RouteAbout and Frame Relay

Making the most of Frame Relay with DIGITAL RouteAbout products

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1 Executive Summary

The Frame Relay market continues to grow at double digit rates. In 1997 the total worldwide market for equipment and services was estimated to be over $6.1B (source: Vertical Systems group) and is forecasted to reach $14.5B by the year 2000. By now the attractions of Frame Relay are well known: flexible bandwidth, attractive tariffing and reduced communications equipment costs. The anticipated growth in the market will be driven by new services and technologies such as Switched Access, SVCs, Voice over Frame Relay, ATM Interworking etc. This paper discusses how DIGITAL's RouteAbout products can help you to exploit the benefits of Frame Relay and describes some unique features which can help maximize the bandwidth available while minimizing the costs.

2 RouteAbout and Frame Relay

Digital's RouteAbout products are a family of access and central site routers that provide multiprotocol routing and bridging. They can be used as standalone routers, in the MultiStack hub system, or in the MultiSwitch 900 chassis. This document describes the RouteAbout Frame Relay implementation and covers the following topics:

- What is Frame Relay?
- Frame Relay and RouteAbout
- Frame Relay Subscription Parameters
- How RouteAbout handles network congestion
- Bandwidth optimization and resilience
- Implementing Backup and Resilience using RouteAbout
- Restoring Frame Relay connections using RouteAbout
- Frame Relay SVCs
- Switched Access to Frame Relay Networks
- Telesaving features and Frame Relay

2.1 What is Frame Relay?

Frame Relay is a high speed switching technology which combines high throughput with low latency. It provides high throughput by multiplexing multiple logical channels known as Virtual Circuits (VCs) across a single physical connection.

These circuits are traditionally ‘Permanent Virtual Circuits’ (PVCs), however ‘Switched Virtual Circuits’ (SVCs) are becoming available in some networks.

Permanent Virtual circuits are created and allocated by the network provider. A PVC provides connectivity between the same two end points across a Frame Relay network. Each end-point is assigned a Data Link Connection Identifier (DLCI). This may be different at each end and is of local significance only. No special Call Setup messages are required before this kind of circuit can be used. A PVC is usable as soon as the routers at each end of the Frame Relay network have initialized their frame relay interface.

Switched Virtual circuits are dynamic, they are brought up on demand. Before data can be sent over an SVC a CALL SETUP / CONNECT CONFIRM message exchange has to take place. This can be thought of as very similar to making a telephone call. It is also possible to call different end points within the Frame Relay network. Once an SVC call has been setup then it is treated in exactly the same way as a PVC for data transfer.

In the paper, the term VC will be used to refer to features which apply to both PVCs and SVCs; if the feature is particular to a specific type of VC, then PVC or SVC will be used.

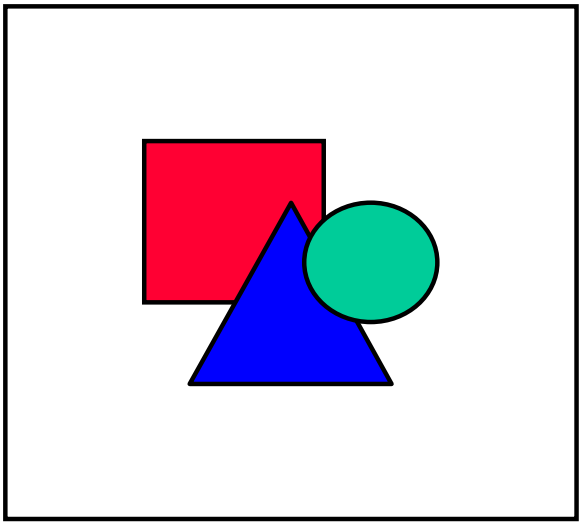

Figure 1: Frame Relay network

A parameter called the Variable Information Rate (VIR) is used to determine the information rate for each VC. Variable Information Rate supports three parameters per VC:

- Committed Information Rate (CIR)
- Committed Burst Size (Bc)
- Excess Burst Size (Be)

These parameters allow each VC to be configured to have a guaranteed minimum throughput but each VC can make full use of any available bandwidth. So you save both on the physical connections you need at the central site and on the bandwidth you need to offer a service to multiple remote sites.

