Buyer's guide

Frame relay grows up

More mature services ease selection process.

By CHRIS FINN and CHRIS HECKART

After a turbulent two-year roller coaster ride, frame relay services have finally begun to smooth out. With more mature switching platforms in place and a couple years of experience under their belts, carriers have overcome early problems with physical network infrastructure, congestion management and support services.

Based on this progress, it is now easier for network managers to select basic frame relay transport services. Skeptical at first, net managers are today finding frame relay is the best or only option for local-area network interconnection and data network consolidation.

"The service works as advertised," says Thomas Martin, manager of communications and operations of Lithonia Lighting in Conyers, Ga. "It quite simply fulfills my business needs."

Instead of focusing on whether frame relay can do the job, net managers can feel confident in installing it now while they concoct a migration strategy to higher speed services such Asynchronous Transfer Mode (ATM). To make their frame relay selections, net managers must wade through a confusing pricing structure and a set of feature-rich service options carriers are now rolling out.

While carriers have been more forthcoming about quoting prices than just a year ago, it is still very difficult to make an apples-to-apples comparison. Each carrier has put its own twist on frame relay pricing, charging differently for access circuits and permanent virtual circuits (PVC) that mimic operation of a leased line. Carriers also offer a mix of committed information rates (CIR) — a form of performance guarantee — on a fixed or usage basis.

Other major factors to consider in evaluating frame relay include emergence of such options as switched virtual circuits (SVC) that mimic operation of a dial-up line, new forms of frame relay access, disaster recovery and stronger network management options.

Other important considerations include the carrier's willingness to provide customer premises equipment under a mix of financial terms and its expertise in accommodating particular network applications such as IBM System Network Architecture networking (see story, page 35).

There are essentially two broad types of service offerings: a premium service that is national and global in scope and one that has more of a local/regional flair.

Interexchange carriers offer premium services that provide connectivity throughout North America and to most global business centers. They also include a plethora of different configuration and support options, such as turnkey outsourcing in which the carrier runs the entire frame relay network for that customer, and a wide range of speeds.

All seven of the regional Bell holding companies and a handful of regional carriers such as EMI Communications Corp. and PacNet, Inc. now offer some level of frame relay service. These services are generally simpler in scope than interexchange offerings, providing fewer speeds and options.

However, net managers can mix and match service providers in a single logical network as long as the carriers have implemented the frame relay network-to-network interface (NNI), a standard for interconnecting separate frame relay networks. Ameritech, PacNet, NYNEX Corp. and US West Communications, Inc. currently support the NNI. AT&T, Southwestern Bell Corp., Sprint Corp. and WilTel will support NNI this year.

As a rule of thumb, three locations within a metropolitan area makes a company a candidate for local frame relay. Otherwise, an interexchange service is better (see story, page 35).

FRAME RELAY: THE PATH TO ATM?

Both forms of frame relay service offer much the same scalability, flexibility, simplified network management, consolidated network architectures and cost-effective connectivity that ATM promises. Yet, many bandwidth hungry customers that will eventually migrate to ATM shy away from frame relay for fear of technology obsolescence.

"They are missing the boat," says Jim Fey, director of strategic technology at PMI Mortgage Insurance Co. in San Francisco. "This is not an either/or situation," he says. Frame relay can be used comfortably today because carriers are laying out plans to interconnect frame relay into their ATM backbones.

Fey has been utilizing frame relay for nearly two years, choosing the technology to improve connectivity, reduce cost and improve performance for the mission-critical data applications running across the company's enterprise network. He recognizes the need for a smooth migration path between frame relay and ATM, which requires carriers to support a transparent protocol conversion that will enable frame relay traffic entering the carrier network to ride across the public ATM backbone.

All major carriers have painted such a picture of the future. The carriers say they will provide a multiprotocol broadband backbone with complete service interoperability. Such a backbone will accomplish two things: It will provide an insurance policy to users waiting for ATM and ensures investment in frame relay will not be wasted.

Carriers are beginning to describe this backbone as one that consists of a cell-relay switching fabric that utilizes T-3 — and eventually Synchronous Optical Network — backbone facilities. A mix of interface protocols such as frame relay, ATM or even Switched Multimegabit Data Services can be used to access this backbone, and conver-

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1994 NETWORK WORLD SHORT LIST

Frame relay services

- ✓ **MCI Communications Corp.** *HyperStream Frame Relay*
- ✓ **Sprint Corp.** *Sprint Frame Relay Service*
- ✓ **US West Communications, Inc.** *Frame Relay Service*
- ✓ **WilTel** *WilPak*

Complete details about The Short List appear on page 34.

