This presentation focuses on Passport's role as an adaptation device which covers multimedia and legacy applications to ATM. The current and future Passport ATM capabilities are described and the value of moving to ATM is assessed. This workshop is of particular interest to product and marketing managers, as well as to service and network planners who are either implementing or considering the implementation of an ATM network.

About the presenter:

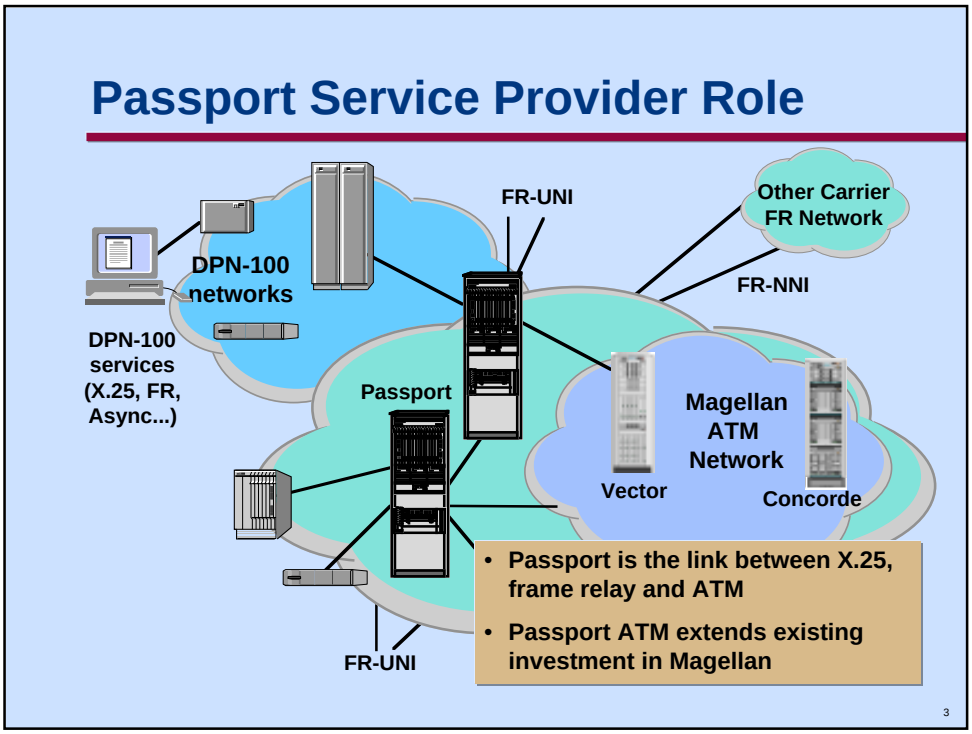
David Smith graduated from the University of Waterloo with a Masters degree in Electrical Engineering in 1985. As a co-op student in the early 1980's David worked on the development of X.25 PADs at Gandalf. After graduation, he worked on semiconductor optoelectronics and imaging systems, prior to joining Nortel in 1987. At Nortel, he has been part of the R&D, network planning, and product management groups. Since 1991, David has been focusing on ATM technology and ATM product planning. In 1994, he joined the Passport Product Management team with responsibility for introduction of Passport ATM.

This presentation is divided into four major sections. The first section describes the existing Passport ATM capabilities which are now generally available and in live deployment globally. Secondly, the presentation will address the evolving ATM capabilities on Passport. This includes those additional capabilities which will be available on Passport over the next 12-18 months.

The third major section is a description of the Passport ATM technology, explaining the technology which enables the full support of multimedia services over ATM.

Finally, the summary will highlight the benefits which Passport can provide for your business operations.

The next three charts will present an overview of Passport's role in the network, and the way that Passport's ATM capability affects that role.



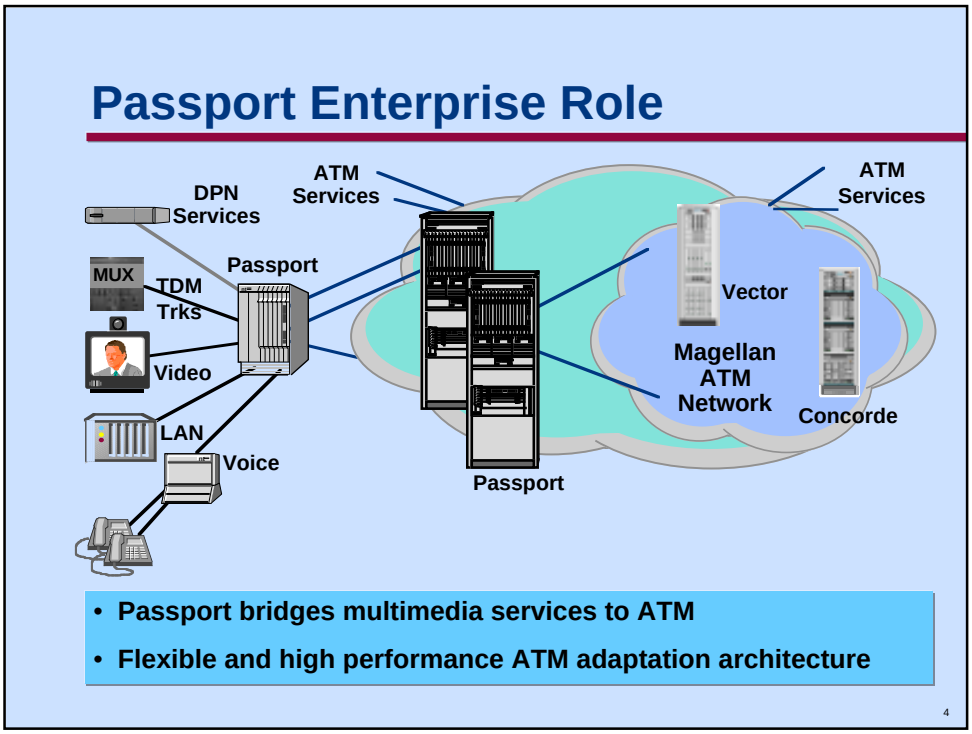
Magellan Passport is Nortel's multi-service ATM switching platform providing backbone capacity support for DPN-100 networks as well as higher capacity and fanout frame relay (FR) services. In this role, Passport ATM bridges legacy technology and ATM services, providing the following benefits:

1) Magellan DPN-100 networks can enjoy the benefits of an emerging ATM network as well as smooth and consistent DPN-100 services across a Passport frame/cell or ATM backbone.

2) FR services deployed on DPN-100 and Passport platforms interwork smoothly, thereby preserving and extending existing investments. FR Services on DPN-100 can also interwork with ATM services on Passport, enabling FR to ATM service interworking between the two switches.

3) With Passport today, a network can support high-speed, high capacity and high fanout FR and ATM services. In cases where ATM evolution is planned for the future, Passport provides an ATM ready vehicle which can be extended at any time for network evolution.

5) As Magellan Vector and Concorde are deployed in backbone ATM networks to provide high capacity ATM networking, Passport provides the adaptation of the legacy services to ATM.

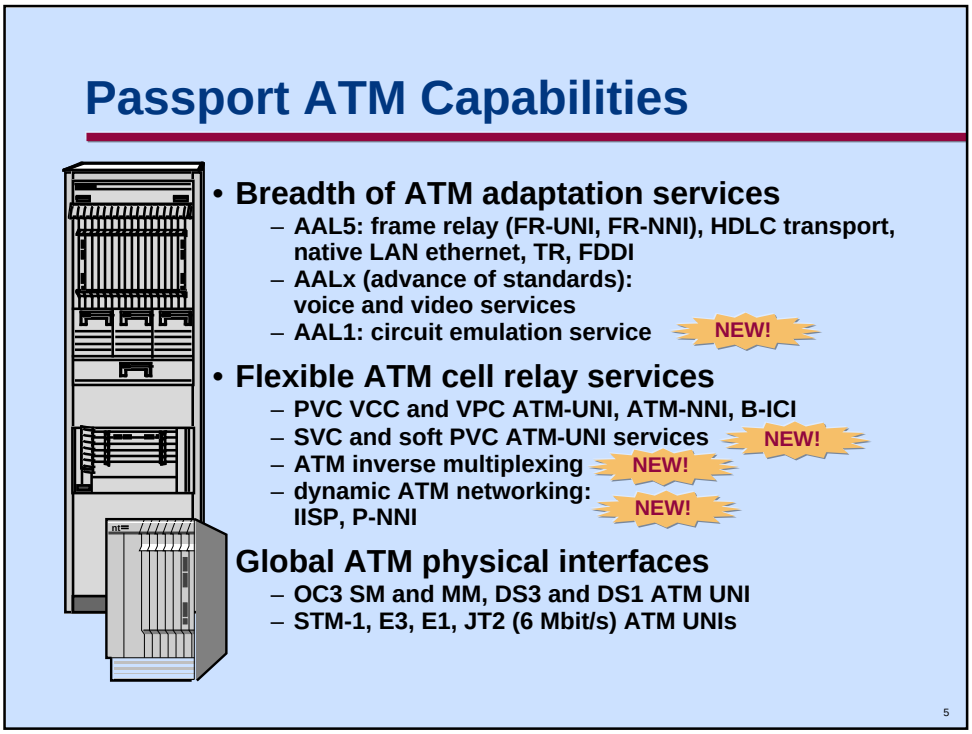


In the enterprise network role, Passport is a platform which provides:

- Network consolidation of many services onto a single network interface
- High reliability, from a platform and network perspective
- Flexibility to use private lines or public ATM networks

Passport supports a wide range of access services and their adaptation to ATM. Its flexible ATM adaptation capability enables the preservation and extension of investment in existing CPE equipment and legacy services. In this role, Passport provides the platform to bridge the gap between legacy equipment and services to the world of ATM.

