TMX 880™ MPLS Core Switch

Provisioning ATM and Frame Relay Virtual Circuit Services with an MPLS Core

Economic Study

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This document is part of a set of three case studies evaluating the economic benefits of a converged MPLS multiservice core. The studies in this series include:

- Economic Overview:
  Cost Justifying a Converged MPLS Multiservice Core
- Economic Study:
  Provisioning ATM and Frame Relay Virtual Circuit Services with an MPLS Core
- Economic Study:
  Identifying the Network Path of an ATM/Frame Relay Virtual Circuit Service with an MPLS Core

Executive Summary

This study examines the economic and operational impact on virtual circuit (VC)/label switch path (LSP) provisioning of an existing ATM/Frame Relay (FR) network built with CBX 500® and GX 550™ Multiservice WAN Switches when upgraded with an MPLS switch core. Specifically, the analysis compares the time requirements and costs associated with VC and LSP provisioning in CBX 500®/GX 550™ switched networks that have been upgraded with a TMX 880™ MPLS core switch versus CBX 500®/GX 550™ networks that have been upgraded with a third-party MPLS core router. The study examines the changes in operations and expenses associated with each migration path.

The Lucent Navis™ iOperations software and Virtual Network Navigator™ (VNN™) multiservice architecture used in the CBX 500®/GX 550™ operating environments are key contributing factors to the profitability of today's ATM and FR service solutions. Using the TMX 880™ switch as the MPLS core switch within these networks enables service providers to continue using their current GX 550™ and CBX 500® switch operating environment and maintain a low cost structure to support profitable ATM and FR services. Navis™ network management software's (NMS) unique ability to integrate ATM-MPLS operations combined with the TMX 880™ switch's unique *Fluid Signaling* capability reduces complexity and equips network administrators to efficiently manage ATM, FR and IP traffic across a converged MPLS core. Because operators continue using Navis™ software and VNN™ to provision VCs, their current service provisioning operations model and associated expenses remain unchanged.

In contrast, operators that upgrade their CBX 500® and GX 550™ networks with a router or third party MPLS core switch solution that lacks these integrated ATM-MPLS features may increase administrator provisioning time by approximately 7.2 minutes for each new VC. If a service provider provisions 2,000 VCs each business day, a router-based MPLS core can add $8.3M+ annually to the operating cost of these services.

Using the TMX 880™ switch as their MPLS core switch within these networks enables service providers to continue using their current GX 550™ and CBX 500® switch operating environment and maintains a low cost structure to support profitable ATM and FR services.

Provisioning ATM and FR services in CBX 500®/GX 550™ networks

Today, many service providers with Lucent equipment use Navis™ software and VNN™ to establish new ATM/FR services for their customers. Figure 1 below illustrates a typical ATM/FR network built with the CBX 500® and GX 550™ switches, and managed by Navis™ network management software.