INSIDE

Frame relay services

Company	Service	CPE provided (B = Bridges C = CSUs R = Routers)	CPE financing (C = Carrier financing L = Leasing P = Purchase option)	Oversubscription: Percent allowed	Bursting: Up to access speed	Bursting: Up to port speed	Bursting: Duration (seconds)	Paper reports (R = Raw traffic statistics S = Statistics on frames marked "Discard Eligible" T = Traffic by location U = Utilization by PVC)	On-line mgmt.: SNMP	On-line mgmt.: Terminal	POPs	Gateways (A = ATM S = SNA T = TCP/IP X = X.25 O = Other)	Extended capabilities: International availability (no. of countries)	Extended capabilities: Integrated access	Extended capabilities: Disaster recovery	Port speeds (bit/sec) and monthly cost: 56K/64K	112K/128K	256K	384K	512K	768K	1.024M	1.536M	CIR: Zero	CIR: Incremental	CIR: Port speed	CIR: Usage-based pricing	CIR: Fixed price
Ameritech (800) 832-6328	Ameritech Frame Relay Service	B, C, R	C, L, P		✔	✔	4		✔		9					ICB			ICB				ICB			✔		✔
AT&T (800) 248-3632	AT&T InterSpan Frame Relay Service	C, R	C, L, P	200		✔	(1)	R, T, U	✔	✔	200+	A, S, T, X	17	✔		(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)		✔			✔
Bell Atlantic Corp. (800) 422-0455	Bell Atlantic Frame Relay Service	B, C, R	L, P	200		(3)	1	R, S, T	✔	✔	11				✔	$175							$435		✔	✔		✔
BellSouth Telecommunications, Inc. (404) 529-6757	Frame Relay			200							6				✔	$170-$210							$600-$800					✔
BT North America, Inc. (800) 872-7654	GNS LAN Interconnect	B, C, R	L	200	✔		(1)	R, T, U	✔		40	T, X	14		✔	$400		$750		$1,400		$2,100	$2,300		✔			✔
Cable & Wireless Communications, Inc. (703) 790-5300	LAN Connect	C, R	L	200		✔	(1)	S, T, U			110		2	✔	✔	$145	$175	$190	$400	$900	$1,100	$1,400	ICB		✔	✔		✔
CompuServe, Inc. (800) 433-0389	Frame-Net	C, R	L			(4)	(1)	R, T, U	✔		98		8	✔	✔	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)		✔	✔		✔
EMI Communications Corp. (800) 456-2001	EMI-Frame Relay	C, R	C, L, P	200	✔	✔	(1)	R, S, T, U			18			✔	✔	$120				$590		$987			✔	✔		✔
MCI Communications Corp. (800) 933-9029	HyperStream Frame Relay	B, C, R	C, L, P			✔	(1)	R, S, T, U	✔		391		3	✔	✔	$180	$330	$400	$600	$750	$950	$1,200	$1,600	✔	✔	✔	✔	✔
NYNEX Corp. (914) 644-5470	NYNEX Frame Relay Service	C	L					R	✔		63	T		✔	✔	$53-$67			$256-$350				$769 - $985			✔		✔
Pacific Bell (510) 901-6498	Frame Relay Service	B, C, R				✔		R, S, T, U			4				✔	$75	$150		$400				$500		✔			
PacNet, Inc. (206) 232-9900	Paklink			400	✔		(1)	R, S, T, U	✔		12	A, S, T	5	✔	✔	$24-$350	$75-$440	$104-$520	$320-$675	$340-$800	$427-$975	$535-$1,175	$668-$1,475			✔		✔
Southwestern Bell Corp. (800) 992-2355	Frame Relay Service	B, C, R	C, L, P	(1)				R, S, T, U			16	X		✔	✔	$164			$295				$575			✔		✔
Sprint Corp. (800) 877-4646	Sprint Frame Relay Service	B, C, R	C, L, P	100	✔		1	R, S, T, U		✔	330	S, T, X	14	✔	✔	$160	$275	$440	$660	$825	$1,045	$1,375	$1,800	✔	✔	✔	✔	✔
US West Communications, Inc. (800) 328-2879	Frame Relay Service	B, C, R	P	200	✔		1	R, S, T, U	✔		75	X, O		✔	✔	$99-$286							$347-$784	✔	✔	✔		✔
WilTel (800) 364-5113	WilPak	B, C, R	C, L, P	200		✔	(1)	R, T, U	✔	✔	175	A	4	✔	✔	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)		✔	✔		✔

Chart compiled by Cheri Paquet

Products highlighted by color were selected for The Short List.

