Operations Systems: A Perspective

Dan Stanzione The U.S. communications industry today is experiencing great change. Telecommunications companies are vying with—and in some cases merging with or acquiring—cable television companies to bring interactive broadband services into the home. Computer companies are developing products to provide video-conferencing and other interactive broadband capabilities. In Washington, lawmakers are grappling with such issues as the "Information Highway," loop communication, access, local service monopolies, and equipment manufacturing. One result is that the telecommunications industry will soon evolve into a new industry, with less regulation and more intense competition. These developments will lead to rapid technological innovation and plummeting prices—the same phenomena that shaped the computing industry in recent years. Like other parts of the telecommunications industry, operations systems will be dramatically affected by these events. To respond to the changes and to remain innovative and competitive, AT&T's Operations Systems Business Unit (OSBU) is revamping not only its methods for developing software, but its entire business strategy.

Introduction

Operations systems (OS) link the evolving telecommunications network with both the personnel who operate and maintain the network and the customers who use the network. These computer-based systems are the behind-the-scenes workhorses of the network, keeping it operating day after day. They maintain inventory records, watch for alarms in central offices, track trouble reports, design circuits, and handle a host of other jobs. In AT&T's network, hundreds of operations systems are at work, and many more serve telephone operating companies. The costs for operations systems, including hardware and software development, maintenance, and research, are in the millions of dollars.

Many operations systems were developed to support a specific type of equipment, function, or service. Some operate in the central office, for example, and help keep switches running. Others work in the loop, which is the physical link between customers and the central office. But tomorrow's systems will become more universal and more integrated, even as new services and network technologies grow more complex and customers demand more customization.[1]

Operations systems provide value to AT&T customers. They provide strategic, up-to-date information. They increase productivity by integrating and automating systems and reducing duplication. They optimize the planning of network growth and enable quick deployment of new services. And finally, operations systems help provide faster, more flexible response to competition.

Over the past two decades, AT&T's Operations Systems Business Unit (OSBU) has been a leader in developing global operations software. Figure 1 summarizes the OSBU's achievements in this area. In 1974, for example, AT&T developed the first operations systems based on UNIX* technology, and in 1982, the first off-line expert system. Four years later came the first operations systems

to use a graphical user interface, and three years after that MACSTAR, the first operations system to use object-oriented programming, was introduced. The 1990s saw the first introduction of software fault tolerance in an operations system.

These achievements were based on pioneering software efforts of AT&T Bell Laboratories researchers, such as the UNIX time-sharing system (1970s); software-driven terminals for windows (1980s); C++, the object-oriented version of the C high-level programming language (1980s); and, most recently, software fault tolerance (1990s).

Market Trends Affecting Operations

Since rapidly changing market forces play such a large role in the OSBU's business strategy, it is worthwhile to examine some of the major market trends that affect operations for both the domestic and global telecommunications industries.

Need For New Services. The relatively slow growth in the number of telephone lines in the U.S., coupled with the increasing importance of telecommunications to U.S. businesses, have pressured carriers to move aggressively into providing new services for subscribers. New high-capacity private lines, sophisticated data-based services provided by the signaling system 7 (SS7) network and ancillary equipment, and new protocol-based data services are being implemented at an unprecedented rate. Plans are now being made, for example, to bring interactive broadband services to consumers. These services include video-on-demand, integrated services digital network (ISDN), and multimedia services.

All of these affect the operations of the carrier. The general trend in operations systems support for these new services is to create as few new operations systems as possible, and to evolve currently embedded systems to incorporate the additional functions needed by the new services. During the first few months or years of the new services, however, a dedicated work group often is created, sometimes with its own specialized operations systems support, to deal with them.

Key new services include high-speed data services for terminal access and local area network interconnection; data-base services provided by the SS7 network and ancillary equipment in an intelligent network architecture; and virtual private network services for large business users.

