## Structured Networking for the Enterprise.

Increased competition and a weak global economy are driving businesses to rethink their basic business practices and streamline operations in an effort to do more with less. The structured networking architecture brings this concept to corporate data communications systems.

# Introduction

Increased competition and a weak global economy are driving businesses to rethink their basic business practices, including organizational structure and staffing. One result is a worldwide trend toward restructuring — streamlining business operations and organizations in an effort to do more in less time, often with fewer people.

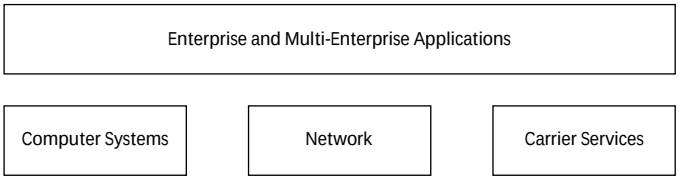
The benefits of restructuring include improved productivity, customer service, and time to market, which give restructured businesses significant competitive advantages. But achieving these goals usually requires both a flattened management structure and decentralized decision making. Frontline workers empowered to make decisions must have access to accurate information in a timely fashion. As a result, organizations are restructuring their information systems, too.

The need to provide information to make decisions is driving the emergence of a set of enterprise — and, in some cases, multi-enterprise — applications that were unheard of just a few years ago. Specialists thousands of miles apart confer on medical images to help a patient; factory managers access their vendors' production outlooks to decide when to order important components; and a cross-functional team of engineers distributed throughout the world designs airplanes. These applications must be supported by three key components: computer systems, the network, and carrier services (see Figure 1).

The fastest growing, most dynamic component of this model is the network. The foundation of the network is a managed high-speed communications system that Bay Networks refers to as the "network infrastructure." With intelligent hubs as its key building block, the network infrastructure integrates other communications devices, old or new, into a system that is self-managing, easily expandable, and transparent to end users. Bay Networks is a leading provider of this network infrastructure, offering a complete family of intelligent hubs, switches, routers, remote access servers, and sophisticated network management products.

This backgrounder describes how the push to provide accurate, timely information to frontline decision makers is driving the need for a new way of designing networks. Bay Networks refers to this new design as "structured networking." This backgrounder also discusses how the advent of structured networking has created a need for a new, advanced class of intelligent hub and a synergistic model for network management — and describes the solutions that Bay Networks has introduced to address these challenges.

Figure 1 | **Enterprise Information Systems Architecture**



# Structured Wiring and Intelligent Hubs

From the 1960s into the 1980s, terminal-to-host networks were the predominant network architecture. Then, in the 1980s, shared-media local area networks (LANs) such as Ethernet and Token Ring became prevalent. These shared-media networks operated in the range of 4 to 16 megabits per second (Mbps) and enabled distributed, client/server computing. Ethernet and Token Ring were originally designed to link computer systems directly to one another in a bus or ring topology.

By the late 1980s, a new way to design these networks, called "structured wiring," became popular. With structured wiring, all the computer systems were physically star wired to intelligent hubs, enabling almost universal deployment of reliable, manageable LANs for workgroups and departments. Intelligent hubs and structured wiring made troubleshooting and fault isolation faster and easier because each end station was attached to the network through its own individual port, which meant it could be monitored individually and, if needed, easily turned off without affecting the rest of the network. In addition, structured wiring and intelligent hubs made network moves, additions, and changes simpler. In short, structured wiring led to the widespread deployment of LANs by making them more manageable, easier to troubleshoot, and more economical to operate.

**Structured Wiring Is No Longer Enough**

Since shared-media technologies are limited to handling only one user at a time, these networks are prone to "overcrowding" as a result of advanced applications and increased utilization. This situation often degrades the effectiveness of end users who rely on immediate access to information. To correct this problem, organizations are subdividing, or "segmenting," their networks so that fewer and fewer end users share a single segment, resulting in a substantial boost in performance.

