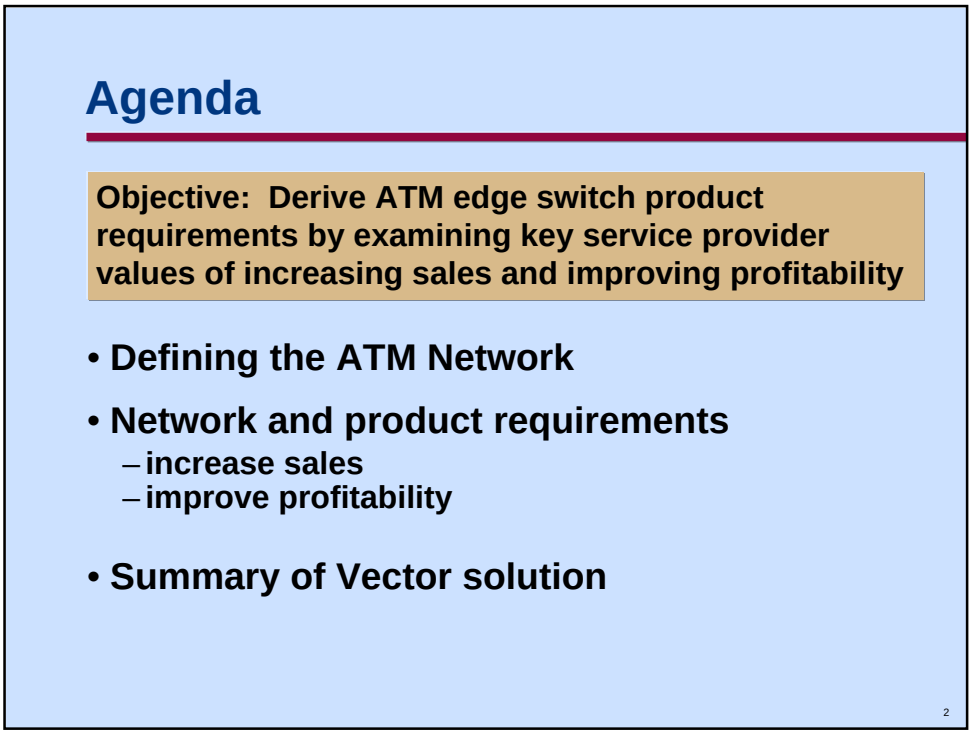
As service providers contemplate the deployment of ATM networks and services, they are concerned with key values such as competitive differentiation and risk management. These key values will be explored, and the product and network requirements necessary to realize them will be derived, with particular focus on the smaller ATM switch in its role as edge ATM vehicle or combined edge/core switch. Participants in this workshop will become knowledgeable about the values and benefits of the capabilities of the Magellan Vector product, and its ability to provide the service provider with the key product attributes required to realize market success with ATM.

About the presenter:

Karen Kobierski is with the Magellan Vector product management team at Nortel. She has been with Nortel for the past six months, and was previously at Nortel Technology (formerly Bell-Northern Research for 10 years. While at Nortel Technology, Karen was a manager in the Broadband Architecture group of the Systems Engineering division. Karen holds a Bachelor of Engineering degree in Electrical Engineering from Memorial University of Newfoundland (1983), and obtained an MBA with top of class standing from the University of Ottawa in 1990.



Session objectives

The objectives of this session are to:

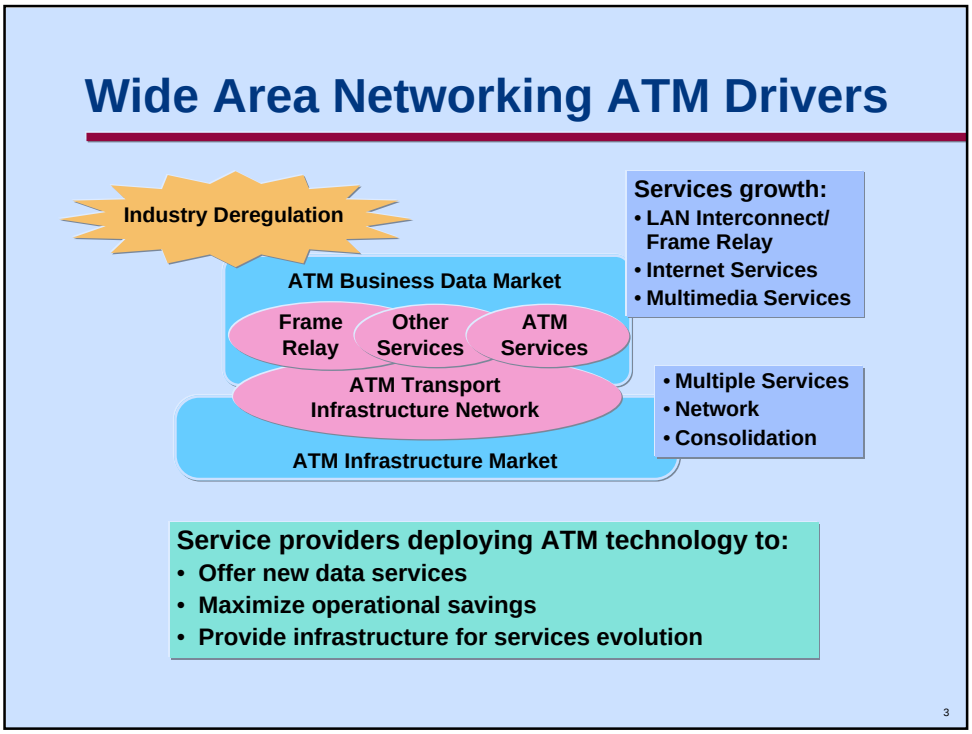
- cover key service provider values to support deployment of competitive ATM networks and services from ATM edge switch perspective;
- determine product and network requirements to meet those values;
- highlight Magellan Vector's ability to deliver those capabilities.

The presentation is organized as follows:

The forces behind the market for ATM networking are first examined, and a common view of the ATM network architecture identified.

ATM service provider objectives are then proposed, and the ATM edge switch network and product implications of the service provider objectives are assessed. These are organized under the headings of revenues (increase sales) and costs (improve profitability)—the major aspects of any business case. The ability of Nortel's Magellan Vector ATM edge switch to meet the requirements is discussed.

The presentation closes with a summary of the Vector solution, and some overall conclusions.

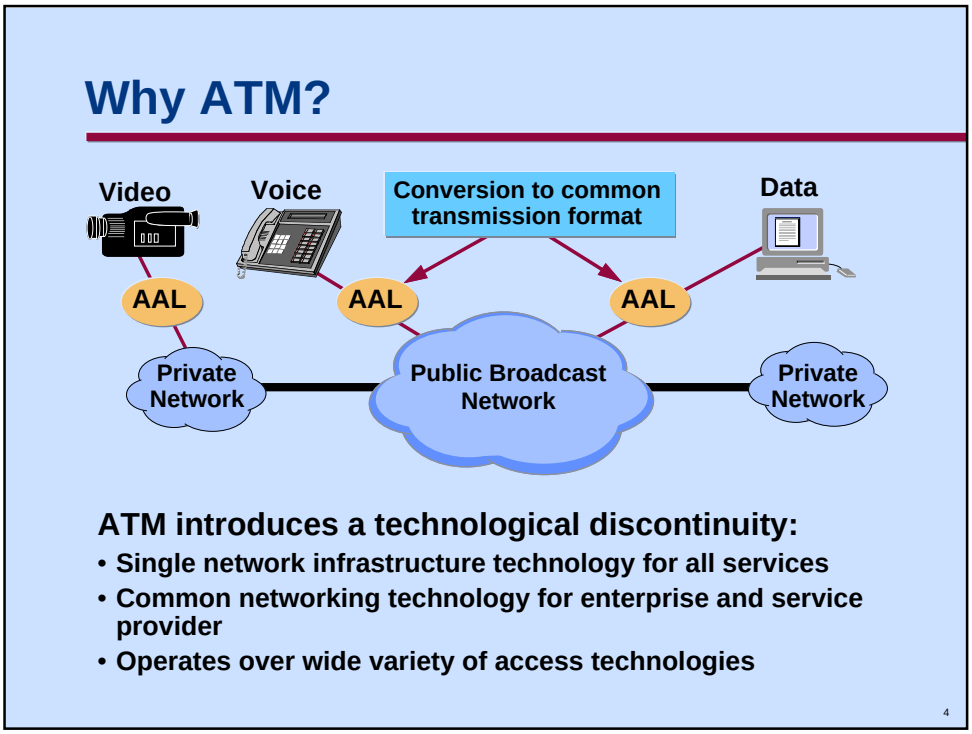


Although the ATM WAN networking market is in its infancy, there are strong indications that it has great potential to grow over the next four years, and into the next century. At this time, most of the industry activity is still focused on technology and market trials, but is expected to shift increasingly towards deploying revenue-generating networks throughout 1996 and 1997.

A key factor impacting the growth of ATM networking both in the United States as well as in Asia and Europe is the recent trend towards deregulation. In the United States, the recent signing of the telecommunications reform bill is removing barriers on the market presence of telecommunications providers. The well-understood boundaries of "long distance carrier" and "regional carrier" are open for redefinition as the more traditional players broaden their market scope, and as new, smaller players increasingly challenge the established service providers. A significant consequence is that service providers are making plans which will accelerate the deployment of competitive networks and services, utilizing the newest technologies available—including ATM and SONET—to:

- ensure coverage of services options for customer benefit in the face of market and technology uncertainty; and
- to maintain competitive differentiation over competition.

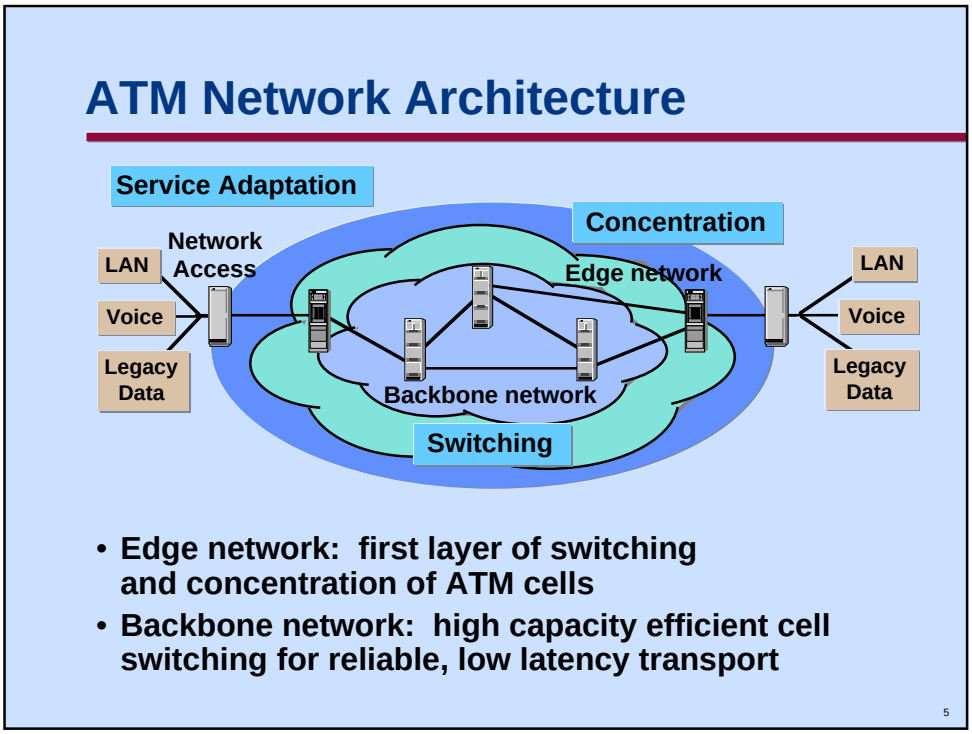
Although the current driver for ATM in the service provider network is to support business data networking, there is a widely accepted view that ATM will, over time, become a core infrastructure component of service provider networks. Hence, service providers are deploying ATM technology today, not only to offer new data services in response to the drivers such as growth in LAN interconnect, Internet services, and multimedia services, as well as residential services, but also to maximize operational savings in the mid-term, through consolidation of services networks, and to prepare for the ATM-based infrastructure of the future.