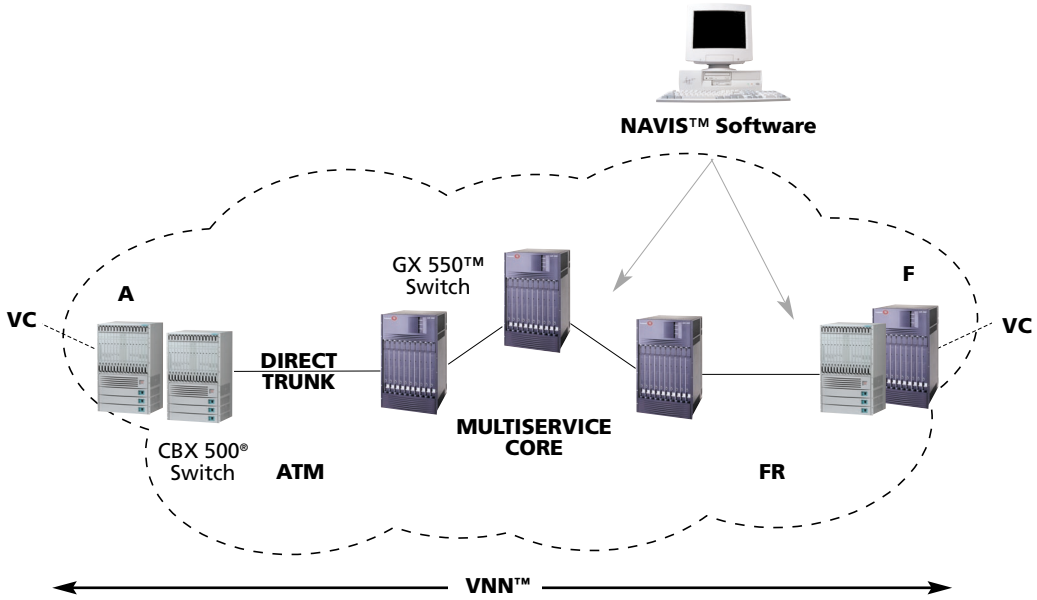

Figure 1 - Navis™ Network Management Software Automated ATM/FR Provisioning

Provisioning ATM and FR services over an MPLS core

This portion of the study focuses on the changes in daily ATM/FR VC service provisioning associated with adding an MPLS switch core to the current CBX 500®/GX 550™ network. The study compares two different MPLS core scenarios. In the first scenario, the service provider upgrades the current ATM/FR network by adding a TMX 880™ MPLS core switch and continues to use Navis™ software and VNN™ for VC and LSP provisioning. In the second scenario, the service provider upgrades the current ATM/FR network by adding a third-party MPLS core router. In this situation, the service provider uses Navis™ software and VNN™ to provision VCs in the GX 550™ and CBX 500® switched sections of the network and the Command Line Interface (CLI) to provision the ATM to MPLS cross-connect, MPLS LSPs and MPLS core router.

The following two sections compare the activities and estimated costs associated with provisioning a new ATM VC customer service transported across an MPLS core in each scenario.

Understanding the changes associated with adding a TMX 880™ MPLS Core. From an administrator's perspective, the process and the time to completely provision new VCs is not affected by introducing a Release 9.0 TMX 880™ MPLS core switch. Because the TMX 880™ switch uses VNN™ and *Fluid Signaling*[1] to enable the ATM and MPLS domains to interoperate, **provisioning a new VC still takes only one to two minutes**.

Since MPLS LSPs are uni-directional and FR/ATM circuits are bi-directional, the MPLS core must select two uni-directional LSPs with the same bandwidth, QoS and policies as the ATM/FR circuits require. In the TMX 880™ MPLS core switch, *Fluid Signaling* and VNN™ work together to automatically map a bi-directional ATM/FR VC into a pair of uni-directional label switched paths (LSPs) that meet these requirements.

Figure 2 illustrates this interoperability. In Figure 2, ATM/FR VC traffic is mapped into LSPs A and B at label edge routers (LERs) C and E. Within the MPLS core, this traffic is dynamically mapped to the appropriate TMX 880™ switch queue based upon ATM QoS. The TMX 880™ switch forwards the traffic across the MPLS core in trunk LSPs based upon its class of service and destination. (See Appendix A for a more detailed description.)