In addition, many organizations are trying to integrate ad hoc departmental LANs and segments into a unified enterprise network. Internetworking equipment is introduced into the network to provide connectivity between these segments. Unfortunately, this process often lacks sufficient planning, so networks can easily become a patchwork of LAN segments rather than a truly integrated system.

As these networks are pushed to their limits, organizations pour more money and resources into efforts to scale the systems to the needs of the organization, resulting in degrading performance and spiraling costs. Clearly, "more of the same" is not a viable long-term strategy.

To cope, organizations are being forced to change their fundamental approach to network design. The main challenge facing information systems professionals is to rationalize ad hoc network designs so that their enterprise can operate as a unified, coherent organization today, as well as grow and change to meet advanced needs.

# Structured Networking: An Advanced Topology for Enterprise Networking

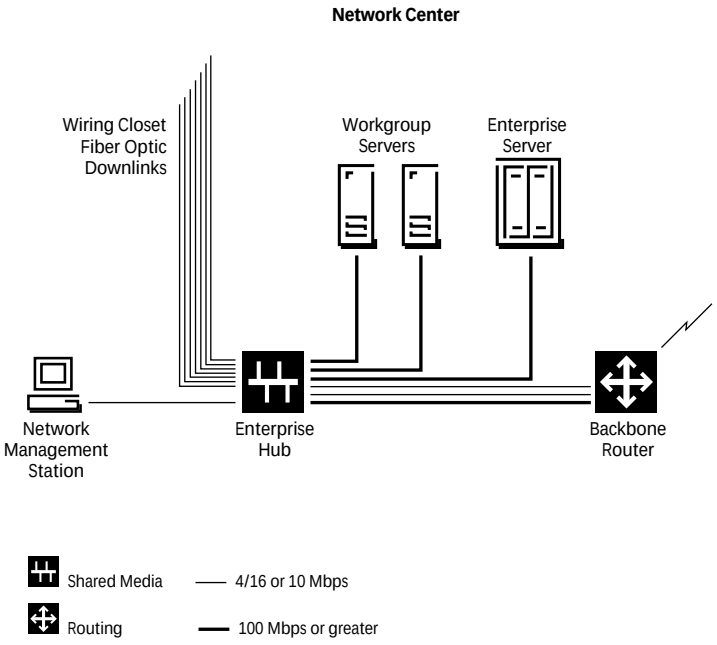
Structured networking is an extension of the powerful concept of structured wiring. The same logic that drove the move toward structured wiring designs at the department or workgroup level is now driving a network design in which intelligent hubs in wiring closets are star wired to central connection and control points (see Figure 2). Structured networking is the key to rationalizing building-level and campus-level network environments into a solid base for client/server computing and a platform for introducing switching technologies when bandwidth relief is needed.

In this design, structured wiring continues to provide end users with flexible connections to network segments. In a structured network, these segments are then further organized into a multitiered design that allows segments to be created, moved, and managed in a highly flexible manner. Structured networking gives network managers the flexibility to change, add, evolve, and assess the network, both at the user level and at the segment level.

Structured networking offers three key benefits:

- *Better performance* Structured networking enables the graceful, economical introduction of advanced technologies such as switching into the existing network infrastructure.
- *Greater flexibility* Networks can be built and modified to reflect the way the enterprise and its resources are organized — not according to how the building is wired.
- *More manageability* Servers, routers, and test equipment can be easily centralized for greater security and administrative access. Locating these critical resources with end users is no longer an issue; instead, equipment can be deployed where it is most efficient.