Passport service card:	**Applications supported:**
Frame relay	Frame relay UNI and NNI
ATM	ATM access and trunking
Voice service	PBX interconnect
Bit transparent data service (BTDS) emulation	Video, TDM mux transport, circuit
HDLC transparent data service (HTDS)	HDLC forwarding
LAN (ethernet, token ring and FDDI)	LAN routing and bridging
Frame cell and UNACK trunks	DPN-100 trunking, Passport trunking



This chart introduces a 'NEW!' icon which indicates a capability which will be introduced over the next 12-18 months. Throughout the presentation this icon will be used whenever a new capability is discussed. More detailed rollout information can be obtained from your account manager.

Passport is both an ATM switch and a multi-service ATM adaptation vehicle. Frame based services such as frame relay, DPN-100 trunking, and LAN traffic are all converted to ATM using the standard ATM adaptation layer type 5 (AAL-5). Since standards for conversion of voice and video traffic are not yet mature, a pre-standard AAL is used which allows this traffic to be carried across ATM networks and facilities in an efficient manner. Also, an enhanced circuit emulation service, based on AAL-1 is under development to allow multi-vendor transport of TDM traffic over an ATM network.

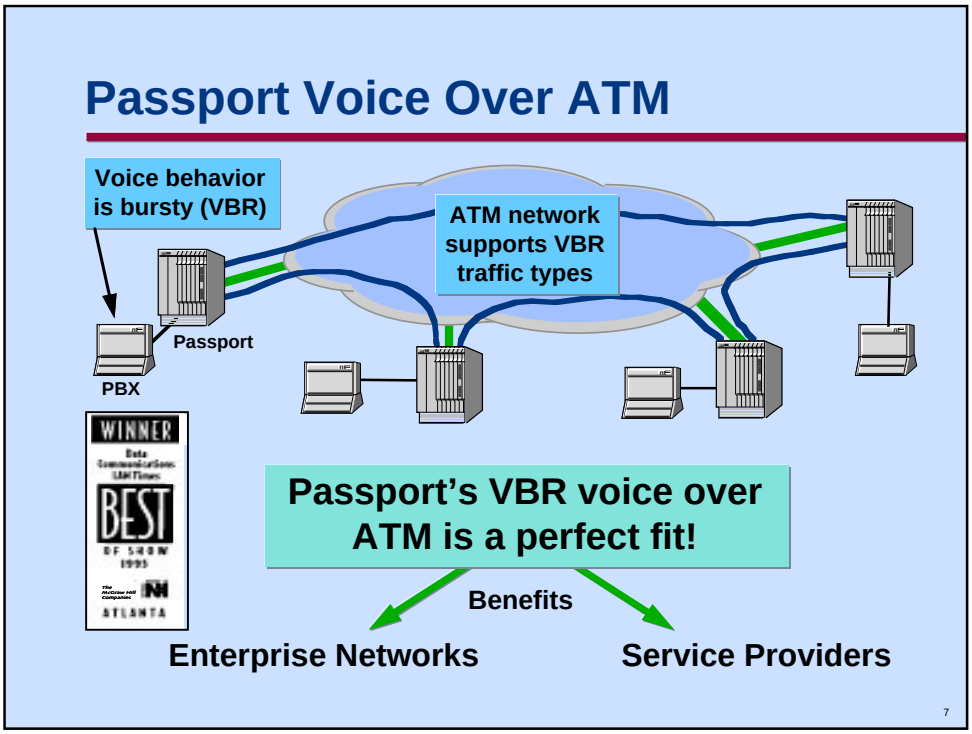
Passport supports direct ATM cell relay access service. This includes PVC capability, in addition to the development of SVC, ATM inverse multiplexing and dynamic networking. More information and details will follow throughout the presentation.

Passport also has a very wide range of standard ATM physical interfaces to meet our customers' global deployment requirements. These interfaces range in speed from 1.5 Mbit/s (DS1) to 155 Mbit/s (OC-3/STM-1 optical fibre). Specifically for the Japanese marketplace, a 6 Mbit/s ATM interface is now available.

Now, the presentation will describe each of the applications which are currently available on Passport for adaptation to ATM. This includes voice and bit transparent data, frame-based services and direct ATM access service.

ATM is the technology basis which enables Passport to support several leading edge applications today. These are:

- Voice over ATM
- Frame over ATM
- ATM access services



The carriage of voice over ATM has been a topic of hot debate for several years. While conceptually there are some significant advantages to be gained by the consolidation of voice and data over a single network, many technical challenges have existed in taking this concept to reality. Passport has adopted an industry-leading approach by matching the bursty variable bit rate nature of voice with the variable bit rate capabilities of ATM. Passport's voice approach has the capability of only generating cells containing voice information when the user of the service is speaking. Since each ATM cell only contains information from a single DS0, if the user is not speaking, no ATM cell traffic is generated. This feature is called 'speech activity detection', and is sometimes referred to as 'digital speech interpolation'. In typical speech, this results in a bandwidth reduction of over 50%.

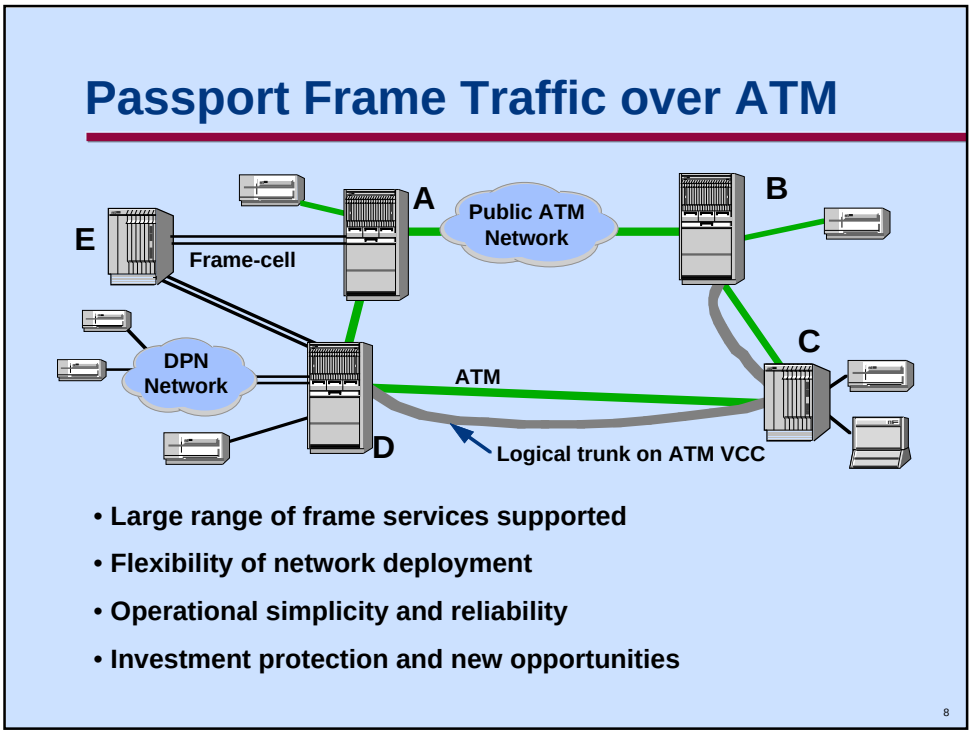
Passport's approach to voice over ATM was instrumental in winning the 'Best of Show' award at InterOp in Atlanta (Sept. 1995).