ATM represents a significant technology discontinuity that has the potential to break down traditional barriers separating and protecting industry players. It is a communications protocol which, through its adaptation capability, represents a common networking technology for all services. Voice, video and data can all be adapted and carried in the ATM 53-byte cell, thereby enabling the interworking of these previously disparate services. The promise of ATM is the eventual elimination of multiple overlay networks.

ATM is a unifying technical solution applicable to each architectural network segment. This common networking technology can be deployed with equal ease within the enterprise—at the desktop, through the workgroup and enterprise switch—and by the carrier, within the public network. End-to-end presence of this scope has previously been unattainable with any previous data networking technologies.

Additionally, ATM operates equally well over twisted pair, coaxial cable, satellite links, dark fiber (asynch), SONET and SDH. As a result, it can be deployed over the existing plant currently owned by all major industry players, as well as over newer media, to capture a wide variety of services including voice, video, data and multimedia.

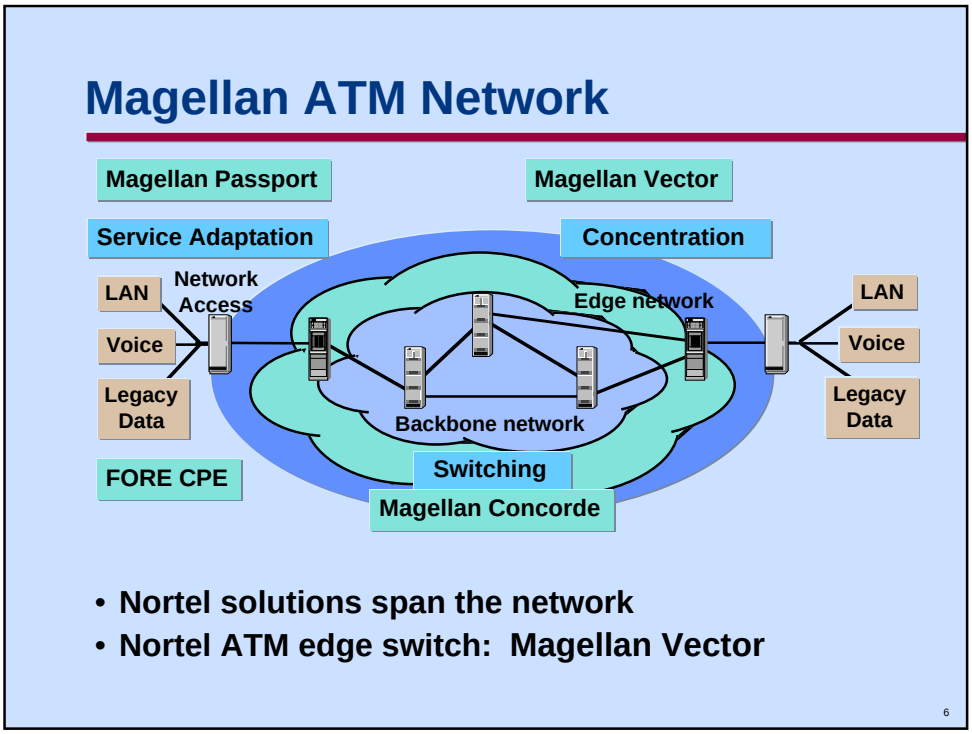


This chart provides a representation of the ATM network architecture, comprising several layers.

In the outermost layer reside the network access devices—such as enterprise switches, services access multiplexers, or other devices—which directly support the service interfaces and provide the adaptation function of the connectivity ATM functionality. These devices may reside on the customer premises or within the service provider central office.

Feeder ATM sites within the ATM edge network receive cells from the network access devices, and provide concentration and switching. The traffic is sourced by the edge switches within the edge network into the innermost layer which is the backbone ATM network providing switching.

Outside North America, the enterprise switch is likely to reside within the service provider access network today, while the edge switch is functionally adequate to handle the backbone responsibilities as well as access network functions. A backbone network may be deployed when warranted by the level of traffic within the network.

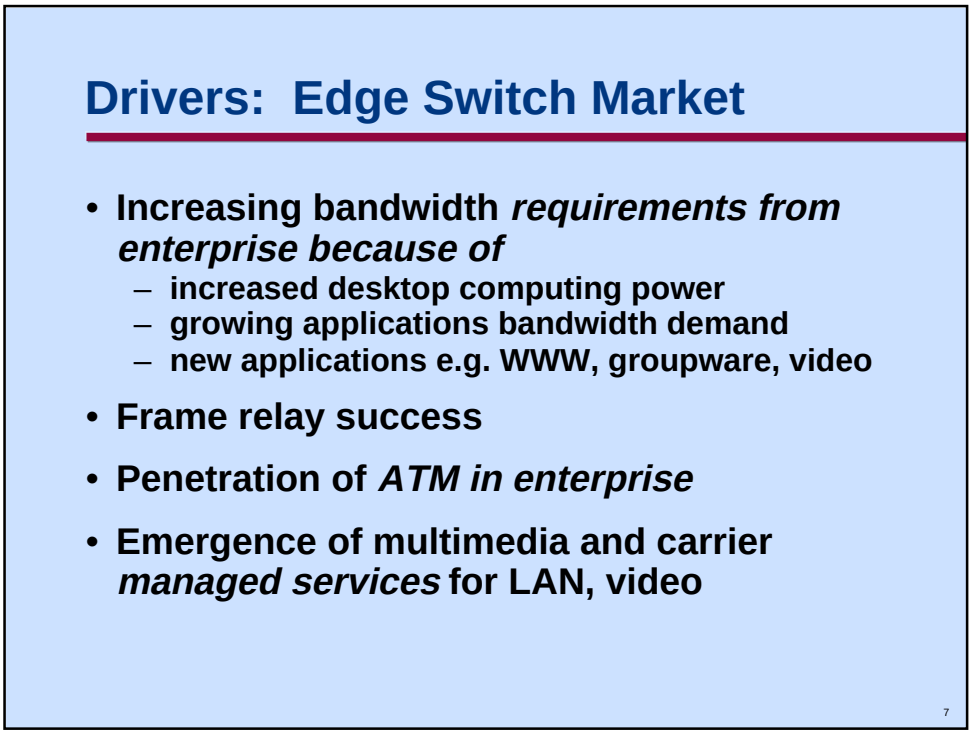


This multi-layered architecture is consistent with Nortel's view of an ATM network comprising concentric layers. Nortel has a portfolio of broadband products which can be configured and scaled to meet the network needs of service providers.

The Magellan Passport is the enterprise switch in the family, accommodating a wide range of service interfaces and providing an ATM cell stream into the network. A wide range of ATM CPE products are also provided by FORE Systems, an alliance partner of Nortel's. The Magellan Vector, based on technology from FORE Systems, provides the edge switch functionality. The Magellan Concorde is the backbone switch in the product portfolio.

The Magellan ATM products are designed to work with each other through common end-to-end routing and signalling mechanisms, consistent ATM traffic management and congestion control schemes, and integrated network management. Each of these network components can also be deployed independently within a service provider's network if other devices are present to provide the complementary functions. This stand-alone capability is facilitated through Nortel's commitment to standards-based products.

The remainder of the presentation is from the perspective of the ATM edge switch.



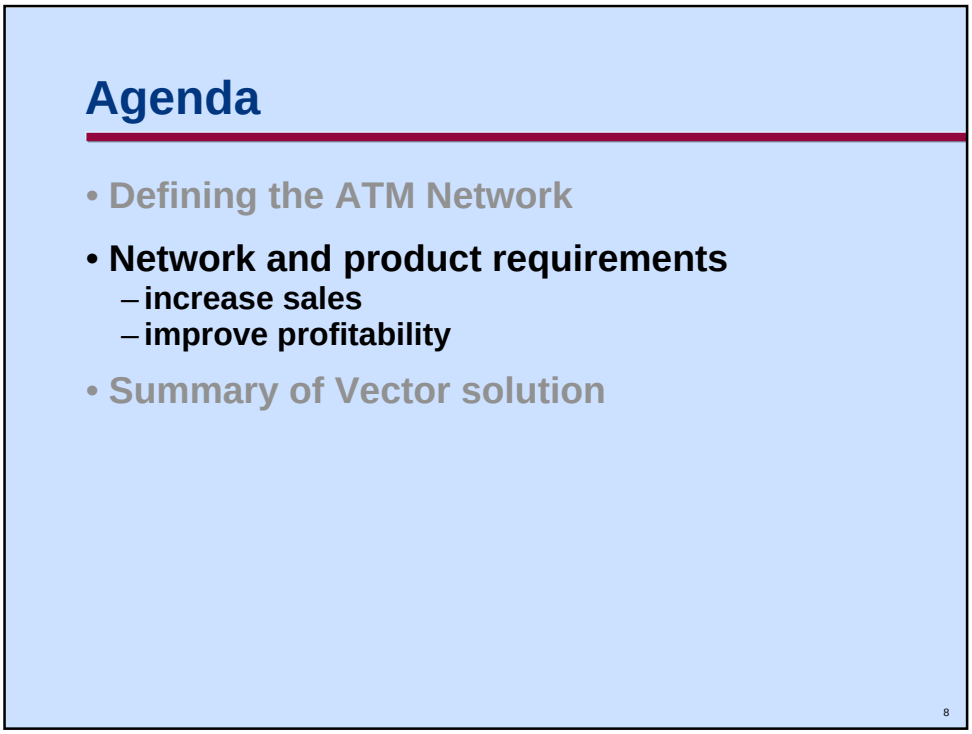
This chart summarizes the key drivers which are creating a need for an ATM edge switch.

