The intended audience for this presentation is network planners and strategists operating in public, private and hybrid environments.

This presentation will provide an update to the frame relay market, focusing on changes in 1995 and anticipated market requirements going forward. An update on Magellan frame relay, features and applications available, as well as the evolution of Magellan frame relay, will be provided with a focus on contributing to customer profitability.

About the presenter:

Ian Merritt is currently a senior manager within the Passport Product Line Management group with responsibility for the service provider market and applications. He has been with Nortel since 1988 in a variety of positions (business development, market planning, product management, marketing), but all associated with data networking. Ian worked for Bell Canada in a variety of roles, including Datapac product manager for 10 years prior to moving to Nortel.

Agenda

- **Frame Relay Marketplace Updates**
- Magellan Frame Relay Achievements
- Frame Relay Evolution
- Summary

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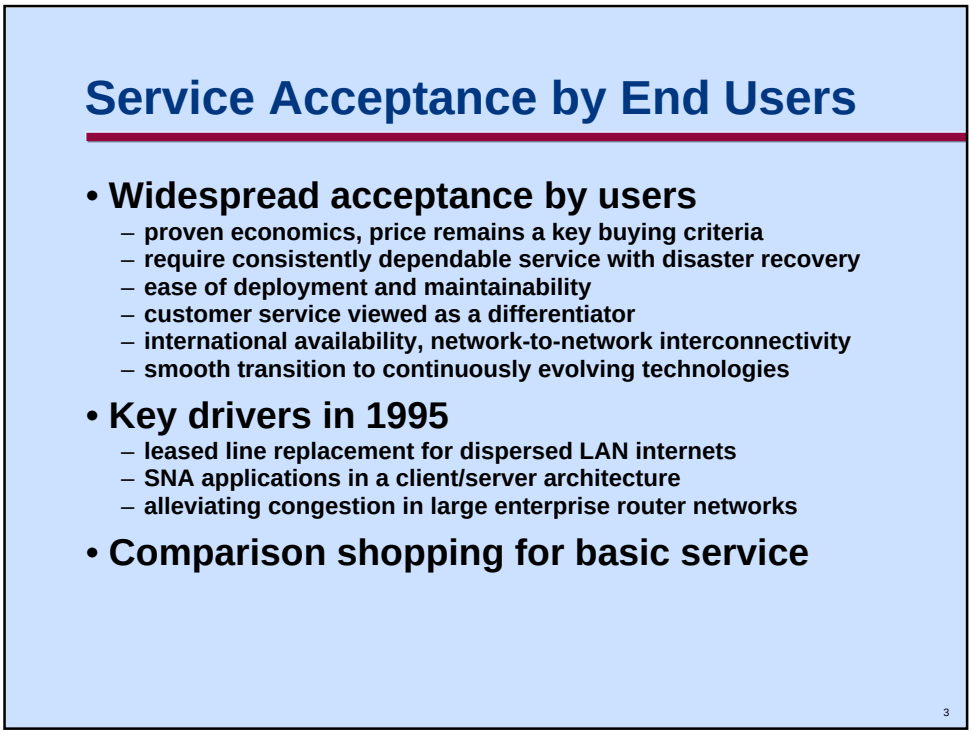


As a widely accepted transport mechanism by users on a global basis, basic frame relay is developing into a commodity service. Cost remains the key decision criteria with the assumption that a reliable service which consistently meets or exceeds quality of service guarantees is a basic requirement. Users are demanding solutions beyond the technology of frame relay.

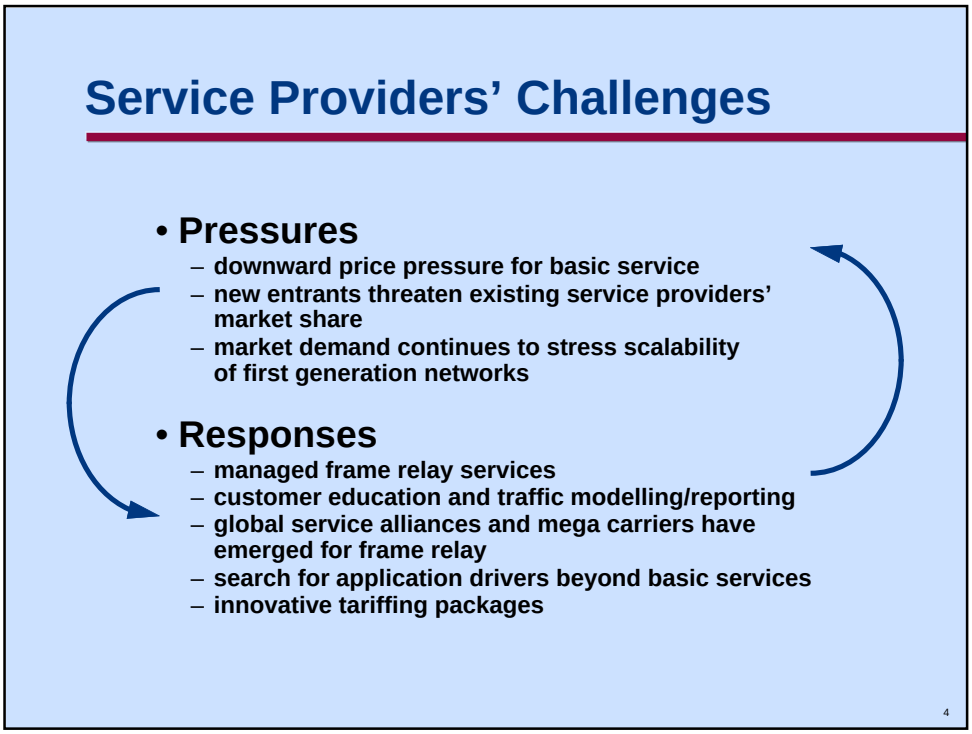
Top 10 user frame relay criteria required from service providers*

- Existing ommitments
- Integrated access opportunities
- Disaster recovery
- International availability
- Hybrid designs and gateways
- Network management systems and reports
- Router and FRAD vendor flexibility
- Network-to-network interconnect
- SNA experience
- Sustained burst capability

* Source: Enterprise Network Strategies, Gartner Group, September 1995

While the primary application for frame relay in 1995 was as a leased line replacement, other drivers are quickly emerging. SNA has been a key driver in 1995 and a major growth area with the explosion of FRADs (frame relay access device) and acceptance of frame relay for mission critical data.

As a basic service in a very competitive environment, users are taking the opportunity to do comparisons of service provider offerings in head-to-head tests. Multiple providers are being chosen for some networks requiring basic frame relay in a manner similar to leased line auctions. The opening up of published tariffs in the U.S. further intensifies the competitive environment. Service providers must differentiate their service beyond the technology to successfully operate in this environment.



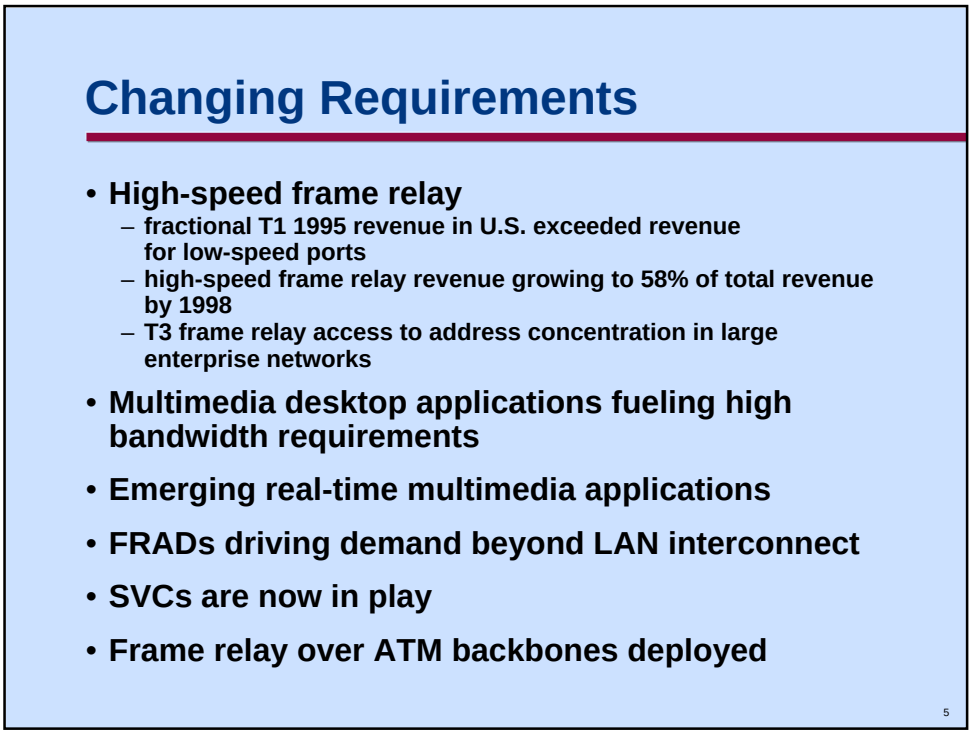
With wide scale acceptance of frame relay, the market has become increasingly competitive. New entrants may be either national or international. In addition, enterprise networks are entering the market and are beginning to offer services. Even the responses of specific service providers themselves are new pressures for others in a competitive market.

To respond to pressures, service providers and enterprises must offer differentiated services beyond basic frame relay. A managed frame relay service provides such a vehicle. The top 10 criteria as captured by Gartner group are listed below. However, even within such an offering, there are many opportunities to differentiate your service. Many of these are based more on the service delivery and management capability of the provider than the basic frame relay technology.