Frame Relay provides low latency by removing virtually all of the packet processing from the switches in the network. Unlike X.25 networks which operate at OSI Layer 3 or the packet level, Frame Relay networks operate at the sublayer of OSI Layer 2 or the frame level. Also, unlike X.25 switches which provide extensive error recovery and correction, Frame Relay switches do not provide error recovery and correction, relying on the high quality and low error rates of modern digital transmission equipment and end to end error recovery by upper levels such as TCP.

Frame Relay is cost effective because it uses transmission lines efficiently. Like most data systems, it generates variable length frames from a few bytes to 1600 bytes or more and is transparent to most commonly used protocols such as IP, IPX and DECnet. Frame Relay is therefore an ideal technology for "bursty" LAN to LAN traffic.

2.2 Frame Relay on RouteAbout

The RouteAbout implements Digital's Distributed Routing Software. This routing software supports connections over Frame Relay as specified in the following standards:

- ANSI T1.617-DSSI Signaling Specification for Frame Relay Bearer Service
- ANSI T1.617 Annex D-Additional Procedures for Permanent Virtual Connections (PVCs) Using Unnumbered Information Frames
- ANSI T1.618-DSSI Core Aspects of Frame Protocol for Use with Frame Relay Bearer Service
- ITU Q.933 Annex D-DSSI Signaling Specification for Frame Mode Basic Call Control
- FRF.4 Frame Relay Forum SVC Specification
- ITU Q.922 - LAPF
- Frame Relay Interface Specification, Revision 3.0, StrataCom, Inc., 1990
- RFC 1315 - Frame Relay DTE MIB with extensions to the LMI
- RFC 1490 - multiprotocol interconnect for extended LAN services over point-to-point and point-to-multipoint connections

Some of the unique Frame Relay features implemented by the RouteAbout products include:

- Up to 64 PVCs can be configured per interface with support for manual or dynamic configuration of PVCs.
- PPP over Frame Relay allows the RouteAbout to treat Frame Relay PVCs and SVCs as point-to-point links (which is what they are) rather than simply treating the Frame Relay network as an extended LAN.

It also allows RouteAbout to support important PPP features across the Frame Relay network, such as compression, security, multilink, backup and resilience.

- Support for Backwards Explicit Congestion Notification (BECN) allows RouteAbout to act on information in the Frame Relay header set by the switches in the network when congestion occurs. The RouteAbout is able to throttle back to the CIR when the network sets the BECN bit to avoid congesting the network further.

2.2.1 Frame Relay Subscription Parameters

The following tables show the Frame Relay subscription and PVC parameters supported by the RouteAbout.

Subscription Parameters	Max	Min	Default
Maximum frame length	8189	5	2048
Maximum number of PVCs	992	0	64
N391 Full Status Polling Cycles	255	1	6
N392 Error Threshold	10	1	3
N393 Monitored Events Count	10	1	4
T391 Link Integrity Verification Timer	30	5	10

Table 1: Frame relay Subscription Parameters

PVC Parameters	Max	Min	Default
Bc	204800	300	64000
Be	204800	0	64000
Tc		1	
Maximum Frame Size	8189	5	2048

Table 2: Frame Relay PVC Parameters

2.2.2 How RouteAbout Handles Network Congestion

Frame Relay networks implement a basic flow control mechanism called congestion notification. This allows a switch in the network to set bits in the Frame Relay headers to tell other switches that congestion has occurred. The Backward Explicit Congestion Notification (BECN) and Forward Explicit Congestion Notification (FECN) bits allow congestion information to be communicated

backwards or forwards in the network.

The Variable Information Rate (VIR) allow devices connected to the network to determine the information rate for each VC. Variable Information Rate supports three parameters per VC:

- Committed Information Rate (CIR),
- Committed Burst Size (Bc)
- Excess Burst Size (Be).

These parameters, when used in conjunction with each other, allow devices connected to the network to implement congestion monitoring so they can increase or decrease the packet transmission rate depending on network conditions.

Some routers and Frame Relay Access Devices (FRADs) implement congestion monitoring, some don't. The problem is that unless congestion monitoring is implemented, the router or FRAD will continue to forward data when the network becomes congested, the network will start to discard data, and the router will try to retransmit the data leading to further congestion.

The following diagram and notes show how the RouteAbout implements flow control when using Frame Relay.