The growing complexity of the new services, especially those based on SS7 and involving database lookups, will require a new set of operations capabilities. Unaided, humans cannot handle the complexity of these new services. Provided by geographically dispersed network elements, they are often time-dependent. And in

First use of software
fault tolerance ("PQRS"-1992)

First online expert system ("TERESA"-1988)

First object oriented programming ("MACSTAR"-1987)

First graphical user interface ("ATOMICS"-1986)

First off line expert system ("ACE"-1982)

First multiple system access from a single terminal ("BANCS"-1980)

First operations system to front end IBM MVS* system ("LMOS"-1979)

First use of a relational data base ("NOC" and "COSMOS"-1977)

First operation system based on UNIX* technology ("SCCS"-1974)
First use of a browser to find intermittent problems ("SCCS"-1974)

First used to test transmission equipment ("CAROT"-1970)

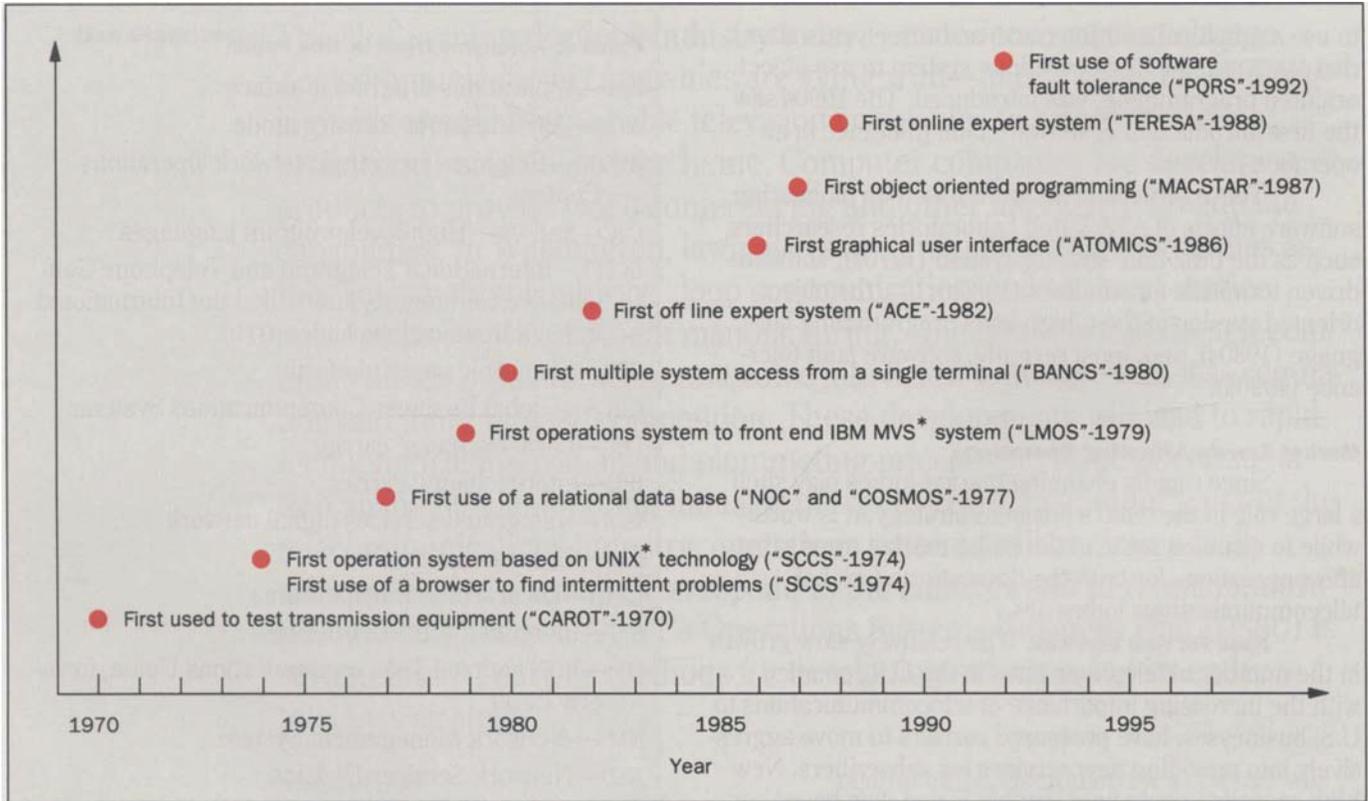1970   1975   1980   1985   1990   1995

Year

Figure 1. AT&T's Operations Systems Business Unit (OSBU) has led in developing global operations software. In 1974, AT&T developed the first operations systems based on UNIX* technology and, in 1982, the first off-line expert system. Four years later came the first operations systems to use a graphical user interface. Three years after that, MACSTAR, the first operations system to use object oriented programming, was introduced. The 1990s saw the first use of software fault tolerance in an operations system. These achievements were based on pioneering software, such as the UNIX time-sharing system; software-driven terminals for windows; C++, the object-oriented version of the C high-level programming language; and the most recent development, software fault tolerance.