Top 10 managed frame relay criteria in service provider offerings: *

- Frame relay network performance
- Implementation support
- Implementation timing
- Personnel stability
- Network modelling
- Educational services
- Router software testing and deployment
- Network management integration
- New features
- Performance upgrades

* Source: Enterprise Network Strategies, Gartner Group, September 1995

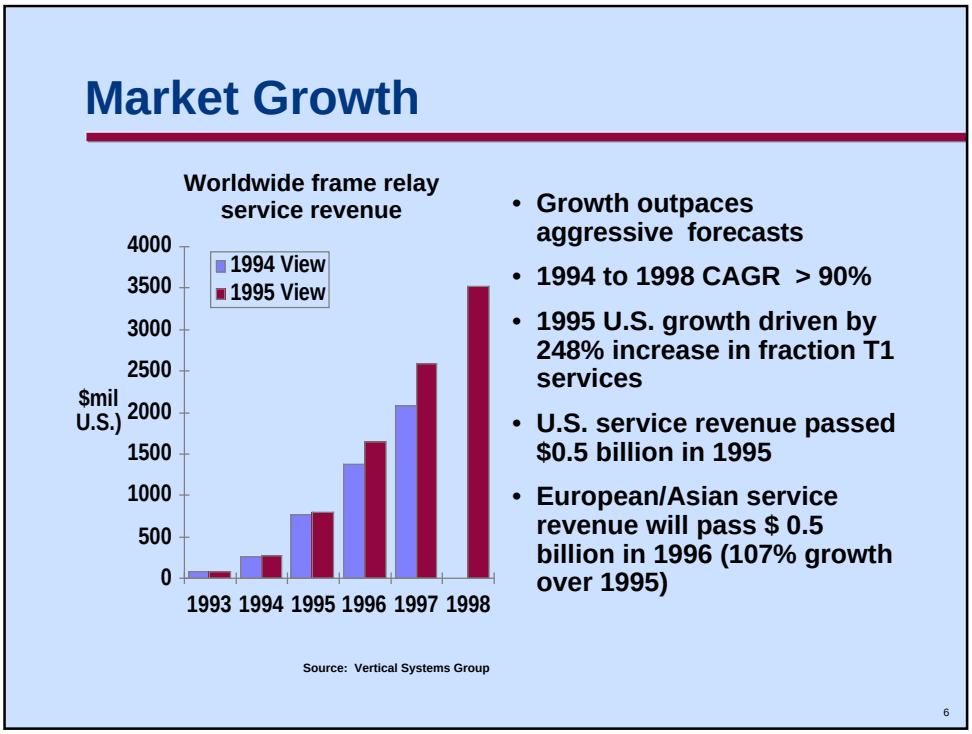


As defined by Vertical Systems, high speed frame relay includes anything greater than 64 Kbit/s. Frame relay growth in the fractional T1 speeds represents more than half of the current U.S. service revenue and will grow each year in overall market share. There is also increasing demand for frame relay services at T3 speeds for large enterprise networks and Internet concentration. The demand for high speed is fueled by desktop applications which incorporate many multimedia formats. These may include e-mail which now includes pictures and even sound clips. Presentations are now in colour and video clips are frequently available across the Internet. Where a presentation used to be less than 100k, multi megabits are not uncommon.

Real time interactive multimedia applications are also emerging. These include voice and video over frame relay. These will not only influence the bandwidth requirements but also the quality of service requirements.

FRADs represent the largest and fastest growing element in the access equipment market. The growth is primarily driven by increased market demand for SNA over frame relay.

The deadlock to switched virtual circuits (SVCs) has now been broken. Service providers were planning to offer the service once available from vendors. Vendors were waiting for service provider demand. SVCs are available now and availability from customer premise equipment (CPE) vendors has been initiated.



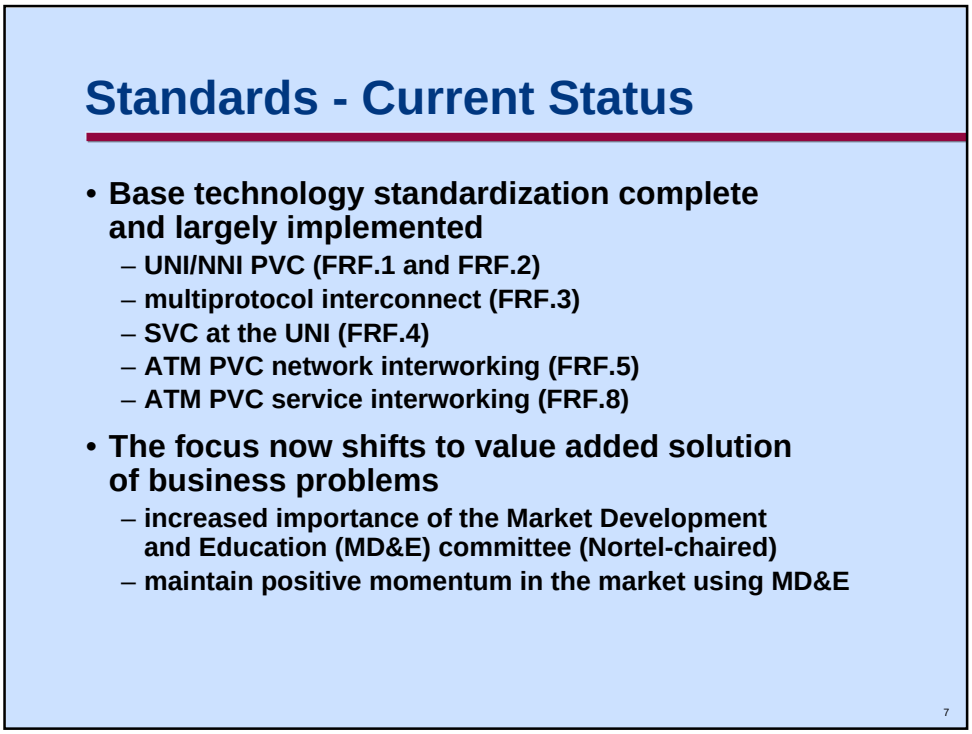
Growth continues to be explosive. Even aggressive forecasts from last year are viewed as low and have been updated in 1995 with greater growth. The growth is also not anticipated to slow down until at least 1998.

Growth outside the U.S. is also explosive with the rest of the world (non-U.S.) service revenues only a year behind, rather than the common perception that the U.S. has a two year lead.

A significant continuing revenue stream from the installed base has been established, providing ongoing revenue for years to come.

There is also steady growth of private network switches which will more than double over the next three years.

With the continued growth and significant market size, there is lots of opportunity to grow existing frame relay revenue, and opportunity to capture some of this market for those network operators who have not already deployed a frame relay service offering.



Nortel has always been a leader in telecommunications standards development, principally through its research and development arm.

Nortel is a founding member of both the Frame Relay and ATM Forums and a long time participant in the work of the ITU-T (formerly CCITT) and many other global and regional organizations.

Nortel has been very active in the development of base UNI and NNI standards in both the ITU-T and also the Frame Relay Forum (FRF) in Implementation Agreements FRF.1 and FRF.2.

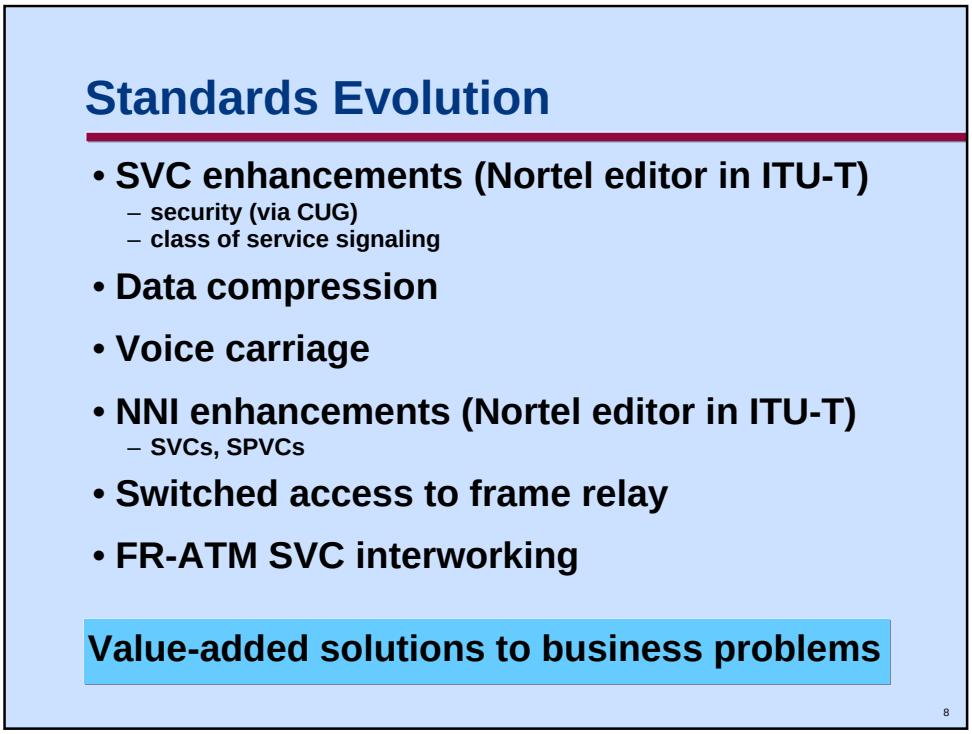
Nortel also contributed to the development of the Frame Relay Forum Implementation Agreement FRF.3 which describes a method for the encapsulation of multiple protocols over frame relay.

The FRF has completed work on FRF.4, the Switched Virtual Circuit Implementation Agreement, with Nortel acting as co-editor.

Nortel is currently the editor of X.36 and X.76 within the ITU-T.

Nortel will continue to provide leadership and develop standards-based solutions, particularly in conjunction with our customer partners.

In a manner similar to wide scale acceptance by users, the base technology standarization has been completed. Going forward, an increasingly important body will be the Market Development and Education Committee of the Frame Relay Forum. This Nortel-chaired committee has been instrumental in raising the global profile of frame relay as a technology. In the future, an increasing focus on business applications and solving real world problems involving the integration of frame relay with other technologies will require the participation and leadership of this group.



The evolution of standards is increasingly focused on an applications basis, moving beyond basic frame relay. As editor in ITU-T for SVCs, Nortel will continue to work to include enhancements for SVCs.

Data compression standards are largely driven as CPE-to-CPE standard. Voice over frame relay is also an example of a specific data compression application which has also been largely driven by CPE devices.

An ongoing area of activity is the enhancement of the network-to-network interface (NNI), both to increase available capacity and to add resiliency. Nortel is contributing in this area in conjunction with service providers.

Switched access to frame relay has recently been raised in the Frame Relay Forum for further study.

Nortel continues to contribute in the development of the service interworking IA.

