Advantages of Multiprotocol Switched Services

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1 Preface

This document looks at the advantages a customer would experience from installing Multiprotocol Switched Services, a key component of IBM's Switched Virtual Network architecture. It discusses the past and future growth of networks, and the problems that need to be solved. It also looks at how MSS compares with competing solutions.

For more details on MSS and IBM's ATM Campus solutions check the following URLs on the World Wide Web:

- `http://www.networking.ibm.com/820/820over.html` - MSS 8210 Release 1.1
- `http://www.networking.ibm.com/826/826atmc.html` - IBM 8260

2 Networks Yesterday, Today, and Tomorrow

2.1 Yesterday

Local Area Networks (LANs) were developed to make it easier for computers (and the people using them) to communicate. Initially LAN networks were expanded by attaching more computers to the same wire or concentrator. This quickly ran into physical limitations, so the next step was to connect LANs through Layer 2 bridges - transparent bridges for Ethernets, and Source-Route bridges for Token-Rings. Bridging worked well in environments where most of the traffic was unicast. Unfortunately several popular protocols relied heavily on broadcast traffic, which could quickly clog up a bridged network.

The solution was to add routing at Layer 3 for routable protocols (e.g., IP) to bridging at Layer 2 for non-routable protocols (e.g., NetBIOS). Routers partitioned the network into logical subnets which allowed them to restrict broadcast traffic, and to provide some mechanisms for security. This worked well as long as most of the traffic between users was confined to a given subnet, and as long as users didn't move very often (since the logical subnet was based on physical location). It does, however, require the router to do a lot of work for each packet, typically in software. Specifically, for each incoming packet:

- Look up the Layer 3 address in its address tables and determine the outbound port
- Update the Layer 3 header (for example, to decrement the hop count)
- Strip and replace the Layer 2 header

This work has to be done by all the routers in the path between the two endstations that want to communicate - the more routers, the more work.

Routers have become so popular that most networks now use them. In a routed network endstations only need to know how to get to the nearest router. The router needs to understand the network topology, and determines the best route between endstations. There are a number of different protocols used to do this. Routers use the protocols to exchange topology data with each other, and then use the data to build tables indicating which subnets are attached to which adjacent routers. If a router learns multiple paths to the same subnet, it will choose the best path, or split traffic equally or nearly equally.

2.2 Today

There are two key changes now being implemented in today's networks - ATM in the backbone, and LAN switches at the periphery. ATM backbones will be key for building tomorrow's networks. LAN switches are used to deal with bandwidth limitations at the workgroup level, by providing microsegmentation at the edge of the network. Switches look a lot like multi-port bridges, and can be used to replace hubs. They are generally fast and cheap, but lack adequate intelligence for some networking needs. Some switches ship with support for Virtual LANs (VLANs) which allows for logical segmentation. Since the IEEE VLAN standard (802.1Q) is still in the early stages of development these implementations lack standardization.

While different types of networks have different problems, there seems to be a common set of issues:

- **Bandwidth Limitations**

  Switches were developed to deal with this problem at the workgroup level - local networks can be segmented to the point where each endstation has a dedicated, full-duplex, attachment to the switch. This moves the problem to the backbone since it has to handle more data faster, and LAN switches do not scale well. The increase of network computing is also impacting the backbone as users access central site servers, intranet servers, and internet/World Wide Web servers, not just local servers. We are moving from a world where 80% of traffic was local to a subnet to one where 80% of traffic is inter-subnet. The emergence of multimedia applications will only make the situation worse, as each connection will require support for continuous data rates of 1 to 6 Mbps.

- **Bottlenecks**

  As computers and their busses get faster, networks need to get faster too. Switching and faster media can help with the endstation and server attachments. Faster media can give some relief to backbone bottlenecks, but simply increasing the media speed is not enough - the latency of the interconnect boxes is also critical.

- **Network management problems**

  Addresses in a routed network reflect the physical location of the endstations. But people, and their computers, aren't staying still anymore. They don't stay in the same workgroups, or in the same organizations, and often they have mobile computers that need to work in multiple locations.

- **Bigger networks**

  Networks are growing in both complexity and number of users. Sometimes this is because a company or part of a company is growing, and sometimes it's because formerly isolated networks are linked together. This exacerbates the other problems, and makes the job of managing the network harder - a problem made worse by the growing shortage of skilled network managers.

- **New applications**

  We keep finding new and exciting things to do with our computers, and they all need more resources. New multimedia applications will need more than just raw bandwidth, they will need guaranteed bandwidth and guaranteed arrival intervals - Quality of Service (QoS) - requiring new functions in the network.

- **Investment protection**

  Customers want to know that the network gear they buy today will work with what they bought yesterday, and what they may buy tomorrow. They want to be able to update incrementally. And they don't want to hear about "fork-lift upgrades", although John Chambers of Cisco has said "customers should also be aware that products they buy may become obsolete in two or three years and require an expensive and disruptive up-grade" (*Network World*, 2-6-97).

Routers were a great solution to yesterday's problems. Now they are part of today's problems. Specifically:

- **Throughput** - if forwarding is handled in software, routers have trouble coping with increasing demands, but forwarding using dedicated hardware is very expensive, and difficult to upgrade.
- **Latency** - the more routers between two endstations, the longer the transfer time for a given packet. Each router in the path must handle the frame.
- **Network management** - layer 3 addresses are tied to physical location.
- **Quality of Service** - current routing protocols provide "best effort" service only. This is inadequate for voice and real-time video. We don't yet know how well the emerging standards (e.g., RSVP) will work in practice.
- **Protocol separation** - each Layer 3 protocol handled by a router needs different code in the router. This requires additional configuration, and additional storage. Both address resolution and packet forwarding will be handled differently for different protocol types.

One note on the performance difference between routing and switching, with respect to latency. Data Communications magazine published a study by Infonetics Research in their December 1996 issue. The configuration they looked at had 3 floors to a building, with 16 end-stations per floor. The best-case router scenario was for 100 Mbps Ethernet hubs connected through routers - 732 microseconds of delay. The worst-case switch scenario was for 100 Mbps Ethernet switches connected through ATM switches - 231 microseconds of delay. That's more than three times as long for data to make it through a routed network. (The best-case switch scenario? 155 Mbps ATM to a 155 Mbps backbone at just 53 microseconds of delay.)

2.3 Tomorrow

So if today's routers are inadequate for tomorrow's networks, and LAN switches solve problems at the periphery but not in the backbone, what is tomorrow's solution? The successor to bridges, routers and brouters?

Just as yesterday's answer was to "route when you can and bridge when you must", tomorrow's answer is to "switch when you can and route when you must", using ATM switches in the backbone and LAN switches at the periphery. This approach builds on the innovations in today's networks - ATM backbones and LAN switches - and integrates switching and routing. This integration is a key part of IBM's Switched Virtual Networking, and is available today with Multiprotocol Switched Services (MSS). The rest of this paper will look at how MSS fits into a network, and the benefits it brings.