The benefits which this capability provides to enterprise network users include:

- Inexpensive carriage of voice over ATM as ATM tariffs are expected to be very competitive, enabling voice to be carried at rates below either private line networks or voice VPN (virtual private network) services
- Cost reduction by the consolidation of other services in addition to voice over same ATM facility
- High service quality for voice is preserved over ATM

Service providers can also realize benefits in terms of:

- Bandwidth savings in facilities
- Greater fiber efficiency



Breadth of frame services

- FR-UNI, FR-NNI, HDLC transport, and carriage of DPN-100 traffic

Flexibility of deployment

- Passport's ATM logical trunking support of frame based services over ATM enables the building of an ATM network or a hybrid of leased lines and public ATM service
- An external ATM network can be used to provide flexibility or reduce costs

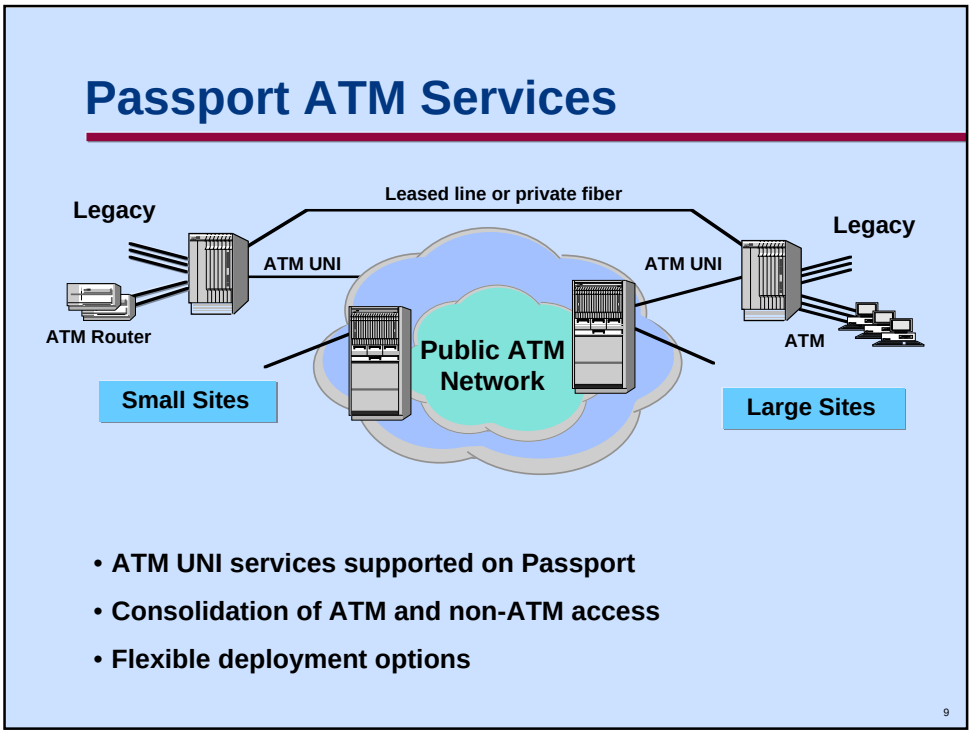
Operational benefits

- Minimal ATM provisioning
- Instantaneous reroute around failures
- Lower cross network delays and reduced facility costs

Investment protection and new opportunities

- Smooth integration of legacy frame traffic onto the ATM network
- Extends capability of investment in DPN-100 networks
- Interworking between DPN-100 and Passport

In developing Passport's ATM trunking capabilities, a concept which is called the 'ATM logical trunk' has been created. A logical trunk allows the carriage of frame-based traffic over an ATM virtual channel connection (VCC). Since a logical trunk is equivalent to a Passport frame trunk from a routing perspective, all of the frame relay dynamic routing capability is preserved as the network is migrated to ATM. This includes such features as re-routing on failure, and load sharing.



Passport's capabilities and flexible deployment options allow it to be deployed as CPE in small or large enterprise sites, or as a multi-service ATM access switch in a service provider network.

As CPE, Passport supports:

- ATM UNI connections ATM routers, in-building ATM switches or ATM network interface cards
- ATM UNI wide area network connection is used to connect Passports together over leased lines or over a Public ATM network

As a service provider multi-service ATM access switch, Passport supports:

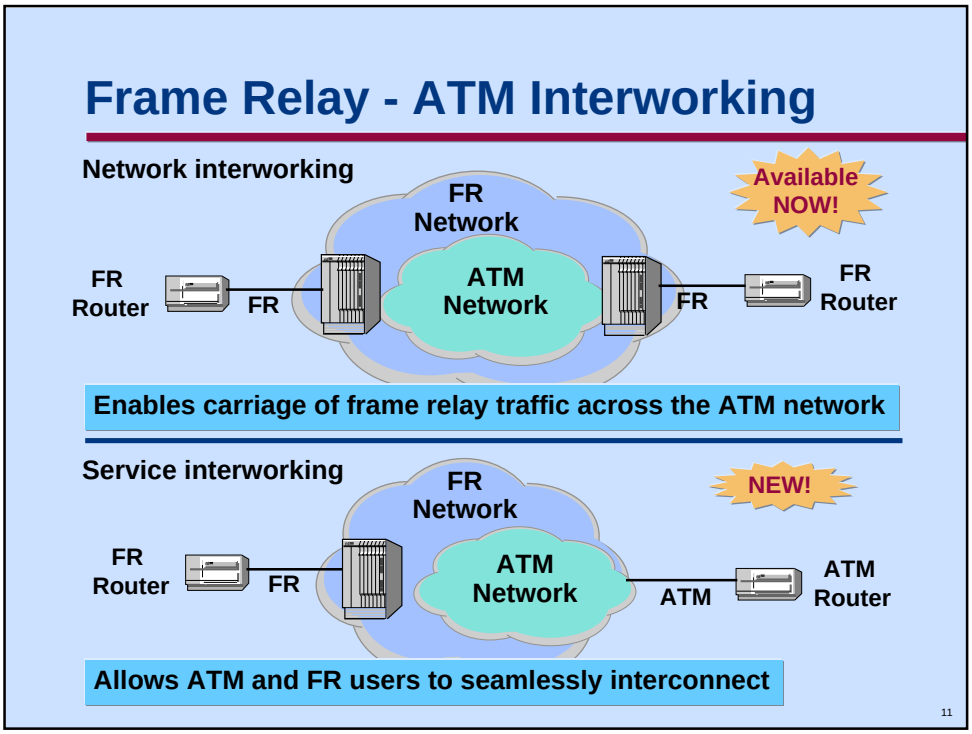
- ATM UNI access services and ATM trunking
- Connection to other ATM backbone switches such as the Magellan Vector or Concorde.

Passport's ATM service capability includes:

- Permanent VC and VP connections
- Multiple quality of service support
- Migration to ATM without service disruption
- Standards-compliant ATM solution
- A wide range of ATM interfaces for global deployment

The excellent features of Passport were recognized by the awarding of the 'Hot Product of the Year' award in the wide area networking category from *Data Communications Magazine* in January, 1996.

In 1996, further enhancements are being made to this product to help make it even better for our customers. This next next section will highlight some of the more significant product enhancements which are underway.



One of the key areas of growth is in frame relay to ATM interworking. There are two distinct requirements, and Passport is able to support both. They are identified as network interworking and service interworking.

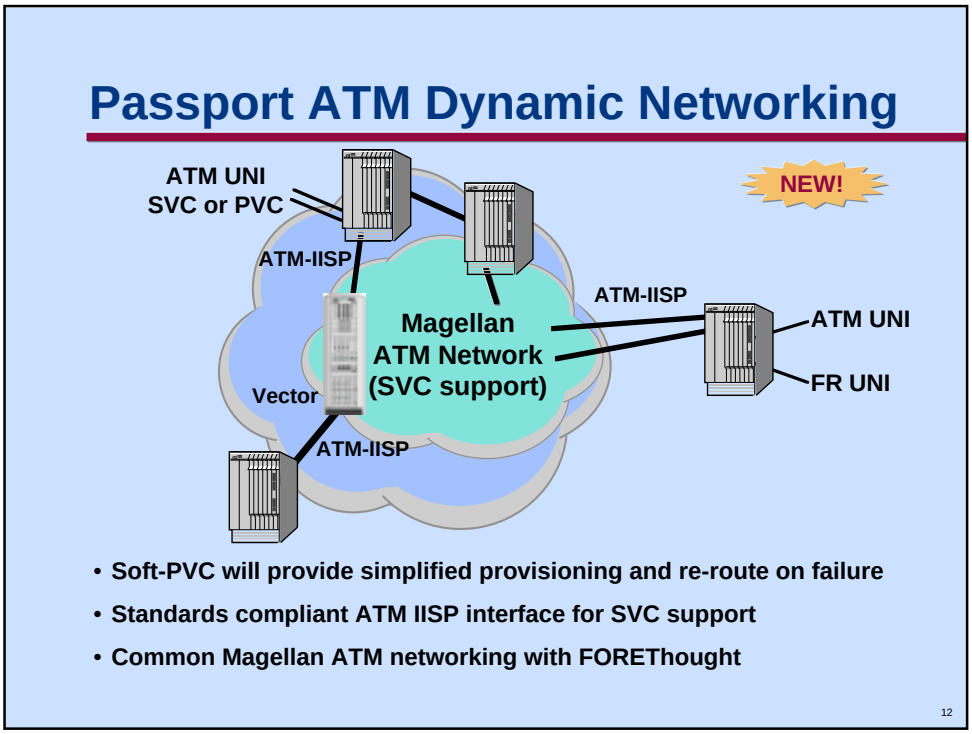
Network interworking enables carriage of frame relay traffic between frame relay users over a backbone ATM network. This capability is described in the Frame Relay Forum as FRF.5 and by ITU as I.555. Passport currently implements a network interworking capability using logical trunking which allows Passport frame relay traffic to be carried over an intermediate ATM network to a destination Passport node.