Figure 2 **Distributed Workgroups in a Structured Network**



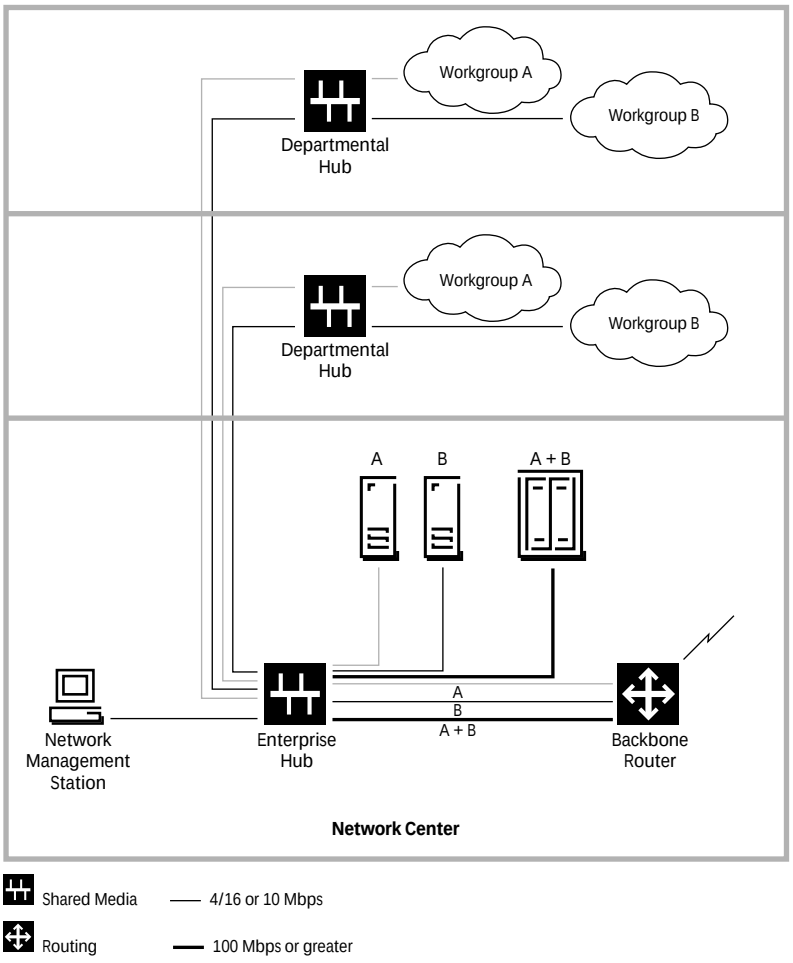
### The Network Center: The Focal Point of Structured Networking

The structured networking approach is implemented at the site level or building level by establishing network centers (see Figure 3). These are physical points of connection and control in a business campus or an office tower where workgroup segments from wiring closet hubs are terminated, spliced, and managed. Network centers are also where servers, routers, bridges, and gateways may reside, providing a secure, controllable environment in which to house these valuable, shared resources. Centralization also makes fault isolation, repair, and management of these devices much easier and less costly.

In structured networks, each workgroup segment at the floor level has one or more fiber optic downlinks directly to the network center. Fiber optic cabling not only handles the potentially long distances between network centers and wiring closets, but also offers the ability to create fault-tolerant links. An advanced class of intelligent hub in the network center provides the high-density terminations for these downlinks, as well as the ports required for connecting centralized resources.

Once segments are terminated in network centers, this advanced class of hub and accompanying network management software begin to break down the rigid link between physical location and logical association. Workgroup segments can be "spliced" together, thereby rationalizing multiple distributed workgroups into logical network segments for presentation to servers, routers, or bridges. Expensive test equipment, located in the network center, can be dispatched via software to analyze problems on any segment throughout an enterprise. And, most important to a restructuring company, workgroups of end users can be logically configured despite the physical distances between them.

Figure 3 | **The Network Center: The Consolidation Point**



Enterprise hubs and network management also enable servers, even though centralized, to be coupled to their clients on the same segment with minimal latency. Centralized, high-capacity routers provide firewalling and wide area links, as well as intersegment communications. Server centralization greatly facilitates such functions as backup and software updates, thus reducing the overall cost of administration.

Network centers are convenient sites for the deployment of internetworking devices such as switches, routers, bridges, and communications servers, which provide communication among the various network segments and rings that comprise the enterprise network.

By "front ending" these devices with enterprise hubs, workgroups can be organized into logical network segments more easily. This enables network planners to amortize the cost of these more expensive devices across the largest end-user population, thus controlling costs while increasing performance.

As a related benefit, structured networking will usually help justify the expenditure for larger, high-performance switches, routers, and bridges, as opposed to investments in many smaller, lower-capacity devices.