The increasing traffic demand originating in the enterprise can be attributed to increasing desktop computing capabilities, ever more intensive applications, and the emergence of new applications such as the Web and groupware such as Lotus Notes which depend on networking for their efficacy.

The success of the frame relay service provides a strong indication of the opportunity that exists for service providers to enhance their offerings for the business data market. While frame relay is cost-effective for connecting networks of more than four or five sites, particularly over long distances, current implementations are PVC-based and the growth is becoming difficult to manage. ATM accommodates larger bandwidths, and is better suited to carrying multiple traffic types.

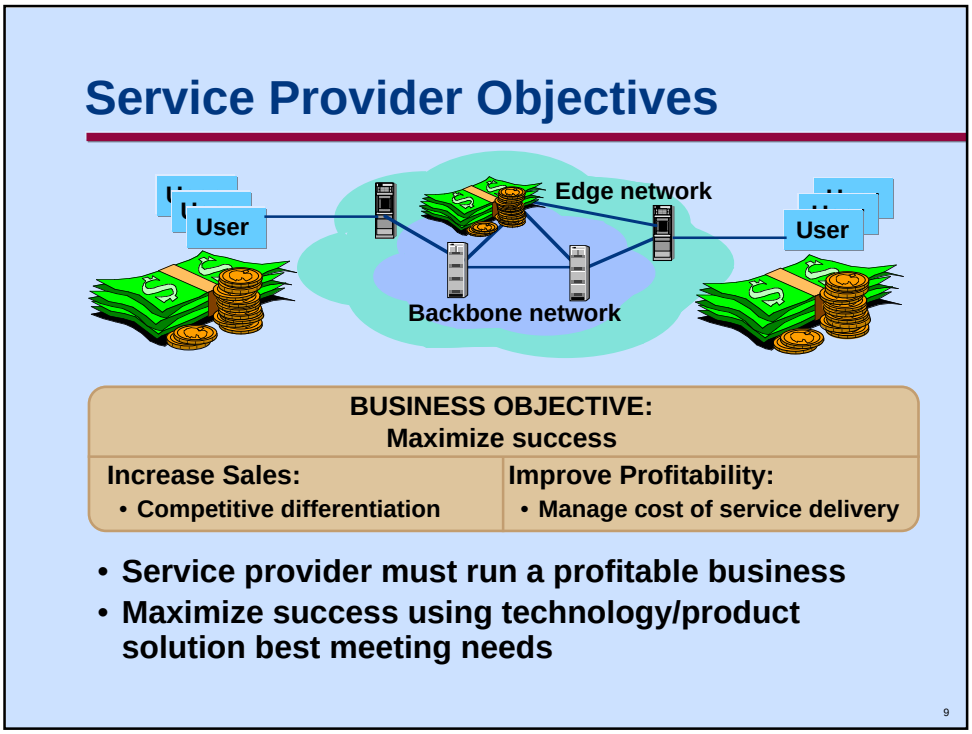
A major source of the demand for public ATM networking capability is originating with enterprise customers who have already deployed ATM internally within larger sites. Indeed, the ATM enterprise market—comprising ATM-to-the-desktop, workgroup switches, enterprise switches, and other ATM-based networking equipment—is currently two to three times larger than the public ATM switch market. It is experiencing growth of about 90% per year, compared with growth of 70% for the public ATM market. The desire to reach out and to link geographically distributed locations across the wide area is creating a demand for publicly provided ATM services. For example, FORE Systems, the market leader in ATM LAN and campus enterprise solutions with more than 70% market share, has deployed networks to more than 1000 customers, many of whom are now creating a pull for wide area ATM services.

From the service provider perspective, an ATM edge switch plays a key role in the deployment of new managed services such as LAN native rate connectivity and video delivery.



Having reviewed the drivers for ATM WAN networking and established a reference ATM network, product and network requirements from an ATM edge switch perspective are considered next.

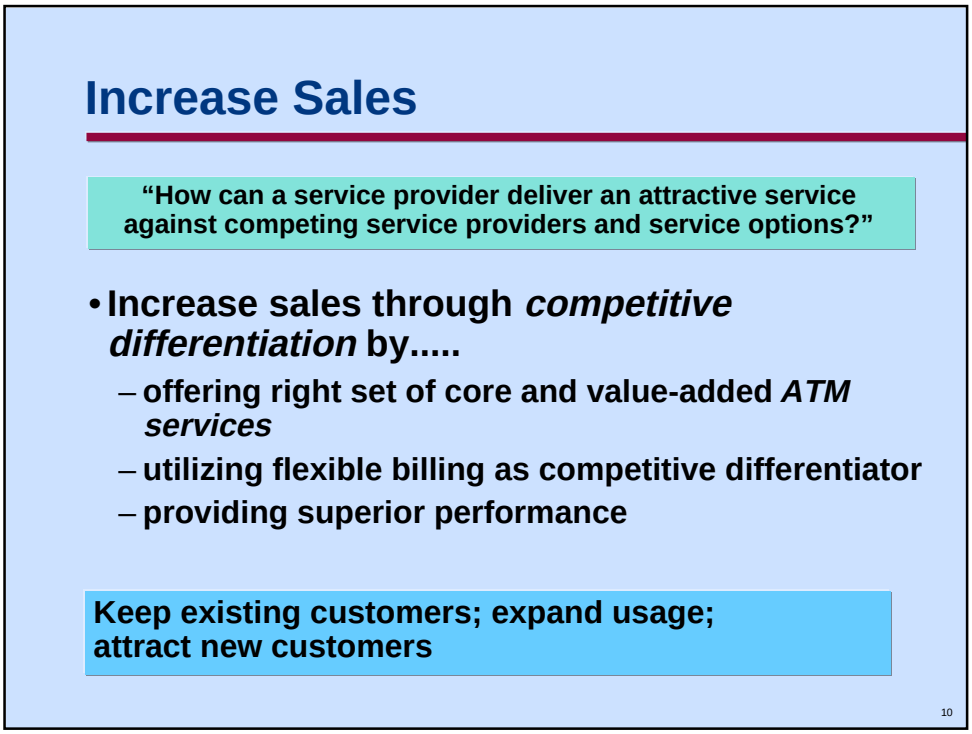
In the following section, the two components of “increase sales” and “improve profitability” of the overall service provider business objective will be covered. Key network and ATM edge switch product requirements will be identified in terms of these two components.



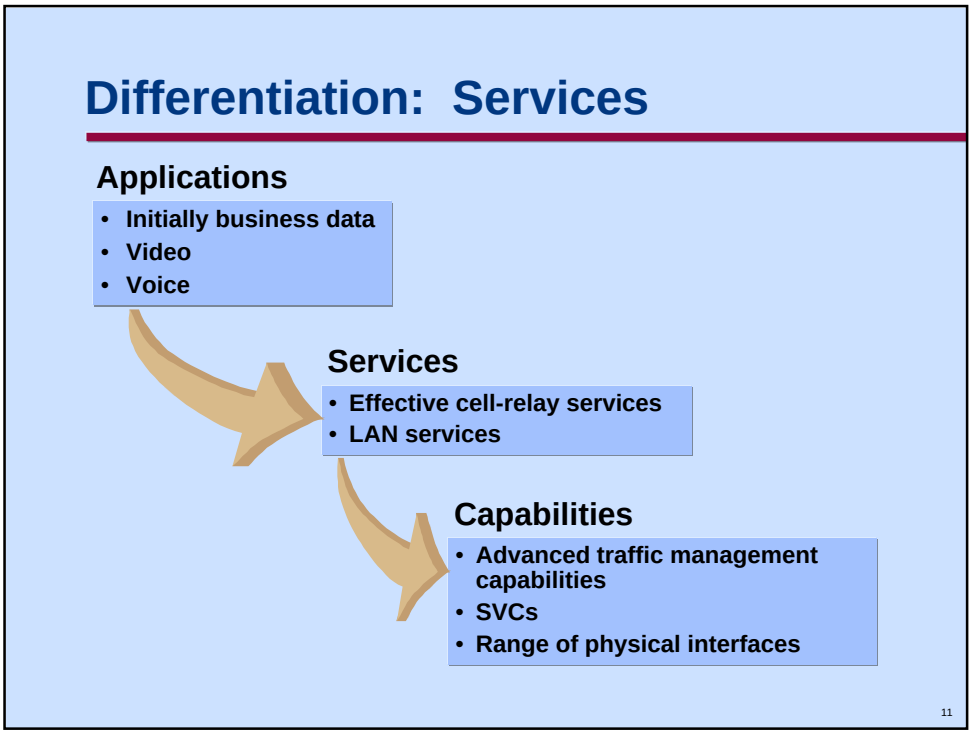
Like any other business entity, a service provider wishes to maximize the success of the corporation. Typically this can be achieved by focusing either on increasing sales by being a highly differentiated player in the market, and/or by focusing on improving profitability by managing the cost of service delivery.

Since the service provider must run a profitable business, it follows that he will select the best technology and product solution that best matches his needs.

Each of the dimensions, “increase sales” and “improve profitability”, can be examined in the context of the ATM network and the edge switch market, to derive a set of product requirements for service provider competitiveness.



A primary means by which a business owner attracts more revenues is by ensuring that his product has some clearly discernible differentiation over competitor offerings. In ATM networking, a service provider could ensure competitive differentiation through the selection of an appropriate mix of ATM services, through the use of flexible and highly capable billing solutions, and by providing superior performance relative to competing service alternatives.

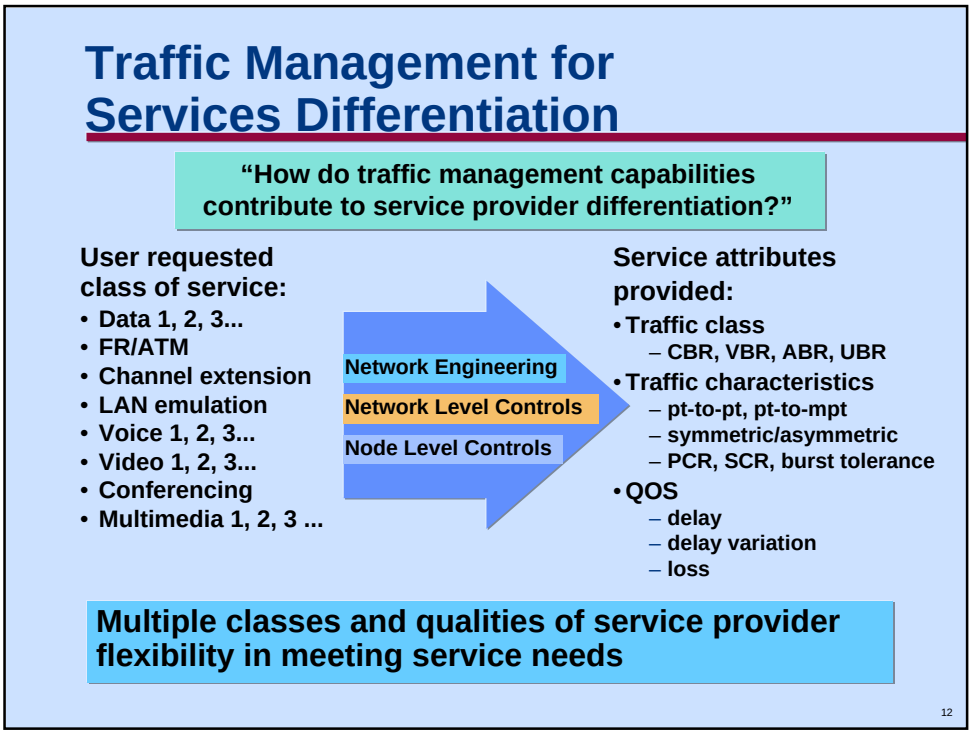


The primary applications being run on today's ATM networks, both in the enterprise and across the wide area, are business data applications. For example, the need to move e-mail over LANs and WANs is growing rapidly, according to data communications managers. Additional growing applications are the World Wide Web, work group and group ware applications such as Lotus Notes, and electronic data interchange (EDI). A common characteristic of these applications is that they are run on frame-based transport and network layers, leading in recent years to the deployment of frame relay in the wide area.