3 Migrating to Switching

If the next generation of networks will integrate switching and routing, how do we get there with the least disruption to the customer? The first stage is to move the backbone to ATM, offering:

- High bandwidth
- Switched infrastructure
- Parallel links between switches
- Parallel paths through the network (no spanning tree limitations)
- Quality of Service
- VLAN support
- Heterogeneous networks
- And more...

The ATM backbone, with ATM attached LAN switches, provides the foundation, and there are several possibilities for integrating the new backbone with the rest of the network. MSS can support all of them, and can be installed stand-alone or as a module in the 8260 Nways Multiprotocol Switching Hub.

- **Traditional LANs and centralized routing**

  Existing LANs are connected through LAN switches with ATM uplinks, and a router is attached to the ATM backbone. MSS can support this environment for LANs using ATM Forum LAN Emulation, IBM LAN Emulation (Release 1.1), Classical IP over ATM (RFC 1577), and IPX over ATM (RFC 1483). MSS is a superior offering for this architecture since the router function is packaged with the LAN Emulation Servers, and a separate box is not needed. If LAN Emulation is used, then multi-protocol and VLAN support can be provided. However, this basically treats ATM as just another media type for routing, and doesn't take advantage of the performance enhancements made possible by switching.

- **Edge Routing**

  This approach puts routers at the edge of the network, connected by the switched backbone. Again, this solution simply runs routing over ATM, requiring at least two hops across the backbone. Support for VLANs requires the routers to also support LAN Emulation or Classical IP over ATM (CIP).

- **Distributed Routing**

  This technique separates the functions of the router into route discovery and frame forwarding, allowing them to be physically separated. A single "route server" can be shared by multiple edge devices (clients) each performing the forwarding function. The server and clients communicate using a protocol such as NHRP (Next Hop Resolution Protocol), which is supported in MSS Release 1.1. A client will ask the server for the route to a particular destination, and then cache the route for future use. In an ATM network the source client sets up a direct connection - a "short-cut" route - to the target client, eliminating router hops in the backbone.

- **Integrating Switching and Routing with MSS**

  MSS builds on the ideas discussed above to deliver a solution that takes the maximum advantage of the switched infrastructure provided by ATM. Instead of using ATM as a transport media for routing, MSS provides the ability to "switch when you can, route when you must",

delivering the superior price/performance made possible by a switched network. This approach uses NHRP to deliver one-hop routing today and zero-hop routing tomorrow, or IP cut-through to deliver zero-hop routing today.

Installing MSS does not require reconfiguring legacy LAN endstations - MSS can simply be dropped into the middle of the network as part of the ATM backbone. For example, a typical network might have a number of switches attached through a central router, with each switch representing a different IP subnet. Step one is to add ATM uplinks to the switches and install an IBM 8260 Multi-Protocol Switching Hub. Note that multiple 8260s can be installed in the backbone, distributing function and eliminating a potential central point of failure and congestion. Step two (which may be combined with step one) is to activate MSS - either as a module in the 8260 or as stand-alone 8210. After configuring the MSS Server for domains and ELAN types, each sub-net is now an Emulated LAN. The next step might be to combine the former sub-nets into one Emulated LAN. All the stations can now communicate, and can be moved at will, but broadcast traffic will still be kept under control by MSS's Broadcast Manager. Further growth of the network can be supported with Super VLANs in Release 1.1. This allows multiple ELANs of the same type, containing multiple subnets.

4 MSS: Functions, Features, and Advantages

MSS Release 1.0 shipped in September, 1996. Release 1.1 shipped in April, 1997.

4.1 MSS Hardware Overview

MSS consists of hardware and software; the hardware comes in two forms:

- **The 8210 stand-alone box** with two slots for 155 Mbps ATM adapters.

  The provision for two ATM adapters allows for complete redundancy. Since MSS supports the ATM Forum standards UNI 3.0 and 3.1 it can be used with any ATM switch also supporting the ATM Forum standards.

  The 8210 has a PCMCIA slot available for a WAN connection, and an ASCII port for terminal attachment, for use in configuration and monitoring. Configuration options include a Graphical User Interface, and a web browser interface.

  Release 1.1 provided a significant enhancement by supporting an FDDI adapter in one of the slots - providing a migration path from FDDI backbones to ATM.

- **An 8260 module** occupying two slots and accessing an ATM network via the 8260 ATM switch function.

  The module in the 8260 takes advantage of the dependability and fault tolerance provided by the 8260 - hot swappability, intelligent power management, distributed management, and redundancy for critical components including power supplies and switches.

4.2 MSS Software Overview

The software for Release 1.0 provided four sets of functions - support for LAN Emulation, support for Classical IP over ATM, support for routing, and support for bridging. Release 1.1 incorporates improvements for all four functions, improvements in capacity and performance, and exciting new functions - notably Super VLANs and Next Hop Resolution Protocol (NHRP).

This section gives a quick overview of these functions:

4.2.1 LAN Emulation - ATM VLANs

LAN Emulation allows legacy LAN applications to run transparently over an ATM network, and allows legacy LANs to be attached to ATM backbones. An Emulated LAN (ELAN) is a particular logical grouping of such applications or endstations, emulating an Ethernet LAN, a Token-Ring LAN, or a Classical IP network. Note that this is not necessarily a physical grouping - an ELAN is an instance of a Virtual LAN. In order for an ELAN to work, certain standardized server functions must be provided in the ATM network, specifically:

- **LECS** - LAN Emulation Configuration Server, providing configuration services for one ELAN. (Not required if endstations/proxies are preconfigured with a LES address.)
- **LES** - LAN Emulation Server, providing address resolution support, and controlling ELAN membership, one per ELAN. IBM's LES offers optional control of VLAN membership, for security. The MSS LES component will check with the LECS component before allowing an endstation to join an ELAN and communicate with the existing members.
- **BUS** - Broadcast and Unknown Server, used when transmitting frames to a broadcast address, or to a unicast MAC address when the corresponding ATM address is not yet known.

MSS Release 1.0 provided support for these functions for ATM Forum compliant ELANs; Release 1.1 added support for IBM ELANs. More information on ELANs can be found on the ATM Forum web site: `http://www.atmforum.com`.

4.2.2 Super VLANs

A Super VLAN (SVLAN) is a set of interconnected ELANs. A client on an ELAN within the SVLAN may communicate directly with any other client on any ELAN within the SVLAN. A key advantage of SVLANs is the ability to distribute LAN Emulation services - each ELAN within the SVLAN has its own LAN emulation services, increasing reliability despite the increase in network size. ELAN connectivity is established using a technique called Short Cut Bridging (SCB). SCB forwards specific frames between the member ELANs, which are used for address discovery. (An SCB port operates like a transparent bridge port, and forwards LAN Emulation ARP requests and responses, LE ARP NAK requests, and LE FLUSH requests and responses.) Subsequent data transfer between clients uses direct VCCs - i.e. the traffic is switched, not bridged. This makes more efficient use of the backbone and cuts down on latency because it cuts out bridge transfer(s).

