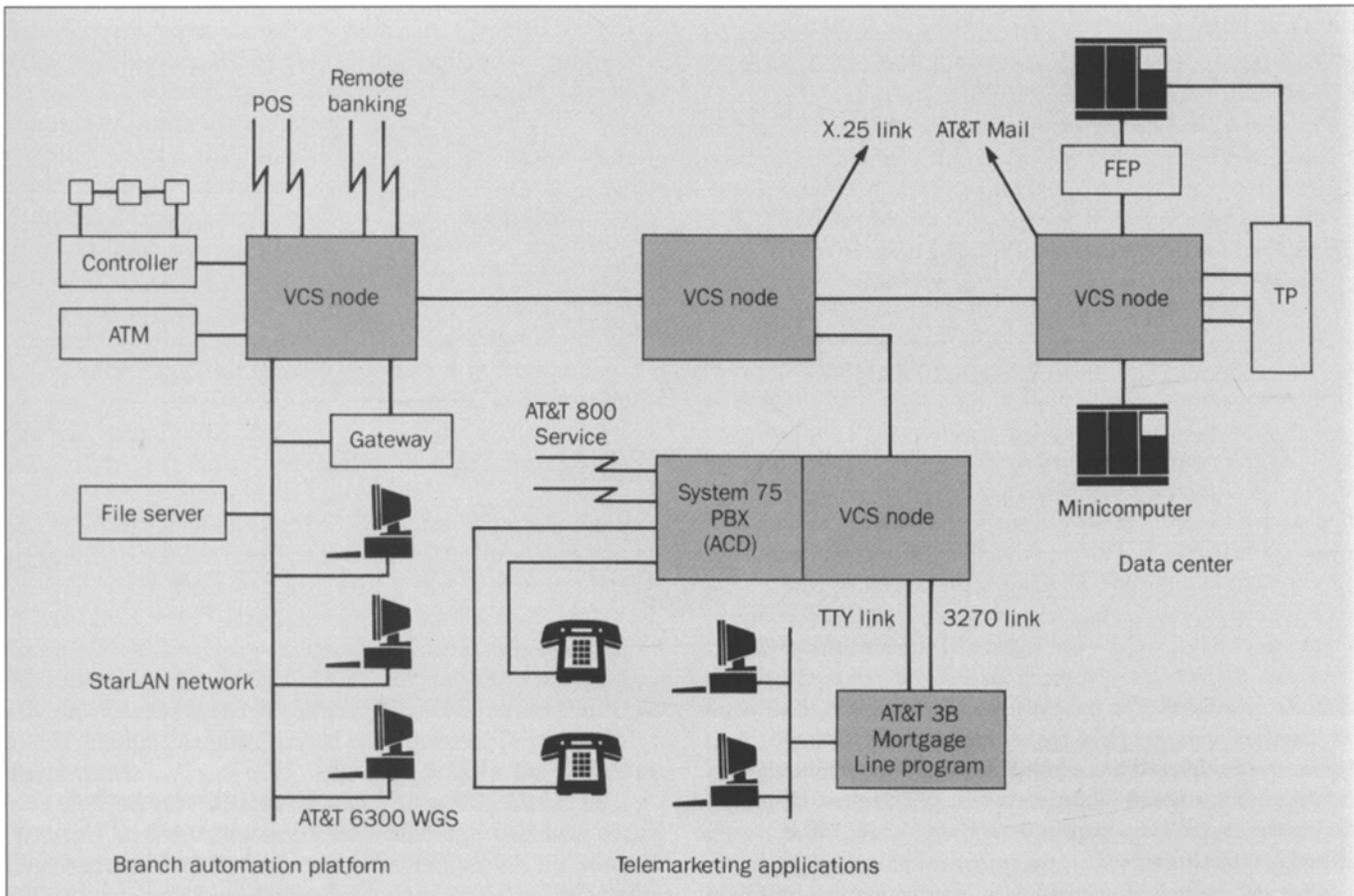
Specifically, banks have a wide variety of network needs to support their teller, lending platform, customer service, and back office functions at the branch level. For example, banks are evolving to greater sharing of their automated-teller-machine (ATM) networks (that eventually

may be used to dispense airline tickets, theater tickets, etc.) with more on-line processing. To be competitive, loan processing times need to approach real time, even though multiple databases (e.g., credit bureau, bank accounts) and several, potentially decentralized applications and people are involved. Innovative banking services, such as providing a local business with PC applications and direct access to the bank's databases, are being tried. Today, banks are looking for solutions that leverage their existing applications, networks, distribution channels, and people to increase profitability.

The traditional solution for banks has been a controller-based network on the premises, with hierarchical, private-line connections to the mainframe. In the past, such an architecture has been satisfactory but it constrains banks, which lose the agility needed to integrate quickly new and more-competitive network products that would better serve their business objectives. The host-oriented controller is a closed architecture with proprietary interfaces. This type of network has performance problems because of bottlenecks that limit transaction capacity and slow response times. For most banks, the recourse involves periodic "controller upgrades" that can be expensive and disrupt operations. Also, a private-line controller network lacks the flexibility to bring new applications or locations on line quickly.