As the frame relay solution is not well suited for bandwidth requirements above T1/E1, ATM-based cell relay services are being increasingly deployed to supplement frame relay access and to provide backbone networking for frame relay. The ATM service provider must therefore ensure that the offered cell relay services are well-suited to accommodate frame-based, bursty business data. In addition to basic cell relay services, the service provider should be prepared to offer LAN services, enabling end users to interconnect their LAN networks and applications seamlessly at native rates across the wide area.

A fundamental set of ATM network capabilities is required to effectively support the business data applications and related services. First and foremost, advanced traffic management capabilities are necessary to ensure that the ATM network can accommodate the volume of business data traffic without adversely impacting the performance realized by ATM network users preferring different traffic classes such as CBR. Since business data can be carried via VBR, UBR and ABR traffic classes, each with their attendant costs and benefits, the service provider must be able to offer all three. Secondly, ATM SVCs are required to provide flexibility in reach and end point connectivity. Finally, a range of physical interfaces must be provided to ensure that end users have a set of options available by which they prefer to connect to the ATM network.

The traffic management and SVC capabilities are further examined in the next two charts.



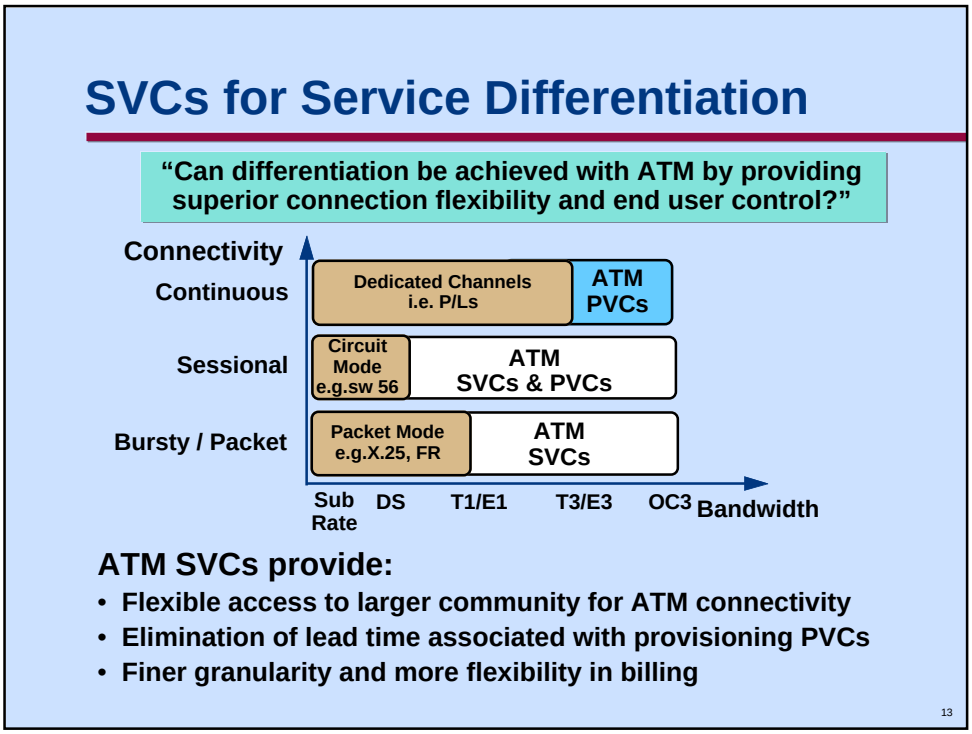
Traffic management is the primary mechanism whereby multiple services can be supported on the ATM network by guaranteeing end-user connection quality while maximizing network utilization. While the end user may request a particular class of service, as shown on the left side of the chart, the network service attributes are specified in the terms shown on the right side of the chart—traffic class; traffic characteristics; and QOS parameters.

Effective traffic management capabilities within the network provide flexibility in supporting a range of known and new applications and service types. Traffic management must function on an end-to-end basis to deliver the required quality of service (QOS) level for a given service type. The QOS is met by ensuring the availability of appropriate bandwidth, loss and delay levels.

Traffic management components include nodal level controls such as connection policing and traffic shaping; network level controls such as connection admission control, routing, and congestion management; and off-line network engineering capabilities. These are all required and utilized to give the user service flexibility. An ATM edge switch must be particularly effective in the area of connection policing to ensure that traffic entering the network is in accordance with the agreed-upon traffic contract.

ATM wide area networking products must incorporate a minimum baseline of traffic management capability, as specified in interface specifications and related standards. Additionally, vendors may incorporate other features and enhancements that build on the basic required functionality to deliver superior services performance.

Magellan Vector implements traffic management features that make it the most advanced ATM switch for carrier grade service. These include: multiple classes of service for multiple traffic types with varying service levels; per-VC queuing to manage each VC's service level individually; large output buffers to accommodate bursty data; dynamic buffer allocation to flexibly allocate buffers to VCs on an as-needed basis; and packet-level discard for maximum goodput under congestion conditions.



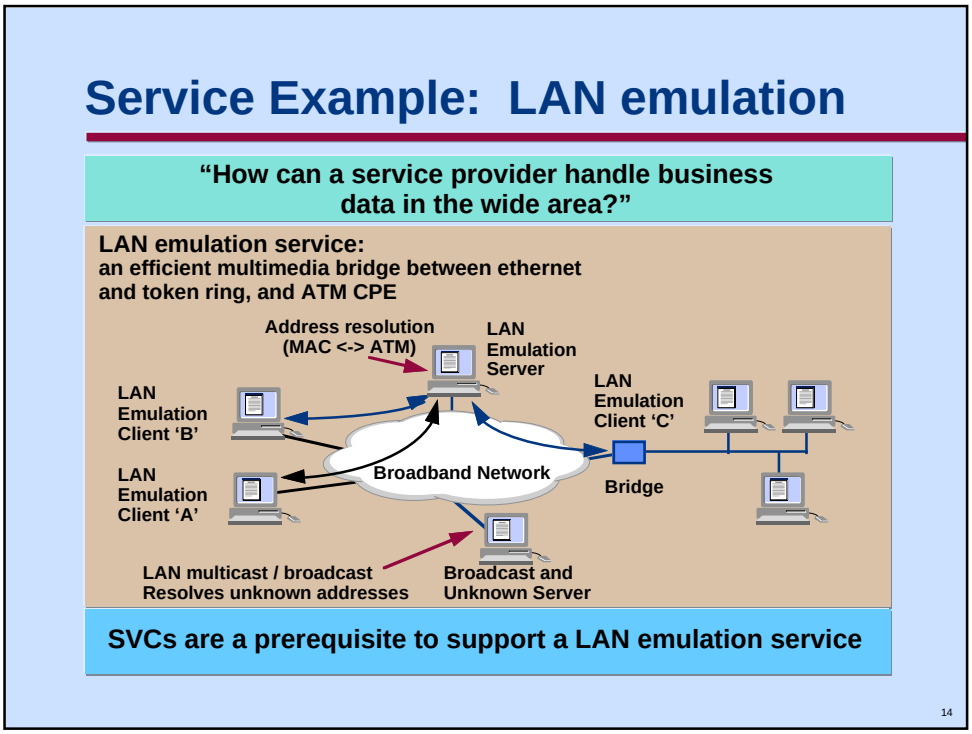
ATM connectivity is achieved through either permanent virtual connections (PVCs) or switched virtual circuits (SVCs). Permanent virtual connections require the service provider to manually configure a connection path between predetermined endpoints in response to a customer request accommodated through a provisioning system. They have greatest utility when continuous connectivity is desired over an extended period of time.

Switched virtual circuits, SVCs, are set up in response to a user-initiated request directly to the network via signalling over the user-to-network interface. Therefore, SVCs are able to provide flexible and on-demand connectivity between any sets of endpoints capable of performing ATM signalling. This on-demand method of setting up, maintaining and clearing ATM connections yields scalability in network reach, flexibility and manageability. SVCs are most appropriate if the traffic is of a bursty nature when higher bandwidths are required, or sessional in nature with a dynamic community of interest.

From the end user's point of view, SVCs provide greater scalability of logical connections and greater flexibility in the utilization of bandwidth on the access facility—thereby lowering costs due to better utilization of physical terminations. The user value increases with the number of SVC-capable endpoints—i.e. ubiquity—both intra- and intercompany.

From the service provider's point of view, SVCs offer more flexible bandwidth utilization and connectivity, allowing greater revenue generation. Furthermore, SVCs provide more flexibility to price ATM service to meet specific market segment requirements—an important differentiator.

Magellan Vector is among the first carrier ATM edge switches to fully support SVCs. Vector also supports smart PVCs (also known as soft PVCs within the industry), a mechanism whereby the network automatically creates the path given the endpoint of the PVC connection. This greatly simplifies the task of provisioning the PVC.



Although ATM-based networking in the enterprise is growing at over 90% per year, the overall size of the ATM enterprise equipment market is currently only a fraction the size of the market for other data networking alternatives such as multiplexers, bridges and routers, modems, etc. Therefore, it is paramount that ATM supports existing networking applications and interfaces. The solution is to define an ATM service—LAN emulation—which emulates services of existing LANs on an ATM network without requiring a change in the ATM or legacy terminal equipment. The emulated LAN provides communication of user data frames among all of its users.

LAN emulation provides for:

- all existing LAN applications to run over ATM;
- the use of ATM as a backbone to interconnect existing legacy LANS;
- the interconnection of ATM-attached servers/workstations to each other and to those on legacy LANS; and
- multiple emulated LANs, which are logically separate, to use the same physical ATM network.

It is important to note that ATM SVCs are a prerequisite to properly provide the LAN emulation service due to the very dynamic nature in which connections are set up between LAN emulation service components and the LAN emulation clients.