IBM's SVLAN implementation is compliant with the ATM Forum's LAN Emulation standard. It was expected that the Forum would include support for this function (known as LNNI) in the LANE 2.0 standard, but it will now be delayed until later in the year.

4.2.3 Protocol VLANs

VLANs have been generating considerable interest among users, with the expectation of several potential benefits:

- VLANs can improve performance by:
  - Reducing broadcast traffic
  - Restricting frames to segments running the relevant protocol
- VLANs can simplify network management by:
  - Removing the need for manual reconfiguration when endstations are moved
  - Conserving IP addresses by removing the need for reassignment when endstations are moved

- VLANs can improve network security by limiting access to traffic

A VLAN is a logical subset of a physical network or networks - an ELAN is also a VLAN, it's one of the benefits of ELANs. Unfortunately, until IEEE 802.1Q is finished there will be no standard definition of a VLAN for legacy LANs (ATM ELANs are already standardized). A VLAN could be based on physical port location, MAC address, network address, or some other defining characteristic. A PVLAN is a VLAN where membership is based on the protocol type.

MSS establishes PVLAN membership dynamically using a technique called Dynamic Protocol Filtering (DPF). DPF monitors the traffic on bridge ports, and forwards traffic for a given subnet only to ports that are actively participating in that subnet. Support is provided for IP, IPX, and NetBIOS. Use of DPF means that no preconfiguration is required in the endstations, and endstations can be moved without reconfiguration.

However, there is one configuration change that, together with SVLANs and DPF, can deliver zero-hop IP routing. Modifying a subnet mask can change a routed connection through MSS to a bridged connection, and when DPF is active the bridged connection then becomes a direct connection. In an environment where the bulk of the traffic is from server to client, it would make sense to change the masks only on the servers, gaining the most advantage for the least effort.

4.2.4 Next Hop Resolution Protocol (NHRP) - Short Cut Routing

NHRP is a key function in introducing IP Switching into a routed network. Using NHRP a source station finds the closest ATM point of attachment to the target station - the target itself, or an egress router. The source then establishes a direct VCC (Virtual Channel Connection) to that address. This Direct VCC is a "shortcut" route, since it eliminates all the intermediate routers, and their associated overhead.

NHRP is defined in an IETF draft to support IP environments. MSS has implemented the draft standard, together with some significant enhancements:

- Support for ELANs - MSS will support IP applications running on an ELAN as well as on a CIP LIS.
- Support for non-NHRP clients - ATM end-stations and switches that do not have NHRP client code installed can still be the target of a shortcut established using the NHRP protocol, since the MSS Server responds to the NHRP requests on behalf of the target.
- Support for non-NHRP routers - it is possible that not all the routers have NHRP capability. With proper configuration the MSS Server will allow the shortcut to be established to the last NHRP-capable router in the path, instead of dropping the traffic.
- Support for low-volume traffic - a configuration option is available to request that the shortcut only be established when the traffic between two stations reaches a specified data rate.

4.2.5 Broadcast Management

MSS includes a Broadcast Manager that is a key improvement over standard BUS operation, allowing broadcast frames to be converted to unicast frames, when possible. This service is provided for IP, IPX, and NetBIOS protocols. The BCM software dynamically identifies frames that can be converted to unicast - special configuration is not required. One customer enjoyed an 80% reduction in IPX broadcast traffic using BCM! Clearly, the less multicast traffic that has to traverse the backbone, the more bandwidth there is available for all traffic. MSS also offers Intelligent Bus mode (IBUS) - in IBUS mode unicast frames are sent directly to the destination station without disturbing other stations.

The Broadcast Manager function in Release 1.0 reduces the number of broadcast frames sent through the BUS. Bridging Broadcast Manager (BBCM) in Release 1.1 provides similar function for

frames bridged by MSS. BBCM is implemented for IP and NetBIOS, and converts broadcast frames destined for a learned protocol address to unicast frames.

While IBUS and BCM provide attractive functionality, these capabilities do increase the processing required for each packet. Two new modes of operation are offered in Release 1.1 for customers who want performance more than function. In adapter mode BCM is deactivated, and in VCC splicing mode both BCM and IBUS are deactivated. The expected throughput is on the order of 100 Kpps for 64 byte packets.

4.2.6 Reliability

With the 8260 and MSS Server IBM offers a comprehensive redundant infrastructure for both ATM backbone and VLAN implementations. The MSS Server has been designed with specific redundancy features. Two MSS servers can be configured such that one is primary and one secondary. If the primary server goes down, the secondary will take over, and connections will be reestablished using the backup. When the primary recovers, it will take over from the secondary. This provides redundancy for the LES and BUS. Redundancy can also be obtained for the LECS by installing duplicate LECS on different platforms, and including both in the ILMI database. MSS servers do not have to be dedicated to providing only backup functions - an MSS server can act as primary LES/BUS for some ELANs and as secondary for others.

In Release 1.1 the following improvements have been added for ELANs:

- Ability to designate more than one LANE server as a backup
- Both primary and secondary IP gateways may be active as routers, although only one will be acting as the gateway

There are also improvements for Classical IP:

- The user may now configure which server is primary and which is secondary
- The MSS Servers performing ARP server functions will now also perform IP routing simultaneously.

4.2.7 Support for Classical IP over ATM

The IETF group has defined a standard (RFC 1577) for running IP protocols over an ATM network. MSS provides the functions required by the standard -

- ARP Server support - used for address discovery
- Support for Permanent and Switched Virtual Circuits
- Operation as an IP router

Plus value-add functions:

- Operation as an internetwork router - routing between ELANs and Classical IP subnets
- Provision for redundant ARP servers and redundant default gateways

4.2.8 Routing Support

MSS can operate as a router for two popular protocols:

- IP - the MSS server can route between any combination of ELANs and Classical IP subnets. OSPF is supported for both types of subnets, and RIP for ELANs.

- IPX - the MSS server can route between ELANs and between ELANs and interfaces supporting RFC 1483 encapsulation

Again, MSS provides support above and beyond what is called for in the standards:

- Dynamic IPX configuration - the server supports a combination of RFC 1483 encapsulation and InATMARP that allows it to learn destination IPX host numbers dynamically, instead of requiring them to be configured.
- Redundancy - as for CIP, a backup default gateway can be provided for ELANs

4.2.9 Bridging Support

Support is provided for three bridging modes. An emulated Ethernet bridge port provides Transparent Bridging only. An emulated Token-Ring bridge port provides either Source-Route bridging or Transparent Bridging or Source-Route/Transparent bridging. A server with a mix of emulated Ethernet and Token-Ring LANs can provide a combination of the three bridging modes, as appropriate. There are six possible bridging behaviors when the base modes are combined.

The already extensive bridging support in the MSS Server has been enhanced in Release 1.1 with support for frames conforming to RFC 1483 (Multiprotocol Encapsulation over ATM AAL5). This is especially significant since it allows the MSS Server to attach to a Frame Relay/ATM switch.