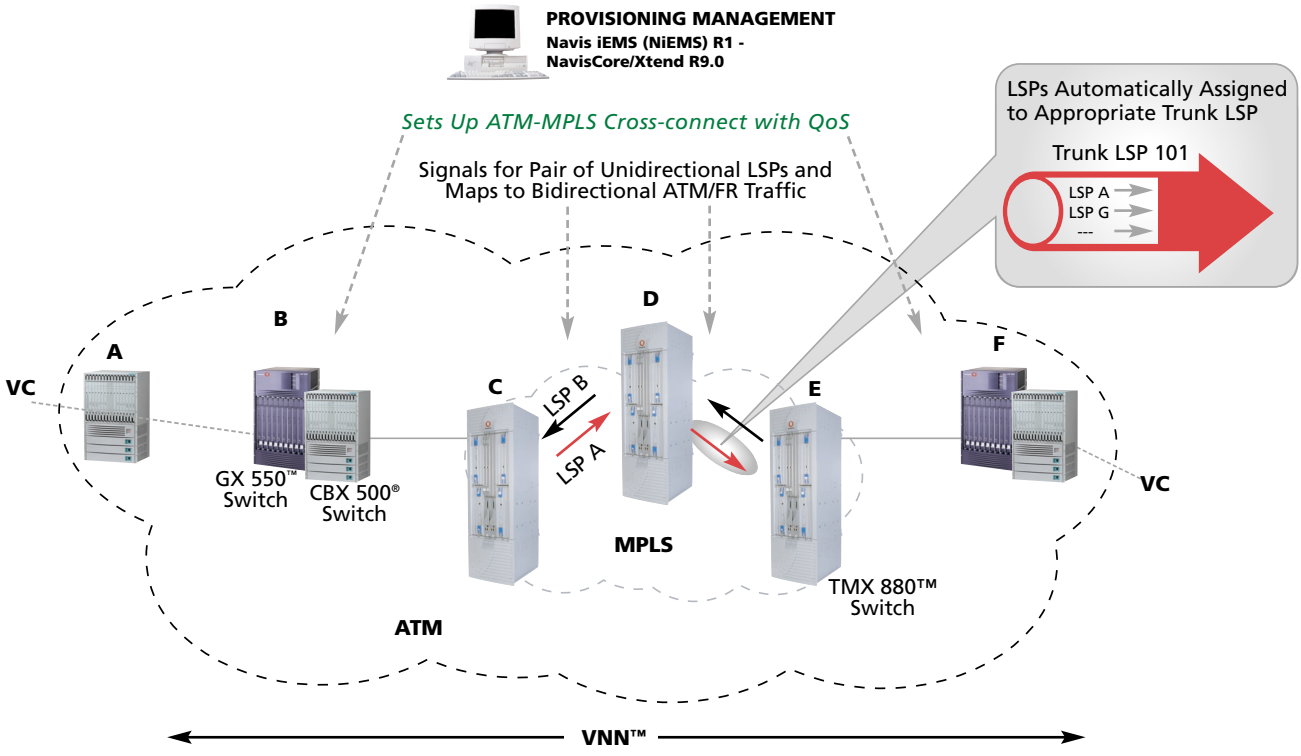

Figure 2 - Navis™ Automated ATM-MPLS Integrated Provisioning

1. *Fluid Signaling* enables service mapping and interworking across the ATM VNN™ and MPLS domains.

Provisioning services over a TMX 880™ MPLS core takes approximately 1-2 minutes per VC. Provisioning services over a router-based MPLS core takes an average of 8.2 - 9.2 minutes per VC.

Because the TMX 880™ switch supports both VNN™ and *Fluid Signaling*, the MPLS core can automatically create VC to LSP cross-connects while preserving ATM QoS and end-to-end operations. Consequently, the day-to-day permanent virtual circuit (PVC), soft permanent virtual circuit (SPVC), and switched virtual circuit (SVC) service provisioning activities with Navis remain unchanged when traffic is sent over a TMX 880™ MPLS core switch.

To provision services over the TMX 880™ MPLS core switch, the administrator uses Navis network management software to point and click on the network endpoints (A and F in Figure 2). After the administrator defines the specific service characteristics on the two endpoints, VNN™ automatically selects and establishes the path across the ATM part of the core. *Fluid Signaling* on the TMX 880™ switch automatically creates the ATM to MPLS cross-connect (C and E in Figure 2). The TMX 880™ switch automatically establishes the path for traffic associated with a new VC across the MPLS core based upon the incoming traffic's QoS and the network's policy, topology, and available resources. (See Appendix A for a description of the steps involved in provisioning a new VC service over a TMX 880™-based MPLS core.)