Providing a LAN emulation service represents a service opportunity for service providers. Vendors are providing the LAN emulation service components (LAN emulation configuration server, LAN emulation server, and broadcast/unknown server) in the market today, including Nortel's partner, enterprise ATM LAN and campus market leader FORE Systems.

Vector, in conjunction with FORE Systems, provides a best-in-class solution for LAN emulation. FORE Systems products provide the LAN emulation service components (e.g. LAN emulation Server, broadcast and unknown server), while Vector provides the network connectivity through its support of SVCs.

Differentiation: Billing

"What options does a service provider have for billing customers for the services provided?"

Billable attributes:

- **Connection call/connection set-up parameters**
- **Connection usage parameters**
- **Connection quality of service parameters**
- **Connection distance**
- **Service options e.g. LAN emulation; per videoconference**

Flexible billing capability enables:

- **Differentiated ATM service pricing**
- **Customer-specific usage reports**

15

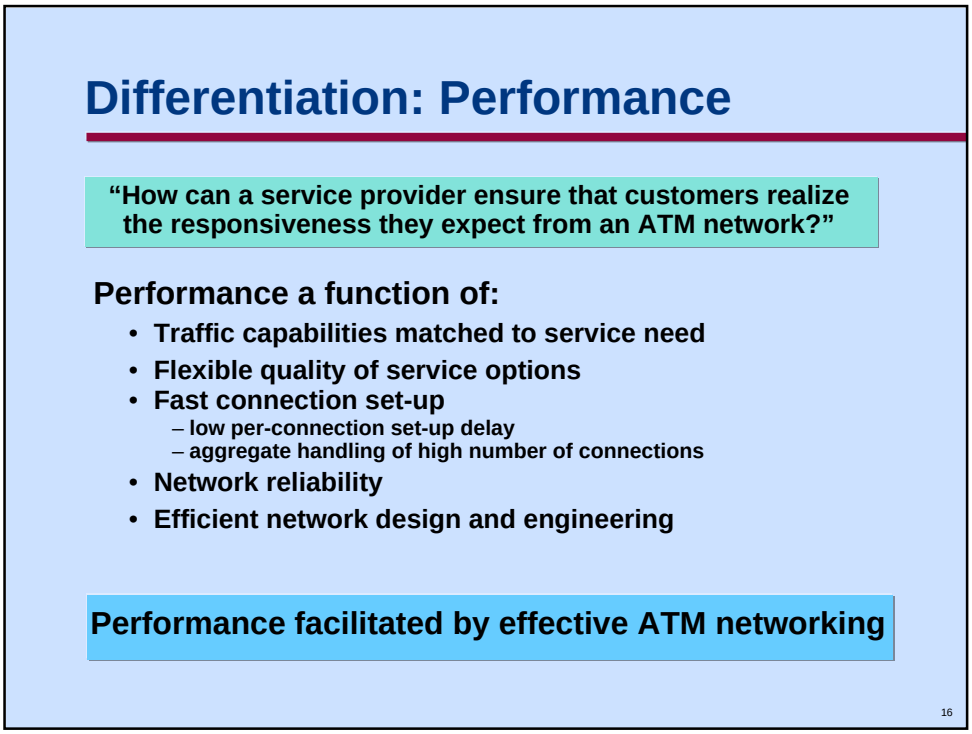
Pricing was used successfully with frame relay services to create service provider differentiation. ATM introduces new attributes that can be used for billing. Clearly, increased billing flexibility provides a service provider with an enhanced ability to differentiate his ATM services through pricing.

The ATM billing system must support the service provider's competitive positioning, taking into consideration the end-user needs and expectations, the service provider market positioning, pricing strategy, and service positioning. The ATM network must be able to provide the necessary information to perform the billing function. There are many options and approaches:

- Requested per connection call/connection set-up parameters e.g. cell delay, cell delay variation, cell loss rate, peak cell rate, connection type (asymmetric, symmetric, point to multipoint), etc. These could be used to determine the applicable rate against which the call or connection will be charged
- Per connection usage parameters—e.g. cells transmitted (per direction), and start/stop time for SVCs. These could be used to determine the actual usage for each call.
- Per connection QOS parameters—e.g. cells received or cells dropped. These could be used to determine the performance of the connection, for example to ensure that it met the requested QOS or to establish whether a discount should be applied because the QOS was not met.
- Connection distance—a more traditional attribute used for determining service pricing.
- Value-added service aspects e.g. service session usage charges such as per transaction/service; different guarantees on delivery and delay such as "premium services" (with a premium price) versus "best effort" (at discount rates)

Some users want a flat rate monthly bill, while others prefer a usage-based approach. A third option would be a capped monthly bill with usage-based benefits. Flexible billing solutions let the service provider decide what these answers should be.

Vector provides a powerful billing system which facilitates the detailed tracking of these parameters for post processing to generate a customer bill. With Vector, the service provider is able to offer innovative pricing structures and be assured of being able to collect the required billing information.



The service provider objective of increasing sales by providing competitive differentiation through traffic management capabilities, SVCs, and billing, has been reviewed. Another approach to achieve competitive differentiation is to provide superior performance.

Performance entails aspects of the foregoing discussion on traffic management and SVCs, looking specifically from the performance perspective.

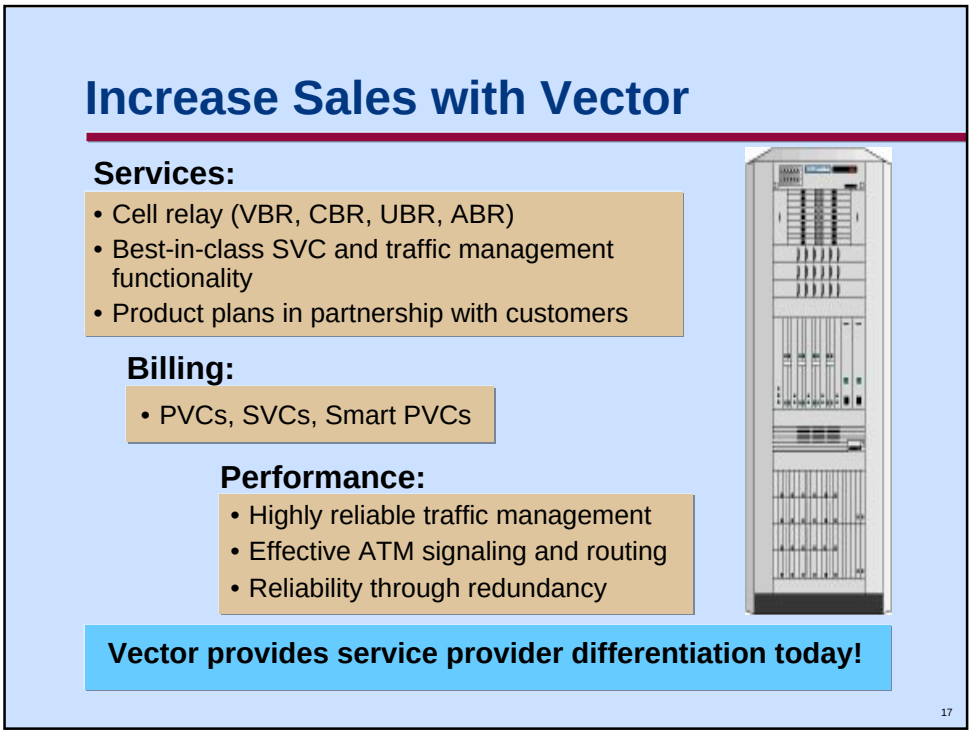
Clearly, performance is maximized if the traffic capabilities provided within the network are well matched to the service need. This is enhanced by having flexible quality of service options, to accommodate a diversity of service needs.

Nor is it enough simply to support SVCs. The rate at which new calls can be accepted into the network, and the end-to-end delay experienced in setting up the new connection, tremendously impact the end-user perception of network performance.

Performance differentiation on the basis of network reliability is also an option. Many end users place high value on service availability, and are willing to pay a premium for this. The network solution must therefore provide reliability through redundancy at the network and nodal level.

Perhaps less visible to the end user, but of very high value to the service provider, is the existence of tools and utilities to assist in the network design and engineering function ensuring that the network is designed to perform at a high level of responsiveness.

Effective ATM networking—the traffic management, routing and signalling functions that enable the setup and maintenance of a virtual connection—results in high end-user performance.



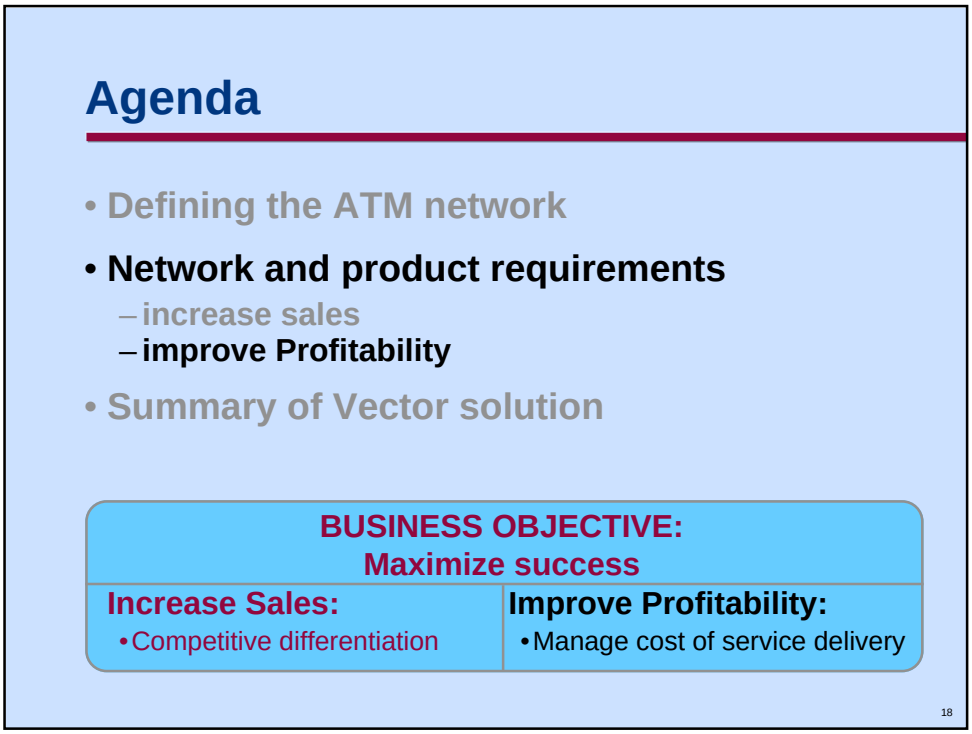
Magellan Vector is available today with functions and capabilities that enable the ATM service provider to grow revenues through competitive differentiation.

Vector has best-in-class traffic management capabilities for flexible services support (VBR, CBR, UBR and EFCI ABR today), through the adoption of the technology from Nortel's partner FORE Systems. FORE System's capabilities in the area of traffic performance, and therefore Vector's, are second to none, as reported in the March 1995 issue of *Data Communications* magazine. Also from FORE Systems is the mature SVC capability (both an early proprietary but highly effective implementation, and the ATM Forum UNI 3.0 compliant implementation). The best-in-class heritage of Vector was also recognized in the September 25 issue of *Communications Week* magazine.