Service interworking is different from network interworking since it allows ATM users and frame relay users to communicate with one another in a seamless way. This is accomplished by having a translation function within the network which translates the frame relay encapsulation technique (known as RFC 1490) to the ATM encapsulation technique (known as RFC 1483). A service interworking translation capability for Passport is currently under development.

Passport's service interworking capability is standards compliant to FRF.8 and ITU I.555, and supports RFC1483 to RFC1490 translation.

DPN-100 FR service to Passport ATM service interworking is also fully supported.

These interworking capabilities allow a cost effective migration from frame relay to ATM networking which can realize the performance benefits of ATM, while preserving the investment in frame relay.



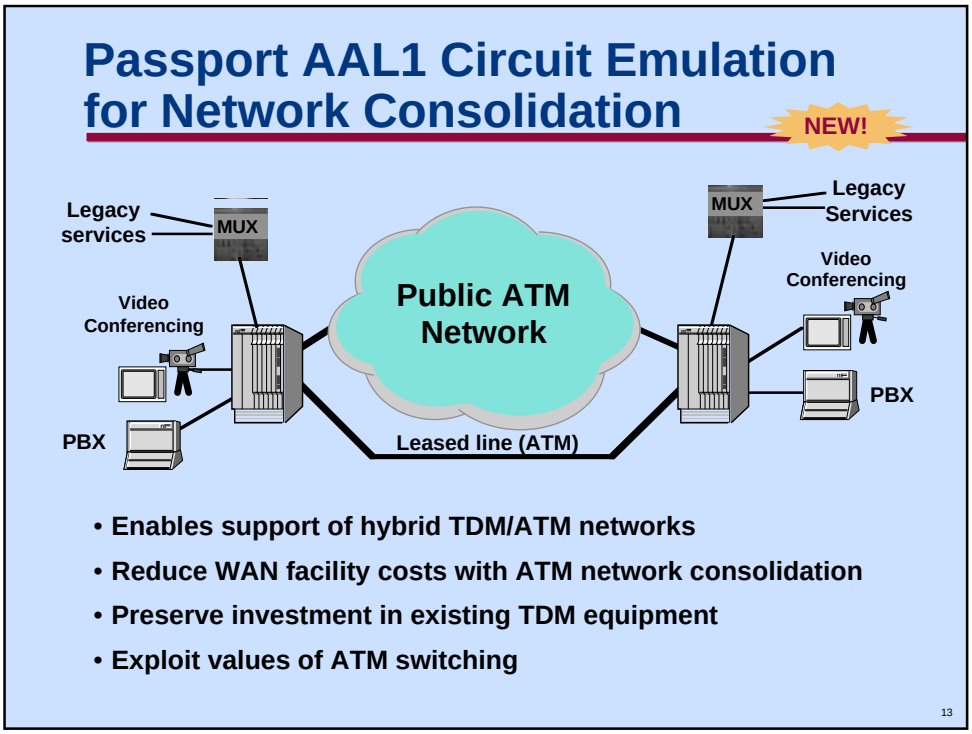
Passport's ATM networking enhancements include three significant components:

- Soft-PVC for simplified end point provisioning and automated connection reroute on failure
- ATM SVC with Interim inter-switching protocol (IISP) trunks.
- Common, standards-based, networking evolution with Magellan Vector and Concorde to support *FOREthought* networking and PNNI

These three capabilities together provide enhanced operational performance and additional service opportunities with ATM SVCs. Also, multi-vendor operation is ensured with the adoption of industry-standard interfaces such as IISP and PNNI.

The *ForeThought* networking capability builds on technology from FORE Systems.

The combination of the networking enhancements described above will improve operations in networks which consist of Passport only, and those which include Passport, and Vector or Concorde.



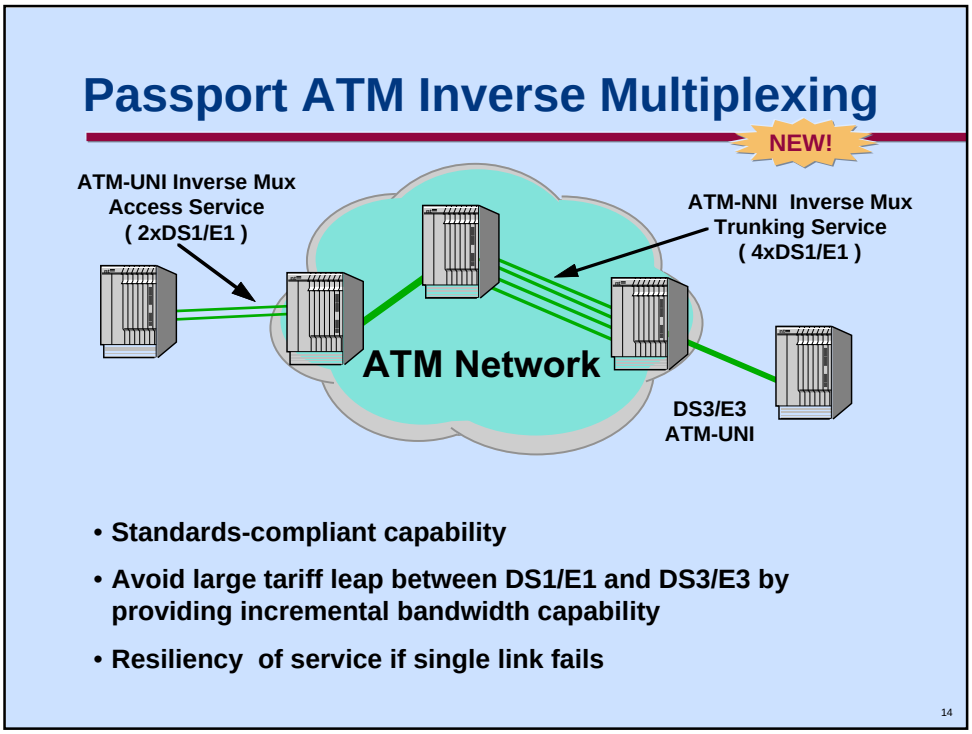
The AAL-1 circuit emulation service allows any existing multiplexer or other device, which usually connects to a DS1 or E1 private line, to connect directly to Passport, and for that circuit to be carried over ATM. The key advantage of this capability is that it enables a migration of any network towards ATM. In addition, it allows a hybrid TDM/ ATM network to exist when this is the most appropriate scenario.

Once traffic from a TDM multiplexer is converted to ATM, it can be multiplexed with other multimedia and ATM traffic onto a single ATM interface which may be connected to an ATM network. This allows a reduction in WAN facility costs since TDM and non-TDM services can now be multiplexed together using ATM traffic management quality of service to preserve service quality.

There are three primary applications for Passport's network consolidation using AAL-1:

- TDM mux replacement
- Carriage of voice in metropolitan network (over private lines or fibre) when VBR voice is not required
- TDM equipment (e.g. CSU/DSU) interconnection over ATM

Passport's AAL1 capability is standards-based and is interoperable with other standards-based circuit emulation products. In addition to the standards-based capability, value added capabilities such as repetitive pattern suppression are planned to allow bandwidth reduction during off peak times when both ends of the connection terminate on Passport.



Inverse multiplexing is the term which describes the use of multiple DS1/E1 facilities in a load shared fashion, when the traffic demand exceeds a single facility. This capability avoids the need for a single step jump from a 1.5 Mbit/s to 45 Mbit/s access facility in North America, and from 2 Mbit/s to 34 Mbit/s elsewhere in the world. While it is possible to do this today using external inverse multiplexer devices. Passport ATM inverse multiplexing integrates this capability onto an 8-port DS1 or E1 ATM card.