The entire service provisioning process takes approximately **1 to 2 minutes per VC.**

Understanding the changes associated with adding a router-based MPLS core. Alternatively, service providers can add a router-based MPLS core to their existing CBX 500® and GX 550™ ATM/FR networks. In this scenario, administrators provision new VCs by:

1. Using Navis to provision the service in the ATM network
2. Manually planning the VC to LSP mapping by:
   a. Using NavisCore to identify the path VNN™ selected at each end of the ATM network connected to the MPLS core
   b. Identifying the LSP to use in each direction
   c. Logging information into a VC to LSP mapping database tool
3. Executing a dozen CLI commands to set up the ATM to MPLS cross-connect (two uni-directional LSPs for each bi-directional ATM/FR VC)

In Figure 3, the administrator manually provisions ATM to MPLS cross-connects on the two routers at the network edge. The cross-connects map bi-directional VC traffic onto the uni-directional LSP A and LSP B in the MPLS core. (See Appendix B for more information on using a CLI to provision services and administer the ATM to LSP cross-connect.)

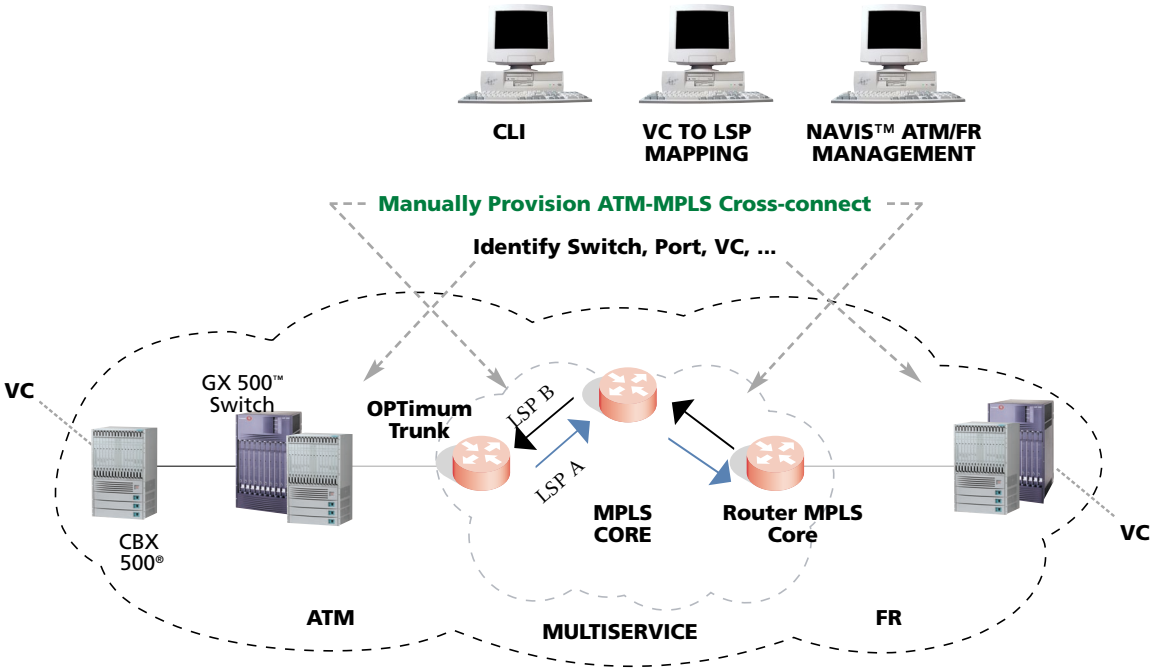

Figure 3 - Manual VC Provisioning with a Router MPLS Core

Service provisioning in a network with a router-based MPLS core **takes an average of 8.2 to 9.2 minutes per VC.**

To simplify the process of identifying the ATM to MPLS domain linkages in the cross-connect, service providers may use a separate VC to LSP mapping database tool. However, introducing a separate database increases the risk of using inaccurate data. Without automatic updates, the database may contain errors from manual data inputs, from routine switch changes, and from changes made to the network during network restoration and fault management activities.