FOOTNOTES:
(1) Determined by customer application and traffic volume.
(2) Carrier declined to give pricing.
(3) Up to CIR.
(4) Up to 150% of port speed.

ATM = Asynchronous Transfer Mode
ICB = Individual case basis
CIR = Committed information rate
CPE = Customer premises equipment
CSU = Channel service unit
POP = Point of presence
PVC = Permanent virtual circuit

The Short List:

Frame relay services

The Short List highlights products Network World *recommends you examine during the purchasing process for frame relay services. The services included in The Short List offer the best mix of low price, service functionality, features and support — the key criteria used for selecting a service provider. Some offer additional useful features. The criteria used for selection to The Short List reflect the needs of users with multivendor enterprise networks. Your criteria may differ based on network configuration and application needs.*

■ MCI Communications Corp.
HyperStream Frame Relay

MCI's HyperStream Frame Relay service offers all the important service features, including a broad mix of speeds, disaster recovery and integrated access. MCI differentiates itself by offering the most innovative pricing options of any frame relay service. These pricing options include a distance-sensitive permanent virtual circuit that can keep costs for connecting nearby sites down. In addition, the carrier has impressive geographic coverage with 391 domestic points of presence (POP) and service to 12 countries. Network management options include everything from paper reports to a fully configured Simple Network Management Protocol-based management system.

■ Sprint Corp.
Sprint Frame Relay Service

What sets Sprint apart is its pioneering of usage-based pricing and a zero committed information rate (CIR) service. Usage-based pricing makes it affordable to add low-volume sites to a frame relay network, while zero CIR eliminates the need to pay extra for guaranteed bandwidth. Sprint also has a wealth of experience in public data networking and has integrated its X.25, Internet Protocol and frame relay networks. The carrier offers service from 330 domestic POPs and 14 foreign countries.

■ US West Communications, Inc.
Frame Relay Service

US West Communications has undoubtedly been the most aggressive local exchange carrier (LEC) in the deployment of frame relay with availability from 75 POPs. Like the other LECs, US West Communications has endeavored to keep pricing simple by taking such steps as offering a zero CIR. But US West Communications has also developed management reporting and offers excellent service support. The carrier has also implemented the frame relay net-to-net interface, which enables it to pass local frame relay traffic to a long-haul carrier.

■ WilTel
WilPak

WilTel was the first carrier to offer a commercially available frame relay service. One of WilTel's strongest points is its fully mature network, which has enabled the carrier to offer users the ability to define a maximum sustained burst rate. WilTel also plans to be among the first carriers to enable frame relay to ride over an Asynchronous Transfer Mode backbone. The carrier offers a full line of internetworking support services, including hardware and management. WilPak customers have several options for traffic management that are facilitated by StrataCom, Inc.'s Foresight software running on WilTel's StrataCom IPX switching platforms.

Making SNA a snap

Thanks to advancements in router technology, carriers have been able to make some headway in their attempts to position frame relay as an attractive alternative to leased lines for carrying delay-sensitive IBM Systems Network Architecture traffic.

Router vendors such as Cisco Systems, Inc., CrossCom Corp. and Wellfleet Communications, Inc. have added SNA support options to their equipment. This enables AT&T, MCI Communications Corp., Sprint Corp, WilTel and other carriers to ship SNA traffic coming from those routers alongside the more bursty, delay-tolerant local-area network traffic that frame relay was originally designed to handle.

Routers get SNA traffic ready for shipment over frame relay networks using at least one of three techniques.

One method is to support source route bridging (SRB). In this scenario, routers convert Synchronous Data Link Control packets into Logical Link Control 2 (LLC2) packets. This approach is well suited for linking token-ring environments into a frame relay network. Converting SDLC to LLC2 also preserves traditional SNA network management by enabling IBM's NetView to view diagnostic data.

While suitable for small networks, SDLC-to-LLC2 conversion becomes less than ideal in large, high-volume networks because of the SNA polling overhead — caused by the ability of LLC2 to carry host-to-terminal polls — that must traverse the wide-area network. Another drawback comes in the area of network recovery and overall distance limitations.

