CISCO SYSTEMS

White Paper

Metro Ethernet Service Interworking with Frame Relay and ATM

Introduction

As bandwidth usage requirements continue to increase, so does the number and size of intra-site network connections that Enterprise networks require. Existing WAN services such as Frame Relay and ATM have traditionally met the bandwidth needs of Enterprises, and at the same time, have generated strong revenues for Service Providers.

However, as business applications dictate the need for higher, more flexible bandwidth options, new Metro Ethernet technologies and services become a compelling solution for both Enterprises and the providers that serve them. As Service Providers are under extreme pressure to decrease their network infrastructure spending while increasing their profit derived from network services revenue, it is vital that they have the capability to offer new Ethernet services while protecting investments in existing WAN services.

This paper discusses how Service Providers can meet their service needs by employing Cisco's Frame/ATM to Ethernet service interworking solutions to integrate their current Frame Relay/ATM services with Metro Ethernet.

Traditional Frame Relay and ATM Services Overview

Frame Relay is a connection-oriented service that transports traffic across a fixed point-to-point data circuit at speeds up to 2 Mbps at a relatively low cost. According to IDC, nearly half of U.S. enterprises use Frame Relay interconnect circuits as their primary intersite WAN connection technology. While Frame Relay's usage by Enterprises is reaching maturity due to bandwidth limitations, IDC anticipates its growth in small and medium-sized corporate sectors is expected to continue to grow yearly by roughly 5% through 2006.

One key issue that limits Frame Relay is that it lacks the intelligent flow control capabilities that are a necessity when transporting much of today's application-based traffic. Frame Relay relies on Forward /Backward Explicit Congestion Notification (FECN/BECN) for communicating current network congestion conditions. These congestion control methods effectively provide a rudimentary level of congestion control, but lack the capability to identify specific application traffic, such as voice and video, and selectively prioritize its delivery over other traffic in the network. This ability is key for these types of applications due to their sensitivity to network latency and jitter.

Unlike Frame Relay, ATM (Asynchronous Transfer Mode) is adept at handling both constant- and variable-rate traffic. It has been proven to be a very effective transport medium for wide-area networks and continues to grow steadily as a WAN connection for medium to large enterprises. It is highly flexible and fully capable of carrying integrated voice, data, and video streams.

However, a downside to ATM is that it is costly to deploy and manage. ATM edge devices are by nature more feature robust than those used in Frame Relay. As a result, complicated router configurations are typical, which increase the amount of time necessary to 'tune' configurations and manage their performance. Another caveat is associated with the cost in upgrading ATM connections to higher bandwidth levels. These upgrades routinely involve replacing fixed-rate interface hardware and are typically an expensive process.

Much of the continued popularity of ATM can be attributed to Frame Relay-to-ATM service interworking, which allows companies to utilize ATM connection services at larger corporate locations where they require ATM's bandwidth capabilities, while maintaining existing, more economical Frame Relay services at remote locations where lower bandwidth connections are suitable. Frame Relay/ATM interworking technology enables the provider network infrastructure to seamlessly pass traffic between ATM and Frame Relay network connections. This technology is generally implemented in switching/routing devices, which reside at the edge of the Service Provider's network, interfacing all data across the network core using a single protocol such as ATM or MPLS. This translation between data protocol types is done in a manner that is transparent to customers.

This interworking solution provides a useful migration path from slower Frame Relay connections to higher bandwidth ATM connections and the flexibility it provides has been a major benefit to both service providers and their customers. However as bandwidth consumption continues to grow and traffic profiles get more complex and demanding, several issues surface with regard to this solution and the abilities of Frame Relay and ATM:

- Solution still suffers from bandwidth limitations associated with Frame Relay connections and high service/upgrade cost associated with ATM. With bandwidth consumption on the rise, branches, and especially headquarters will outgrow the capabilities of Frame Relay connections and will be forced to migrate to ATM or an equivalent technology.
- Solution lacks intelligent congestion control and traffic prioritization mechanisms necessary to support the needs of today's application specific traffic load. Delivery of voice and video services requires high-bandwidth, low-latency connectivity as well as prioritized delivery, which is not possible with Frame Relay.