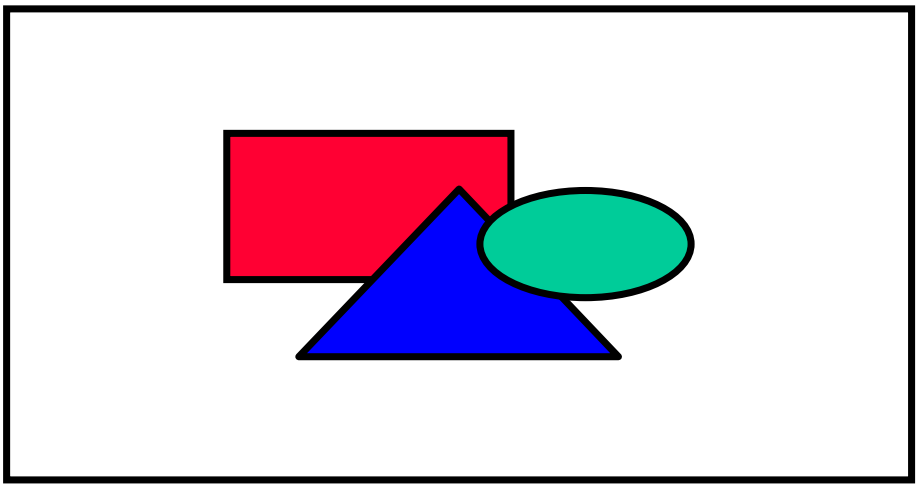

Figure 2: RouteAbout & Flow Control

The RouteAbout implements BECN and uses the CIR, Bc and Be parameters in conjunction with congestion monitoring to optimize VC throughput. When notified of congestion by the switch ahead via BECN, the RouteAbout throttles back in steps and reduces the calculated value for each VC's VIR to the minimum. The RouteAbout also determines the maximum value each VC can transmit using the Committed Information Rate and Committed Burst Size to avoid congestion.

Users can configure the router to do either CIR Monitoring or Congestion Monitoring:

- CIR monitoring keeps the packet transmission rate between 0.25 x CIR and Bc + Be
- Congestion Monitoring keeps the packet transmission rate between 0.25 x CIR and the line rate.

When the switch ahead clears the BECN bit, the RouteAbout increases the packet transmission rate up to and beyond the CIR if there is additional data to send. This mechanism works for all protocols supported by the RouteAbout over Frame Relay (IP, IPX, AppleTalk, DECnet, OSI and bridging).

Some protocols such as DECnet and OSI have mechanisms for flow control. RouteAbout uses BECN to map to the DECnet and OSI congestion bits to notify end systems that congestion has occurred so the end system can reduce the flow control window size, thereby reducing data transmission.

2.2.3 Optimizing Bandwidth Utilization with RouteAbout

Reducing costs is an important consideration when implementing a Frame Relay network. There are several mechanism that can be used to reduce or eliminate unnecessary traffic and to optimize the use of available bandwidth. For example, packet filtering, packet prioritization, protocol spoofing and data compression are some of the mechanisms that can be used. The following diagram and notes show how the RouteAbout can optimize bandwidth utilization when using Frame Relay.