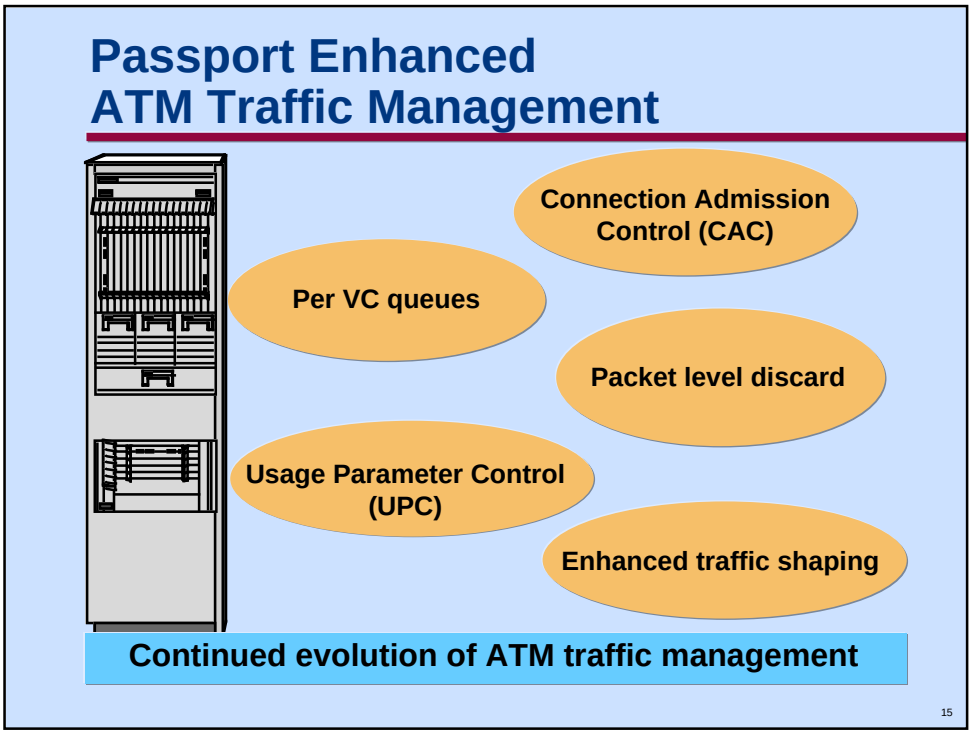
The key attributes of this capability are:

- Support for both access and trunking services
- Supports all Passport and DPN-100 services
- Supports multiple ATM QOS levels for different traffic types
- Interoperability with all other ATM services from different physical interfaces
- ATM Forum standards compliant

The benefits which accrue from this technology include:

- Avoidance of cost/price jump to DS3/E3 levels
- Resiliency of service (reduced bandwidth on single DS1/E1 link failure)
- Incremental ATM VCC bandwidth greater than 1.5/2 Mbit/s streams
- Multi-vendor interoperability
- Lower cost than using external inverse multiplexers

Nortel is a major contributor to the ongoing ATM inverse multiplexing work in the ATM Forum and is the editor of the ATM inverse multiplexing specification.



The following are the near term plans for enhanced Passport ATM traffic management. Additional ATM traffic management capabilities are planned beyond this set of enhanced features.

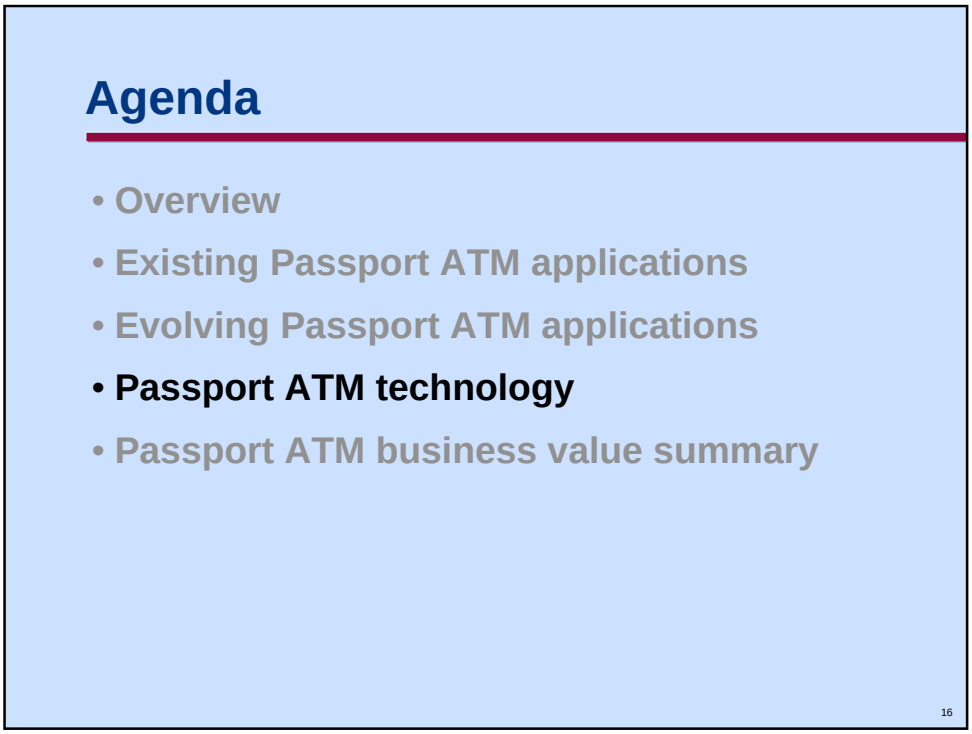
1. Per-connection queuing provides traffic separation between connections resulting in enhanced traffic fairness amongst connections. Passport currently supports traffic shaping on per VC basis. This capability will be extended to include the ability to have per VC queuing with or without traffic shaping.

2. UPC: Passport will enable the UPC functionality of ATM traffic management enhancements. Passport supports dual leaky buckets with the ability to tag, monitor and discard.

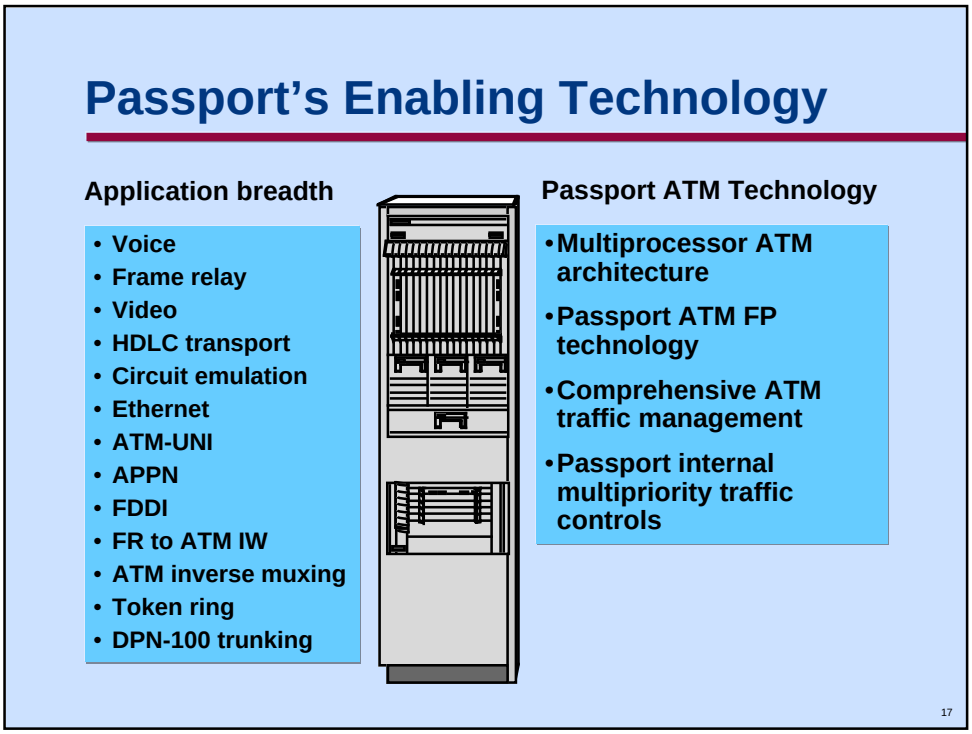
3. With connection admission control enhancements, Passport will be able to accept or reject connection requests while maintaining QOS objectives. The resulting benefit is to avoid unintended oversubscription and better facility utilization. Nortel has developed an industry leading CAC algorithm and will be incorporating it within Passport.