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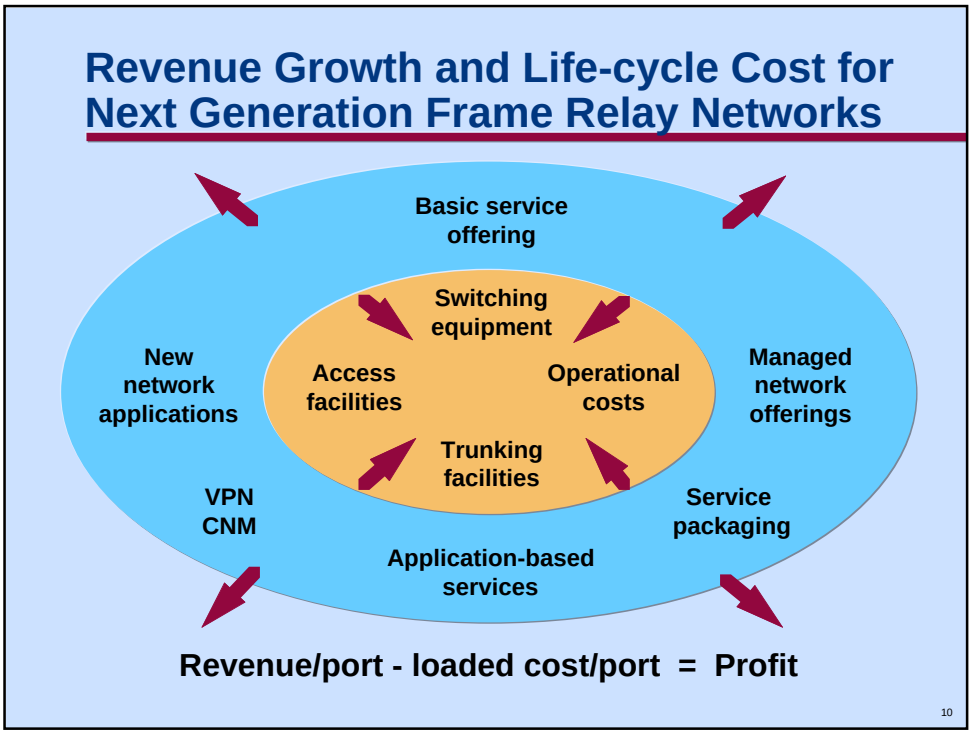
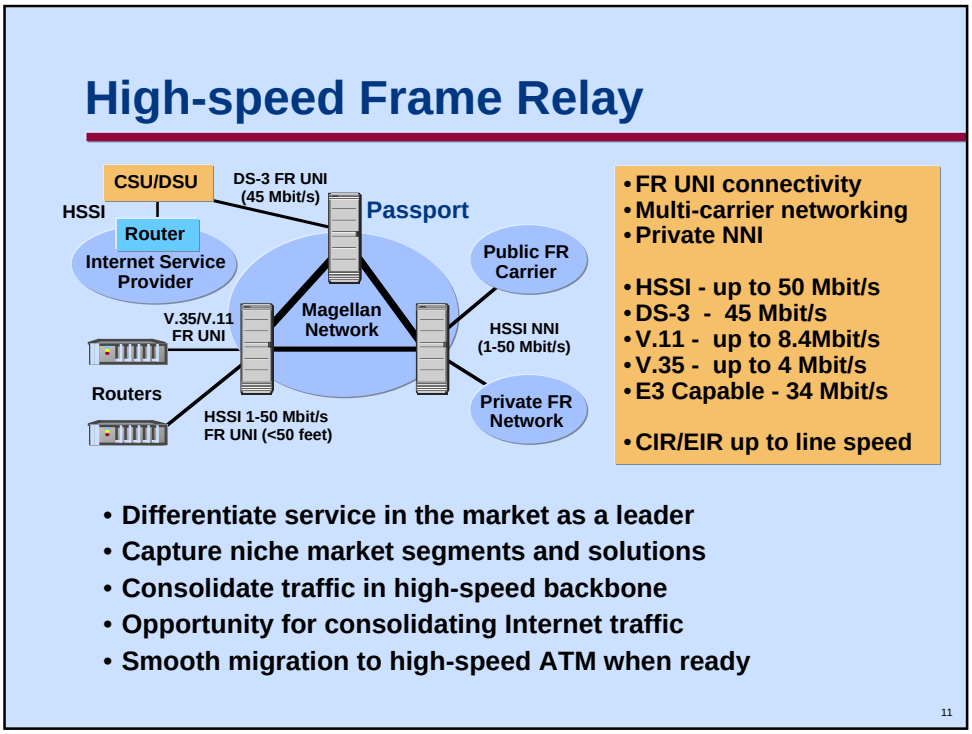


The simplest summary of the business objectives of a service provider is to make a profit on a service. The profit is influenced by factors which provide sources of revenue as well as a number of costs which contribute to a loaded cost per port. Facilities and operations costs represent a majority of the costs. Magellan is focused on both increasing revenue sources and reducing costs which contribute to the ability to generate a profit for a service provider. This model is also applicable in an enterprise environment with the end goal being the ability to support the greatest number of applications at reduced costs.

Frame relay has been established as a basic service. It is necessary to move beyond the basic service in order to generate new sources of revenue and provide service differentiation. New network applications may be facilitated with new frame relay features like SVCs or ISDN. Virtual private networks (VPNs) and customer network management (CNM) provides functionality which can expand the addressable market. With the acceptance of frame relay as a transport technology, customers expect solution based offerings. These application-based services may utilize frame relay as the transport technology, although frame relay would be transparent to the user in such an offering. Creatively packaging frame relay provides a method of differentiation as well as capturing new market opportunities. This is easily facilitated with usage-based accounting. As a further extension to VPNs, managed network offerings provide a solution-based service, with the technology and its implementation transparent to the user. A platform and partnership which can contribute to each of the potential revenue sources is required to build a profitable service.

There is no single answer for the right features for everyone in the world. Different regions have different cost models as well as revenue opportunities. Nortel will continue dialogue with lead customers to identify the best solutions to meet your business objectives. We welcome your input.



High-speed frame relay enables new opportunities for interoperability and frame relay growth. It addresses the concentration points of traffic in both enterprises and service providers which may be high speed routers or internet gateways.

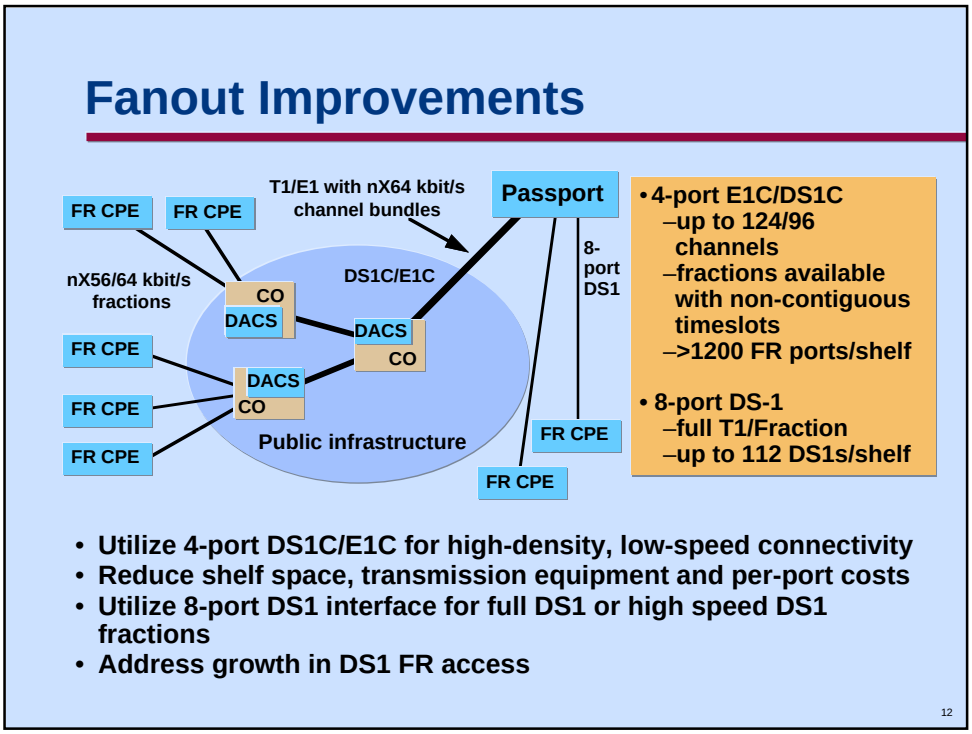
High-speed NNI provides a new opportunity to enhance internetworking between Magellan frame relay networks and other frame relay networks. High-speed NNIs improve multi-carrier connectivity. Private NNIs offer service providers a new revenue opportunity and enterprises the opportunity to build hybrid public/private networks to optimize costs. Remote offices may use the public frame relay network to connect to a private frame network. High-speed private NNIs address the concentration of multiplexed traffic between the public and private networks.

V.11 function processors support sourcing line speeds between 9.6 kbit/s and 7.68 Mbit/s for DCE physical mode. Line speeds up to 8.4 Mbit/s are supported for DTE physical mode.