4.2.10 ATM Virtual Interface

This Release 1.1 feature allows one physical ATM interface to appear to higher-layer protocols to be multiple ATM interfaces. This has several benefits for Classical IP (which were already available for Emulated LANs):

- Increased number of subnets - previously only 32 subnets could be supported on each physical interface
- Support for multicast routing protocols - previously if multiple subnets were configured on the same interface, multicast packets could not be transferred between them (a limitation of routing protocols). This can now be achieved by configuring each subnet as a separate virtual interface.
- Performance improvements - different protocols can use different virtual interfaces, each with its own maximum packet size. This allows each protocol to use the largest packet size it supports.

4.2.11 Configurable Quality of Service (QoS) for ELANs

Release 1.1 provides a standards-compliant method for specifying QoS support on ELANs. MSS supports QoS configuration for an entire ELAN, for a particular ATM interface, or for an individual LANE Client (if the client code supports QoS). Although the current ATM Forum LANE standard does not specify how to use QoS on an ELAN, this implementation is compliant with the standard, and operates with UNI 3.0/3.1 signalling. Thus MSS is delivering on one of the promises of ATM ahead of the competition.

4.3 MSS Advantages

4.3.1 Simplification

MSS has proved very attractive to customers who want to simplify their network. As networks have grown bigger over the years, the router infrastructure has grown more complicated. This fosters the

need for more people to manage the network. Installing MSS in such an environment reduces costs while positioning the network for the future, along with other benefits:

- Adds/moves/changes no longer require re-configuration
- Control is moved to one place in the network
- Using the redundancy features eliminates single points of failure
- Intelligent BUS operation dramatically reduces the broadcast overhead of a router-based network

MSS also can be used to create a flat network using LANE, or a virtual flat network using Super VLAN support.

4.3.2 Packaging

The previous sections showed that MSS contains a lot of function, and one great advantage is that all of that function is in one place - one stand-alone box, or one 8260 module. Installing just one box or module provides significant flexibility. In order to get the same combination of function from competitors two or more separate boxes would be required for:

- The LAN Emulation services
- The ARP server for CIP
- Policy based VLAN support (if available)
- Multiprotocol routing, bridging, and switching

In addition MSS provides software-based broadcast management, security, and redundancy. Offering all this function in one place in the ATM network may be why MSS Release 1.0 was the Grand Winner at the Atlanta Network Expo/Interop in 1996, and the Best of Show at the Paris Interop in 1996.

Another benefit of the IBM implementation is that the LANE servers are implemented, together, in the middle of the backbone. Some vendors are putting this function out in the edge devices, making monitoring and management more difficult.

4.3.3 Broadcast Management

One of the motivations for the development of routers was to reduce broadcast storms. Routers achieved this by segmenting networks into subnets, and restricting the traffic between subnets. But routers themselves make use of broadcast traffic for discovery and table maintenance, and segmenting traffic solely on the basis of subnet is becoming too restrictive.

The BUS extensions developed by IBM provide a VLAN/BUS combination with broadcast management at three levels:

- At the LAN switch - this can be port- or policy-based depending on the switch
- Between switches within the campus - the Broadcast Manager converts multicast packets to unicast packets
- Between ELANs within a SVLAN in the enterprise

Restricting broadcast traffic not only cuts down the load on the backbone, where bridges and switches are acting as proxies for LAN attached stations, but reduces the load on the LANs, and interruptions at endstations.

4.3.4 Spectrum of support

MSS can work in many different environments. It allows for the co-existence of different network types and protocols, while offering the possibility of convergence over time to one common infrastructure. For example:

- SNA and NetBIOS (running on an ELAN) and TCP/IP (using Classical IP) can co-exist
- Ethernet ELANs and Token-Ring ELANs can co-exist
- Bridging and routing can co-exist
- MSS can perform translational bridging between Ethernet and Token-Ring ELANs
- MSS can route between ELANs and Classical IP subnets
- MSS can connect FDDI and ATM backbones

And you can do all of this with one MSS Server (or two for redundancy).

4.3.5 Incremental upgrades

The first step in solving today's problems is to install an ATM backbone. The MSS Server allows the rest of the network to stay unchanged (aside from the backbone connections), or to be upgraded in stages. One likely scenario is to connect LAN switches into the ATM backbone, leaving the legacy LAN stations and applications unchanged. This environment would use ELAN support. Server bottlenecks could then be addressed by upgrading the individual servers to direct ATM attachment, possibly at 155 Mbps. If a particular workgroup wanted to run multimedia applications requiring local bandwidth and QoS support, that workgroup could be migrated to desktop ATM, or converted from shared to switched LAN support.

5 Competitive Analysis

5.1 Key Differentiators

With MSS IBM delivers on the promise of Switched Virtual Networking, and provides functions that clearly separate it from the competition.

- **MSS provides a comprehensive solution for all LAN types.**

  Only MSS provides the Next Hop Resolution Protocol for ATM, Token-Ring, and Ethernet media types, for shared or switched LANs. Unlike most of the competition (Cisco, Fore Systems, and Bay) the 8260 switching hub supports direct attachment of not just ATM, but also shared and switched 10 Mbps Ethernet, 100 Mbps Ethernet, Token-Ring, and FDDI for the campus, and T1/E1, T3/E3, and OC3/STM1 for the WAN. Also, shared and switched Ethernet and Token-Ring can now be connected into the ATM backbone via IBM's LAN switches. Finally, MSS now offers PVLANs that span shared or switched LANs and ATM, as well as the ELANs supported with Release 1.0.

- **The most scalable and reliable LAN Emulation solution**

  MSS provides convenient packaging of LANE and CIP servers. There is support for redundancy for all server types, and with the introduction of SVLANs it is possible to increase network size without reducing reliability.

- **Exclusive broadcast management that allows flat networks to operate efficiently**

- **Multi-vendor interoperability**

  - MSS has been tested and endorsed by the Network Interoperability Alliance
  - MSS has been tested at the University of New Hampshire's Interoperability Lab (particularly for compatibility with ATM switches)
  - MSS is built on existing standards

- **Integrated network management**

  The IBM 8260 and MSS are managed by the NWays Campus Manager which provides:

  - Management of ATM topology, devices, and connections
  - Management of ELANs - domains, policies, etc.
  - Management of LANs
  - Seamless navigation between views of LANs, ATM, and higher protocols

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5.2 Solving Today's Problems

IBM is now offering a comprehensive set of products to solve today's network problems. Revisiting the problems listed in the first chapter:

- **Bandwidth limitations**

  An ATM backbone delivers 155Mbps or 622 Mbps today, with QoS support. Endstations can be attached through LAN switches in shared or switched configurations. Overloaded endstations can be upgraded to 25 or 155 Mbps and attached to the backbone either directly or through an ATM switch.

- **Bottlenecks**

  ATM with MSS and NHRP provides not only a faster backbone, but the opportunity to eliminate all or most routing. While routing between ELANs and LISs is certainly supported, it's not required.

- **Network management problems**

  With ELANs and PVLANs MSS offers the benefits of VLANs today. With SVLANs and IBM's broadcast management techniques a flat network becomes viable - several customers are already successfully running with flat networks.