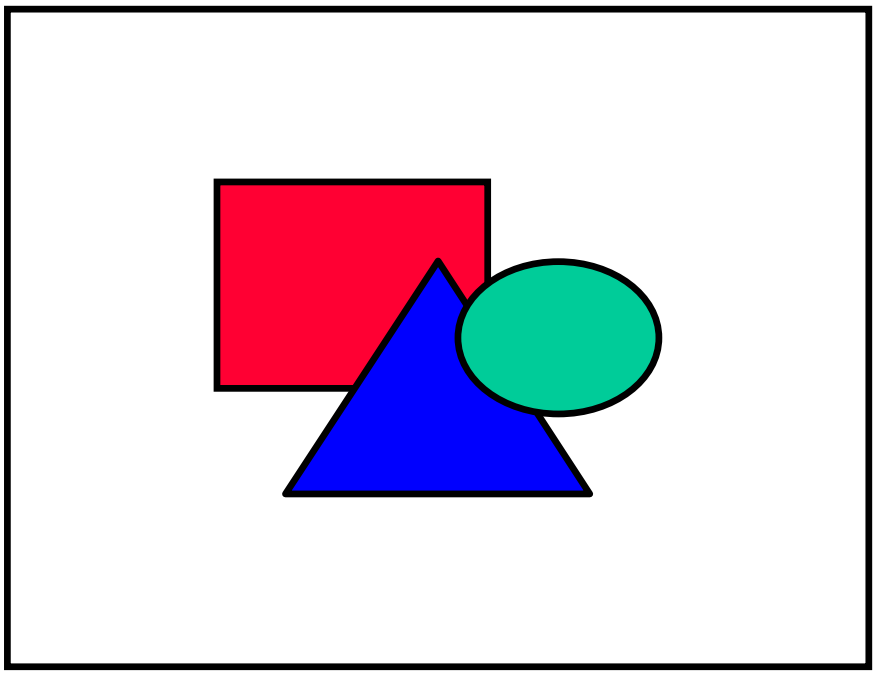

Figure 3: RouteAbout Bandwidth Optimization

The network manager can set packet filters and priorities based on protocol type, MAC address, DLCI, etc. The RouteAbout can then block unnecessary traffic and allocate available bandwidth to remaining traffic according to priority. As the RouteAbout can spoof certain protocols and watchdog timers, it can further reduce the WAN overhead. Any traffic sent over the Frame Relay network can be also be compressed on a per VC basis to further maximize throughput.

RouteAbout implements packet filtering to allow packets to be blocked based on user defined criteria such as protocol type, MAC address, port number, etc. This can reduce the amount of unnecessary traffic transmitted across the network.

Bandwidth Reservation allows bandwidth to be allocated on a per PVC basis to classes of traffic, protocols and filters assigned to those classes. Priority can also be assigned to each protocol and filter in the class. For example, Telnet traffic can be given 50% of available bandwidth, TFTP 20% and IPX 30%. If the network becomes congested, the RouteAbout will throttle back to the CIR or to below the CIR whilst maintaining the bandwidth allocated to each protocol. Alternatively, Bandwidth

Reservation can be applied at the interface (physical DLCI) level. In this case, the bandwidth of the Frame Relay interface as a whole is allocated to classes of virtual circuits (DLCIs). [*Note: Bandwidth Reservation is not currently available on SVCs.]*

RouteAbout can spoof network protocols to reduce costs significantly by filtering out unnecessary protocol overhead such as IPX RIP/SAP, by caching Netbios names to reduce Netbios updates, and by spoofing things such as LLC2 keep alive timers, watchdog timers, and serialization frames.

RouteAbout implements data compression using the PPP Compression Control Protocol to negotiate the type of data compression, and implements the STAC LZS compression algorithm. As RouteAbout can run PPP over individual VCs, it can provide data compression on a per-VC basis to allow greater throughput across network for a given CIR.

These features can be used in combination to optimize bandwidth utilization thereby maximizing throughput and minimizing costs.

2.2.4 Implementing Backup and Resilience using RouteAbout

While Frame Relay combines high throughput with low latency, and is generally a reliable networking technology, what happens if a PVC, access line or a switch fails? Under normal circumstances, if a PVC fails the network will route around the failure and you will not notice the problem. To cope with failures of the access line, or failures of the local switch, some service providers offer backup PVCs using alternative access lines and switches. However, this facility is expensive and is not offered by all providers as it requires additional equipment.

An alternative is to implement a backup strategy using ISDN or dial-up. ISDN in particular offers cost effective, high speed backup and is more suited to Frame Relay backup from a throughput point of view. Dial-up offers lower speed at lower cost and is more flexible as it is easily available.

The following diagram shows how RouteAbout can provide backup of Frame Relay access lines and individual PVCs using ISDN or dial-up if the Frame Relay access line fails. It is also possible to use an SVC to back up a PVC should the PVC be lost.