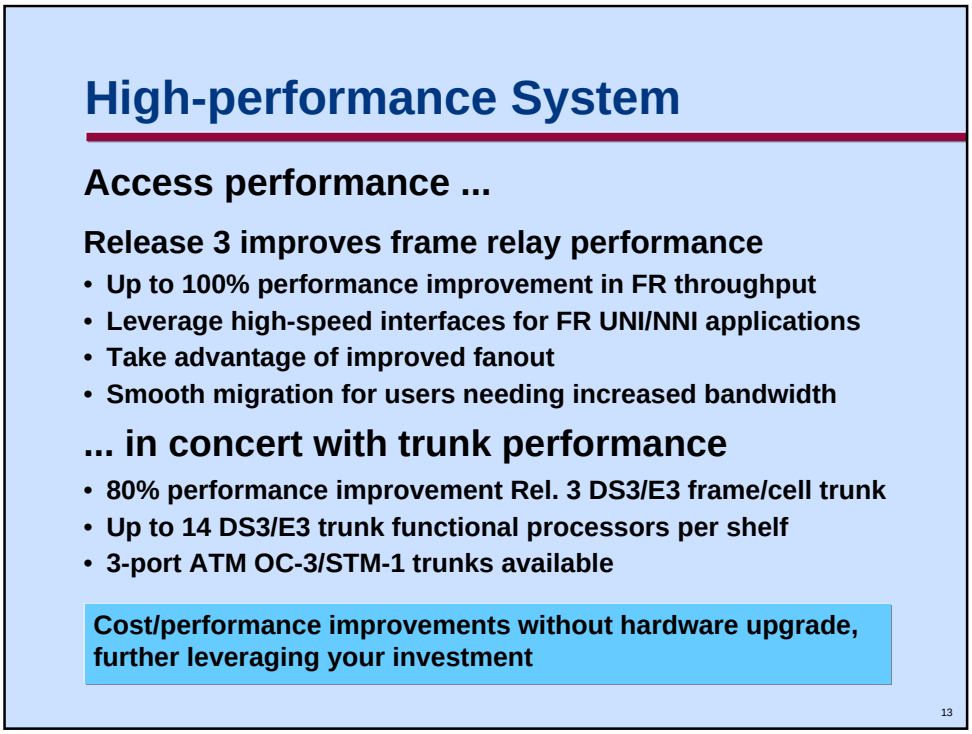
V.35 function processors support sourcing line speeds between 9.6 kbit/s and 3.84 Mbit/s for DCE physical mode. Line speeds up to 4 Mbit/s are supported for DTE physical mode.

HSSI (high-speed serial interface) operates at 1-50 Mbit/s either as a DTE or DCE. The HSSI card may operate either as a DCE or a DTE at the physical level.

DS3 supports 44.736 Mbit/s and E3 supports 34.368 Mbit/s. E3 frame relay is implemented such that the E3 frame includes the area defined for multiplexed and justified E1 signals as the payload area. However, no E3 CPE devices have been identified to test against. Based on support for DS3 and HSSI, Nortel is confident that Passport is capable of supporting E3 frame relay and looks forward to working with a lead customer which has identified suitable CPE devices.



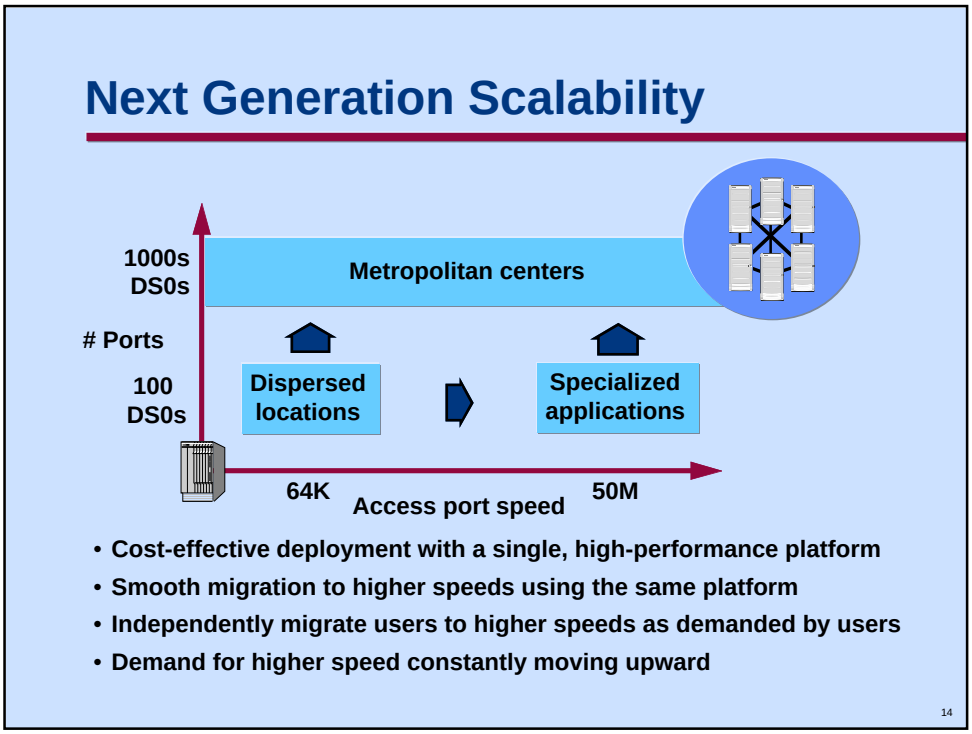
With all 14 slots deployed with channelized cards, using the 4-port DS1C card a total of 1344 - 64k virtual ports may be supported on a single shelf, or up to 2,688 ports in a cabinet in less than a 3 square feet footprint. Similarly the E1C card provides up to 1,736 channels in a single shelf which is over 3,400 channels in a footprint less than 0.3 square meters (two shelves per cabinet). Of course, every configuration will require trunking interfaces in some of the slots which will reduce total available channels for user access. Nonetheless, Passport provides a platform capable of supporting high densities of access ports.



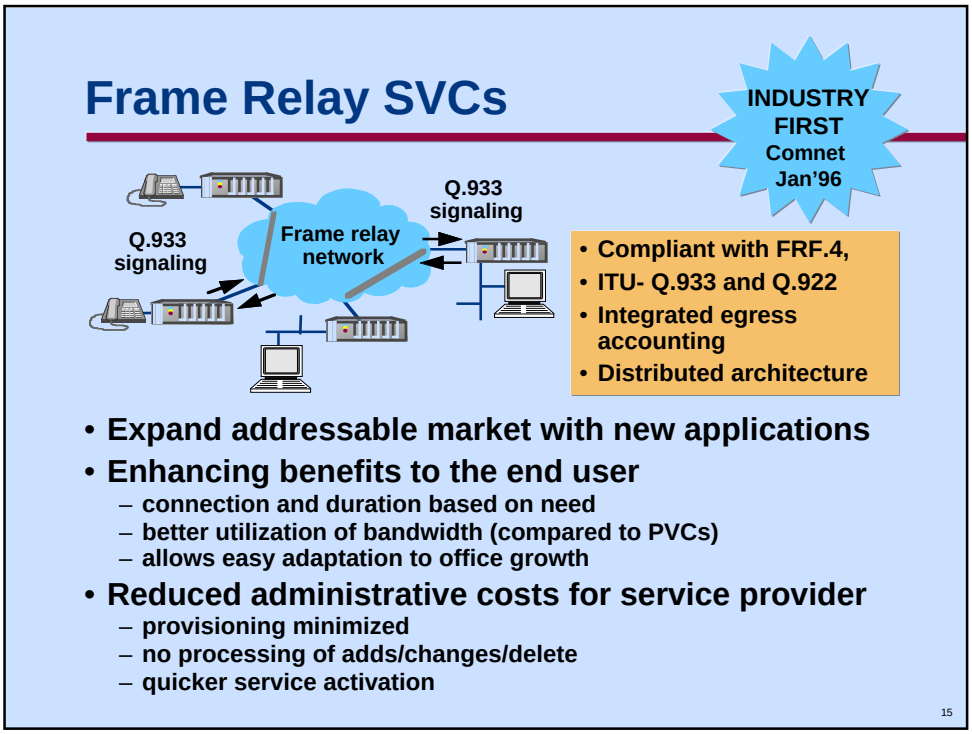
Performance improvements can be made through a software upgrade to Release 3 without any changes to the hardware. This allows one to improve the overall costs of ownership and/or profit margin as the network may potentially carry more capacity without a corresponding cost increase. This provides a very smooth evolution for users who are demanding higher speeds and more bandwidth, without requiring the user to be moved or purchasing additional interfaces.

Passport Release 3 is expected to deliver a total bidirectional throughput for frame relay of approximately 20,000 frames per second on the unchannelized cards. This represents a improvement of 100% from Release 1.3.9. Similarly, the maximum trunk functional processor (FP) bandwidth carrying frame relay traffic is expected to be greater than 70,000 frames per second, a improvement of more than 80%.

The final numbers, based on measurements at R3.3, will be available in the Engineering Performance and Specifications NTP which should be consulted for more detailed information.



Users are demanding increased speeds. High-speed frame relay at DS3/E3 rates are required for specialized applications or points of traffic concentration. These points may initially be few and dispersed. Similarly, lower speed is necessary for the majority of connections. These may be in several dispersed points of presence or concentrated in large metropolitan areas. The Passport model 50 provides a 5-slot chassis which uses the same cards and software as the Passport model 160, 16-slot chassis. Passport's high performance and flexible interfaces allow one to capitalize on all these users requirements and grow both dispersed low-speed and dispersed high-speed requirements as demanded by the users. The service provider or enterprise network manager is able to respond to these requirements quickly with Magellan frame relay.



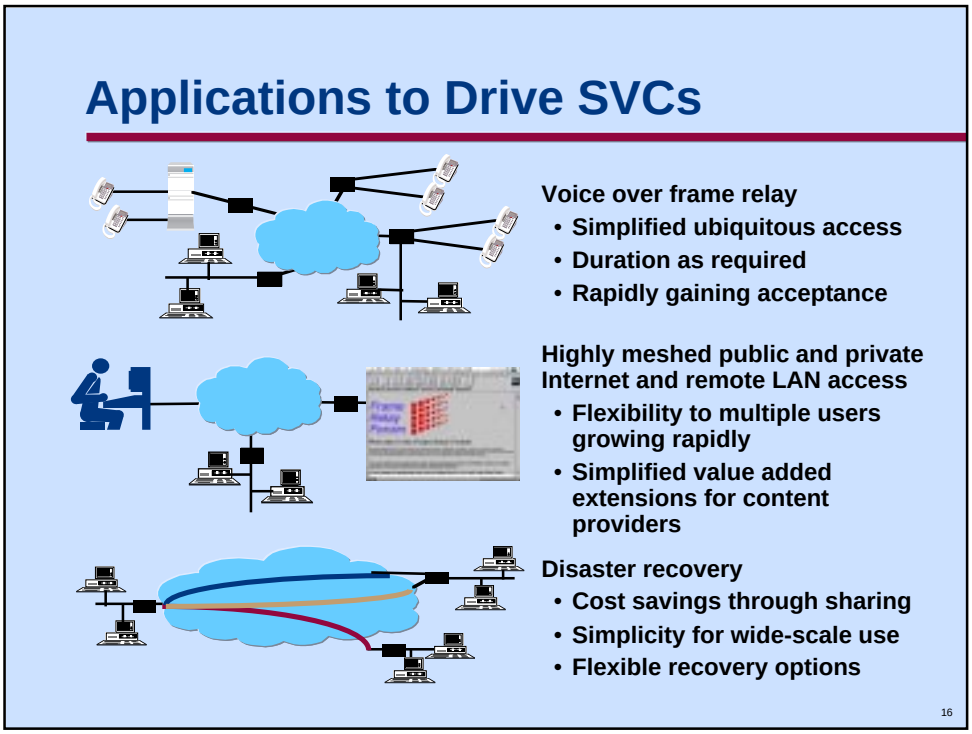
On January 29th, Nortel was the first to publicly demonstrate live SVCs with CPE equipment at Comnet in Washington D.C. The application included an advanced compression technologies (ACT) FRAD running voice over frame relay using SVC signalling. SVCs are available with Release 3.1 for trial as a software update with no hardware updates required.