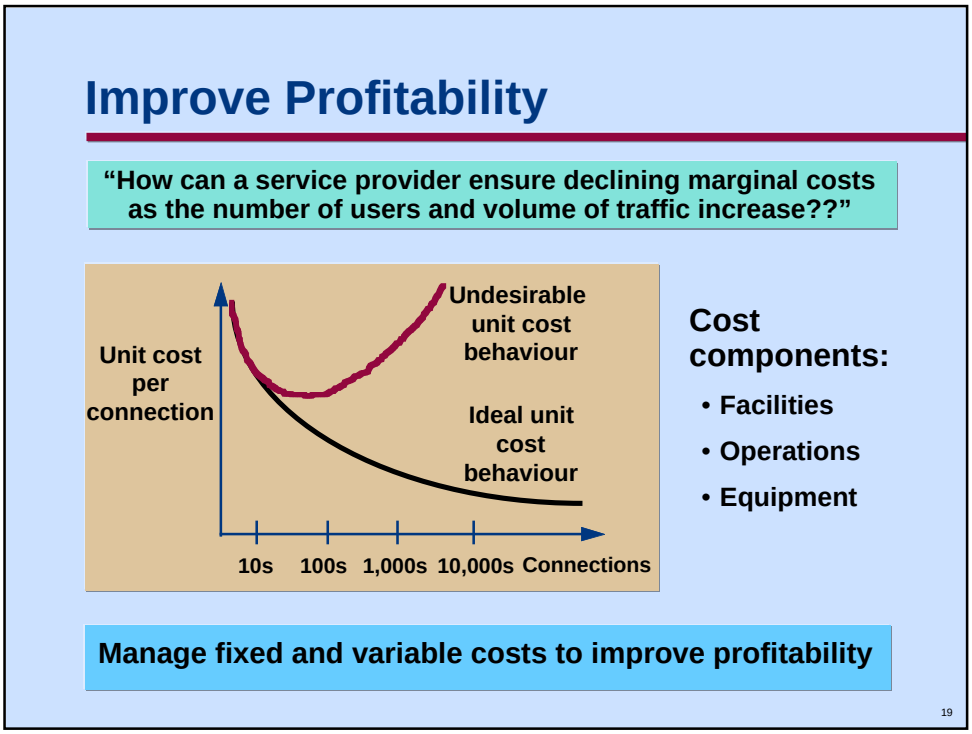
Vector value-added features such as SVC address screening are provided to support even greater service provider differentiability in the area of ATM services. Furthermore, new capabilities are planned such as ABR explicit rate support, as well as new services interfaces such as circuit emulation and frame UNI. Vector features are being developed in consultation with lead customers to ensure that the services and capabilities available on the switch are appropriate to the market's need.

Vector provides an extensive billing capability which collects a large set of accounting information and forwards this to a billing server every five minutes for correlation with records from other switches in the network. The output can be used by the service provider operations support systems (OSS) or specific billing system to generate customer bills.

Vector can assist the service provider in excelling in the area of performance. The routing system ensures efficient route selection for minimal end-to-end set-up delays, while the switch is designed to handle up to 100 connection set-up requests per second. In addition to reliability achieved through networking (e.g. alternate routes), reliability is being provided through transparent redundancy of the switch fabric. All common equipment is also redundant, and within another year, redundant port interfaces will also be available.



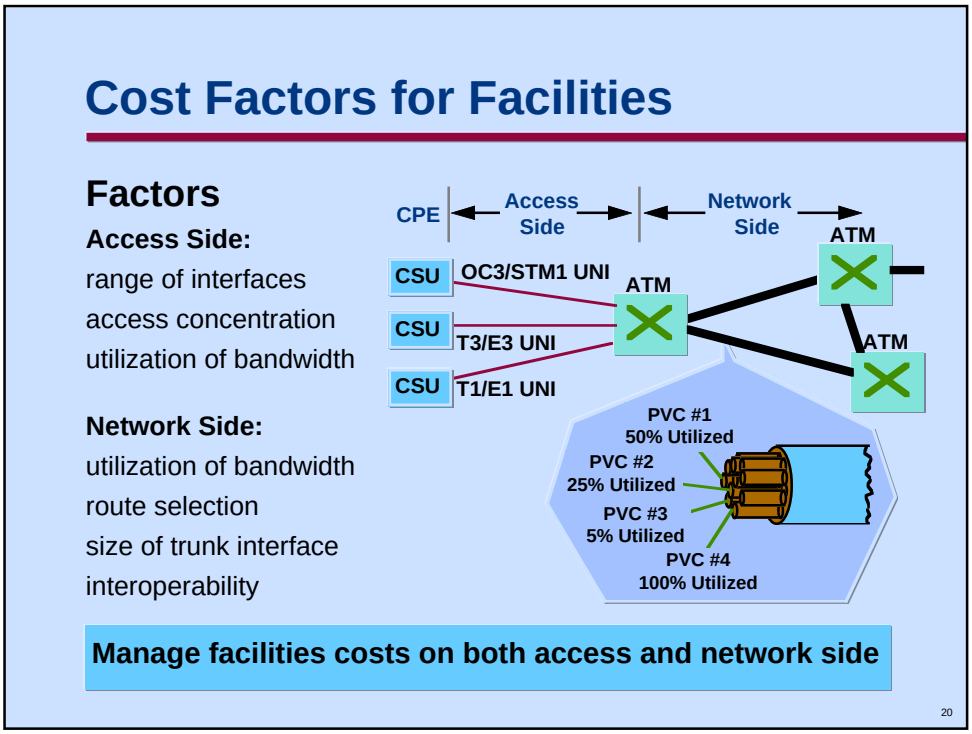
The second dimension to ensuring that a service provider can achieve the overall objective of maximizing success is to improve profitability. One of the primary means of accomplishing this is to carefully manage the cost of delivering the service.



A fundamental cost objective of the service provider should be to realize declining marginal costs as the number of users grows and the volume of traffic increases. There are three major dimensions to cost for telecommunications service providers:

- Facilities: deploying or leasing fiber and associated facilities to interconnect switching equipment
- Operations: managing and running the network
- Equipment: the capital equipment required to provide broadband switching and associated services functionality

Some studies have shown that over a five year study period for a network, equipment costs account for approximately 20% of the overall lifecycle cost while operations (including installation) and facilities account for approximately 45% and 35% respectively.



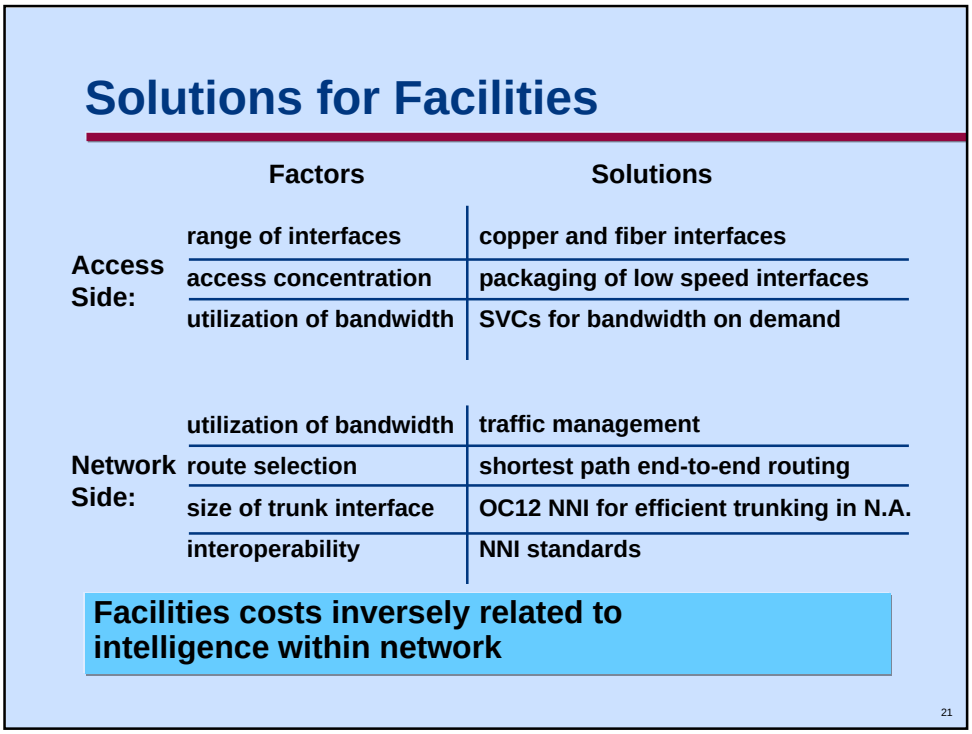
Facilities encompass both the access side and the network side. On the access side, the ATM traffic must be carried from the customer's premises back to the ATM edge switch, which may not necessarily be located in the serving wire center closest to the end user's premises. As there are basic fixed costs associated with providing the facility to the end user, it is important to manage the variable costs carefully to ensure the ability to provide an attractively priced service overall.

One cost-impacting factor on the access side is the type of facility provided. Fiber is expensive to deploy and manage, and may not be available everywhere. However, copper may not provide the bandwidth needed for other end users.

Another cost-impacting factor on the access side is the access concentration, as it is important to ensure that the switch does not become port limited if there is a high requirement for lower speed interfaces.

The service provider will also wish to ensure that the bandwidth on the end-user access facility is effectively utilized. PVCs may be appropriate for initial service availability while end users are retaining a high level of control of the allowable connectivity. However, as more PVCs become provisioned and bandwidth is allocated, the allocated bandwidth may approach the capacity of the facility, although not all PVCs are necessarily active to the reserved level at a given point in time.

Effective utilization of bandwidth similarly contributes to facilities costs on the network side. Another important factor impacting the cost of facilities on the network side is the method by which routes are selected. Inefficient route selection can contribute substantially to underutilized facilities. The size of the trunk interfaces can also impact the facilities costs, as it may be less efficient to deploy multiple lower speed trunk interfaces than to deploy a smaller number of higher speed trunk interfaces.