**Structured Networking Is the Foundation to Integrate Switching**

One key benefit of structured networking is that it provides a way to introduce various forms of switching technology into the network incrementally and economically. Switching technology converts networks from a purely physical infrastructure to a "virtual" infrastructure, where network topologies and data flows can be modified with minimal or no cable rearrangement.

One basic form of switching technology is configuration switching (sometimes called "port assignment"), which can be deployed in shared-media networks in wiring closets and network centers to allow segments or rings to be merged, split, reassigned, or connected to shared resources via software control. Configuration switching delivers unprecedented levels of flexibility and administrative cost savings as networks are segmented to improve performance.

Powerful advanced applications, such as medical imaging, desktop videoconferencing, and even electronic mail with multimedia attachments, eventually will drive the need for higher-speed networks.

However, what is driving this demand for advanced network technology isn't the long-awaited explosion in multimedia traffic. Instead, it's the increased amount of existing traffic — client/server, shared database, file transfers, and e-mail, plus the enormous increase in traffic generated by World Wide Web browsers — that is putting the pressure on most networks these days.

The last 18 months have been a watershed for switching technologies, which have moved from research and development labs into mainstream corporate networks. Advanced technologies such as Fast Ethernet, 10/100 Mbps switched Ethernet, Token Ring switching, and ATM have matured to become architectural choices for network planners, while even newer technologies, such as Gigabit Ethernet, are on the horizon. There is little doubt that switching, of one kind or another, will soon form the technology base in the majority of large networks.

Yet integrating switching technology into existing networks raises special issues. First, while it can deliver enormous dedicated performance, only a fraction of end users today require such performance levels. Considering the large investments organizations have made in their existing shared-media LAN technologies, it's not likely that switched technologies will replace LANs overnight.

Consequently, the primary challenge facing network planners today is how to deploy switching technology in the most cost-effective manner, integrating it into the network in such a way that it can be managed along with existing shared-media LAN technologies under a common network management scheme.

A structured network design, with its sophisticated enterprise hubs and network management, provides the right topology for incrementally adding switching technology. The logical approach is to begin adding switching in the network center, where the biggest gains in performance and flexibility can be achieved at the lowest cost per end user.

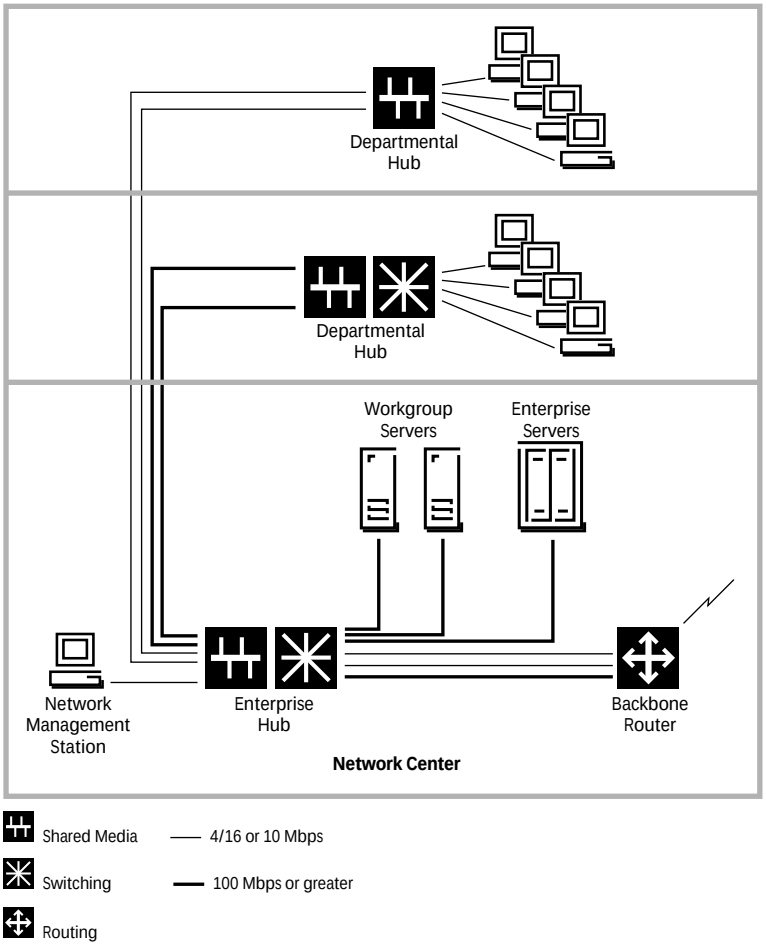
With switching in the network center, wiring closet segments gain an immediate performance boost. Centralized servers can be connected to dedicated, high-speed switch ports for even greater performance. Switching can then be deployed on an as-needed basis outward to wiring closets and, if appropriate, on to desktops (see Figure 4).