In addition to carrying out exhaustive conformance testing against an HP PT502 protocol analyzer, Nortel continues to be active in practical interworking testing with lead CPE vendors as implementations become available. The Passport frame relay SVC service has been successfully tested against a router implementation of frame relay SVC. In addition to the ACT testing, Nortel has shared implementation details and consulted with a number of other CPE device vendors to increase the success of standards-based operation when their frame relay SVC implementations become available.

SVCs are fully compliant with all mandatory requirements of FRF.4, based on ITU Q.933 (signalling layer) and Q.922 (link layer).

One may signal delay priority using the transit delay selection indicator (TDSI) bit in the SVC call request. Optionally, each frame relay interface has a provisionable attribute to specify the maximum aggregate CIR and maximum aggregate EIR that can be allowed for SVC calls. The aggregate CIR and EIR of all the existing SVCs will not exceed the corresponding maximum values. If the DTE requests a call with CIR and EIR that will cause the aggregate CIR and EIR to exceed the maximum value, the call will be rejected.

As a key element of SVCs, egress accounting is available for effective service deployment. Magellan SVCs are based on a distributed architecture with no central server required for call set-ups. This provides maximum scalability and availability with reduced call set-up delays.

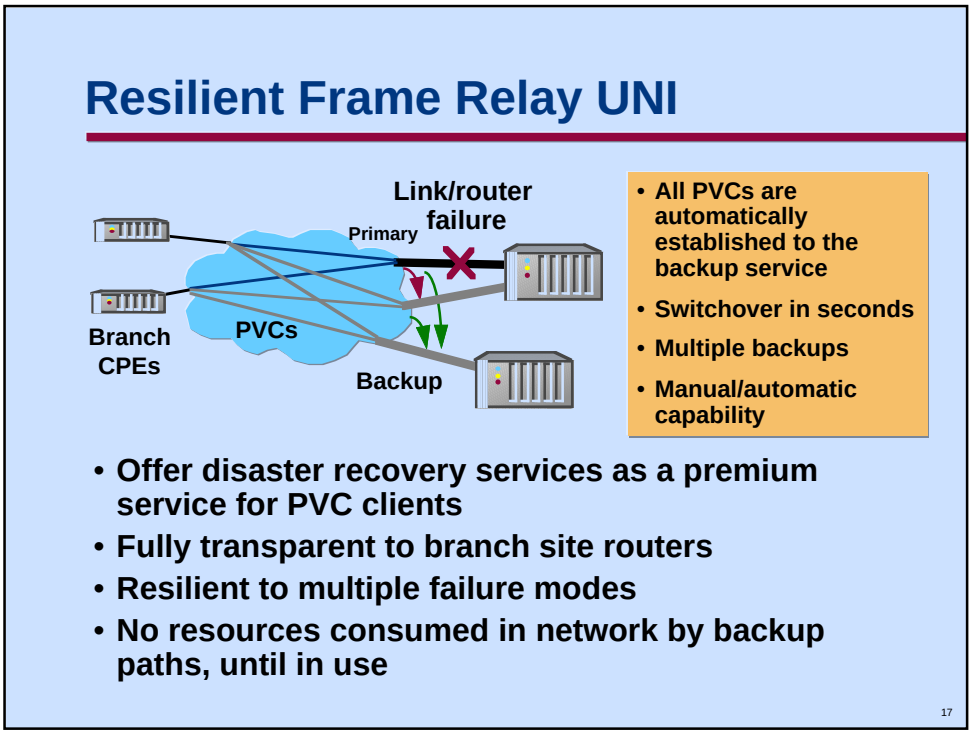


The general characteristics of services requiring SVCs include the ability to connect multiple remote sites on an intermittent basis. Scalability of pre-provisioned PVCs for ubiquitous any-to-any point access is growing beyond reasonable manageable limits. SVCs enable true peer-to-peer networking. Some applications which are emerging to drive SVCs are presented here for discussion. There will no doubt be many others.

The concept of voice origination is synergistic with SVCs - *on demand.* Usage based tariffing could contribute to further cost savings. Video conferencing is another application with similar connectivity requirements which could capitalize on SVCs.

The proliferation of Internet users has been exponential—estimated at 10 million users growing up to 40 million by the end of next year. Residential users are driving demand. Selective access to information providers is required. Access is often determined by time of day costs or services offered. In addition, companies are emphasizing work-at-home programs where access to corporate computing is essential.

SVCs provides increased flexibility for disaster recovery services. Disaster recovery locations would not have to be pre-defined, minimizing additional administrative services.



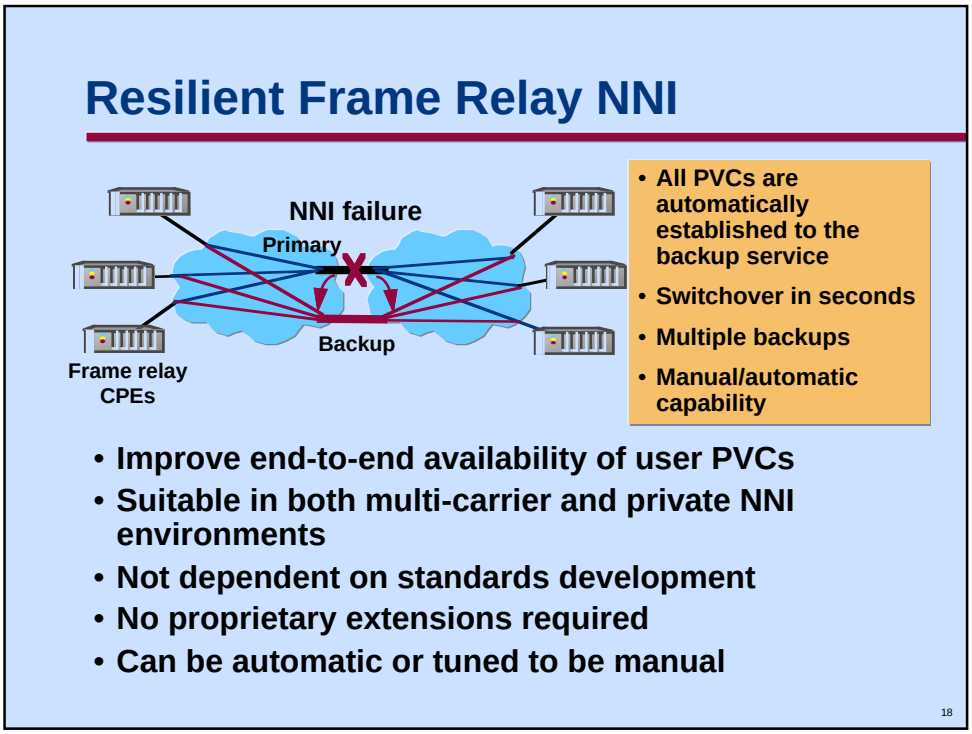
PVC backup is similar in functionality to X.25 call redirection. The backup links are not restricted to the same FP or even the same switch. They may be anywhere in the network including one end on Passport with the other end on DPN-100. Resilient FR UNI uses the DPN-100 call redirection server.

As illustrated, the backup link may be to the same router, providing resiliency against facility failure. In this case each of the links could back each other up with half the PVCs shared across the links during normal operation. Another backup application could be redirected to an entirely different site. Both of these scenarios could be implemented, providing failure against facilities as well as failure of a site since the primary link may have multiple backups which will be attempted in sequence.

The backup will automatically be invoked with any of the following failures:

- Node isolation (control processor failure or no operational trunks)
- Functional Processor failure carrying FR UNI service
- Access link failure
- LMI failure
- Port or DLCI locked

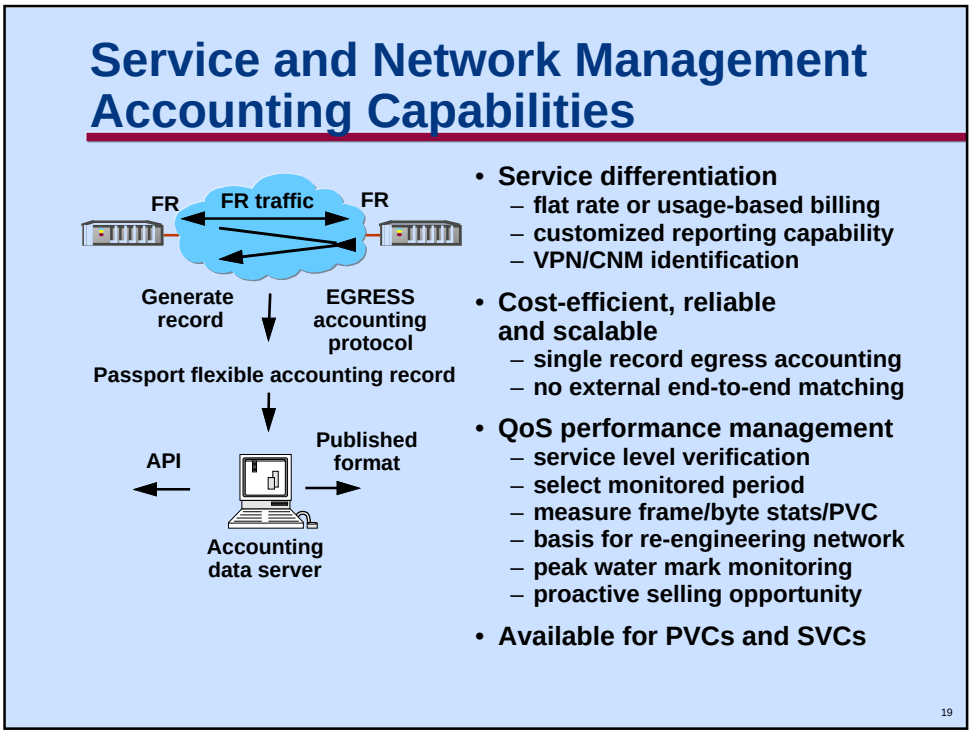
Resilient frame relay provides the opportunity for service differentiation. It is also ideally suited for enterprises with a key network concentraction (ie. host or server) locations.