4. Packet level discard provides substantial improvement in network efficiency and facility utilization in the network. Inherent in ATM adaptation of frame based traffic, if one cell out of a frame is lost in the network, the rest of the cells belonging to that frame (also known as orphaned cells) are still transported across the network towards the destination. At the frame-to-ATM adaptation point, Passport implements an early packet discard (EPD) capability. At ATM cell relay points, Passport inplements partial packet discard (PPD).

5. Enhanced Traffic Shaping: Passport currently supports single port shaping on ATM cards. This feature enables traffic shaping for all ports on the ATM card.



To enable these applications requires sophisticated underlying hardware and software technology. The next section provides some details on Passport's ATM technology.



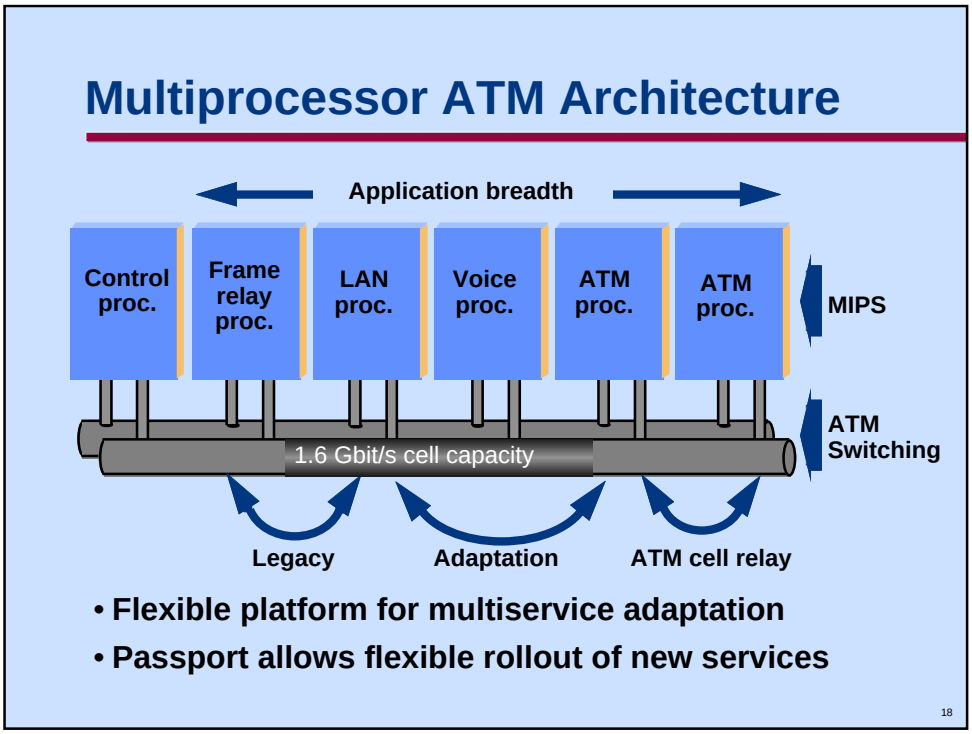
Support for the wide range of applications, services and capabilities indicated on the left hand side of this chart has established Passport as a world-leading multimedia ATM access product. From an ATM adaptation perspective, there are four technology areas that will be discussed in this presentation, represented in the next four charts.

1) Passport uses a multi-processor ATM architecture that provides service flexibility, high performance and high reliability.

2) Passport ATM functional processor technology is based on custom-developed application specific integrated circuits (ASICs), and on a modular architecture which has allowed rapid development of many different interface types.

3) Comprehensive traffic management capabilities are implemented to build networks which provide appropriate end-to-end quality of service assurances.

4) Passport has sophisticated internal multi-priority traffic controls which ensure fair operation and enables the transport of both data traffic and delay sensitive voice and video traffic.

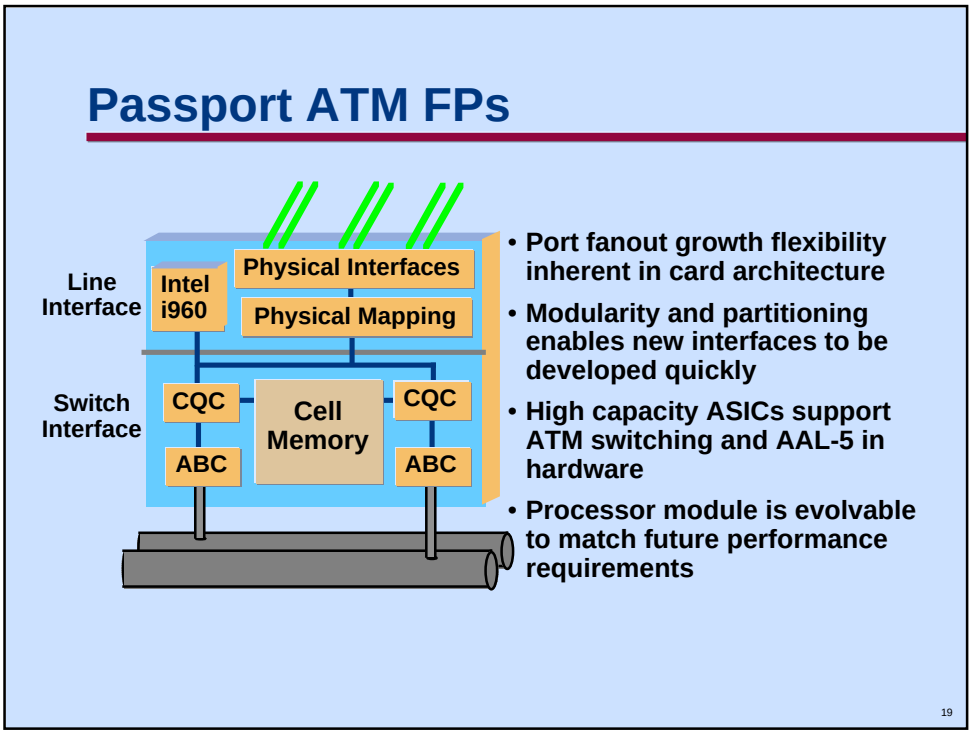


The power of the Passport platform is its ability to combine an ATM switching infrastructure, large amounts of processing power and a wide breadth of application interfaces into a single system. This combination enables Passport to provide unsurpassed flexibility in meeting the networking demands for a wide range of enterprise and service provider networks.

Passport has 1.6 Gbit/s of cell switching capacity. This enables Passport to provide pure ATM cell services at both the VP and VC level. Duplication at both the bus and card levels ensures that this capacity is available under failure conditions and that there is no single point of failure that can disable the whole system.

The bus architecture chosen for Passport is optimal for use in a multi-service environment since:

- The Passport cell bus uses a sophisticated, hardware-controlled, two stage, pipelined, multiple priority arbitration scheme to maximize bus utilization, and minimize latency. Since this arbitration occurs out-of-band, it ensures that 100% of the bus bandwidth can be used for information transfer.
- Each access card can use as much, or as little, bus bandwidth as needed. This makes Passport ideal for support of a wide range of access speeds, from 9.6 kbit/s to 155 Mbit/s.
- Each card has large amounts of processing power—the i960 RISC (reduced instruction set computing) processor—which provides service adaptation flexibility, and allows new services to be added in an incremental fashion.



Multiple ATM FP (functional processor) cards have been developed for Passport. This enables Passport to meet the interface needs of networks that are deployed on a global basis. The range of speeds enable network enterprise and service providers to select the interface bandwidths that meet both traffic needs and budget limits.

To maximize flexibility and to ensure that new features are available on all ATM FPs at the same time, each ATM FP is partitioned into an SI (switch interface) side and an LI (line interface) side.