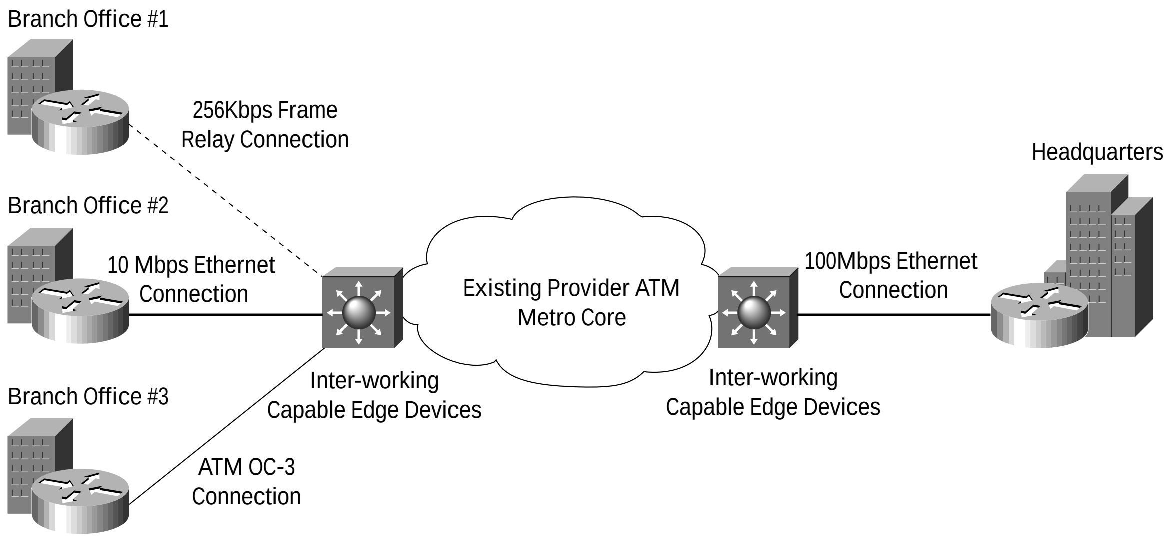
These issues cannot be effectively resolved using current Frame/ATM interworking technology. Migrating oversubscribed Frame Relay connections to ATM is costly and does not offer the traffic management intelligence required for today's mixed media traffic. What is needed is a flexible, low cost technology, which offers a smooth migration path for Frame Relay and ATM services, while offering the necessary intelligent bandwidth management capabilities and strong investment-protection with respects to bandwidth growth. Furthermore, this technology must participate in the service interworking paradigm, allowing cross interoperability with existing Frame Relay and ATM technologies. Finally, this technology must be adaptable to support future network services, such as voice and video.

Integration of Existing Frame Relay/ATM Interworking with Metro Ethernet

An emerging solution to the issues identified with the current FR/ATM interworking solution is to introduce support for an Ethernet User Network Interface (UNI), integrated with existing Frame Relay and ATM interworking technology. Proven as an ideal source of low-cost, scalable local-area network (LAN) bandwidth, Ethernet is a strong solution for providing cost-efficient wide-area network (WAN) bandwidth services. A major advantage Ethernet services offer over traditional offerings is flexible bandwidth provisioning. Developments in Ethernet technology allow hardware interfaces to support bandwidth rates from as low as 8 Kbps all the way up to 1 Gbps. As a result, no expensive hardware upgrades at either the customer site or Service Provider edge are typically required to support multiple bandwidth rate increases. Service Providers can even enable customers to dynamically provision their own bandwidth over the Web as their connection needs change.

The following diagram depicts a typical provider network and customer interconnects utilizing ATM/Frame Relay/Ethernet services internetworking.

Figure 1. Frame Relay/ATM/Ethernet Interworking Example



As the opportunities for metro Ethernet grow, so does its potential for interworking with Frame Relay and ATM services. Just as ATM has been used to upgrade bandwidth-starved branch offices, Ethernet UNI serves the same upgrade purpose. Figure 1 above shows that branches 1 and 3 are using Frame Relay and ATM technology respectively for connections to the headquarters site, while branch office 2 is connected via Ethernet. These three branch offices feed in to a single provider edge device, which is where the actual technical service interworking takes place. This device must be capable of exchanging traffic between different transport protocols and formats represented by the connection service offerings (Frame, ATM, T1/E1,T3/E3…etc) supported by the Service Provider. In the Figure 1 example, the branch connected Provider Edge device must support ATM, Ethernet, and Frame Relay service interworking.