- **Bigger networks**

  As outlined above, MSS supports the interconnection of many different networks. By solving the bandwidth and network management problems of today's networks, it reduces the complexities that tomorrow's managers will have to handle.

- **New applications**

  Of course ATM is ideal for the new multimedia applications. It was specifically designed for networks supporting voice, video, and data, whereas it is still unclear how the efforts to retrofit this support to Ethernet will work out.

- **Investment protection**

  An ATM backbone can be installed without disrupting the workgroups it will support. Installing MSS will allow disparate outlying networks to co-exist across the same backbone. One of the advantages of ATM is its scalability - 25 Mbps to 622 Mbps and beyond for the LAN, and T1/T3/OC3 for the WAN. With the new features announced for Release 1.1 MSS adds new flexibility, including FDDI attachment. Also note that the Super 8260 IBM has just announced is fully compatible with the current 8260 modules.

5.3 Sample Configuration

Note: The information given in this section for competitive products is based on data from Infonetics Research published in February 1997.

A standard campus configuration would be based on a backbone of one or more interconnected ATM switches. (One of the switches might connect off-campus via a WAN.) Support would be required for LANE and CIP servers. Workgroups would be attached through ATM switches (for 25 Mbps), and Ethernet and Token-Ring switches (for legacy LANs). IBM has all the necessary equipment available today. For the backbone and interconnect support there is the IBM 8260 NWays Multiprotocol Switching Hub, with available 155 Mbps ATM modules, plus the MSS Server either as an 8260 module or as a standalone 8210.

IBM's switching support:

- IBM 8285 NWays ATM workgroup switch (12 to 48 ports) with 155 Mbps ATM uplink
- Token-Ring switches:
  - IBM 8270 (4 - 28 ports) with 155 Mbps ATM uplink
- Ethernet switches:
  - IBM 8271 (8 or 16 ports) with 155 Mbps ATM uplink

What is available from the competition?

- **Cisco:**

  Cisco does not offer many of these functions in one package. To get the features available on the 8260 by installing an MSS module, Cisco requires the purchase of a standalone router in addition to the ATM switch. Pricing the Cisco Lightstream 1010 ATM Switch with 12 OC3 multimode fiber ports and IP/IPX routing on a Cisco 7507 multiprotocol router against IBM's solution shows that IBM is over $10,000 cheaper than Cisco. Adding a redundant switch to the solution makes IBM's offering even more attractive - over $57,000 cheaper.

  Cisco's switching support:

  - ATM 25 Mbps - not available
  - Token-Ring - no ATM uplinks available
  - Ethernet 10BaseT Switches:
    - Etherswitch 1420 (25 ports) - distributor pricing only
    - Catalyst 3016 (16 ports) with 155 Mbps uplink

- **Fore Systems:**

  Fore Systems does offer integrated LES/BUS support for the ASX-1000, but only for Ethernet, and it shares the same processor as the switch functions. The other MSS functions are not available on the ASX-1000.

  Fore's switching support:

  - 25 Mbps ATM switch - ASX-200WG (18 or 24 ports) - no 155 Mbps uplink available, no PNNI support available
  - Token-Ring - not available
  - Ethernet 10BaseT Switches:
    - ForeRunner ES-3810 (16 or 24 ports), with ATM uplink
    - ForeRunner ES-3850 (16 ports) with one or two fixed ATM ports

- **3Com:**

  3Com's CoreBuilder 7000 Switch is missing a number of the connectivity options offered by IBM's 8260, plus its ATM support also falls short. The call set-up rate is half that of the 8260, plus it does not support VP tunnelling, link aggregation, clustered peer groups, and dynamic routes, nor does it offer Constant Bit Rate and Variable Bit Rate support.

  3Com's switching support:

  - ATM 25 Mbps - Cellplex 4000 Switch (12 ports) with 155 Mbps uplink
  - Token-Ring - SuperStack II Switch 2000 (12 ports) with 155 Mbps uplink
  - Ethernet 10BaseT:
    - SuperStack II Desktop Switch (24 ports) with 155 Mbps ATM uplink
    - SuperStack II Switch 1000 (12 or 24 ports) with 155 Mbps uplink

- **Bay Networks:**

  The Bay chassis actually consists of two separately managed switches, which do not communicate. Bay is lacking in redundancy - no redundant switch is available, and the control processor is not hot-swappable. As with Cisco, the Bay solution relies on an expensive external router, and is missing not only the integrated functionality of an IBM 8260 with MSS, but also can support many fewer types of media connections. As with 3Com's CoreBuilder 7000 switch, Bay's 5000BH intelligent hub is missing support for a number of ATM features - in fact it only supports one class of service, Unspecified Bit Rate, or "best effort".

  Bay's switching support:

  - ATM 25 Mbps - not available
  - Token-Ring - Centillion 10 Switch (8 ports) with 155 Mbps uplink
  - Ethernet 10BaseT Switch:
    - EtherCell 10328-F (12 ports) with one fixed 155 Mbps ATM port

- **Cabletron:**

  Cabletron does offer some of the integrated functions found with MSS with an architecture called Virtual Network Services. However, their MMAC-Plus SmartCell ATM switch is lacking in redundancy - many ATM configurations do not have hot-swappable power supplies, there is no redundant power controller, processor/control point, or LES/BUS server. They are also lacking in integrated ATM features. Unlike the IBM 8260 they do not provide an ATM carrier card for third-party functions, an MPEG-2 video distribution module, or Ethernet and Token-Ring switching modules attaching directly to the ATM backplane.

  Cabletron's switching support:

  - ATM 25 Mbps - not available
  - Token-Ring - not available
  - Ethernet 10Base Switch:
    - ESX-1320 or 1380 (12 ports)

The bottom line is that IBM, with the 8260 and MSS, offers the most complete solution for tomorrow's networks. The 8260 has unmatched reliability features, and MSS offers redundancy for network functions. Also, IBM offers the most connectivity options for the 8260, plus the only full line of switch attachments to ATM. In addition, IBM's vision of Switched Virtual Networking provides the solution to today's and tomorrow's problems - today.

6 MSS In The Real World

6.1 MSS Configurations

In this section we will look at three customers who are installing ATM backbones and MSS servers: one in government, one hospital, and one manufacturing company.

6.1.1 Migrating a FDDI Backbone

The government customer's existing installation consisted of Ethernet LANs connected by routers and hubs into a FDDI backbone. (See Figure 1.) There were between four and fifteen subnets per router, and four physically isolated FDDI backbones with 1,000 to 2,500 users per backbone. This was a multiprotocol network using TCP/IP, NetBIOS, SNA, and IPX.