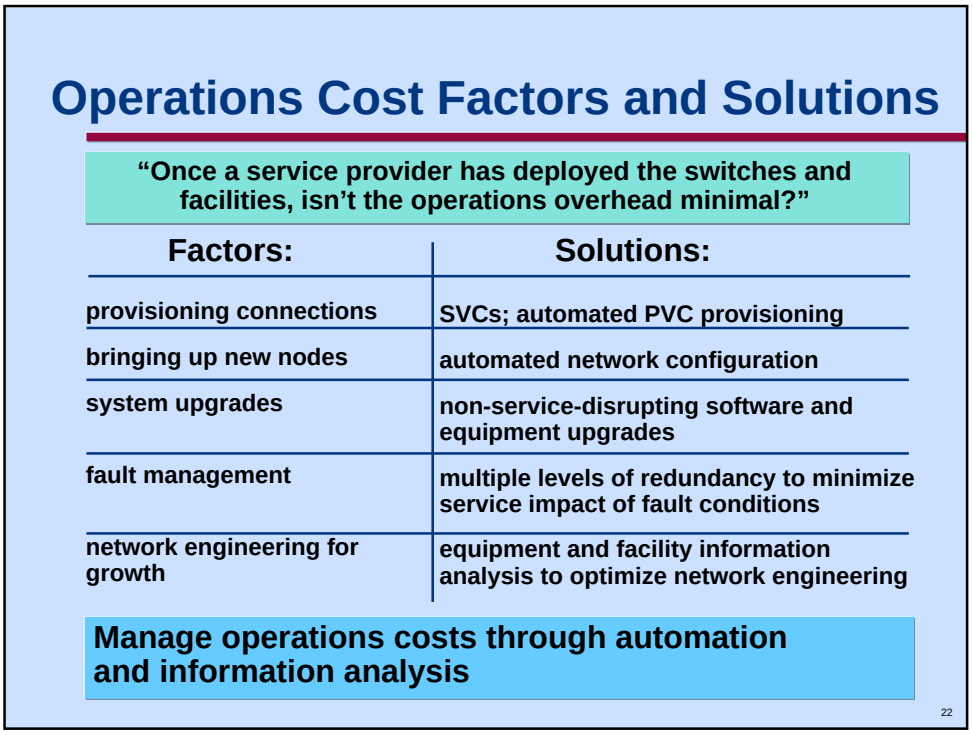


The service provider must offer a range of access interfaces from low speed T1/E1 ATM on copper to OC3/ STM1 ATM on fiber. Access concentration must be provided to ensure high utilization of the switching capacity of the edge switch, especially for a larger proportion of lower speed ports. The bandwidth-on-demand capability of SVCs provides efficient bandwidth allocation at the access. SVCs therefore become not only an important services-impacting differentiator, but also a powerful mechanism helping to control costs on the access side. Additionally, the ABR traffic class enhances the dynamic allocation and utilization of bandwidth by providing feedback to the CPE traffic sources to reduce or increase traffic depending on the congestion state of the network.

On the network side, sophisticated traffic management capabilities are fundamental to ensure that connection traffic is policed, network resources are fairly consumed on the basis of quality of service, and actions are taken when impending congestion is detected. End-to-end intelligent shortest path routing ensures that connections are assigned a least cost route which optimizes the use of facilities between network nodes. In addition to OC3/STM1-based trunking for smaller edge switch installations, an OC12/ STM4 NNI should be provided for cost-effective and efficient trunking of ATM traffic from the edge switch to backbone switches. Studies have demonstrated that larger trunks provide greater statistical gain. For example, an OC12 trunk will result in higher efficiencies than an OC3 trunk for the same mix and volume of input traffic (VBR and CBR).

Since control mechanisms such as traffic management, routing and signalling for SVCs are all aspects of intelligence within the network, increasing levels of sophistication in these mechanisms have an increasingly favorable effect on the ability of the service provider to manage facilities costs.

Vector provides interfaces from T1/E1 ATM through to OC3/STM1, with OC12/STM4 also available today. Concentration of interfaces is competitive at up to six ports per interface card, with plans to expand the T1/E1 fan-in by orders of magnitude in the late 1997 timeframe. An early form of ABR (EFCI) is supported today, with plans to support standards-compliant ABR as the specifications are finalized.



A successful broadband network is not likely to be a static entity—designed and deployed, and thereafter effectively running itself. Change is constant at every level under normal operating circumstances. Efficient network operations is critical for service provider profitability; otherwise, revenues will quickly be consumed in services rebates and in operations personnel salaries.

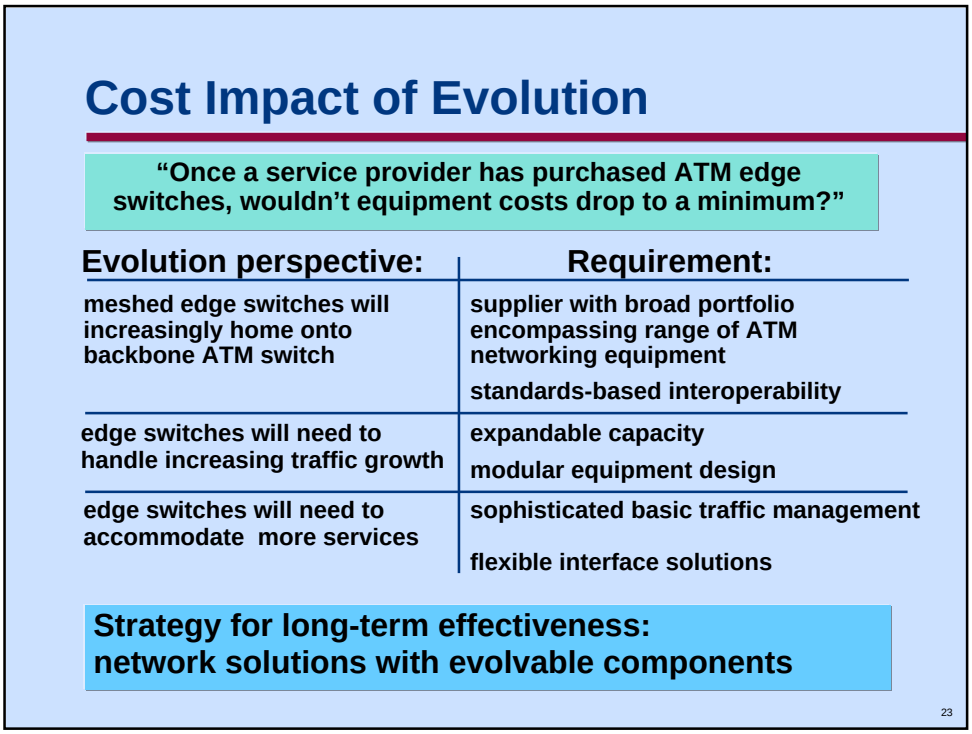
Equipment providers can offer capabilities that simplify operations solutions. SVCs—a recurring theme—impact the cost of provisioning connections by eliminating operator intervention in setting up a new connection. The same network procedures for setting up an SVC connection (signalling and routing) can also be applied to automate PVC provisioning through "smart PVCs" (SPVCs).

Automated network configuration provides the ability for the network to automatically discover new network nodes, and to intelligently incorporate this information into subsequent routing decisions. Service providers will wish to ensure that equipment can be upgraded (software and hardware) without disrupting service, to minimize the lost revenues that might otherwise be associated with scheduled downtime.

Both at the nodal and at the network level, redundancy is required to minimize the services impact of various types of faults. Examples might be the ability to automatically reroute connections around failed facilities, the ability to switch all traffic from one switch plane to another, and the ability to protect individual interfaces. Costs can be directly impacted in the area of non-real-time operations by using information on switch resource and network facility utilization in planning the evolution of the network.

Efficient operations functionality within the ATM edge switch contributes to managing costs by automating data flows and processes wherever possible.

Vector provides automated network configuration, non-service-disrupting upgrades, and redundancy to minimize the impact of faults, as well as fault management capability. Vector also has an extensive performance monitoring capability to assist in the network engineering task.



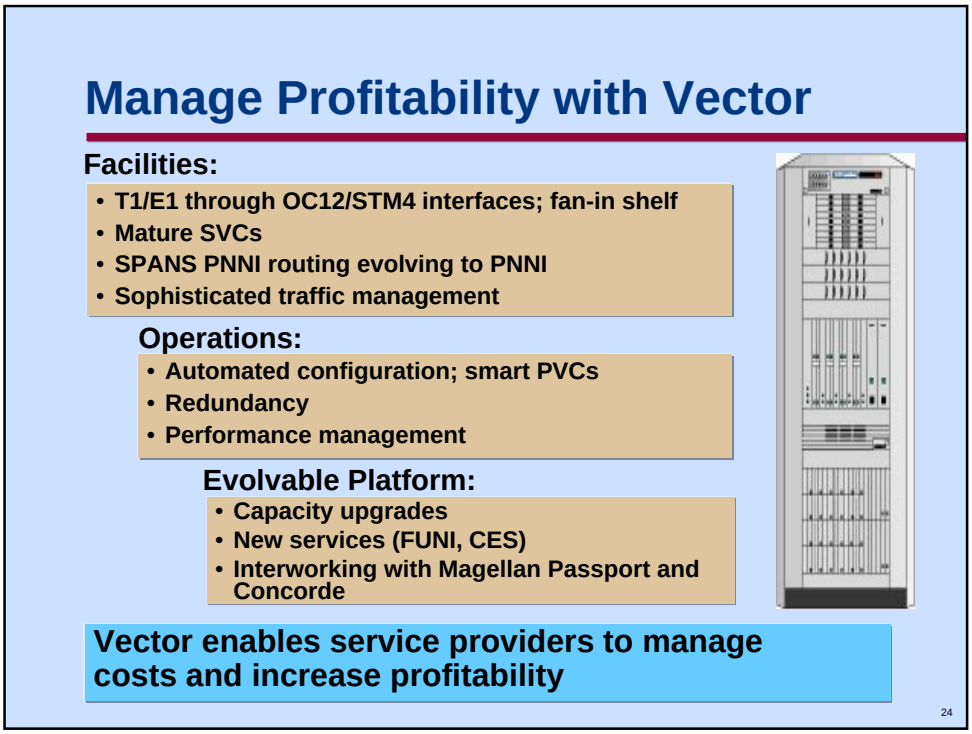
As the broadband network grows, it is desirable to invest in equipment as the demand is realized. At the same time, the service provider does not wish to have to replace components of the network every 18 to 24 months as the technology matures.

The growth of access, in the edge network, should be decoupled from the growth in the backbone to provide flexibility in scaling each independently. Solutions for both access and backbone equipment will be needed, and a single supplier with a broad portfolio would be in a good position to ensure that end-to-end networking can be accomplished through common traffic management and control (routing and signalling) mechanisms. Standards-based interoperability on the edge switch is a requirement to ensure interoperability between the edge switch and edge or backbone equipment provided by another vendor, as well as between networks operated by different service providers.

Edge switches will need to handle increasing traffic. This requires an ability to add switching capacity in a modular fashion, as well as additional interface modules with increasing densities of ports per module. Appropriately sized trunk interfaces are also required in a timely fashion to efficiently move the increased traffic into the backbone network for switching as the communities of interest become larger.

As the broadband network matures, more services will be defined which need to be accommodated on the edge switches. This will be much easier to accommodate on existing edge switches if the underlying traffic management capabilities are sophisticated enough to support new service definitions, and if the design of the interfaces is done in a modular way independent of the core switch architecture.

To ensure maximum long term benefit from capital equipment investments therefore, service providers should be looking for modular, evolvable edge switch solutions with core networking capabilities that will support both the increase in traffic and future services.