Figure 5 shows AT&T's alternative solution, which is based on intelligent PCs that are connected by a LAN, with file and print servers, and host gateways across a virtual-circuit WAN.

The AT&T 6300 work group system (WGS) in the figure is used as a customizable, "intelligent workstation" to automate traditional teller functions and support new platform functions (e.g., on-line account opening and file access). MS-DOS applications offer a wide range of PC-based solutions today. But the increasingly advanced, banking-automation applications will require the advanced communications and multitasking functionality of the UNIX system. Development environments for third-party applications offer the banking industry a foundation for easy



customizing, thereby placing more computing power on the desks of bank employees so they can do a better job of responding to customer needs.

AT&T's StarLAN (802.3) network links these intelligent PCs and permits application flexibility to be distributed across the LAN, file servers, and gateways to mainframes and commercial information providers. This configuration fully uses the power of the PC as an integrator of host and other information sources on a peer-to-peer basis. Also, the modular architecture provides protocol

Figure 5. AT&T architecture for a retail banking application. VCS designates a node of the Datakit virtual-circuit switch; 3270 refers to a device that is compatible with IBM's 3270 synchronous terminal/cluster controller system, e.g., the AT&T 6500 MCS. ACD is automatic call distributor; ATM is automated-teller machine; FEP is front-end processor; PBX is private-branch exchange; ISDN PRI is the Integrated Services Digital Network primary-rate interface; POS is point of sale; TP is transaction processor; and TTY designates a teletype device.

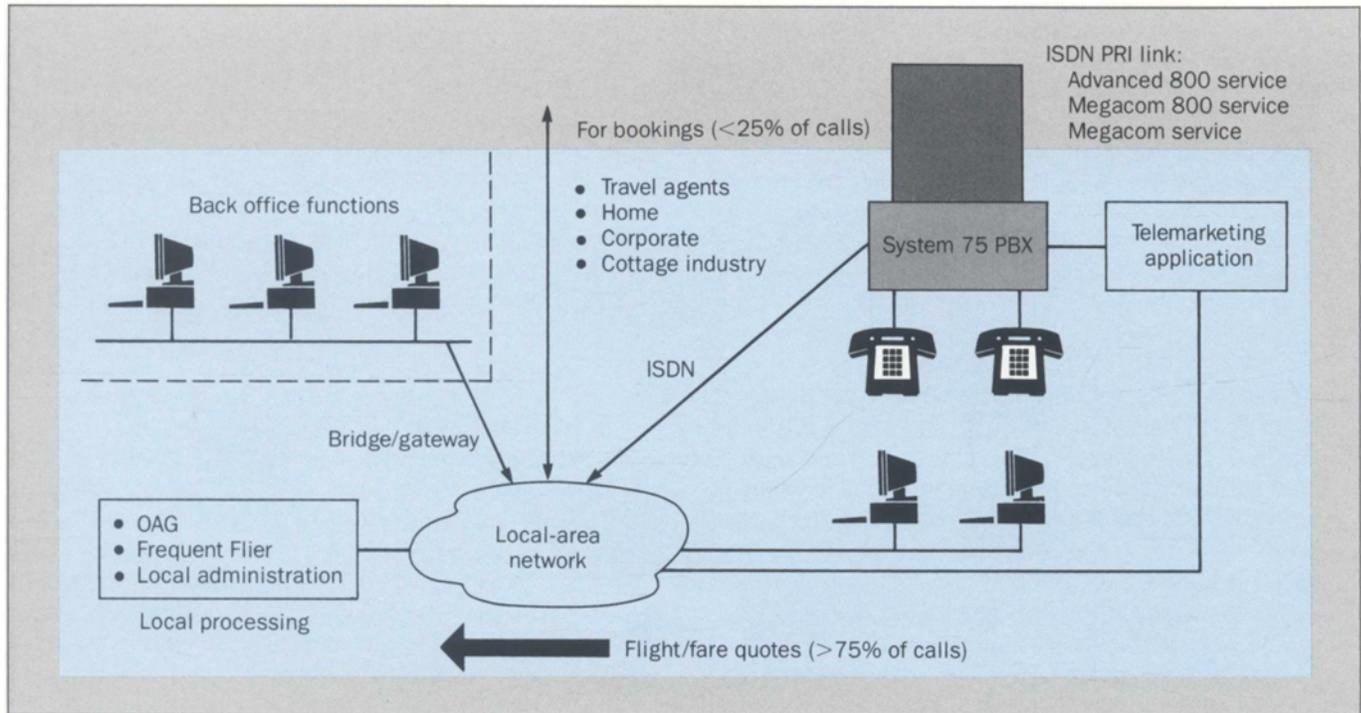


Figure 6. Architecture for an airline reservation center. ISDN is Integrated Services Digital Network; OAG is the Official Airline Guide; PBX is a private-branch exchange; PRI is primary-rate interface.

compatibility for the multivendor branch equipment environment and offers higher reliability because backup servers are less expensive than traditional controllers. Thus, the intelligent workstation, combined with the open connectivity of the LAN, opens a wide range of distributed processing options at the branch level.