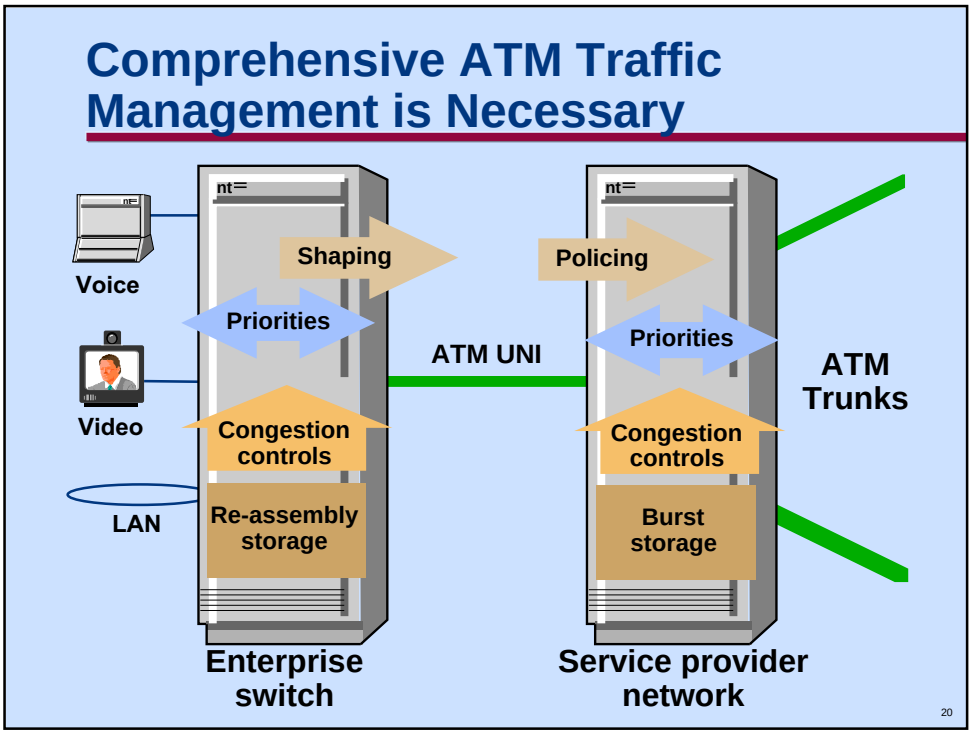
Multiple LIs or “front ends” have been developed to support the various interfaces listed above. Each LI has interface-specific hardware for mapping cells onto the respective physical media. For ATM VC/VP switching, the Intel i960 RISC processor is not used in the data path and only provides management functions. This ensures that software does not impact ATM performance and frees the processor to support the adaptation of legacy protocols to ATM.

The SI side of the card incorporates two custom ASICs; the ABC (ATM bus controller) and the CQC (cell queue controller). These ASICs enable Passport to provide competitive features, high throughput and the Magellan MPS (Multiple Priority System) traffic controls.

The ABCs can support peak cell rates of 800 Mbits/s and sustained cell rates of 400 Mbits/s. They also provide multiple queues that prevent head of line blocking which is discussed on a later chart.

The CQC provides ATM header processing. It also incorporates AAL5 frame adaptation in silicon plus custom software interfaces that enable the i960 to provide legacy protocol support at very high rates.

Available ATM Cards include: Three-port cards for OC3/STM-1 SM and MM fiber, DS3, E3, DS1 and E1. A two-port J2 (6 Mbit/s) card is available for the Japanese market. An 8-port version of the DS1 and E1 cards with ATM inverse multiplexing will be available within 12 months, and 4-port AAL-1 cards with DS1 or E1 interfaces are also under development.



This chart illustrates, at a high level, the traffic requirements for both enterprise and service provider switches. These functions ensure that a high end-to-end network service quality is provided.

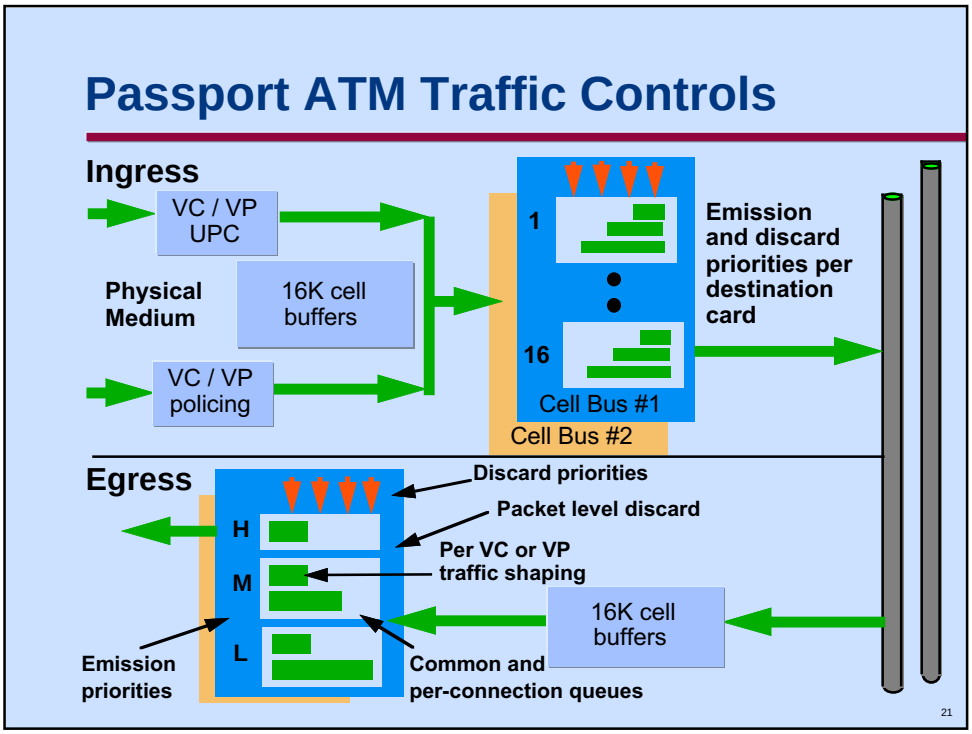
The system on the left represents an enterprise traffic consolidation switch while the system on the right is a multi-service access system in a service provider ATM network.

Both systems must support traffic priorities to ensure that delay-sensitive traffic is never impeded by data. In addition, both systems must provide congestion controls such as EFCI (explicit forward congestion controls) to advise when the sources must slow their cell flow rates to match the trunk capacity of the network.

Both systems must provide large amounts of cell storage. For cell relay, the purpose is to handle cell bursts and avoid cell loss prior to the sources slowing their cell flow rates. For a system that is converting cell flows back into legacy protocols, there is a need to buffer cells from partially assembled frames.

The service provider must provide policing functions to ensure that ATM sources honor their service commitments and do not send at rates higher than agreed. The service provider has the option to conditionally forward or to discard cells in violation.

The enterprise switch must be able to pace the cell flow to the service provider switch to ensure that the cell arrival rate does not exceed either the agreed peak or sustained cell rate which would trigger the policing function to discard cells. This pacing function in the enterprise switch is called traffic shaping.



This chart illustrates the MPS (Multiple Priority System) traffic management implementation within a Passport ATM FP. The upper portion illustrates the ATM cell ingress processing and the lower half, the egress processing.

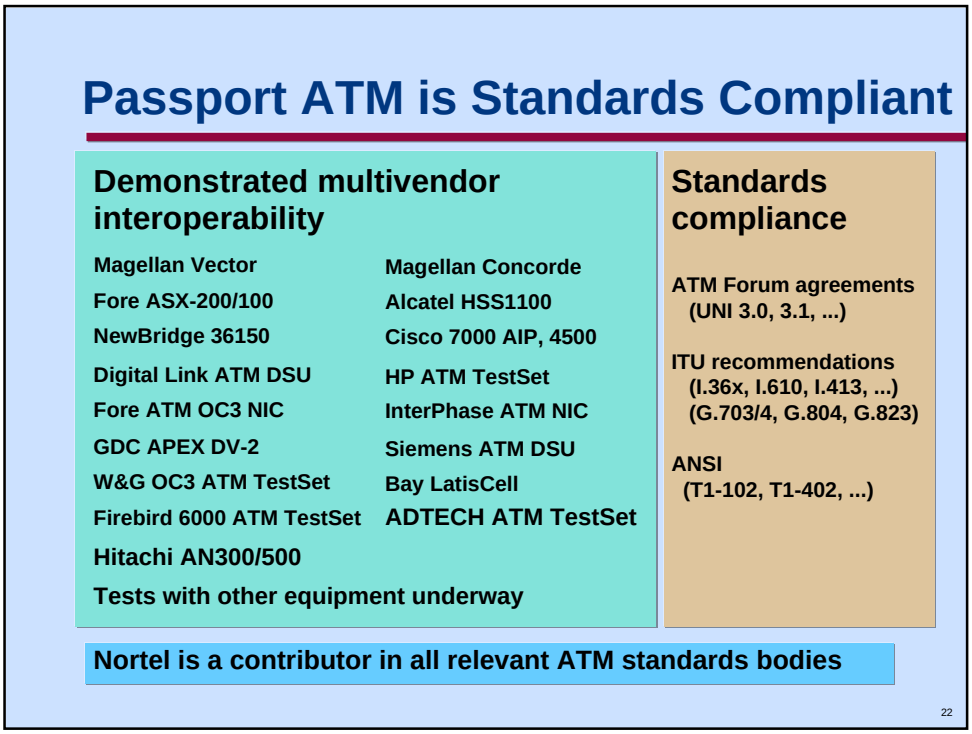
On ingress, the ATM FP contains service state data for each VC or VP on up to 32 different physical ports. The ATM FP is able to apply UPC (usage parameter control) policing on each VC or VP and tag, discard, or monitor cells that are in violation of the UPC values. The cells are briefly held in ingress memory before they are transferred to the cell bus. This storage exists to reduce the probability of cell loss under extreme congestion. Although this storage contains up to 16K cells it is rarely used under normal circumstances.