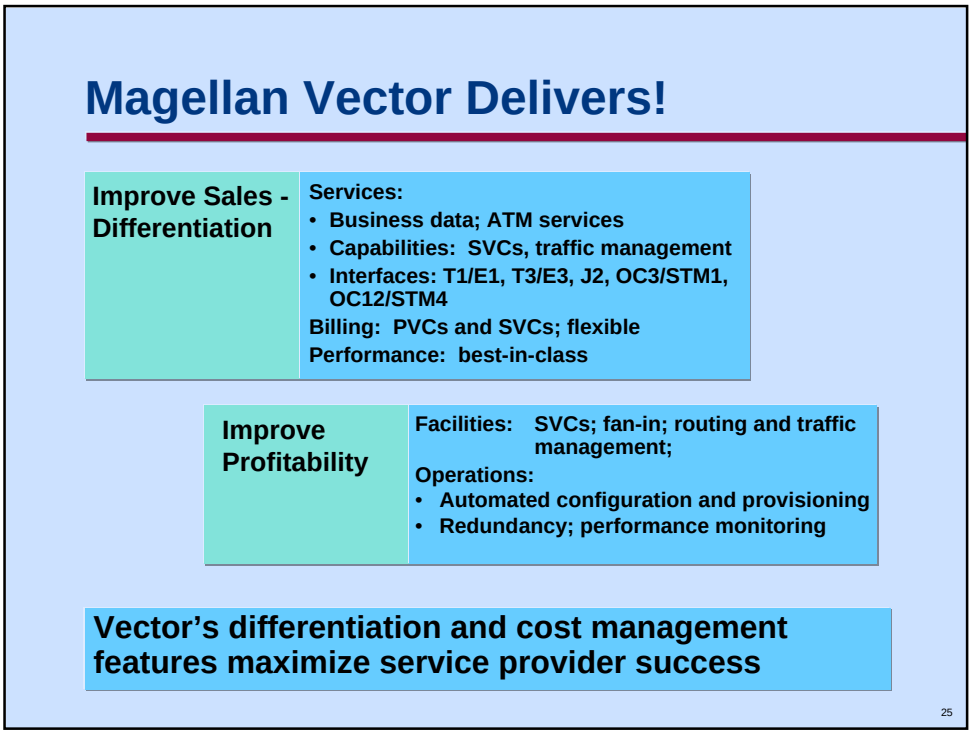


Nortel's Magellan Vector is designed to enable service providers to manage costs. The highest priority was placed on Vector providing a substantial level of redundancy. Redundant power supplies and fans were provided on Vector from the outset, with an imminent release (available in August of this year) providing redundant processors and switch fabrics. Electrical port redundancy will be available in early 1997, with optical port redundancy soon thereafter.

SVCs and highly sophisticated traffic management have been the hallmarks of Vector since its initial availability. The ability to automatically have the network identify the presence of new nodes is another feature that has been available since "day one".

The ability to collect performance management information will be generally available in June. Data from the switch and port level ranging from queue occupancy levels to transmission errors will be transferred from the switch to a Magellan Data Provider workstation (MDP) at five minute intervals, for correlation and aggregation and subsequent handoff to an operations or postprocessing system.

The Vector platform is evolvable—with current capacity options of 2.5 Gbit/s and 5.0 Gbit/s in a redundant configuration, and possibly future versions of up to 10 Gbit/s (simplex and redundant). Since Vector is a member of the Magellan broadband product family, it provides optimized interworking with both the Magellan Passport enterprise switch and the Magellan Concorde backbone switch. This will be facilitated by the common adoption of *ForeThought* networking software across all three platforms.



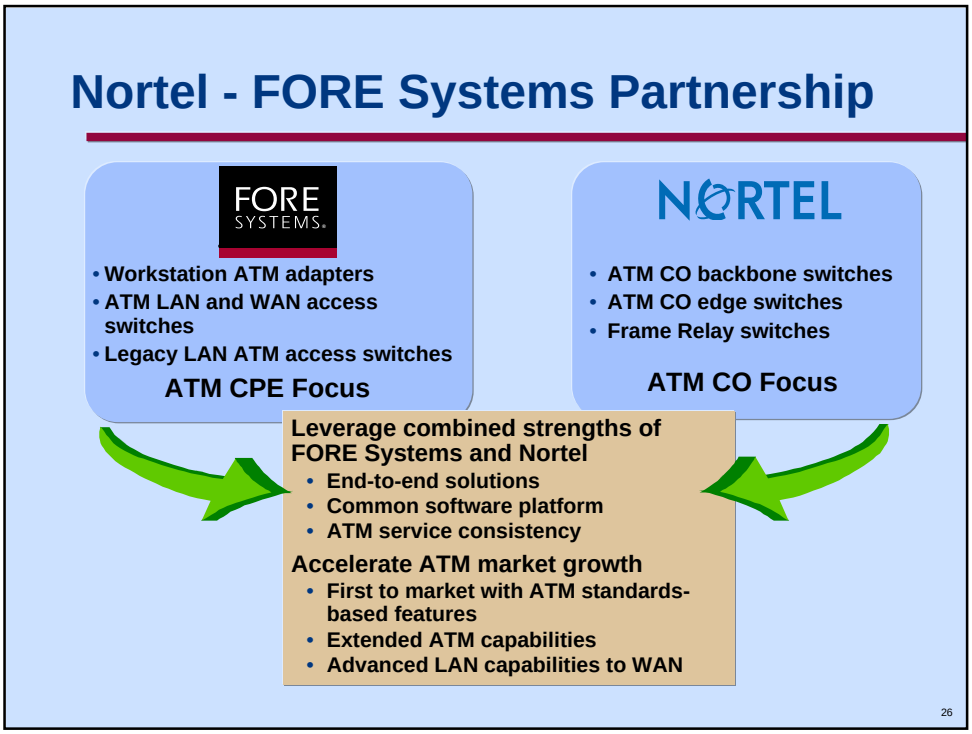
To summarize:

Magellan Vector is the product of an alliance between Nortel and FORE Systems. Building on this foundation, Vector provides service providers with the ability to improve sales via differentiation, and to improve profitability by managing costs—today.

Vector's SVC and traffic management capabilities are second to none, and are highly effective in creating flexible network solutions. The redundancy features added by Nortel clearly propel the Vector switch into the service provider league by ensuring that the network will meet the stringent availability expectations of service providers and their customers. The billing and performance monitoring capability being added by Nortel add an important new dimension to the basic ATM edge switch definition, and will be a strong differentiator for Vector and the service providers who choose to build their network using Vector.

To ensure that service providers can deploy end-to-end services using Vector in a multi-vendor environment, Nortel is committed to continuing to ensure Vector's compliance with ATM Forum specifications, as these are finalized.

The Nortel partnership with FORE Systems further maximizes service provider probability of success by providing unparalleled interoperability with the installed base of ATM CPE, and by providing the assurance of solid, proven technology.



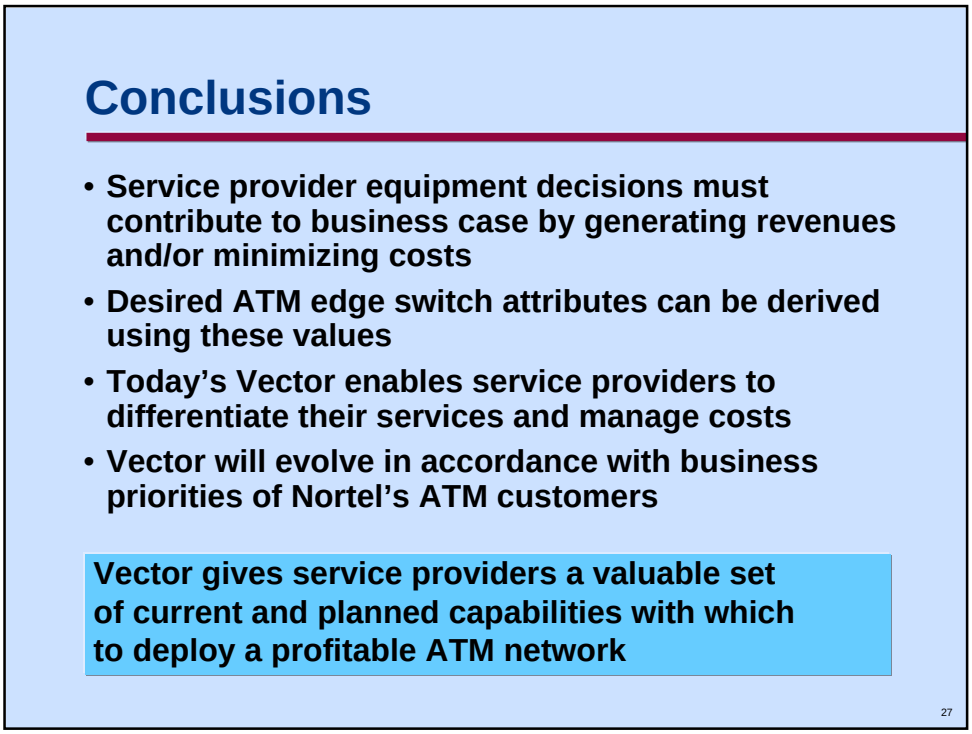
The alliance between Nortel and FORE Systems has been mentioned several times throughout this package. This chart summarizes the key strengths of Nortel and FORE Systems respectively, and describes the common objectives for the partnership.

FORE Systems is the leader in enterprise ATM LAN and campus products with 70% market share worldwide in enterprise ATM switches, and an even higher share with ATM adapters. FORE Systems is the industry ATM technology leader, as demonstrated through its comprehensive and successful ATM product line.

Nortel is a world leader in networking technology, with over 180 Magellan networks deployed worldwide. Nortel has the benefit of extensive R & D capabilities and a global carrier customer base.

Nortel in association with FORE Systems has the ability to offer service solutions to service providers out to the desktop, comprised of Magellan products in the central office and FORE LAN components on the premises. Because all components are built from common technology, seamless operation is assured.

Together, Nortel and FORE Systems are committed to promoting ATM solutions and stimulating ATM market growth by continuing to be be first to market with both ATM standards-based and value-added features and by ensuring that advanced LAN capabilities are extended into the WAN.



In conclusion, the service provider decision of which ATM edge switch vendor to invest in, must be made in the context of the service provider business case and the ability of the product to provide competitive differentiation and to manage costs. These two dimensions can be analyzed to derive the set of ATM edge switch attributes.

The Magellan Vector is Nortel's response to global ATM edge switch requirements. Developed in partnership with FORE Systems, Vector is available today to support differentiated ATM service offerings and manage networking costs. As Vector evolves in partnership with Nortel customers, their business concerns are being taken into consideration in prioritizing the feature rollout on Vector.

With its superior traffic management capabilities, mature SVCs, open network management, solid billing and performance monitoring capabilities, and standards commitment, Vector provides service providers with the right feature set with which to deploy a profitable ATM network.