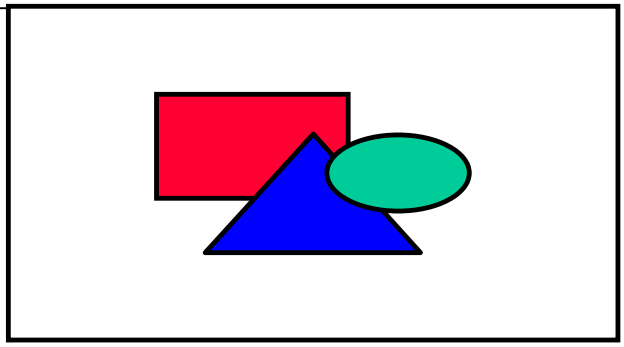

Figure 4: RouteAbout & Back-up links

RouteAbout can provide a backup capability for Frame Relay using ISDN or dial-up because it can run PPP over Frame Relay PVCs. So it can treat the Frame Relay network as a mesh of individual point-to-point links (which is what a Frame Relay network really is) rather than treating the Frame Relay network simply as an extended LAN. Using RFC 1490 does not allow this kind of back-up as the Frame Relay connection is treated like a broadcast LAN rather than a group of point-to-point circuits.

If an individual PVC or an access line fails, RouteAbout can automatically enable a backup link to a destination router for the duration of the failure. When the PVC or access line is re-established, RouteAbout will automatically disable the backup link. To save costs, timers can be set to determine how quickly a backup link is enabled and disabled.

2.2.5 Restoring Frame Relay connections using RouteAbout

Multinational customers may use different Frame Relay services in different countries, partly because of cost and partly because it is often difficult to obtain a Frame Relay service from a single provider in all the required countries.

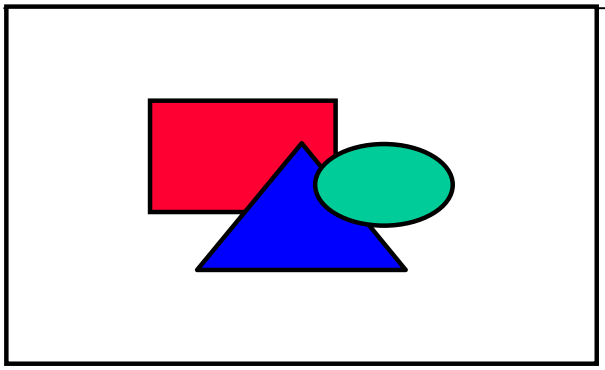

Figure 5: RouteAbout Re-routing

In the above diagram, RouteAbout A connects to Frame Relay network A while RouteAbout B and C connect to Frame Relay network B. But what happens if RouteAbout A's connection to Frame Relay network A fails? Failure of a connection in one location can mean a loss of service to users.

RouteAbout implements a feature called WAN Reroute which restores the Frame Relay connection via another router using dial-up or ISDN. In the above diagram, RouteAbout A notices the failure of the link to Frame Relay network A, dials-up RouteAbout B and tells it that its Frame Relay link has failed. RouteAbout B forwards this information to RouteAbout C so that it knows it must send traffic to RouteAbout B in order to reach RouteAbout A.

WAN Reroute is particularly useful at a central site if a large number of PVCs are lost when a single connection fails. Instead of trying to restore each failed PVC using separate dial-up connections, the RouteAbout can use a single dial-up connection to another RouteAbout and can re-route all traffic via the other RouteAbout.

WAN Reroute ensures that users in one location have an alternative method to connect into the Frame Relay environment and do not suffer loss of service should a Frame Relay connection in that location fail.

2.3 Frame Relay SVCs

Frame Relay Switched Virtual Circuits (SVCs) provide the equivalent of X.25 SVCs for Frame Relay users. Calls can be established when data transfer is required and taken down when data transfer is complete. Parameters such as CIR can be requested at call set-up time allowing true bandwidth-on-demand services to be implemented. SVCs also reduce the burden of administering large numbers of PVCs as circuits can be established directly between routers without the need to pre-define them in the Frame Relay network. Some of the major benefits that SVCs will provide are:

- **Reduced costs for customers.** Although carriers have not fully announced their SVC tariffing, it is highly likely that they will provide attractive cross-over points between SVCs and PVCs to make Frame Relay a more cost-effective proposition for smaller sites or users with lower bandwidth requirements

- **Better Mesh Topology.** Since an SVC can be established between any to points in the network, it allows a complete network mesh to be built so that all sites are only one hop away from each other. Due to the extra costs involved with defining PVCs, current tariffing has encouraged users to design star network topologies where all site-to-site traffic gets routed through a central hub with the extra hop and latency involved. Overall network performance can also be improved as a more direct trunk route can be established between the tow DLCIs.