Backup PVCs across an NNI increases the availability of PVCs between multi-carrier networks as well as potentially between a public carrier and a private frame relay network using a Private NNI. A resilient private NNI is a unique differentiator.

Resilient FR NNI automatically moves all PVCs on an NNI to a backup NNI. The same failures as outlined in resilient FR UNI will initiate the backup. As this action is taken without notification from the remote network, there is no signalling activity between the networks. Consequently, no standards are required for this implementation and there are no proprietary extensions required. Each network must be able to detect a failure and move the PVC end-points. The other network may choose a variety of mechanisms to achieve this including automated re-provisioning or even manual PVC relocation commands. Through the use of "lock" operator commands, the Magellan network may also manually initiate the backup in the event that specific synchronization with the other network is required.

In the case both networks are Magellan, the backups will be synchronized as each network would detect the same failure and move the PVCs.



This cross platform accounting capability provides highly detailed information on a per PVC basis on traffic movement across the network.

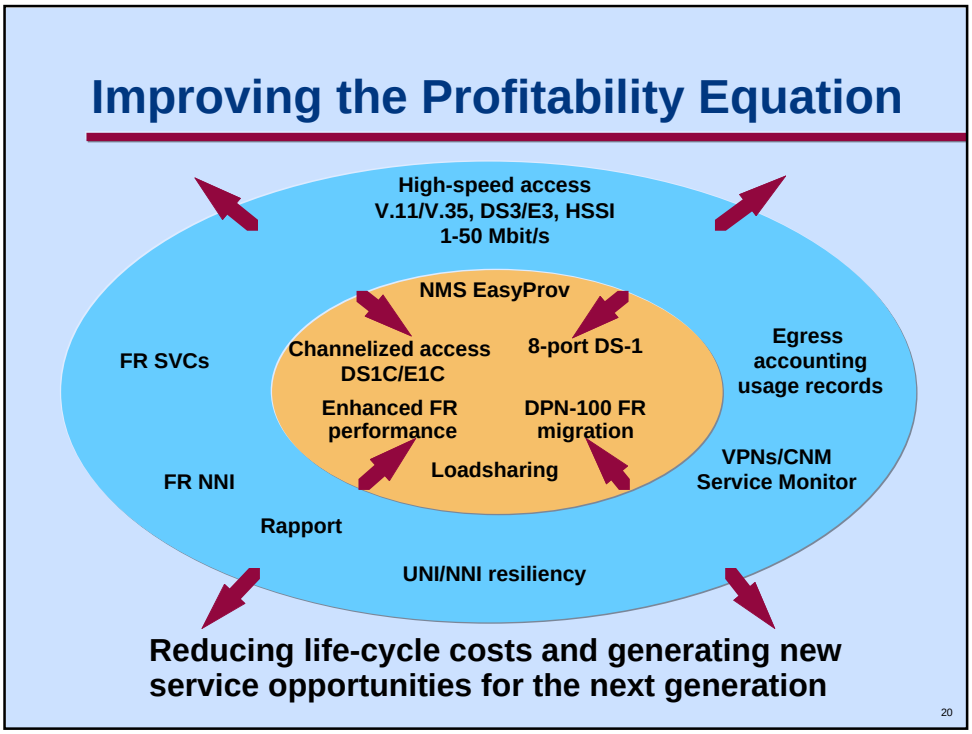
The views from each end of the PVC within the network are resolved and consolidated into a single record. These records are made available for off-net processing in a billing host via the published record format or the records can be made available via API to the planning and analysis tool set.

The ability to spool this data to local shadowed disks and dump off-network, as convenient, makes this a very robust and scalable accounting architecture.

Quality of service (QOS) measures include counts for all ingress and egress activity. Consequently, one can verify CIR and EIR service levels using traffic discarded by the network measurements. Also, the ability to track peak water mark (PWM) activity levels is provided. This means that, on a per DLCI basis, the activity throughout a time of day (TOD) period can be monitored in adjustable PWM windows of between one minute and fifteen minutes. The peak activity in each of these PWM windows is preserved and spooled at the end of the TOD period as part of the accounting record.

The peak amount of committed information (CIR), excess information (EIR) and the overall traffic are each individually captured.

Frame relay SVCs and PVCs both use the same egress accounting system. This accounting architecture will be used by ATM.



In addition to the frame relay features already discussed, Rapport, Loadsharing and NMS EasyProv also contribute to the profit model for a service provider or enterprise.

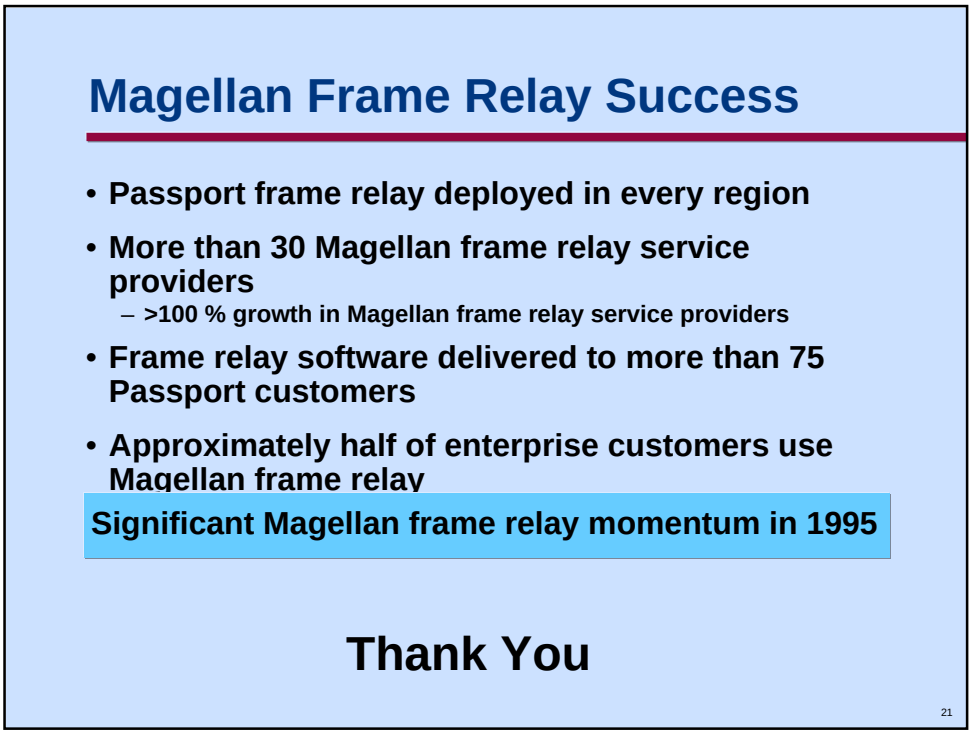
Rapport is a Nortel product line which provides dial-up remote LAN access. Several models are available ranging from 8 user ports to 672 user ports.

Loadsharing provides the ability to share the traffic across the links in a link group in a manner that is sensitive to the capacity of each of the links and provides the full bandwidth of the link group available to a DLCI.

NMS EasyProv is an improved provisioning process which allows both ends of the PVC to be provisioned in a single step.

Some customers have migrated DPN-100 users to Passport to take advantage of the higher performance or improved port densities. They have found this to be a very smooth process.

NNIs are operational with live traffic. Magellan NNIs have been successfully used by customers between Magellan and Stratacom, Cascade, Newbridge, BayNetworks (Wellfleet), Cisco, and N.E.T. equipment. At least one carrier in the U.S. is offering private NNIs.



1995 has seen the deployment of Magellan frame relay by many networks including both new networks and existing Magellan customer networks in regions throughout the world. There is a significant installed base to grow the service and establish feedback to improve the offering.

Thank you for your business. We look forward to continued success throughout 1996 and beyond, working with you to meet your business objectives.