different service scenarios, these new services will be more often controlled by the customer. Operations systems, especially surveillance systems such as the OSBU's Total Network Surveillance, are being enhanced to deal with this complexity.

Better Service To Major Customers. Major business customers now have a choice in carriers for their telecommunications needs—their own private microwave or other facilities; the "bypass" carriers in the local exchange; or a variety of long-distance carriers. These business customers are demanding lower costs, decreased interval, and increased quality, reliability, extensibility, predictability, and responsiveness for both their existing services and new services. The latter have led to the concept of "Major Account Centers." In this case, a group of operations personnel are dedicated to that major account, handling all billing inquiries, requests for service, trouble reports, and other interactions to the extent that, to the business customer, they become "the phone company."

Multinational corporations also are key players in driving the global telecommunications market. They demand the same suite of advanced services from their various carriers, the smooth interconnection of these services, and the flawless execution of the operations supporting these services.

Demanding Long-Distance Carriers. Interexchange carriers (IECs), which provide inter-LATA long-distance service, are increasingly demanding better levels of service from local exchange carriers (LECs). This is true particularly in network reliability, a result of pressure from their own business customers. With the IECs being able to choose which carrier to use for the local exchange portion of the circuits, the LECs are becoming more responsive to the IECs needs. Responses include special ultra-high reliability equipment, such as self-healing fiber rings, dual homing of critical customer telephone lines to two switches in two different offices, and diverse placement of cable and routes in the loop. Each of these requires special operations capabilities.

Network Vulnerabilities. Special "events" in the U.S. telephone network over the past two years have heightened the awareness of the IECs and the LECs to the need for overall surveillance and control of the network through a "Tier Two Center." This is a group of people, supported with tools and information, who can quickly determine if there is a major problem arising from an equipment failure, mass-calling event, or network instability, and who can take appropriate action. Such centers are being planned, or are already implemented, in most regional Bell operating companies (RBOCs) and in many independent telephone companies. These centers are often modeled after the AT&T Network Operations Center (NOC) in Bedminster, N. J.

Paradigm Shift for Operations Infrastructure

After two decades of providing systems that made telephone service super reliable, while reducing the cost of operating them, the OSBU now enters an optimization phase. At the same time, it faces growing competition, particularly in the international marketplace. The business unit realizes it must leverage its people and processes to compete more effectively. To increase its competitiveness, the OSBU has established these overarching objectives:

- Increase product quality,
- Decrease time to market,
- Integrate operations systems to provide full seamless network management, and
- Embed element management into the element itself.

To reach these goals, the OSBU has moved from being a technology-driven organization toward becoming a customer-, market-, and process-driven organization; one in which the process is supported by fully integrated practices, technology, tools, and platforms. The overall, end-to-end management of all network elements —switches, transmission equipment, and loop plant equipment—can first operate on an OSBU software development platform, BaseWorX,™ in a standalone fashion. Then, the BaseWorX hardware processor cards can evolve to be embedded in the elements themselves, providing a single, distributed database for administration, provisioning, etc. BaseWorX will be discussed below.

For operations in telecommunications networks, this paradigm shift has four dimensions. First, like other AT&T business units, the OSBU has shifted its focus from being *technology-driven* to being *business-driven*. For example, rather than just focusing on the technologies involved in switching, data transmission, and signaling system 7, the OSBU is concentrating on fully integrated, seamless solutions that support its business objectives.

Second, operations is moving from *labor-intensive* operations to *customer-focused* operations. In the past, the customer was required to interface with a number of different organizations or systems to obtain provisioning, network management, and other services. With the new focus, integrated operations systems will provide the customer with only one interface, through a computer terminal, to get the needed services. This will give customers streamlined support, on-demand provisioning, and control of network management.