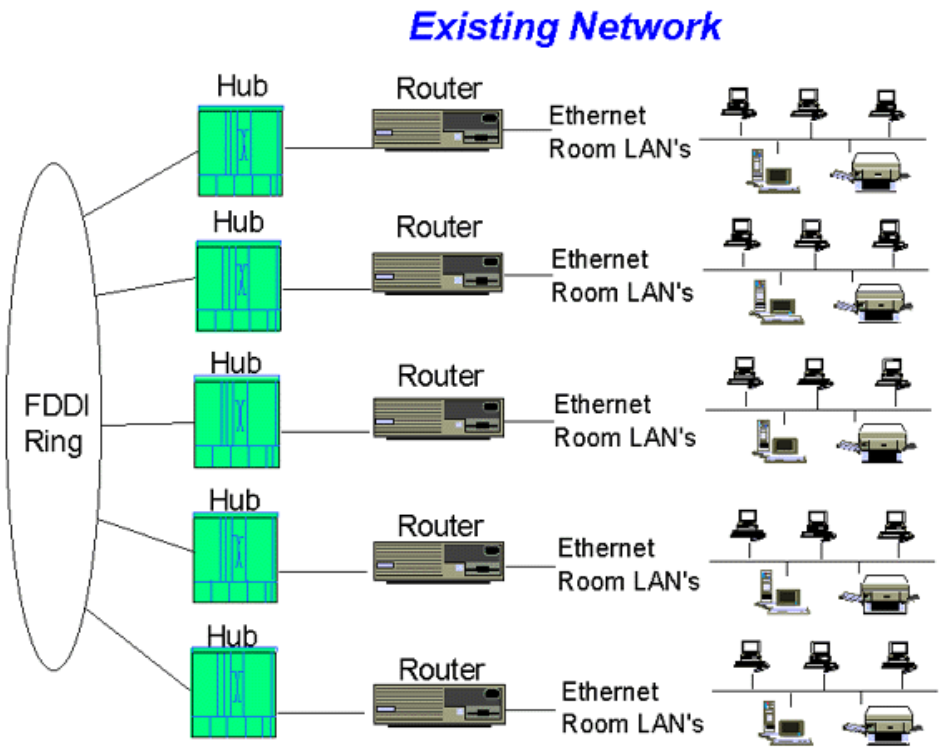


Figure 1: Existing FDDI-based Network.

The customer had a number of concerns that needed to be addressed:

- Server congestion and a desire for server consolidation
- Need to support collaborative applications
- Need to support multimedia applications and video conferencing
- Performance
- Security
- A strong desire to upgrade rather than replace existing equipment

IBM's approach to this situation was threefold:

- Migrate from the FDDI backbone to an ATM and switch-based backbone

- Put ATM modules in the existing 8260s
- Flatten the network to one subnet, using MSS with multiple ELANs

Note that this is a migration strategy, not a replacement strategy. The FDDI and ATM backbones will start out coexisting, as shown in the following figures:

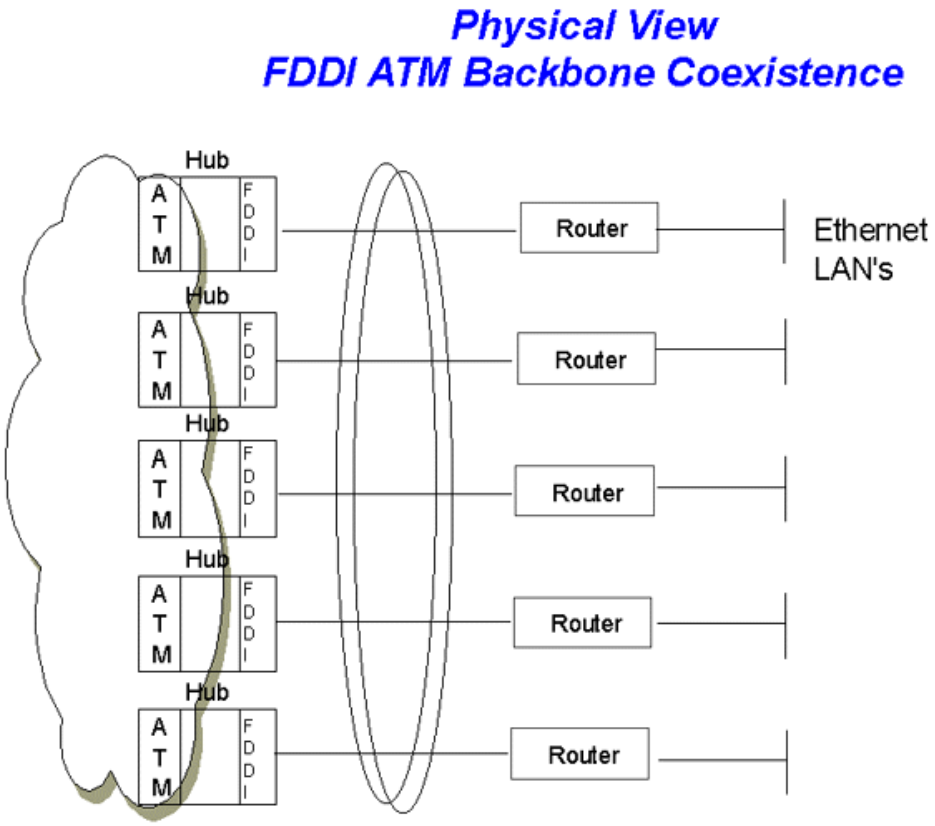


Figure 2: Physical View of FDDI and ATM Backbone Coexistence.

The difference between step 1 and step 2 is that some Ethernet workgroups are now directly attached to the 8260 switch - some using Ethernet and some using ATM.

6.1.2 Implementing for Tomorrow's Applications

The second scenario involves a leading university hospital interested in installing a strategic network to support new applications. They wanted to move to paperless records, and were also driven by the need to install a medical imaging application. Their list of concerns included:

- Reliability:
  - 24 hours a day, 7 days a week operation
  - No single point of failure
- Universal access - from anywhere in the hospital
- High bandwidth - support required for next generation applications

The logical design of the new network is shown in Figure 5. The installation supports around 3,000 users, and there is a mix of ATM and legacy LAN endstations. The MSS Server support provided a number of benefits:

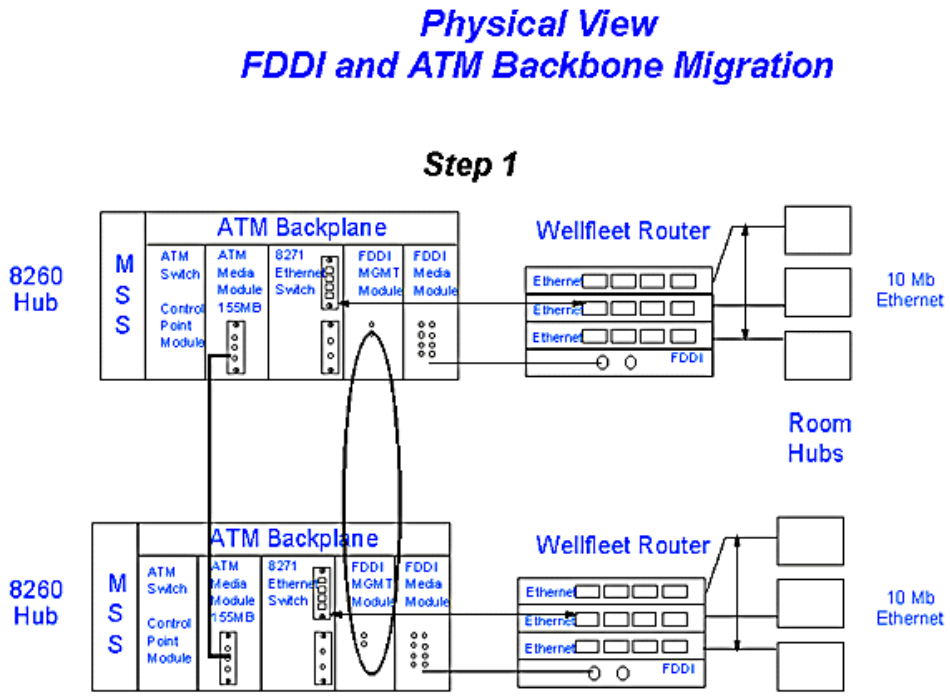


Figure 3: Physical View of FDDI and ATM Backbone Migration - Step 1.