From a network management perspective, once a network manager has implemented a management system sophisticated enough to handle the divergence between physical and logical relationships, it can be upgraded to accommodate performance switching in the future.

### Getting from Here to There

When organizations plan to implement true multimedia applications, such as video-conferencing with real-time whiteboarding, the requirements of the applications tend to drive an ATM-based solution. For many organizations, the combination of 100 Mbps Fast Ethernet and 10/100 Mbps Ethernet LAN switching represents a very cost-effective and mature solution that addresses the problems their end users are experiencing.

Figure 4 | **Switched Internetworking Using Structured Networking Architecture**



For these networks, a few simple tips can help the evolution to a switched internetwork. First, structured networking should be implemented to build the topology required to move the network forward. Second — and this is key — a bandwidth hierarchy that emanates from one or more network centers must be created. Areas with shared resources are usually the most stressed, so adding switching at these locations (typically in the backbone at network centers) makes the most sense. If switching technology is first implemented at the desktop or in wiring closets, the existing backbone won't be able to handle the aggregate traffic load.

Third, 10/100 Mbps LAN switches should be installed to provide the optimal connections for servers and routers so that they can quickly clear transactions. This can be accomplished without touching the rest of the 10 Mbps network. It's a relatively simple and straightforward "weekend" addition to the network, literally transforming slow response times on Friday to fast response times on Monday — and resulting in very happy end users.

The fourth step is to push switching out to the segment level in wiring closets. This step adds capacity to the backbone by enabling 200 Mbps full-duplex Fast Ethernet riser links — and provides more capacity than 155 Mbps ATM risers at a fraction of the cost. This step also makes very effective use of fiber optic riser cable by multiplexing VLANs, or workgroups, on a single fiber optic pair and using the capacity of installed fiber optic cable much more efficiently. Placing 10/100 switching technology in the wiring closet also allows network managers to add higher-capacity 100 Mbps shared-media LANs for end-users with heavy traffic applications. This "multisegment shared service" is a very cost-effective way to increase bandwidth in those environments where 10 Mbps shared-media LANs need relief, but the greater expense of desktop switching is not yet justified.

Network managers can simplify the transition to 100 Mbps performance through the use of autosensing network interface cards (NICs) on all new desktop computers and servers. By locating 10/100 Mbps switches in the wiring closet, managers can provide 10 or 100 Mbps switched ports to end-users or local shared resources who need a dedicated, or private, connection.

### Advanced Capabilities and Devices Required for Structured Networking

Structured networking calls for an advanced class of intelligent hub for the network center, plus a sophisticated network management system to maintain control over the system.

***The Intelligent Enterprise Hub*** An intelligent hub designed for the network center must provide higher performance, greater flexibility, unmatched resiliency, and more sophisticated management capabilities — all important features that directly correspond to its critical position in the network.

As the focal point for most network activity, enterprise hubs must deliver the bandwidth necessary to carry high volumes of traffic while offering low enough latency to keep real-time applications running smoothly. They must also serve as a consolidation point for multiple segments and rings, as well as shared network resources such as servers, routers, and remote access devices. Consequently, an enterprise hub must accommodate a high density of fiber connections plus a full range of network protocols.