It takes quite sometime for SRB to recover from link failures because each SRB device must undertake the entire network discovery process again by sending out and responding to discovery packets. Likewise, IBM's recommendation that there be no more than seven SRB nodes between sending and receiving workstations limits how far an LLC2 packet can be sent through a frame relay network.

For melding larger SNA nets into frame relay, the second option in which routers perform SDLC tunneling becomes viable. In this environment, SDLC is encapsulated into Transmission Control Protocol/Internet Protocol packets by the router prior to being forwarded onto the frame relay net. While response to network failures is not as troublesome as in the SRB environment, network management functionality is lost because SDLC packets encapsulated in TCP/IP cannot be seen by NetView.

Other SNA characteristics, such as priority levels and service classes, are also ignored in the encapsulation scenario. Traffic in this environment is also increased because SNA polls wrapped in TCP/IP are passed across the frame relay net.

Multiprotocol routers that offer a combination of SRB and encapsulation may provide the best alternative. In this approach, SDLC is first converted to LLC2, then encapsulated into TCP/IP. Doing so allows the packet to be routed instead of bridged, which provides for automatic link recovery from failure.

This approach can cut down on the amount of polling traffic traveling across the network through the use of spoofing. The spoofing technique enables the router receiving data from an SNA device to send out an SNA acknowledgment that fools the sending device into believing the host has responded.

Finally, there are routers that support IBM's Advanced Peer-to-Peer Networking (APPN) architecture, which provides standard class of service and prioritization for SNA applications in native form. However, while APPN may be the way of the future for many true-Blue networks, it also may require host-based VTAM and front-end processor-resident Network Control Program upgrades.

"We had to make a decision," says Steve Engel, network engineer at Minnesota Mutual Life Insurance Co. in St. Paul, Minn. "I could support both LAN and SNA traffic together or continue to operate my [9.6K bit/sec] multidrop network for about the same monthly cost. It turned out to be totally painless."

Minnesota Mutual chose AT&T's InterSpan frame relay service and has over 20 locations on the network.

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sion routines will enable traffic from a site using one interface protocol to communicate with a site using another. For instance, one site will send frame relay to the carrier for delivery as ATM traffic to another site.

This interoperability will allow carriers to provide connectivity to locations requiring anywhere from 64K to 45M bit/sec over a single network with a single management system. The ability of carriers to deliver on this promise is a matter of timing. Each carrier will achieve this goal with different network platforms, different service packages and features, and via a different service strategy.

Sprint already offers connectivity across its Internet Protocol, frame relay and X.25 networks. A single network platform supports multiple interfaces and gateway devices to provide the protocol translation. ATM integration is planned by 1994.

AT&T has laid out a similar strategy. WilTel is deploying an integrated broadband network with its High-Speed LAN Service already supporting ATM at 1.536M bit/sec.

PRICING

While the carriers seem to be in agreement that they will fold frame relay into an integrated backbone, there is a very striking contrast in how they price their frame relay services. And now that frame relay services are operating more smoothly, an evaluation of carrier pricing strategies becomes paramount in the selection process.

Frame relay prices are generally based on the provision of the following components: an access line that may also be used to provide a link to other carrier services, a port connection fee for hooking into the serving carrier's frame relay switch and PVC charges that are based on CIR — or guaranteed minimum speed.

To throw a monkey wrench into what appears to be a somewhat understandable pricing plan: Some carriers cover the cost of a single PVC or multiple PVCs in the port connection charge, while others impose an additional fee for each PVC on top of the port connection price. PVCs are used to establish a predefined path that traffic from one site on the network must take to another site.

Similar to how virtual circuits work in the X.25 world, a single frame relay access line can support multiple PVCs. The carrier switch examines incoming traffic to learn the PVC number and thus ascertain which predefined path must be taken to reach the destination.

To make matters worse, there is most always a charge for CIR on each PVC.

Some carriers also offer a hierarchy of extra cost options such as assistance with network configuration, equipment packages and outsourcing.

Some carriers, such as CompuServe, Inc. and BT North America, Inc., bundle the cost of the local exchange carrier lines needed to access their frame relay switches into the port connection fee. Other carriers, such as AT&T, MCI Communications Corp., Sprint and WilTel pass along the local access charges they incur in order to link the customer to their nearest point of presence (POP).

The difference is that the carriers who bundle local carrier access charges into the port connection fee usually charge more for a frame relay network connection, but that price is not mileage sensitive. Other carriers price access lines according to mileage, which opens the door for having access at one site cost more than access at another site.