Third, operations is moving from *technology and organizations-based systems* to *boundary-free integrated solutions*. In short, the OSBU is evolving from a software development and support organization to a provider and implementer of solutions and offerings. No longer will the OSBU just be a business selling software to address specific problems. Instead, it will become more of a consulting business, providing complex integrated solutions and support, backed by a strong library of software products, to national and international customers.

Finally, "*dumb*" network elements are being replaced by *intelligent* network elements. Intelligent network elements are self-aware, contain their own real-time, easily derivable configuration information, and the accuracy of their data can be readily verified.

These developments are based on a set of solid technology imperatives. Operations systems that have

many user interfaces must be replaced, for example, by systems that have a common user interface. Similarly, the use of many, unsynchronized databases must be replaced by a common, virtual database.

Standards must be changed as well, from those that are proprietary and closed to those that are universal and open. And operations systems development cycles must shrink from years to just a month or so. In the past, for example, it required about three years to develop an operations system, progressing from idea through development, deployment, and enhancements. Today, the time span is down to less than one year. Yet tomorrow, the time must be cut from months to just weeks—yes, weeks—by using a library of OS components to move from an assessment of customer needs through establishment of joint requirements, designing a prototype, conducting trials, and deploying the system.

Process Engineering As a Competitive Advantage

The need to continually increase productivity and radically shorten intervals, especially provisioning intervals for major customers, has led to the introduction of process engineering in the OSBU.

Process engineering is the integration of practices, technology, tools, and platforms to form an environment for the development of software products. Integrating each practice, technology, and platform has a synergistic effect, increasing their value to the software development process several times. OSBU also is moving toward an Infoware platform, an example being the electronic paper platform (EPP), which supports synchronized products and the information about them.

Before going further, a few definitions are in order. A *practice* is a recommended way of performing a task, whereas a *process* is a set of tasks to be performed through practices. *Technology* is the method applied to execute a practice or process; it may consist of algorithms, tools, templates, or methodologies. A *platform* is the architectural framework within which products, such as operations systems, are built. A platform is typically a software system or intersystem communications.

The practices include best current practices, as well as other best-in-class practices for development, such as architecture reviews, business cases, and project plans. Best current practices encompass the software development life cycle, emphasizing product development, as well as interaction with, and commitment to, customers.

Platforms are used to capture repeatable work and allow maximum reuse of technology and products. Platforms include common architectures, operating systems, and reuse libraries. A *software* development platform is important to help integrate AT&T's development tools within a seamless environment. As previously noted, BaseWorX is just such an example. A *product* platform contains software that can be reused from one product to another.

Technology supports the execution of processes, and includes application generators, artificial intelligence, computer languages, and translators and compilers. Examples of software technologies developed by AT&T include the C and C++ languages, and the C5 language for expert systems development. A major movement is underway toward object oriented design and programming, and the use of both personal computers and workstations.

The OneOS Change Program. The OSBU is in the process of changing its traditional business methods by introducing a number of programs designed to assist in integrating operations systems. One of these programs, called the OneOS Change Program, uses the concepts of process engineering, including lessons learned from Project Silver Bullet (discussed in this issue), to help reengineer the OSBU's end-to-end business.

The goal of the OneOS change program is to:
- Provide a common, functional platform for OS development,
- Define and implement a set of engineering rules for quickly delivering to customers integrated product offerings (IPOs), composed of new and/or existing products, and
- Provide the set of assets required to develop the IPOs. The focus is on inter-product architectures, platforms, processes, environments, tools, and the resulting intra-product implications.

Today, every product team in the OSBU uses different combinations of architectures, platforms, processes, environments, and tools to realize their products. Not surprisingly, this makes it difficult to deliver integrated solutions to customers. The OneOS Change Program develops and institutionalizes a set of engineering rules for easily integrating the OSBU's products into solutions that are tailored to meet customers' requirements.

These engineering rules select and balance the best attributes of existing architectures, platforms,

processes, environments, and tools to provide the most effective end-to-end product realization. The change program institutionalizes the engineering rules as a core competency of the OSBU's business. The rules are implemented in all OneOS products. Metrics are established to measure product conformance to the OneOS engineering rules. Many of the engineering rules are part of the BaseWorX platform.