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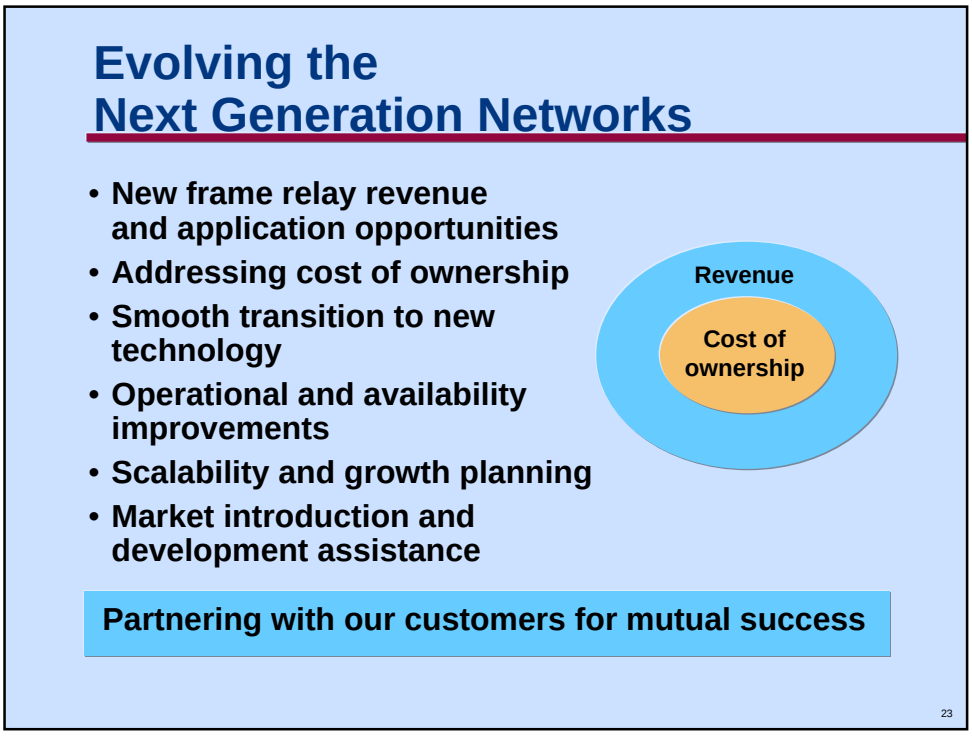
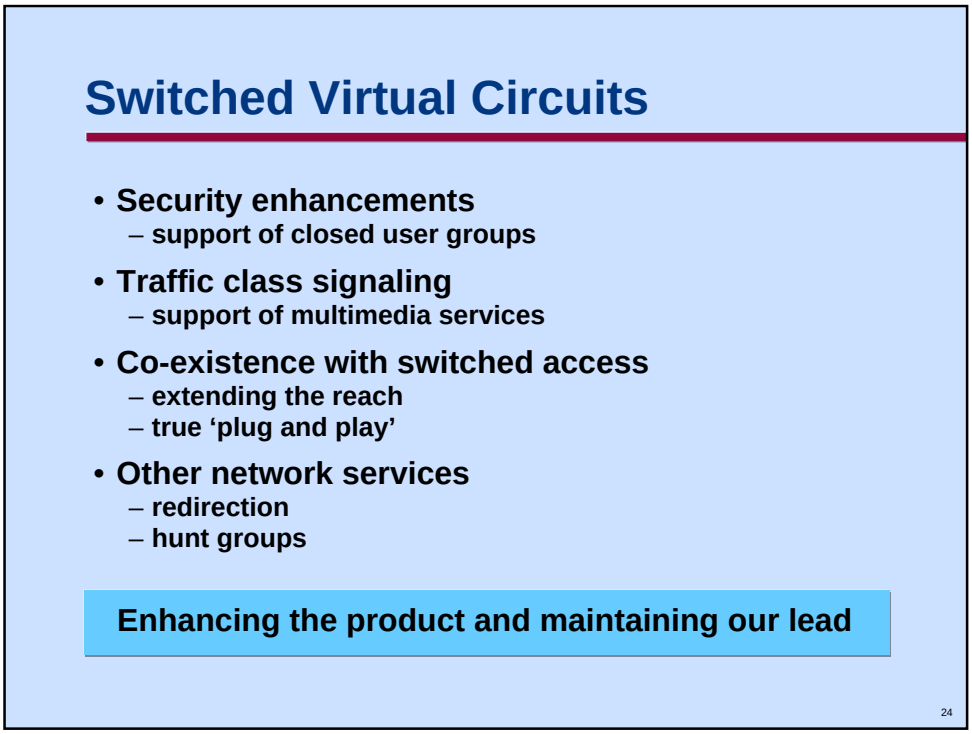


Elements of the business case for service providers and enterprises go beyond the technology and platform choice. As Magellan continues to evolve the frame relay portfolio, that evolution will also include partnering with our customers to deliver solutions, not simply features or changes to the platform.

Related sessions include the Passport Update workshop.



Magellan will be adding powerful value-added capabilities to augment the service building opportunities of frame relay SVCs on Passport.

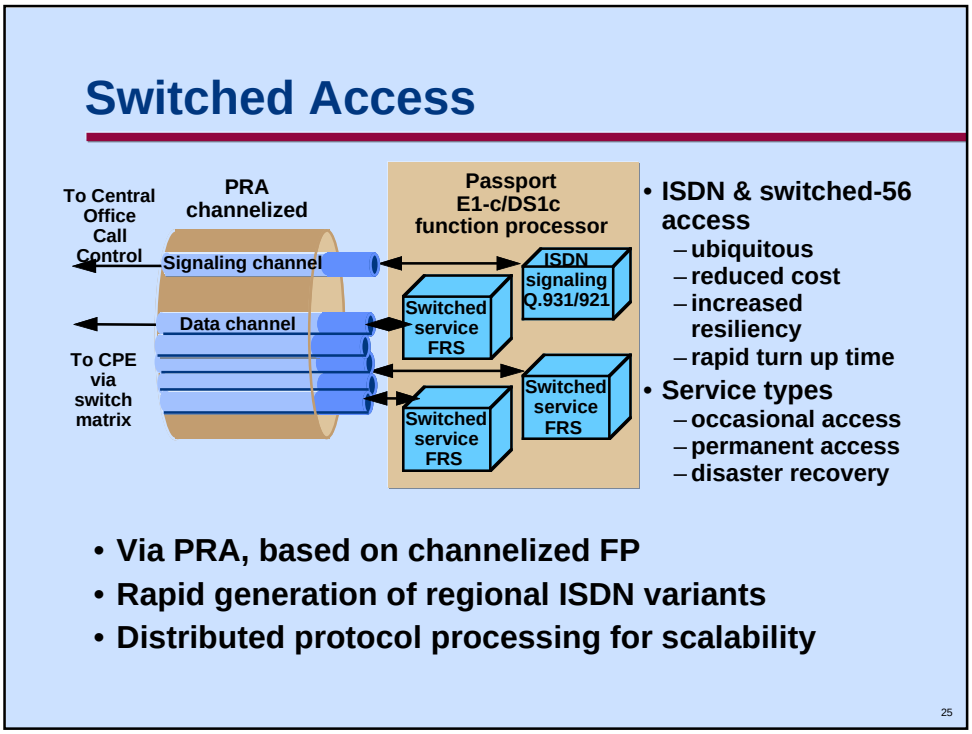
Magellan's experience in implementing network-wide services will be brought to bear in providing closed user group support for network based security.

The ability for user devices to select, on a per PVC basis, the traffic class desired will also be provided.

In both the above cases, Nortel is participating in the ITU-T and the frame relay Forum to standardize signalling for these functions.

The coexistence of SVCs with switched access potentially provides a very powerful 'plug and play' capability for user devices using a first stage access via Q.931 signalling to establish a circuit to the Passport followed by Q.933 signalling in band for virtual connectivity.

Access to other network services will be delivered as commercial and application requirements warrant. Services such as redirection and hunt groups can be deployed in a switched frame relay environment for much the same purposes as they have been successfully deployed in the X.25 world.



The availability of ISDN service at highly competitive tariffs provides an opportunity for a frame relay access vehicle to complement conventional leased line access.

The use of ISDN (or switched-56 where available) can provide the opportunity for a number of service types to be supported for the occasional access user, for permanent switched access or for disaster recovery.

This development will be supported in the E1c and DS1c channelized cards for high fan in and low cost per ISDN user.

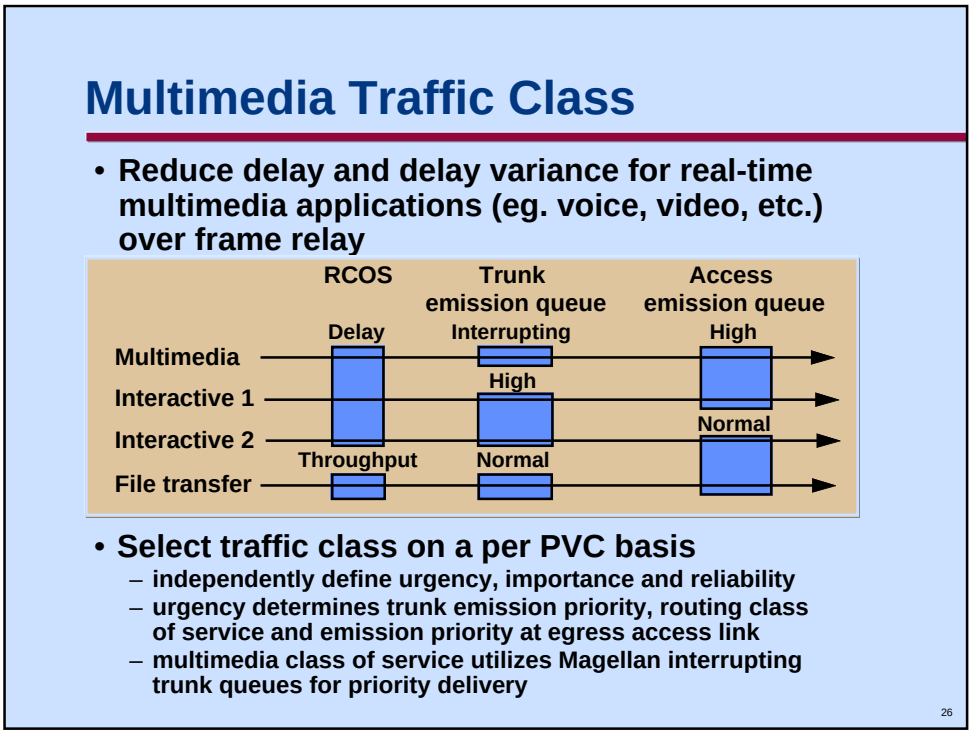
The design approach is to employ the Meridian protocol stack to minimize a development effort and provide the ability to rapidly produce regional variants for global certification.

Protocol processing will be distributed rather than implemented on a centralized platform for better scalability.