Internally, Passport supports a three queue priority system to provide the ATM Forum classes of service. On the ingress side of the card, 16 sets of three queues for each bus (96 queues in total) are used to queue traffic for other cards. This capability improves performance when traffic focuses on one specific outgoing FP in the system and causes buffer congestion for a specific grade of service. The multiple queue structure enables cells in a specified priority, destined to this card, to be held without delaying the transfer of cells in other classes of service and to other cards. This is referred to as avoidance of head-of-line blocking.

The egress portion of the card also has up to 16K cells of buffer storage. The CQC supports priority queueing for up to 32 physical ports. In addition, separate queues are maintained for each VC or VP where shaping is enabled and cells are held and “paced out” at the required rate.

The ASICs also support four classes of discard priority for each queue priority. This enables a service provider to give different grades of service and tariff accordingly.

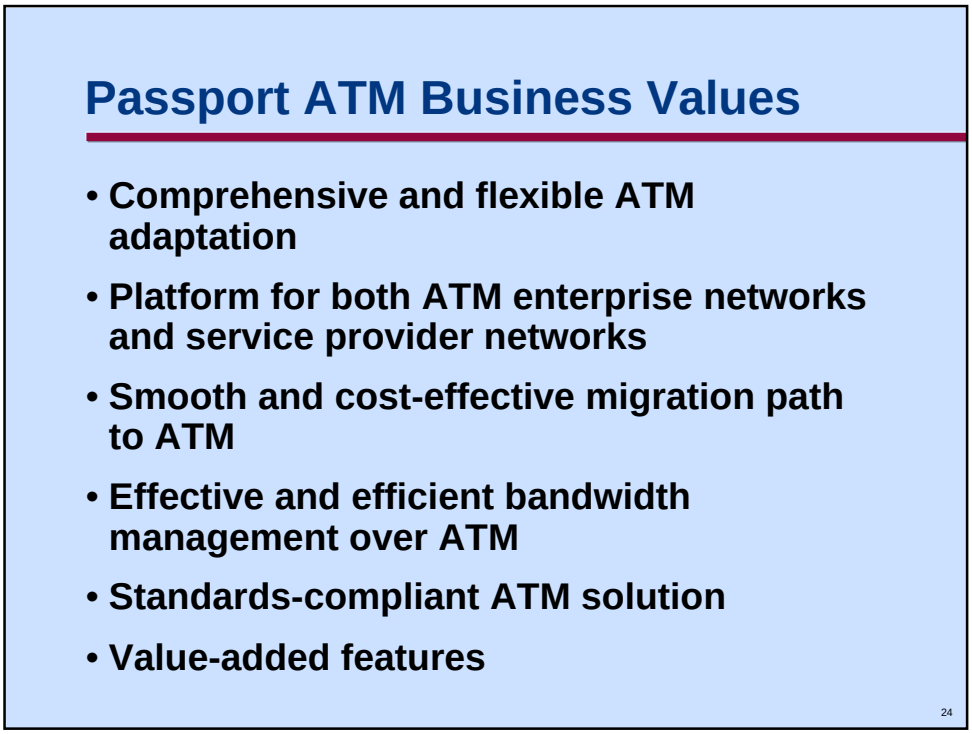
Other features such as limits on buffer size per class of service, hardware setting of EFCI, and a software- controlled threshold, enable Passport to provide low cell loss for data applications, while ensuring that voice and video traffic delay and delay variance will not be impacted by data traffic.



From an interoperability and standards compliance perspective, Passport is well positioned. Over the past year, Passport has successfully interoperated with every other ATM product that it has been connected to. This high level of interoperability success is due primarily to the excellent work done in the ATM Forum on the ATM UNI specification.

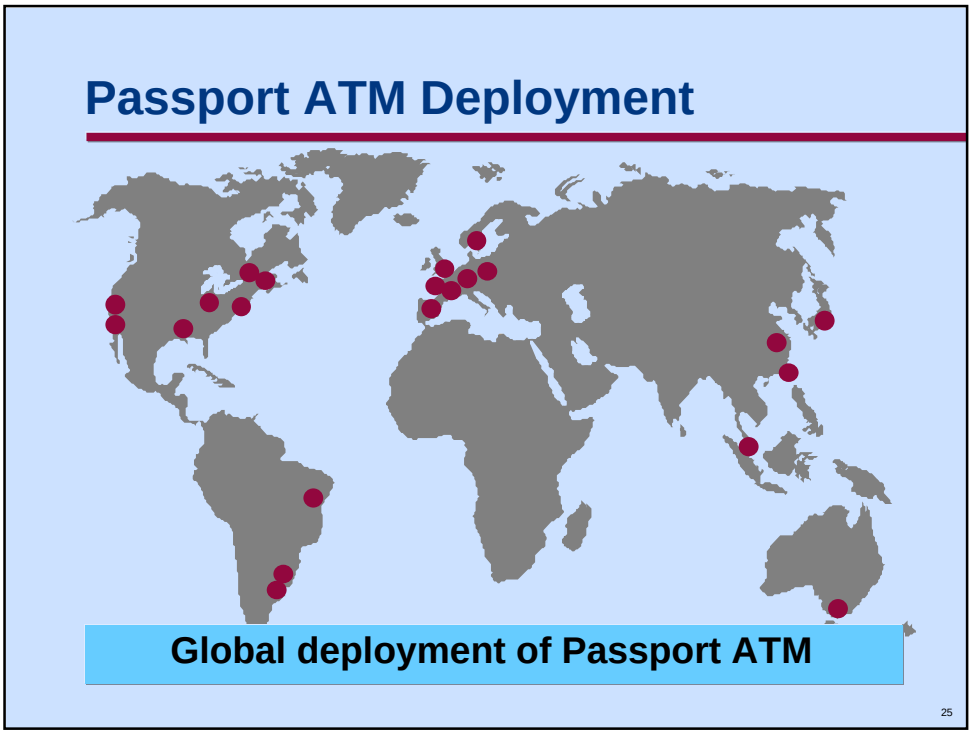
The intent is for Passport ATM to be compliant with all relevant ATM standards, and Nortel is an active participant in all relevant ATM standards bodies, in addition to being one of the founding members of the ATM Forum.

This final section will reinforce some of the business values that have been discussed today.



The business values identified here are the keys which will help make your network more cost effective and profitable with Magellan Passport.

Every customer network, and operating environment is different. The account and marketing teams work directly with our customers as required to develop specific business cases, and network cost analysis studies.



The dots on this map show locations where Passport ATM has been deployed over the past year. The rapid deployment and product launch of Passport ATM exceeded our expectations. The total number of customers at year end was 50% higher than had been previously planned.

The demand for ATM in 1996 is continuing as many customers are moving towards live deployment of ATM capability in their networks.

"HOT Product Award" *DataComm Magazine* Jan. 1996

At the end of each year the editors of *Data Communications Magazine* select the products that they deem to be most significant in that year, focusing on those products and services that could make a crucial difference—whether because of price points or technological advancements—and that will transform corporate networks and change the way its readers do their jobs. Their selections are included in the January 'Hot Product' issue. The major criteria are that these products have to be 'exciting and cutting edge'.

This year, Magellan Passport was selected as one of six products in the WAN equipment category. In this case, the editors of *Data Communications Magazine* highlighted Passport's VBR voice on ATM capabilities, in the context of its broad functionality as an ATM enterprise network switch. VBR Voice is important in that it makes better use of bandwidth and provides the network operator the capability to trade off performance vs bandwidth cost.

Fall InterOp '95 Best of Show Award

At Networld+Interop in Atlanta (Sept 95), the editors of LAN Times and Data Communications chose best of show products in the eleven categories. Passport was highlighted in the WAN equipment category for which Magellan Passport was selected as a feature rich ATM Enterprise Network Switch. Additionally, in the same show, MFS Datanet was selected as an award winner for their very innovative Passport-based wide-area voice exchange (WAVE) service.

Other Passport recognitions

- Network World short list in their ATM Switch User Buyer Guide (Oct 9 1995)
- Network World short list in their Bandwidth Manager User Buyer Guides (Dec 11 1995)