OneOS can be likened to a flexible factory that can manufacture and configure an integrated set of operations systems functions tailored to customers needs. In effect, customers would not be buying operations systems, as in the past. Instead, they would be buying operations capabilities. The customer would have a single interface to needed applications, all served by a single database, which increases data integrity. Even non-AT&T applications and databases could be integrated into the solution. OneOS would also give customers scalable, modular capabilities that enable the flexible assembly of applications.

BaseWorX: The Enabling Platform. A key aspect of the OSBU's process engineering, and of OneOS, is large-scale software reuse—specifically the reuse of proven software architectures and components that speed the development of software systems. The fundamental concept is to build and accumulate software components, then reuse them in new software systems.

To provide a framework for large-scale reuse, the BaseWorX application platform delivers an architecture, a set of integrated software components, and numerous customer support services. This integration, the large number and variety of hardware platforms on which the software operates, and the accompanying services, set the BaseWorX platform apart from other development platforms or operating environments.

BaseWorX is a UNIX-based system that enables telephone companies to rapidly develop software for telecommunications services. It is divided into two elements that co-exist within the same computing system. One is a *development environment* for the creation of applications; the other is the *real-time platform* on which applications are executed. Separating the two elements helps assure that applications and software are protected during upgrades or changes in the execution environment.

BaseWorX provides standard capabilities, such as communications, database access, and integrated operations, administration, and maintenance (OA&M) for

better control of the development environment. The BaseWorX applications platform has five main components: a user-interface subsystem; an OA&M integrator; an applications integrator; an applications program interface (API) backplane; and a database subsystem. BaseWorX includes network management objects that are built off C++ object oriented technology. The object library can be accessed via the platform, permitting network management to move into object oriented technology. The functions and interrelationships of these components are fully discussed in Beck et al.[2]

BaseWorX represents the latest step in the evolution of computer environments. In the 1960s, computer systems consisted only of hardware and applications. In the 1970s and 1980s, operating systems were added between the hardware and the application. In the present decade, *middleware*, which sits between the operations system and the application, was introduced.

Middleware offers several advantages: It is a means of future proofing, insulating applications from non-uniform and evolving computer environments. By adding products integrated on the BaseWorX platform, customers will be able to change hardware platforms in the future and still have both portability between the new platforms, and better connectivity with various applications—as with the introduction of sophisticated new services, such as video. OSBU also is moving toward the next evolutionary step in OneOS by specifying APIs between BaseWorx and the specific application.

Middleware also provides for the rapid creation of distributed applications: Developers can build a prototype of their application to get early customer feedback, or quickly develop and deploy the application.

New Network Technologies

New network technologies, such as asynchronous transfer mode (ATM) switching, synchronous optical network (SONET), and synchronous digital hierarchy (SDH), demand that operations systems be modified to take into account the new features and functions of network equipment. More and more of these new network elements have operations functions built into them, such as databases describing their capabilities, and software-agile parameters in channel units. These are examples of "intelligent network elements."

At the same time, the rise of a new type of software, the software platform—such as BaseWorX—is

changing the way operations systems are designed. Platform-based operations systems can be built from pre-defined piece parts at much less cost than "built-from-the-ground-up" systems, and in less time, with greater reliability. In addition, advances in artificial intelligence and new ways of presenting complex information to humans (including graphics, such as the OSBU's Display Construction Set) present great opportunities for the next generation of operations systems to meet the challenges of complexity, extendibility, and speed of operation and deployment.

Understandably, LEC personnel will have difficulty absorbing the many new services and network technologies being introduced. Operations systems to support them are often required when the service is first introduced, but before substantial experience has been gained in the field. This situation requires more proactive planning by the operations system vendor.

International Standards

Though not technically a market force, the rise of the telecommunications management network (TMN) standards in the International Telecommunications Union (ITU, formerly CCITT) is affecting OS worldwide. Vendors of operations systems are implementing the standards as they are defined and incorporated into network elements. In the U.S., the TMN standards have, until recently, received little attention from carriers. This situation is changing as the standards mature and carriers perceive the value of deploying products based on internationally accepted standards.