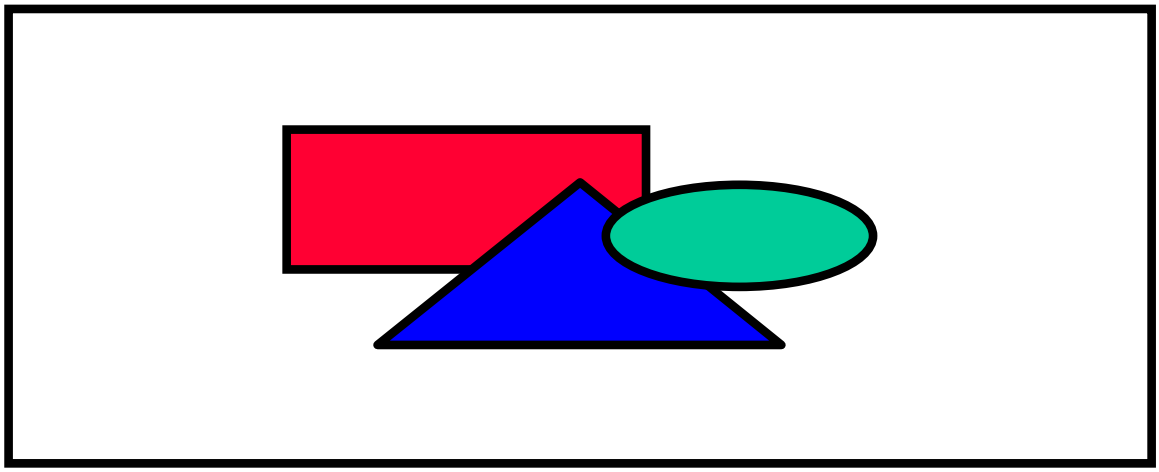

Figure 6: Frame Relay SVCs

- **Bandwidth-on-demand applications**. SVCs make feasible applications such as back-up or overflow traffic and disaster recovery where the connection need only be set-up when required. Using Multilink PPP over Frame Relay the RouteAbout can bundle together PVCs and SVCs allowing the SVCs to provide extra top-up bandwidth during busy periods.

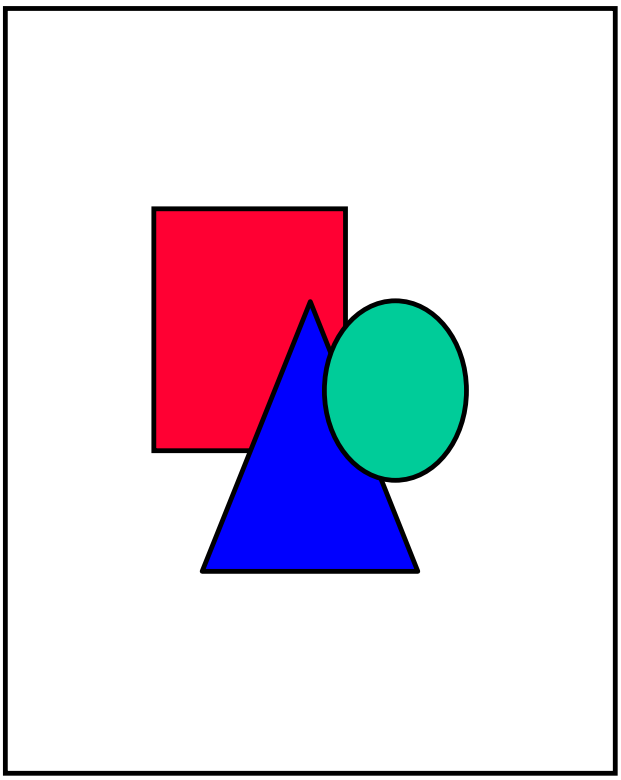

Figure 7: Frame Relay SVCs for BoD

- **Secure SVCs.** Because the RouteAbout uses PPP over Frame Relay it can also provide security by using the PPP security features

of PAP and/or CHAP. These are important features when using SVCs ensuring connections are only accepted from chosen destinations. No security features like this are available when using SVCs with RFC1490.