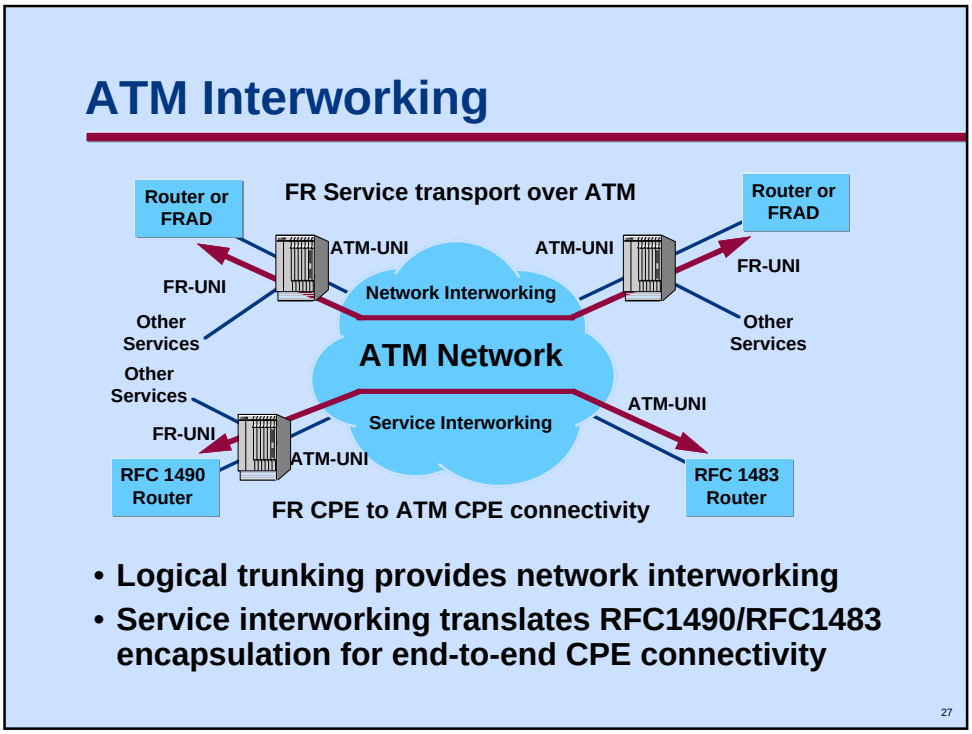
The service can be deployed as a simple software upgrade without requiring any additional third party hardware or software in the network.

User authentication will be provided via examination of the Calling Line IDentification (CLID passed over the PRA).

Both frame relay PVC and SVC will be supported.



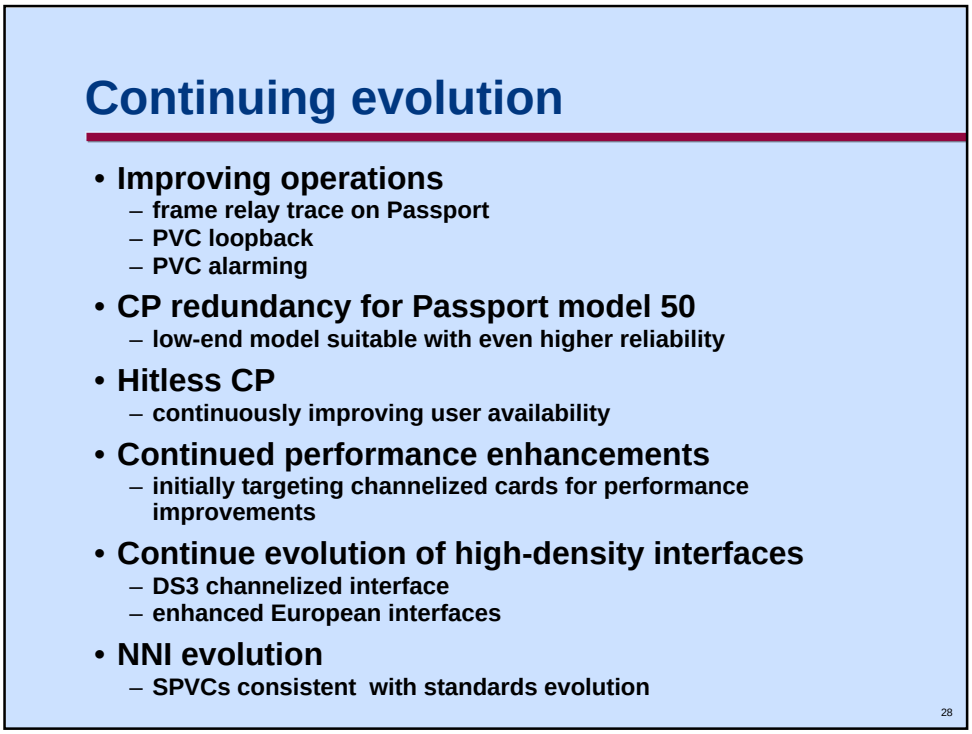
The multimedia traffic class is a new traffic class for frame relay to optimize delay and delay variability. It is ideally suited for real time interactive multimedia applications. The frame relay traffic makes use of Magellan's interrupting trunk queues which were designed for CBR (constant bit rate) type services. DLCIs set with this new traffic class will choose the least delay route (ie. the delay routing class of service (RCOS)). In addition, frames in the interrupting trunk emission queue will be serviced immediately. Existing transmission of high or normal priority traffic will be interrupted. Once the multimedia frame has completed transmission, the frame which was interrupted will continue transmission from where it was first interrupted. The operation of normal and high priority queues remains unchanged with high priority traffic being transmitted ahead of normal priority traffic. Finally, at the egress queue for the access link, multimedia traffic and high priority emission traffic will be transmitted to the CPE access link ahead of normal priority traffic.



Network interworking via Passport ATM logical trunking allows service providers and enterprises to take advantage of ATM infrastructures. With support for both ATM as well as frame/cell trunks in a network, one may take advantage of ATM where feasible and economical without upgrading the whole network. As ATM continues to evolve, Passport provides an excellent multimedia service switch to ATM backbones.

Passport service interworking enables ATM CPE devices to connect with frame relay CPEs. Initially it is anticipated that backbone routers may migrate to ATM with the numerous branch routers using frame relay. Significant growth of either branch or backbone routers may use ATM depending on economics and availability. Frame relay to ATM service interworking provides RFC1490 frame relay multi-protocol encapsulation and RFC1483 ATM multi-protocol encasulation transalation enabling the flexibility to build such CPE mixed networks.

Frame relay to ATM interworking is described in further detail in the “Magellan Passport: ATM Applications” workshop.



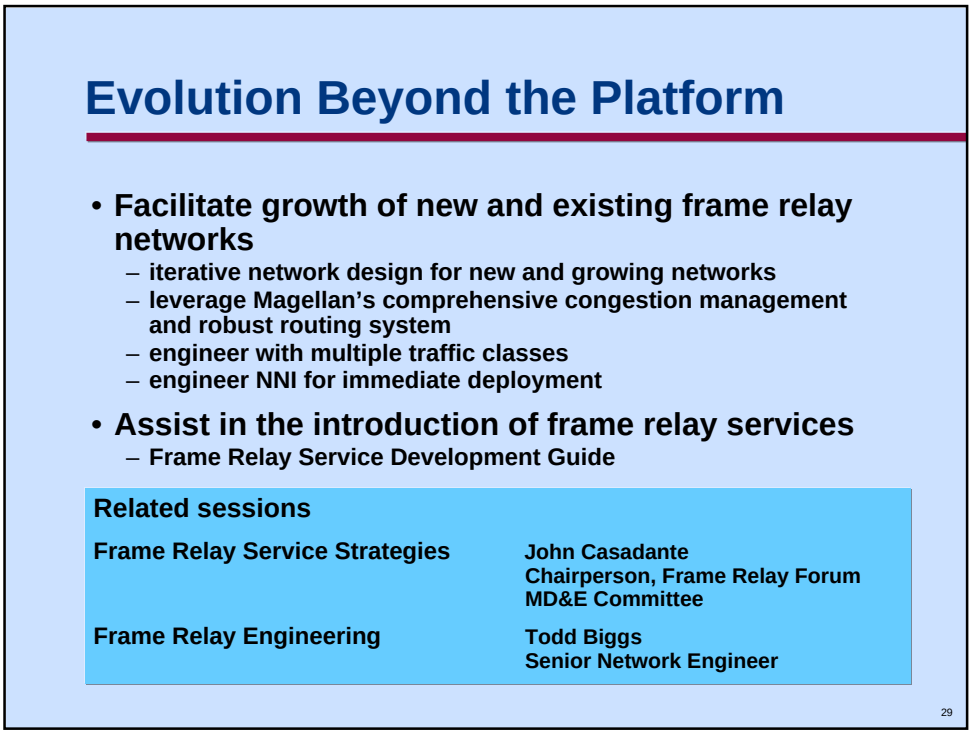
Additional tools will be provided to improve overall operations efficiency. Frame relay trace on Passport provides the ability to trace specific frame relay DLCIs using a number of filters to minimize the quantity of traced data while providing the operator with key information. This will be integrated into the existing trace receiver system. In addition, the ability to loop back a specific DLCI through an operator command further enhances the troubleshooting and installation toolset. Based on customer feedback, a requirement to provide notification of failed PVC was identified. A failed PVC across the network will generate an interface alarm. This option will be provisionable on a per DLCI basis. In addition, an operator command will be introduced to override the provisioned setting to select or remove a DLCI for maintenance or installation purposes.

CP redundancy on a Passport model 50 provides a smaller switch with the same high system availability as a redundant Passport model 160. Using channelized cards for frame relay access, even a redundant Passport model 50 could support more than 200 low-speed frame relay connections or a mix of high-speed and low-speed frame relay.

Hitless CP will preserve user service connectivity in the event of a CP failure, further enhancing availability.

To continue the momentum from 1995, Magellan next-generation frame relay evolution will include additional performance improvements and higher density devices. A channelized DS3 will provide a full 28 DS1s. Nortel would like to continue dialogue to determine the next best step for European interfaces where E3 may not be generally available or feasible for concentrated access.

Evolution of the NNI standards is converging on using SVCs across the NNI while maintaining a PVC to the user. These switched PVCs (ie. SPVCs) are intended to primarily address improved resiliency.



Nortel believes that successful service evolution means working with our customers on aspects beyond just the platform itself. Two related frame relay workshops address some of these areas and Nortel would like to continue to develop solutions to meet your overall needs.

Magellan is currently developing a frame relay Service Development Guide for service providers introducing frame relay. It will initially focus on the North American market but is applicable throughout the world leveraging the North American experience. Topics include developing a strategy for a service provider to sell frame relay, choosing a pricing structure, evolution of North American services and tariffs, sales strategy and marketing program guidance, organizational requirements for operations and service management for a start-up provider, service launch and implementation, and more.

Summary

- **Rapid market growth continuing through 1998**
  - opportunities for both service providers and enterprises
  - gap between North American and rest of world markets is narrowing with explosive global growth
- **Nortel focus on customer profitability**
  - addressing cost of ownership and value-added revenue opportunities
- **Significant customer base established**
  - commitment to evolution and growth through partnering with our customers

Thank you for choosing Magellan frame relay

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