Dynamic Network Operations

As new market forces, customer demands, and technologies bring more sophisticated products and services—and, in effect, a new network—operations will be pressured to keep up. To meet the operational needs of the evolving network, the OSBU has formulated a concept called Dynamic Network Operations. It ensures greater service reliability and flexibility. With Dynamic Network Operations, the network will become self-aware, self-adapting, and self-provisioning.[3]

The self-aware concept implies that each network element keeps its own inventory, assigning resources as needed, and alerting other network elements when resources are low. Network resources include such things as subscriber phone numbers, SS7

addresses, and signaling links. This means the network will really become the master database—a database distributed across the network elements.

The self-adapting concept means that the network will appear to be self-healing from an end-user's perspective. When equipment fails or becomes overloaded, for instance, the network will automatically reroute traffic among elements, maintaining continuous service. Then, repair personnel can schedule maintenance as needed, on a regular basis, rather than on an emergency basis.

The self-provisioning concept is particularly important for intelligent network services. In a self-provisioning network, resources are directly available to end-customers. When a customer requests service, a self-aware network will have in its distributed database the status of all the network piece-parts required to provision the service and, thus, will be able to respond more rapidly than in today's network.

Where AT&T Is Heading

This issue of the *A&T Technical Journal* reviews a number of efforts to ensure that OSBU continues to provide its traditional high quality of service support at prices customers can afford, while being able to support new services, using new technologies, at prices that AT&T can afford.

The BINOC Project. Traditionally, the market for operations systems has been domestic—the local exchanges and AT&T's interexchange voice and data network. Today, that scenario is a thing of the past, as the greatest potential for growth is in global markets.

In 1991, AT&T Network Systems Belgium contracted for OSBU to develop the Belgium Integrated Network Operations Center (BINOC) for BELGACOM, the national telecommunications company of Belgium. The BINOC will provide management functionality, including configuration, fault, performance, and security, for five "subnetworks." These functions will conform to the International Telecommunications Union's ITU-T architecture for a standardized telecommunications management network.

The challenges, opportunities, and lessons learned in developing this operations center are discussed by Lambert.[4] This effort is significant, not only for the financial rewards and the greater presence it gives AT&T Network Systems in the global market, but

for the opportunity given OSBU to learn and adapt in developing its products for a global market.

Easier-to-Use OSs. No matter how powerful an operating system is, its effectiveness is diminished in the eyes of the customer who buys it, and the operator who uses it, if the system is difficult to use. Recent technological advances, including graphical user interfaces, artificial intelligence, and on-line documentation and training, have made operations systems easier to use. But, as Aykin et al.[5] remind us, advanced technology isn't enough; usability engineering processes and other techniques are available to designers and developers, so that customers can maximize their investment, improve productivity, reduce errors that could affect service, and cut training and support costs. The authors outline the benefits of investing in ease of use, and discuss the processes and principles that make it possible.

Focus on Network Reliability. While network power systems receive little attention, given the competition of more highly-visible technologies, the fact remains that without a properly engineered and maintained power system all other network elements, no matter how high-tech, will not be immune from network outages.

In 1992, AT&T's Network Services Division (NSD) deployed a new application, the Power Quality Resource System (PQRS), which supports numerous maintenance and provisioning processes in the operations and engineering of power and building systems. PQRS maintains an inventory of the major AC and DC power systems and infrastructure elements that support other network elements.

Bramley et al.[6] discuss how PQRS supports routine and demand maintenance, capacity planning, life-cycle management, and recording keeping and reporting to meet national environmental regulations. Although one of those critical, but often invisible, applications that keep AT&T's network operating, PQRS had its day in the sun, or rain if you prefer, during Hurricane Andrew in 1992. PQRS's calculations on battery power reserves were invaluable in dispatching portable standby engines to offices affected by commercial power outages.

FASTAR[SM] **Operations System.** Network outages in the past few years affecting both AT&T and its competitors have made customers more aware not only of the complexity of the network, but also of the need for more powerful tools to restore service. A commitment to reliability has resulted in a 10-fold improvement in AT&T's

network reliability over the past three years—thanks to the introduction of the FASTAR Operations System.