Evaluating the economic impact of adding an MPLS core

This section compares the impact on provisioning costs of both scenarios described in Section 3. The numbers in this section are for a service provider that turns up 2,000 new ATM VC services each business day.

Service providers who upgrade their existing CBX 500® and GX 550™ ATM networks with an MPLS core based on the TMX 880™ core switch experience no change in overall provisioning costs—if they continue to use Navis™ software to provision new VCs. In contrast, service providers who upgrade their CBX 500® and GX 550™ ATM networks with a router-based MPLS core will require **an additional 62,000 hours** of administrator time. These providers will incur **an additional $8.3 million annual cost** to create the new services. (See Figure 4.)

Annual Incremental Cost with Provisioning VCs with a Router-Based MPLS core
(or a third party MPLS switch without integrated ATM-MPLS features)

#VCs/DAY	ANNUAL INCREMENTAL COST
500	$ 2.1M+
2,000	$ 8.3M+
5,000	$20.7M+

Assumption: $133/hour loaded labor rate ($100/hour with 75% productivity)

Calculation: (7.2 minutes/VC x 2,000 VCs/day) / 60 min/hour x $133/hour x 5 days/week x 52 weeks/year = $8.3M+ annual incremental expense with a router or third party switch MPLS core.

Note: A plus is added to the results in the Annual Incremental Cost column since service providers typically provision services more than 5 days per week.

Figure 4 - Annual incremental costs associated with a router-based MPLS core

Service providers migrating to MPLS using the TMX 880™ MPLS core switch can continue with an automated VC/LSP service environment using the integrated Navis management system and VNN™ combined with *Fluid Signaling* to automatically establish the ATM to MPLS cross-connect. This automated solution reduces the chance of routing and provisioning errors that can further increase labor costs and end-user dissatisfaction. In contrast, service providers with router-based MPLS cores must use two or three management systems (Navis, the CLI, and the optional VC to LSP mapping database) to set up the ATM to MPLS cross-connect. This is the case even if a third party vendor develops a GUI-based provisioning tool for ATM to MPLS cross-connects for provisioning router MPLS solutions. This complicated procedure creates additional equipment and training costs for service providers over and above the costs shown in Figure 4 and increases the risk that provisioning errors will lead to a dissatisfied customer.

Conclusion

The Lucent TMX 880™ MPLS core switch solution brings the ATM/FR connection-oriented experience to MPLS with unique capabilities such as integrated ATM-MPLS operations. This enables service providers to maintain their current profitable ATM/FR operations environment (Navis™ software, VNN™) and cost structure while realizing the benefits of an MPLS core. In contrast, router MPLS core solutions with operations using connectionless management tools (CLI) increase the cost of providing ATM/FR services.

Figure 5 summarizes the benefits of upgrading existing CBX 500® and GX 550™ networks with the Lucent TMX 880™ MPLS core switch versus implementing a router or third party MPLS core solution that lacks these integrated ATM-MPLS operations.

Total Network Navis Solution with VNN™ Managing CBX 500®/GX 550™ with a TMX 880™ MPLS Core	Navis Solution with VNN™ for Provisioning CBX 500®/GX 550™ and CLI for Provisioning ATM to MPLS Cross-Connect and Router/Third Party Switch MPLS	Number of VCs provisioned per day
No Change in current operations	7.2 Minutes Each	VC Provisioning Time
No Change in current operations	Additional $ 2.1M+ Annual Cost	500 VCs / Day Provisioning
No Change in current operations	Additional $ 8.3M+ Annual Cost	2,000 VCs / Day Provisioning
No Change in current operations	Additional $ 20.7M+ Annual Cost	5,000 VCs / Day Provisioning