The Datakit[®] virtual circuit switch (VCS) further extends open connectivity and applications compatibility across the WAN. The VCS solution provides end-to-end transport, integrating the customer location, local-exchange carrier, and AT&T service node. This economical solution enhances disaster recovery and supports a wide

variety of networking protocols.

This architecture easily supports new banking services, such as remote banking and point-of-sale (POS) transaction applications. Telemarketing capabilities—using AT&T 800 services, AT&T's System 75 or 85 PBX, ISDN, and the AT&T 3B Mortgage Line[®] software application for AT&T 3B computers—show how this architecture may evolve to support voice and data integration. Ultimately, retail banks will want to integrate their networks fully through ISDN to provide voice, data, and video to the branch to support a host of new and distributed applications.

Finally, LAN interconnection through VCS complements the integrated branch-automation architecture by giving a bank the ability to manage its LANs and WAN at the workstation level (e.g., using AT&T's StarKeeper[®] network management system and UNMA). The banking

customer can more easily provision and reconfigure these virtual networks through software control over a single physical-network architecture. Thus, a bank's private-line, controller-based configuration can be transparently migrated to VCS without disrupting daily operations. As described by Al-Chalabi and Liss,¹⁴ this architecture provides an advantageous alternative to the current data-networking arrangements at many banks that have distinct data networks dedicated to distinct banking applications.

Airline Industry. The airline industry also faces specific instances of many trends we have already described. Many current applications are based on mainframes and use separate networks for each application, which leads to multiple, nonintegrated networks for data. Recent large mergers have compounded this problem, resulting in incompatible equipment and protocols.

Deregulation of the industry has led to increased competition, with a corresponding hunt by airline management for strategic advantage. One possible strategic advantage is increased customer satisfaction through improved service. This drives a need for increased MIS flexibility (e.g., reservations systems, airport automation, scheduling). A second potential advantage, enhancements to distribution channels, would require more flexibility in the network.

Several AT&T LAN and WAN solutions can be brought together and integrated to help the airlines meet their business needs. In the reservations center, local-area networking, distributed processing, and an AT&T telemarketing system can improve customer service. Figure 6 provides a picture of a possible configuration.

A digital PBX (e.g., the System 75 or System 85 PBX) is connected to AT&T Advanced 800 or Megacom 800 service via an ISDN PRI link. The PBX's telemarketing application connects to a local-area network to interact with a local database on an AT&T 3B2 computer that contains portions of the schedule data, frequent-flyer data, etc. Attendants can process customer queries about travel itineraries and give fare quotes (75 percent of calls), using on-site processing and data without accessing the central reservations host. For those calls that result in a booked

reservation, the LAN server connects the attendant's PC or terminal to the reservations host and passes along information about the current call. Connections can also be established to hotel or automobile rental systems or credit authorization systems.

If known, telephone-number information about the calling party is passed to the PBX from the AT&T network via the ISDN link. This information can be used to display profile information about the calling party on the attendant's screen just before the voice-call connection is established.

The reservations application shows one way to tie together AT&T's computing and communications solutions to improve a customer's business. Other applications include airport automations, resource scheduling (e.g., crew, flight operations), and backbone data networking. Key to these applications is the need for flexible network management based on UNMA. Such management can support rapid changes in an airlines network when a new travel agency needs access to the reservations network, or when reservations are cross-linked to a hotel chain or other new distribution channel.

The use of standard communications services (e.g., Accunet packet service for X.25 communications) can ease the task of connecting to other airlines to exchange reservations data as part of feeder and trunk airline systems. Increased use of minicomputers, PCs, and standard operating environments—such as AOE and the UNIX operating system—can provide a platform for automation of airport functions that can grow into the future with minimal disruption.

Summary

We have explored some of the business needs and technical trends that are driving the future of data networking. Information has become a competitive resource, highlighting the importance of communications and computing in the business world. Increased intelligence on the desk top has created a demand for greater bandwidth and open connectivity, leading to a need for open standards and integrated network management. In response, many suc-

cessful companies are creating corporate utility networks to support new, distributed applications.

An analysis of the environment reveals a trend toward increased integration of computing and communications. Because applications do not all evolve at the same rate, complexity is also increasing as several different environments need to be interconnected in a single corporation.

AT&T's response to this challenge is networked computing. This solution combines ISDN, OSI, the UNIX operating system and AOE, and UNMA with an integration capability to provide platforms and applications that support interaction between new and old systems.

The banking and airline examples showcase the application of this approach to real customer problems.

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