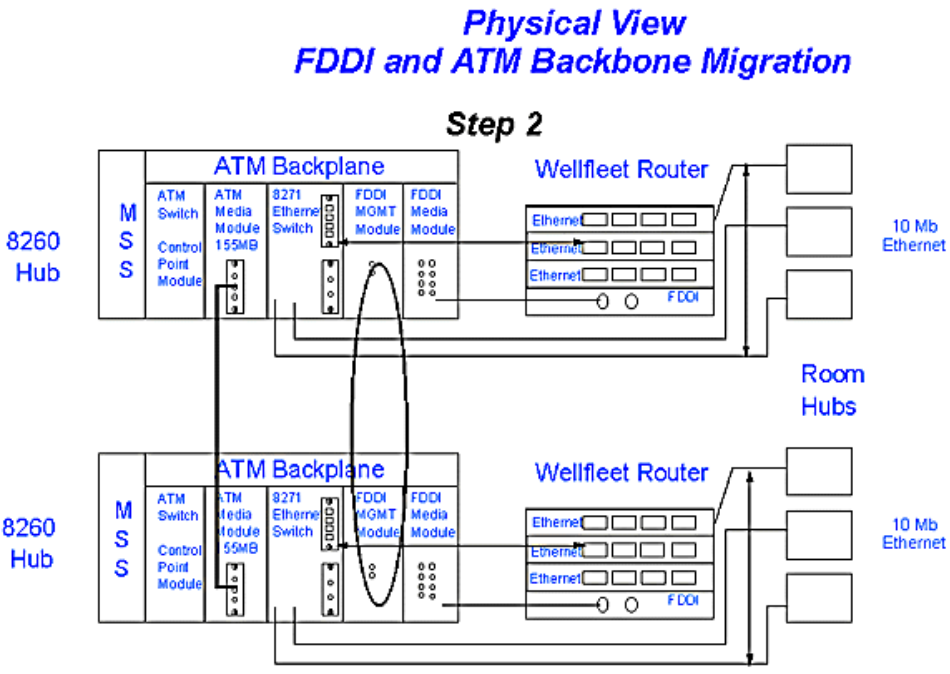


Figure 4: Physical View of FDDI and ATM Backbone Migration - Step 2.

- Simplified network management
- The ability to support conventional traffic on ATM
- The ability to route between CIP and ELANs
- A non-disruptive move to next generation applications

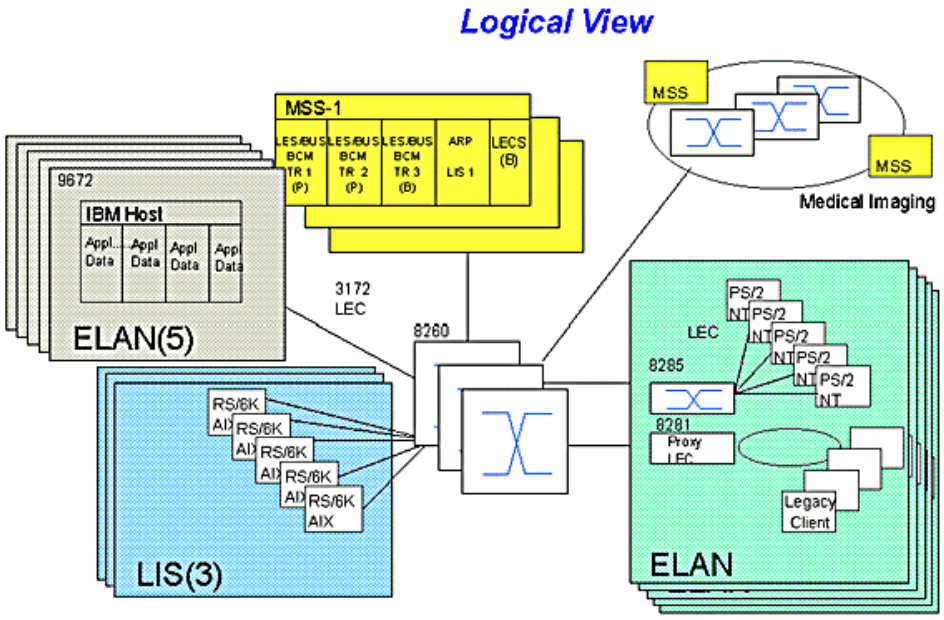


Figure 5: Logical View of New Hospital Network.

6.1.3 Staged Upgrade

The third scenario involves a manufacturing customer with a large-scale routed network spread across a number of buildings. This customer was interested in a technology upgrade that provided:

- Endstation mobility and security
- Improved performance, especially regarding latency
- Support for multimedia traffic
- Manageability
- Availability/reliability

With 108 subnets this particular network had reached its limits with respect to availability and latency. The network served four buildings; the initial implementation of the new network would be for one building.

The proposal for this customer involved a series of steps. Even the backbone installation was staged - one 8260 initially, then a second. At this stage the subnet structure is unchanged, but now MSS can be used to flatten the network as required. Later steps will include moving to dedicated Ethernet for each endstation, and upgrading the 8274s to take over from the 8260s as the backbone switches.