Figure 5 - ATM/Frame Relay VC Provisioning with an ATM-MPLS Core

Appendix A: Provisioning VC services on a CBX 500®/GX 550™/TMX 880™ network

With the introduction of TMX 880™ Release 9.0 and beyond that supports VNN™, Direct Trunking, and *Fluid Signaling* into a CBX 500®/GX 550™ network, the administrator continues to provision new VC services through NavisCore™ Provisioning Server. After the administrator provisions the two end-points, VNN™ selects and establishes the path across the ATM part of the core. Completing this process requires the administrator to use between four to seven NavisCore screens. Many fields in these screens provide a scrolling list of values to choose from or are pre-populated with defaults that the administrator typically only needs to review and leave unchanged. Provisioning a new VC service in NavisCore™ software typically takes a couple of minutes. (With the Navis™ Provisioning Server, administrators can use scripts for bulk transactions for provisioning driven by a service provider's own service provisioning system.)

VNN™ automatically selects the path through the ATM network domain based upon QoS, policy, switch connectivity and available resources.

Understanding the process. Provisioning a new VC service through NavisCore requires the administrator to:

1. Establish the logical port (Lport) for the new customer on the specific physical ports where the new VC service will enter and exit the CBX 500®/GX 550™ network. To administer each end, the administrator uses two to three screens, including the Switch, Back Panel, and L-Port screens.
2. Select the Add button on the Set all PVCs on MAP dialog box to bring up the Select End Logical Ports screen. On this screen, which displays information for the endpoints:
   a. Select the names of each switch endpoint and L-port on which the new VC service resides.
   b. If required as part of the service, add fault tolerant PVC or resilient LMI information.
   c. Click OK.

   NavisCore™ software opens the Add PVC screen.
3. In the *Add PVC* Screen, enter the *Virtual Path Identifier* (VPI) and *Virtual Circuit Identifier* (VCI) values for both ends of the VC. Click the Attributes buttons on this screen to access the administration, traffic type, user preference, and statistics fields in the bottom section of the screen. Navis™ software is typically configured so that standard service values appear automatically in these fields. Consequently, administrators do not need to edit most of these fields.

For example:

   a. To edit the administration information, click *Administration*. In this section, administrators enter the circuit name and select values for up to seven fields; these include: enable, disable, and set a value for the admin threshold cost; enable, disable, and set a value for the end-to-end threshold delay.
   b. To define the type of traffic flowing on the circuit, click *Traffic Type*. In this section, administrators enter information that includes the QoS, priority, and traffic descriptor (PCR, SCR, MBS, MCR) for traffic flowing in both the forward and reverse directions.
   c. To enable or disable other features such as graceful discard, click the *User Preference* button.

4. If the service provider plans to bill for the service, the administrator clicks the Accounting button and completes the required fields on the Accounting screen.

After the administrator provisions the endpoints, VNN™ automatically selects the path through the ATM network domain based upon QoS, policy, switch connectivity and available resources. In Figure 6 below, VNN™ uses the paths from **A to B to C** and from **E to F** to support the service.