A few key advantages to using Ethernet UNI technology for migrating existing ATM/Frame Relay customers who are in need of a bandwidth upgrade are:

- Ethernet technology has been extensively used for many years as the premier transport protocol in Local Area Networks (LANs). As a result, it has become extremely refined and benefits from a high level of commoditization at speeds up to 1 Gbps.
- Ethernet offers unparalleled bandwidth scalability options. Many Ethernet switching devices today offer port and rate limiting features, which allow them to operate at nearly any incremental speed up to 1 Gbps. This flexibility allows the service provider connection to grow with the customer's bandwidth needs, while not requiring any new hardware investment to support incremental bandwidth upgrades. This can result in substantial equipment cost savings for the service provider when compared to the expense incurred with similar bandwidth upgrades for Frame Relay and ATM service connections.
- Ethernet inherently supports the full spectrum of traffic policing and prioritization mechanisms, which have been successfully used in enterprise networks to help ensure the reliable and timely delivery of high quality video and voice traffic. These same mechanisms can be applied successfully for the same purposes in metro Ethernet configurations and are a necessity for providers who plan to roll out state of the art voice and video services to their customers.
- Ethernet, and more specifically service interworking, provides a smooth cost-attractive migration path from existing Frame Relay and ATM service connections.

The Traditional Hub-and-Spoke interworking Model—A Technical Overview

In the traditional hub-and-spoke Frame-Relay/ATM service interworking model, the typical customer headquarters might be connected to the service provider via a 155Mbps OC-3 ATM link while remote and branch offices would be connected via 128Kbps or 256Kbps Frame Relay circuits. When and if branch offices exceed the bandwidth limitations of their Frame Relay connections, they would likely upgrade to a 1.5–2Mbps T1/E1 or faster, requiring new hardware at both the customer and service provider sites. The increase in branch connectivity bandwidth will likely drive an eventual increased bandwidth requirement for the headquarters connection requiring an upgrade. This costly upgrade cycle would repeat itself over and over each time more bandwidth became necessary.

Integrating an Ethernet UNI with Frame Relay/ATM Interworking at the Hub

In reference to Figure 1, the customer headquarters has been connected to the service provider network edge device over an Ethernet UNI configured for 100Mbps. The Provider edge device connected to the headquarters maps each of the 802.1Q tags from the customer to ATM virtual circuits for delivery to another provider edge device supporting the destination branch offices. In order to map 802.1Q tags to ATM virtual circuits, the edge device must generate a "pseudo" media access controller (MAC) addresses for each 802.1Q tag coming into the device. The customer-premises equipment (CPE) associates an IP subnet with that 802.1Q logical interface. When the CPE sends a frame over the IP subnet associated with that 802.1Q tag, it issues a routine ARP request directed to the other side of the provider network. The directly connected service provider's edge device intercepts the ARP request, and returns the MAC address that it associated with the 802.1Q tag.

Once the ARP request has been completed, the CPE has a record of the association between the 802.1Q / MAC address and ATM virtual circuit. Once this process is completed, Ethernet frames transmitted from the headquarters' site are parsed so that only the IP datagram is forwarded to the ATM virtual circuit. A similar process is conducted on the provider edge device connected to the branch offices. Frames arriving at the different branch offices will arrive without the knowledge of any of the 802.1Q tag information used to link headquarters to the provider network. Each branch will receive traffic in its normal native format as if it originated from a source connected via the same type of connection.

This model allows for Layer-2 service interworking between Ethernet, Frame-Relay, and ATM endpoints, without any change whatsoever to the configuration of the CPE devices in the branch offices. Service providers can continue to utilize their existing ATM core to support Layer 2 interworking with Ethernet without being forced to implement Multi-Protocol Label Switching (MPLS) in the network core.

Ethernet-over-MPLS (EoMPLS) And Frame Relay/ATM/ Ethernet Interworking

Many Service Providers with ATM cores are also beginning to build MPLS cores in parallel. Many of these providers have customers that have started deploying point-to-point Ethernet services resembling layer-2 Frame-Relay circuits. Service providers who have both ATM and MPLS core infrastructures can connect their customers who are using Ethernet-to-MPLS services to those using ATM /Frame Relay/Ethernet interworking services by bridging the two services with a Ethernet UNI connection. This service interconnection is possible due to the ability to support both Bridge Route Encapsulation (BRE) and EoMPLS. Customers can connect their various office sites to the service provider core over multiple or multiplexed 802.1Q Ethernet virtual circuits, independent of whether the virtual circuits reach their branches over a legacy Frame Relay or MPLS service, as no 802.1Q circuit is routed in either direction.