Flexibility is a key attribute in enterprise hubs. By virtue of their location in the network center, enterprise hubs must offer built-in management capabilities that provide complete visibility and control of all other connected network components. In addition, enterprise hubs must also allow for network reconfiguration from a central location.

Perhaps the most important attribute of enterprise hubs is resiliency. Because they often carry mission-critical applications, enterprise hubs must exhibit the characteristics required to keep the network up and running — key features such as environmental controls, power redundancy, hot-swapping of modules, and remote testing and analysis.

***More Powerful Network Monitoring and Control*** Just as an advanced class of hub is required in the network center, advanced network management is needed to monitor, control, and view the network. The most important element is the ability to monitor and control the logical network along with its physical topology. This is a fundamentally different capability than most network management systems can deliver today.

The network management system must also be able to see and manage all network components connected in a structured network. A critical design objective must be to gather management information — whether from a wiring closet hub, a router, a server, or even an end-user workstation — and deliver it to the network manager as part of a system-level view of the network. Networking is all about the complex interaction between multiple devices, and the network management system must take those relationships into account and deliver information in that system-level context.

# Bay Networks Flagship Enterprise Solutions

**The System 5000**

Such advanced enterprise intelligent hubs are available today. The Bay Networks System 5000™ enterprise hub was the first, and is by far, the most successful in this class, with more than 2 million installed ports worldwide.

***A Platform for Graceful Integration of Advanced Technologies*** The System 5000 redefines enterprise networking, rendering common perceptions and long-held beliefs obsolete. The debate over hubs versus routers versus switches becomes irrelevant. That's because the System 5000 is all of these, delivering best-of-class capabilities in a single platform that eases installation, configuration, and maintenance chores.

The key is in the design. Utilizing a sophisticated multibackplane architecture, the System 5000 delivers complete shared media, switching, routing, and communications services simultaneously, with no performance degradation. Deploying different technologies is as simple as swapping a module in the System 5000 chassis. It's a flexible approach that leaves your options open when — not if — things change in the future.

The System 5000 is the cornerstone of the new network infrastructure, delivering all the technologies required to support a growing organization. No architectural changes, rewiring, or wholesale equipment upgrades are required. The System 5000 offers a built-in evolution path that lets users select between combinations of shared media, LAN switching, routing, and ATM to satisfy specific needs. The System 5000 makes this possible by supporting a wide variety of technologies simultaneously. Users can implement the solutions they need, at their own pace, to build the ideal network.

With System 5000 hubs in the network center — and various combinations of Bay Networks System 5000, Distributed 5000™, and System 3000™ modular hubs and System 2000™ or BayStack™ stackable hubs connected to them in a structured network — end users have direct access to each other and to centralized servers and other critical resources.

When combined with Bay Networks powerful Optivity® network management system, the System 5000 — by integrating multiple technologies on a single, convenient platform — can be leveraged to empower an organization with greater flexibility, better performance, increased reliability, and enhanced management, all at a lower cost than before.

***Performance*** The System 5000 accommodates more network segments and rings, server links, slots for modules, power options, and network management functionality than anything else the industry has to offer. The System 5000, featuring 12 gigabits per second (Gbps) of system throughout, is capable of supporting up to 52 Ethernet segments, 26 Token Rings, 5 FDDI rings, and 16 ATM ports.

The System 5000 also employs a unique Bay Networks development called the cluster module to unite multiple LAN segments as a single, manageable system. Cluster modules support multiple ring and segment downlinks from physically dispersed wiring closet and departmental hubs, splicing separate LAN segments together in the System 5000 hub. Cluster modules also unite distributed workgroups with centralized servers, creating a single LAN segment that is completely transparent to the end user.

***Reliability*** The System 5000 also provides industrial strength power and environmental control features that are crucial to ensuring the reliability of the enterprise network. Because its position in the network center makes the System 5000 critical to network operations, Bay Networks has built redundancy into the hub to remove all single points of failure. System 5000 customers can specify levels of redundancy for conditioned power options and cooling units, all of which are hot-swappable and remotely manageable. The System 5000 includes sophisticated systems to monitor temperature levels, fan operation, and airflow. Multiple System 5000s can also be configured to create additional redundancy.