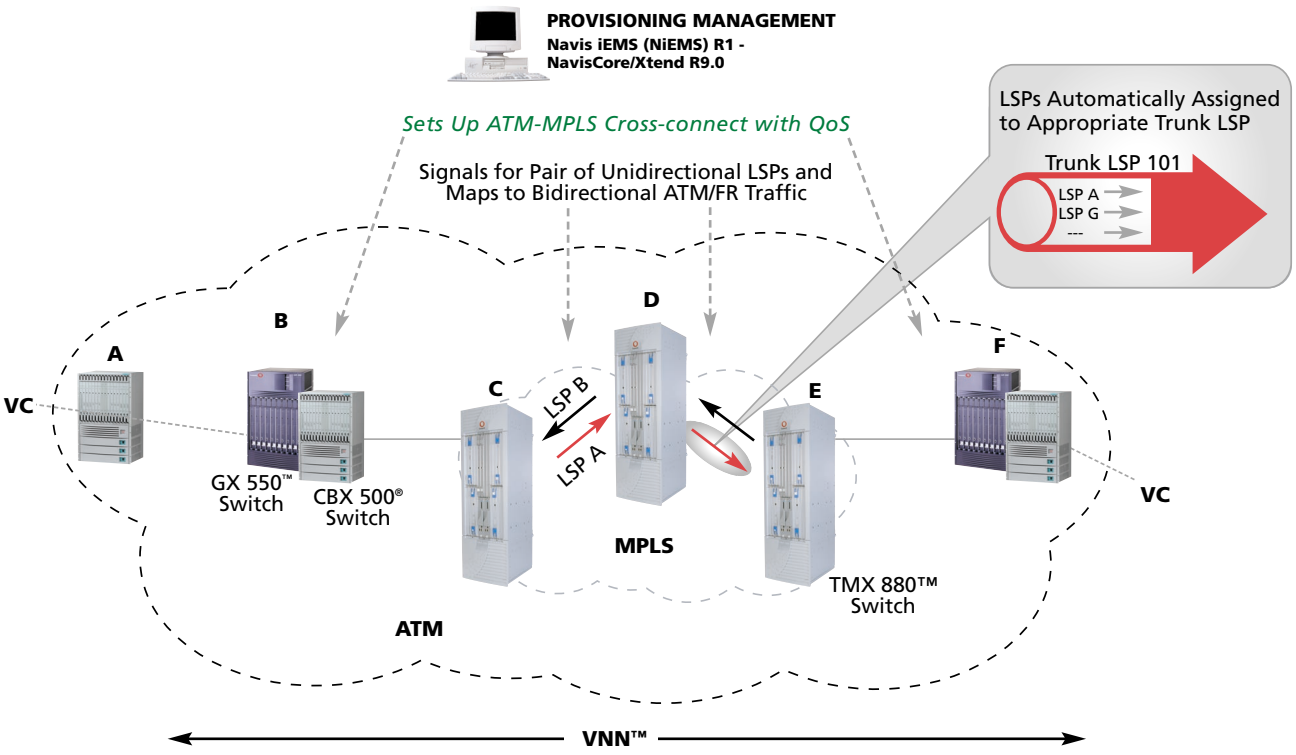

Figure 6 - ATM/Frame Relay VC Provisioning over a TMX 880™ core

The TMX 880™ switch (**C and E** in Figure 6) uses VNN™ and *Fluid Signaling* to automatically establish the path for traffic associated with a new VC across the MPLS core. The TMX 880™ switch bases its path decisions on the traffic's QoS and the network's policy, topology and available resources. The TMX 880™ switch automatically establishes Trunk LSPs to connect each endpoint on the MPLS core. The TMX 880™ switch creates one Trunk LSP for each class of service with a defined minimum bandwidth based upon policy

For each new VC, constraint-based shortest path first algorithms such as OSPF-TE select the route for the VC across the MPLS core based on available resources, policy, and connectivity. This route corresponds to a specific pair of stateful Trunk LSPs. Each new VC is dynamically assigned a pair of new uni-directional stateless LSPs. Using label stacking, these stateless LSPs are automatically associated with the appropriate Trunk LSPs so the VC traffic takes the designated path across the MPLS core. The TMX 880™ switch in the core of the MPLS network domain (D in Figure 6) provides industry-standard MPLS LSR functions. **The current total estimated service provisioning time of 1 - 2 minutes per VC using NavisCore remains unchanged after adding a TMX 880™ MPLS core.**

Appendix B: Provisioning new VC services on a CBX 500®/GX 550™ network with a router MPLS core

Service providers that add a router-based MPLS core to their CBX 500®/GX 550™ ATM networks incur additional administrator time and costs when they provision new VC services. The additional labor result in an average time of 8.2 – 9.2 minutes to provision each new VC service. This additional time and labor represents a 360%+ increase over the one to two minutes required to provision the service in the CBX 500®/GX 550™ network before the MPLS core upgrade.