- **Dial on Demand.** PPP over a Frame Relay allows the RouteAbout to use SVCs in a dial-on-demand mode. Since the connection is treated as a point-to-point link Triggered RIP can be configured to allow IP network routes to be propagated throughout the network without having to frequently re-establish the call. This results in more cost-effective use of the SVC and much simpler routing configurations i.e. fewer static routes.

2.4 SVC Call Set-up and clearing

SVC call set-up works in a similar fashion to X.25 call set-up. Either an ISDN or X.121 address is used to identify the called device and a call set-up sequence is exchanged. Once the call is established, data is transmitted and received as in a normal PVC connection. When their is no more data to send, a call release sequence is initialted and the call disconnected.

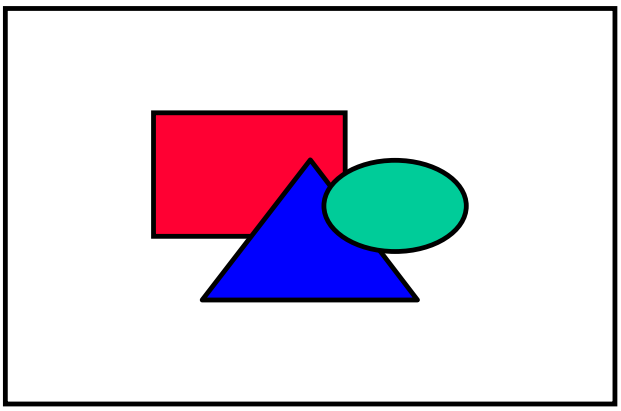

Figure 8: SVC call set-up

2.5 Switched Access to Frame Relay Networks

Since Frame Relay is normally multiplexed over existing leased line services such as 56/64Kb/s or T1/E1, it is usually necessary to have a leased line connection to every remote site. Where a site cannot cost-justify such a connection or perhaps, where such a service is not available from the local carrier, then Switched Access allows services such as ISDN/BRI or 56K DDS to be used to connect to the nearest Frame Relay Network Point-of- Presence. The RouteAbout products support Switched Access to Frame Relay using ISDN making it ideal for applications such as shadowing or back-up where access to the Frame Relay network is not required permanently. All the added ISDN Telesaving features such as Dial-back and spoofing can be used to ensure that the ISDN link is only kept active when it is needed helping keep access costs to a minimum.

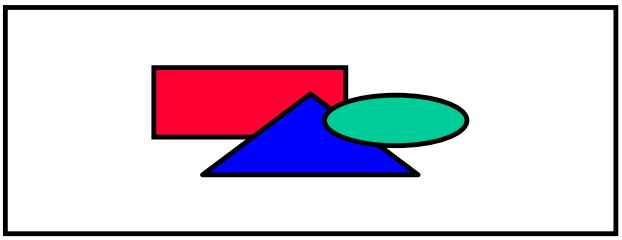

Figure 9: Switched Access to Frame Relay

In the above Diagram Routers B and C both use ISDN Basic Rate Access to connect to the Frame Relay network and thence to Router A.

2.6 Telesaving Features and Frame Relay

A unique feature of the RouteAbout products is their ability to run PPP datalinks over a Frame Relay link. This allows all the relevant Telesaving features available in the software to be made available when using Frame Relay and, in particular, Frame Relay SVCs.

Telesaving group	*Telesaving Feature*	*PVC*	*SVC*
Connection Management	Bandwidth on Demand	N	Y
	Idle timer	N	Y
	Call Blocking	N	Y
	Initial minimum Call Timer	N	Y
	Calling Line-Id	N	Y
	Budget Control	N	Y
	Call Back	N	Y
	WAN Reroute	Y	Y
	PPP Echo suppression	Y	Y
Data Management	Compression (Header & data)	Y	Y
	TCP/IP Filtering	Y	Y
	Triggered RIP	Y	Y
	Static IP routes	Y	Y
	IPX Filtering & Spoofing	Y	Y
	NETBIOS over IPX Filtering	Y	Y
	AppleTalk filtering	Y	Y
	Bandwidth Reservation	Y	N

Table 3: Supported Telesaving Features

The above table shows the Telesaving features supported when using Frame Relay PVCs and SVCs. Please refer to the companion whitepaper Telesaving and ISDN for full details of these features

3 About the Authors

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4 References

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Frame Relay Forum – http://www.frforum.com/