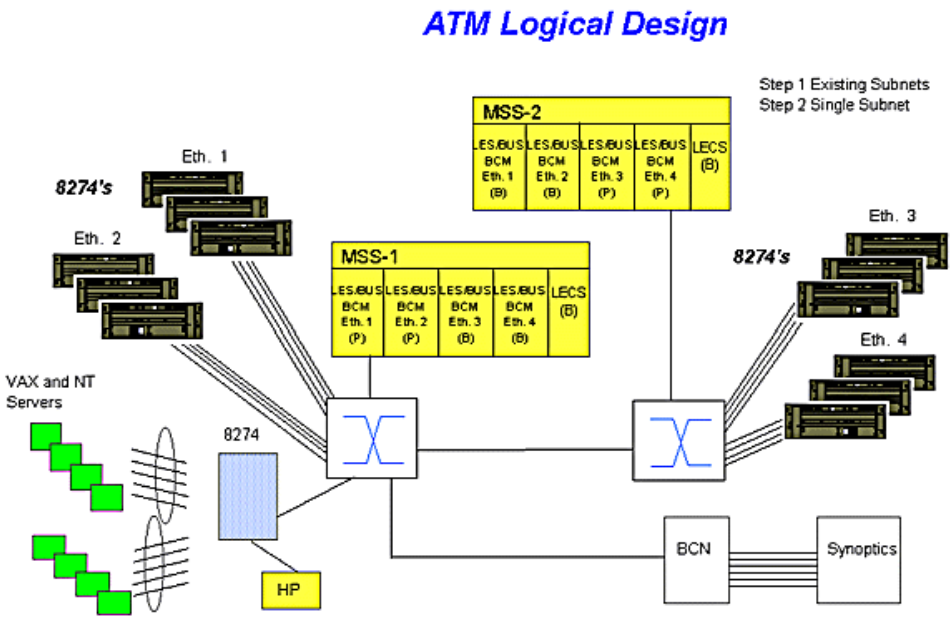


Figure 6: Manufacturer Scenario - Logical Design of New Infrastructure.

6.2 MSS Customers

This is a list of a few of IBM's MSS customers, from different countries and different industries, with their IBM contacts:

- **British Columbia Institute of Technology, Canada:** Education
  - Gwenn Boryski, 604-664-6988
- **Ciba SC, Switzerland:** Chemicals
  - An ATM backbone composed of four 8260s and three 8210s.
  - Bruno Maggi, 41-643-6081
- **City of Little Rock, Arkansas, USA:** Government
  - Todd Smithson, 501-370-2392
- **Columbus State Community College, Ohio, USA:** Education
  - Token-Ring users running LAN Emulation
  - Mark Boyd, 419-774-0501
- **Czech National Bank, Czech Republic:** Finance
  - Currently Ethernet users with 20 VLANs, two MSS servers, three ATM switches
  - Petr Havlik, 42-2-67-106-263
- **European Space Agency, France**
  - Ethernet and Token Ring users with two 8260s in the backbone, MSS routes IP traffic and bridges SNA and NetBIOS.
  - Patrick Daniau, 33-01-4905-5553
- **First International Bank of Israel, Israel:** Finance

  - Token-Ring users on two sites, plus branch offices, using MSS for LAN Emulation.
  - Shimon Agassi, 972-3-5159203

- **Fort Huachuca, Arizona, USA:** Department of Defense ATM interoperability and performance test center for Army rollout
  - Peter Wong, 301-803-2176

- **J. B. Hunt Transport, Inc., Arkansas, USA:** Transportation
  - Todd Smithson, 501-370-2392

- **Hermann Hospital, Texas, USA:** Healthcare
  - MSS Servers supporting LAN Emulation and Classical IP, aiming for a flat network.
  - Sam Labarbera, 713-940-1128

- **La Caixa, Spain:** Finance
  - Token-Ring users with three 8260's forming an ATM backbone
  - Jose Alsina Donadeu, 34-3-4018100

- **Mona Shores Public Schools, Michigan, USA:** Education
  - Six locations, 8260 and MSS in the backbone, supporting voice, video, and data traffic.
  - Kathy Hoffman, 616-942-3805

- **Novartis, Switzerland:** Pharmaceuticals, Agribusiness
  - ATM backbone composed of eight 8260s and five 8210s.
  - Bruno Maggi, 41-643-6081

- **Pekin Public School District, Illinois, USA:** Education
  - ATM, Token-Ring, and Ethernet users, ATM backbone with MSS providing voice, video and data traffic, and Internet access.
  - Gary Steps, 314-469-4134

- **Wrekin Council, UK:** Government
  - ATM infrastructure based on 8260 plus MSS, MSS allows clients using LAN Emulation to communicate with servers using Classical IP.
  - Sarah Powell, 44-01926-465029

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7 Appendix A. Acknowledgements

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Brian Bingham, Hugh Fish, Jeff Mayberry, Andy Rindos, Dee Vig, Greg Wong.

8 Appendix B. Glossary

ARP Address Resolution Protocol - used by the IP protocol to discover network to MAC address mappings, used by LE to discover LAN to ATM address mappings.

ATM Asynchronous Transfer Mode - a transfer mechanism using 53 byte cells, and operating at a number of different speeds, being standardized by CCITT, and in the interim by the ATM Forum.

BBCM Bridging Broadcast Manager - used in the MSS Server Release 1.1 implementation of bridging to reduce broadcast traffic.

BCM Broadcast Manager - used in the MSS Server implementation of BUS to reduce broadcast traffic.

BUS Broadcast and Unknown Server - required for LAN Emulation.

CIP Classical IP - from the IETF standard RFC 1577 defining the operation of IP over ATM.

DPF Dynamic Protocol Filtering - a technique used by MSS to dynamically assign membership in a PVLAN.

ELAN Emulated LAN - a collection of ATM stations giving the appearance of an Ethernet or Token-ring LAN to applications.

FDDI Fibre Distributed Data Interface - an ISO standard for transmission at a 100 Mbps over a fiber connection. (Also used generically to include CDDI - 100 mbps over copper wire.)

IBUS Intelligent Broadcast and Unknown Server - an enhanced operating mode of the BUS.

IP Internet Protocol - a connectionless packet delivery service that forms the basis of Internet communication and is roughly equivalent to ISO layer 3 (network).

IPX Internet Packet Exchange - the network layer protocol used in Novell networks.

LAN Local Area Network - a geographically limited set of physically connected stations.

LANE LAN Emulation.

LE LAN Emulation (alternate abbreviation).

LEC LAN Emulation Client - an entity using, or representing entities using, an emulated LAN.

LECS LAN Emulation Configuration Server.

LES LAN Emulation Server.

LIS Logical IP Subnet - an IP subnet implemented according to RFC 1577 on an ATM network.

MSS Multiprotocol Switched Services.

NBMA Non-Broadcast Multiple Access network - a network that does not support broadcast traffic, but does support attachment of multiple users - e.g. ATM.

NHRP Next Hop Resolution Protocol - IETF draft standard for locating the best switched path through an NBMA network.

OSPF Open Shortest Path First - IETF routing protocol.

PVC Permanent Virtual Connection.

RFC Request For Comments - a document used in the IETF standardization process.

RIP Routing Information Protocol - used with IP and IPX.

QoS Quality of Service - a guarantee of the availability of a certain amount of bandwidth with a network.

PVLAN Protocol VLAN - a VLAN formed on the basis of the protocol used by the member stations.

SCR Short Cut Bridging - technique whereby certain control frames are forwarded across a bridge to facilitate the establishment of direct VCCs.

SVC Switched Virtual Connection.

SVLAN Super VLAN - a set of interconnected ELANs.

SVN Switched Virtual Network - IBM's architecture for switched networks.

VCC Virtual Channel Connection - the link between communicating users in an ATM network.

VLAN Virtual LAN - a set of logically related stations, as distinct from the set of physically related stations that form a traditional LAN.