Provisioning VCs in the new network is broken down into two pieces:

1. Provisioning the service in the CBX 500®/GX 550™ ATM portion of the network through Navis
2. Provisioning the ATM to MPLS cross connects in the router-based MPLS core using a CLI

Assumptions. This analysis assumes that the service provider elects to maintain a separate VC to LSP mapping database tool to simplify the process of linking ATM and MPLS domain information. This makes the process more manageable (less complex) but requires additional labor, adds error risk, and increases cost. Further this analysis assumes that the administrator establishes OPTimum Trunks ahead of time between the CBX 500®/GX 550™ network and the router MPLS core, and that VNN™ selects the appropriate trunk to forward traffic to and from the MPLS core.

Finally, the analysis assumes that the administrator manually provisions the ATM to MPLS cross-connect using the CLI at each end of the MPLS core, using a current version of third party router software that includes support of an IP-MPLS tunnel was utilized. This feature points traffic from an ATM interface (AAL-5) to the MPLS tunnel using a static route or dynamic protocols.

Incremental Provisioning Activities with a router MPLS Core. The additional provisioning tasks required to provision VCs after the CBX 500®/GX 550™ ATM network has been upgraded with a router-based MPLS core include:

1. Using NavisCore to identify the path and VCI/VPI value at each end of the ATM network that interfaces to the MPLS core
2. Planning the ATM to IP-MPLS solution
3. Using approximately 12 strings of CLI commands to create two uni-directional LSPs
4. Updating a VC to LSP mapping database tool.

Service providers can also use the NavisCore™ Provisioning Server to perform bulk transactions and/or provision services on the ATM portion of the network as directed by the service provider's own service provisioning system. With an MPLS core, the administrator needs to identify the path that VNN™ has selected for the VC, including the specific trunks at each end of the ATM network that connect traffic to the MPLS core, and VPI/VCI values as inputs to running bulk CLI scripts to provision the MPLS tunnels.

Understanding the process. To provision new VC services over a router based MPLS core, the administrator must:

1. Continue to provision new VCs within the CBX 500®/GX 550™ ATM domain using Navis (See Appendix A for a summary of the steps) (1-2 minutes)
2. Use NavisCore screens, including the *Circuit Path* field on the *Show all PVCs* screen, to identify the path that VNN™ has selected for the VC, the specific CBX 500® or GX 550™ switch that will pass traffic to the MPLS core at each end, the specific port used for the circuit, and the VPI/VCI value (30 seconds) .
3. Use the CLI to provision the service parameters on the ATM interface on the LER. This requires the administrator to provision information that includes the IP address and VPI/VCI. (Requires two strings of CLI provisioning information with use of inverse ARP and 20 seconds).[2]
4. Use the CLI to create an MPLS tunnel (Requires one string of CLI information and 10 seconds)
5. Use the CLI to provision either static routes or a dynamic routing protocol to point the traffic to the tunnel (10 seconds)
6. Log necessary route information, including the switch ID, ATM port ID, VC, and LSP into the separate VC to LSP mapping database tool (30 seconds)
7. Repeat Steps 3-6 for the LER at the other end of the circuit.
8. Repeat Steps 4-7 to create the associated uni-directional LSP that flows in the opposite direction.

The estimated activity time identified above was benchmarked in a lab environment[2]. The total estimated time to create two uni-directional LSPs and map the bi-directional VC traffic to it in a production network is 7.2 minutes. This reflects the above lab network benchmarks plus 60% as an estimate of the time associated with logging onto the system, correcting occasional errors, increased thinking time with a more complex network, and the slower response times on a production network.

Total estimated service provisioning time of **8.2 – 9.2 minutes per VC (1-2 minutes for ATM domain activities) + (7.2 minutes for MPLS domain activities.)**

Service providers who upgrade their existing CBX 500® and GX 550™ ATM networks with an MPLS core based on the TMX 880™ core switch experience no change in overall provisioning costs—if they continue to use Navis™ software to provision new VCs.

2. There may be additional provisioning steps associated with setting QoS that are not included in this analysis

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