Implementing Interworking In A Partial-Mesh Topology

The above configuration offers customers greater flexibility in connecting with service providers who operate both MPLS and ATM cores. However, with a full- or partial-mesh topology, Frame-Relay-connected branch offices would be able to communicate with Ethernet-connected branch offices over a Layer 2 service. They could accomplish this by allowing interworking and mapping between RFC 2364 BRE and EoMPLS. On the Ethernet side of the BRE, an 802.1Q tag identifies the virtual circuit. That 802.1Q tag can be mapped internally within the router to an Ethernet-over-MPLS circuit. This results in expanded connectivity that allows communication between all EoMPLS L2 point-to-point circuits and Frame Relay/ ATM/Ethernet interworked endpoint. This partial-mesh topology allows Service Providers to offer customers even greater flexibility and more attractive options.

Summary

As bandwidth usage continues to surge in customer networks, Service providers must respond to this need with more flexible bandwidth-enhanced services. Service providers have responded with Frame Relay/ATM interworking solutions to address the bandwidth growth of their clients—but this solution has its limitations in terms of cost-effectiveness. Bandwidth upgrades often are costly and time-consuming for both the provider and the enterprise, and fail to offer the leading edge traffic management/ manipulation features necessary for today's bandwidth intensive, latency and jitter sensitive applications. At the same time, service providers are under close scrutiny to reduce their costs and consolidate their networks. They must look at how they can minimize network spending while maximizing their operation profits. One of their largest potential revenue growth areas is in Metro Ethernet services. Providers need to identify a migration technology that will serve their customers immediate and long-term needs, while at the same time supporting existing profitable FR and ATM services. Cisco metro service interworking technology answers this need by utilizing proven, low cost Ethernet as the cornerstone of an interworking strategy that will allow existing Frame Relay and ATM metro customers to effectively communicate with customers who have upgraded to Ethernet. This is done, transparently to the end user over the Service Provider's existing ATM or MPLS core network infrastructure.

Because this solution utilizes Ethernet as the focal local access technology, bandwidth upgrades will be quick and inexpensive when compared to upgrades involving Frame Relay and ATM. Cisco's Metro Ethernet solutions also inherently offer the traffic prioritization and policing features necessary to support data, voice, and video services. Cisco's Frame Relay/ATM/Ethernet interworking feature set ensures that Service Providers can utilize Ethernet for new customers, while slowly migrating existing Frame Relay and ATM connected customers to Ethernet as growth or business needs dictate.

Cisco Systems

Corporate Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
www.cisco.com
Tel: 408 526-4000
800 553-NETS (6387)
Fax: 408 526-4100

European Headquarters
Cisco Systems International BV
Haarlerbergpark
Haarlerbergweg 13-19
1101 CH Amsterdam
The Netherlands
www-europe.cisco.com
Tel: 31 0 20 357 1000
Fax: 31 0 20 357 1100

Americas Headquarters
Cisco Systems, Inc.
170 West Tasman Drive
San Jose, CA 95134-1706
USA
www.cisco.com
Tel: 408 526-7660
Fax: 408 527-0883

Asia Pacific Headquarters
Cisco Systems, Inc.
Capital Tower
168 Robinson Road
#22-01 to #29-01
Singapore 068912
www.cisco.com
Tel: +65 317 7777
Fax: +65 317 7799

Cisco Systems has more than 200 offices in the following countries and regions. Addresses, phone numbers, and fax numbers are listed on the Cisco Web site at www.cisco.com/go/offices

Argentina • Australia • Austria • Belgium • Brazil • Bulgaria • Canada • Chile • China PRC • Colombia • Costa Rica • Croatia Czech Republic • Denmark • Dubai, UAE • Finland • France • Germany • Greece • Hong Kong SAR • Hungary • India • Indonesia • Ireland Israel • Italy • Japan • Korea • Luxembourg • Malaysia • Mexico • The Netherlands • New Zealand • Norway • Peru • Philippines • Poland Portugal • Puerto Rico • Romania • Russia • Saudi Arabia • Scotland • Singapore • Slovakia • Slovenia • South Africa • Spain • Sweden Switzerland • Taiwan • Thailand • Turkey • Ukraine • United Kingdom • United States • Venezuela • Vietnam • Zimbabwe

(0208R) ETMG 202859/12.02