Network outages have always been with us. However, the concentration of traffic on fiber cable means that a single cut can affect hundreds of thousands of telephone circuits, and millions of potential callers. With the FASTAR system, restorations that once took hours now can be accomplished in minutes by rerouting traffic around the cut until repairs are completed. Chao et al.[7] discuss the architecture and restoration process, and software development and implementation strategies. Central to the FASTAR system's success is the RAPID central processor that receives and correlates alarm reports, determines available reroutes based on the shortest restoration path and available capacity, controls the reroute process, coordinates path assurance tests, and supports the cutback to the original circuits after they are repaired.

StarKeeper® **II NMS.** Providers of both public and private data networking services are looking at cell-relay technology used in asynchronous transfer mode and Switched Multi-Megabit Data Service* (SMDS) to interconnect their high-speed local area networks (LANs). Needless to say, these networks are very complicated. AT&T's BNS-2000 data switch supports both frame relay and SMDS access and trunking interfaces. StarKeeper II Network Management System (NMS) supports not only element management of single BNS-2000s, but also network management of multiple BNS-2000s.

StarKeeper II NMS is a distributed graphical system that provides software features and network applications to monitor, administer, and troubleshoot a cell relay network. Becker et al.[8] discuss the major requirements of customers that were influential in the design of the system; the centralized database and distributed architecture of StarKeeper II NMS that supports network expansion and functional flexibility; the system's customization tools; and the stringent performance criteria, including high reliability and rapid response time, that it provides.

The authors also offer examples of how Star-Keeper II NMS met two other concerns of customers: reducing both network *and* network management costs.

The Evolution Laboratory. Two challenges that the developers of operations systems face are having a "stage" on which to showcase products, both to customers and to the rest of the OSBU, and providing a

"forum" for receiving important customer feedback on their products. A recent development that assists in meeting both of these needs is the "Operations System Evolution Laboratory."

Scribner[9] discusses how the laboratory serves as a showcase for customers. It provides a focal point for eliciting customer views about our products, new product ideas, new applications of existing products, and prototypes designed to demonstrate the technical feasibility of new technologies.

In addition, the laboratory has served as a showplace for OSBU personnel, and itself has been the source of several prototypes of new products. This combination of demonstration showcase and test bed for exploratory prototypes has proven to be an effective communications and marketing tool.

System Management in the 1990s. In 1984, a revolution occurred in the systems management of customer-premises-based equipment: the introduction of the System Access Terminal (SAT), for AT&T's Definity™ (System 75) private branch exchange (PBX). This terminal provided the first *easy-to-use* interface for customers to perform system administration, and indicated the direction that such interfaces should take in the future.

Barbier[10] traces the evolution of this development to the Global Business Communications Systems (GBCS) 10-year plan. This plan calls for delivering systems management tools to support the core businesses of PBX and key systems, call centers, and voice processing, as well as telemarketing, telemanagement of non-PBX equipment, call accounting, and security.

This direction will include development of network management applications based on the simple network management protocol (SNMP). It will provide for the continued integration of the Definity PBX features and functionality into the data world.

Silver Bullet: An Optimized Process. When the OSBU wanted shorter intervals than those resulting from even the best-in-class companies, it initiated Project Silver Bullet. Formed in September 1990, the Silver Bullet team was charged with finding innovative ways to reduce time-to-market cycles by 80 percent by 1995. Its purpose is to experiment with the software development process and produce products to validate that process.

The process approach enabled the Silver Bullet team to achieve a number of objectives. These are:

- Identify (and if necessary, design and develop) practices, technology, and platforms optimized for a single domain (operations systems products and services) and objectives.
- Apply a long-term, scientific approach to reduce development time intervals.
- Consider other dimensions, such as culture, staff, and training.

The project numbers about 65 people and has succeeded in reducing time to market intervals from 130 weeks to about 40 weeks. The cost-per-person of those who execute this process runs about 40 percent less than the cost-per-person for projects not using the process. The entire Silver Bullet Project is discussed in more detail in Gelman.[11]

Conclusion

These and other developments will ensure that operations systems, whether embedded in the network, or layered above it, will become more dynamic. They will accept order requests, status information for the network, and network configurations. They will then bring this information together for the service provider's personnel. This, in turn, will give these personnel a global view of the network, full control capabilities, customization and programming tools, and additional analysis to keep pace with escalating customer demands and the changing AT&T domestic, international country-specific, and global networks.

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