**Distributing Advanced Technologies Throughout the Network**

To satisfy the need for mission-critical System 5000 technology in a scaled-down version optimized for Ethernet networks, Bay Networks offers the Distributed 5000, the first enterprise network solution to combine the best attributes of both modular and stackable hub technology.

The Distributed 5000 improves the performance and manageability of production networks by extending System 5000-class features to enterprise wiring closets. The Distributed 5000 is a key component of the Bay Networks Distributed Enterprise solution set, which integrates shared media Ethernet, LAN switching, scalable, high performance routing, and remote access services in a stackable, scalable form factor. Working together, the Distributed Enterprise solutions provide users with incremental growth and expenditure options for their expanding network environments.

**Managing the Enterprise Network**

Structured networking has forced network administrators to look at network management in an entirely new way. Optivity offers that new perspective, enhancing the capabilities of the structured network architecture by giving network managers the power to visualize their network and cost-effectively deploy its resources in ways not previously possible.

Optivity merges new features with enhanced existing capabilities, delivering the tools required to manage networks as a cohesive system — not simply a collection of individual devices. Capabilities such as icon selection and drag-and-drop configuration changes allow end users to unite physical, logical, and topological management within a single solution. Optivity is also the first network management system to allow network managers to isolate and view logical associations of the physical connections among end users and devices on a network.

With Optivity and the System 5000, physical location no longer dictates the network's configuration. Using Optivity's LANarchitect™ tool, network administrators can establish a software-based network topology by assigning end users and shared resources to logical network workgroups, regardless of where they physically reside — a departure from more traditional workgroups, which are defined by the actual location of devices. The object-based user interface masks the complexity of the underlying hardware, allowing managers to focus on building a network configuration that optimizes available network resources and reduces the operational cost of making changes in their organizations.

Optivity also includes built-in configuration rules that assist in designing a structured network, automatically guiding network administrators through the process. With Optivity's integrated design capabilities, network managers have the flexibility to logically "move," or reassign, resources throughout the enterprise with minimal or no cable rearrangements. The sophisticated software allows network planners to design a highly efficient network that is completely transparent to end users, preventing administrators from making "illegal" moves and allowing them to undo unwanted changes with a single command.

The LANarchitect tool bridges the logical and physical views of the structured network, displaying which end users and devices have and have not been assigned to workgroups. Providing such information eliminates the need to navigate through several views for information about available resources.

***Embedded Management*** The key to Bay Networks advanced management capabilities is *embedded intelligence* — processing power distributed throughout the network infrastructure in connectivity and management modules.

In a structured network, network system management is enhanced because the System 5000 employs an advanced distributed multiprocessing architecture, built with custom ASICs, which provides scalable embedded management. Dedicated processing hardware and management agent software provide sophisticated management for multiple networks simultaneously, bringing a new level of visibility and control to the entire enterprise and yielding cost-effective deployment of resources.

Each System 5000 host module has intelligence built in, enabling it to gather critical network management data. All collected information is forwarded to an Optivity network management station, where network managers can observe and control network performance via a graphical user interface. This information helps network managers plan changes to their networks and further reduces the cost of operating the network.

System 5000 network management modules (NMMs) can be equipped with embedded RMON probes to provide full nine-layer functionality for high-performance traffic analysis, packet capture, and filtering. The RMON probes can be selectively reassigned to any segment through LANarchitect, leveraging investments while providing a flexible method for performing detailed management throughout the network. Multiple probes can also be deployed in a single System 5000, increasing management performance by delivering up to 400 MIPS of processing power for critical control and monitoring functions at full wire speed.

# Summary

The network infrastructure, designed with Bay Networks intelligent hubs, can accommodate switching technologies seamlessly, without sacrificing investments in existing network equipment. The network infrastructure easily integrates existing computers and communications devices with advanced networking technologies into a system that is transparent to end users, self-managing, and easily expandable as an organization grows. It provides end users with a powerful means of sharing information and supporting collaborative work that is reliable, efficient, and cost-effective.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05/96 WP510-923WC-D

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