Many carriers that charge separately for access are starting to offer volume discounts. MCI, for example, has its Access Pricing Plan, which trims access line costs in exchange for an agreement to have access at a specified number of sites over an agreed-upon length of time.

Another option offered by the likes of AT&T, MCI and Sprint is integrated T-1 access, which allows net managers to make use of currently installed T-1s for frame relay. Integrated access allows each of the 24 channels on a T-1 to be assigned to services individually.

Carriers that offer a wide array of voice and data services are more likely than others to offer integrated T-1 access, and there is really no difference in how it works (see graphic, page 38).

Other carriers, such as BT and CompuServe, can provide integrated access to their frame relay, value-added network and other data services. WilTel can provide integrated T-1 access to its frame relay, private-line and voice services, although its voice services are more limited than those of other carriers.

Integrating voice, private-line and frame relay over the same local access facilities can save money. However, these savings should be balanced with concerns for single points of network failure. For some network sites or applications, the use of separate voice and data network access can provide an added measure of redundancy.

Virtually all carriers have a fixed charge for a port connection. This component is often the single most costly element. Port charges vary by speed and are often based on CIR. Interexchange carriers typically offer a whole range of speeds, from 56K bit/sec up to T-1. In order to keep their services a bit more simple, RBHCs offer a far more limited set of speeds, typically just 56K bit/sec, 384K bit/sec and T-1.

Access and port connection fees are fairly straightforward, but PVC and CIR pricing is not. Generally, RBHCs include a set amount of PVCs in their port connection fee, which partially accounts for the price range for RBHC

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Choosing between local and long-haul

With frame relay switches popping up in central offices across the country and around the globe, network managers are finding it a tad difficult to decide when to use one type of carrier over another. But there are some general rules that can help make that selection easier.

On the local or regional level, users have the option of choosing a local exchange carrier or small, regional carrier. The most basic advantage here is that these carriers offer more dense coverage within the geographic area they serve than national carriers do so prices are lower, and the networks may offer more redundancy.

Regional carriers such as PacNet, Inc. and EMI Communications Corp. have stated that their goal is to have at least one frame relay switch per local access and transport area in their respective regions. These carriers can use the network-to-network interface (NNI) to provide a link to national carriers' frame relay networks.

Regional Bell holding companies provide an alternative for frame relay among LATA sites. These local carriers also plan to use NNI to tap long-haul carriers for inter-LATA frame relay traffic.

As a rule of thumb, companies that have the bulk of their sites concentrated within one LATA will be better off using a local carrier's public frame relay service and employing leased lines to the few sites outside the local area, says Joseph Zell, director of service development at US West Communications, Inc.

Zell says companies with one or two sites in a number of cities will be better off using a national public frame relay service. Companies with a number of offices concentrated in a few key cities as well as single sites scattered across the country have another option. These companies can use local public frame relay service in the cities with multiple sites and an NNI gateway to a national provider that can reach the others.

On the other side of the coin, national service providers have made their networks more global. AT&T now serves 17 countries, while Sprint Corp. and BT North America, Inc. offer frame relay service to 14 countries each.

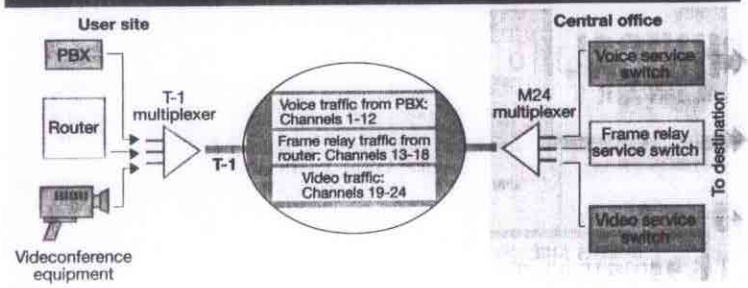
Currently, most international frame relay connections are extensions of U.S. networks. One point to note is that many users have experienced mixed results with transcontinental frame relay links.

"There is a certain amount of propagation delay inherent to a 6,000-mile connection, which mitigates performance," says Ray Kang, senior manager of data services at MCI Communications Corp.

Of course, the ability to provide global support will be an issue when choosing a global service. Carriers with backgrounds in the value-added network (VAN) arena, such as CompuServe, Inc., look to leverage their strengths and experience in traditional VAN markets when supporting international frame relay locations.

C. Finn and C. Heckart

Integrated access option



Integrated access enables users to cut access line costs by grooming different forms of traffic into channel groups on a T-1 circuit to central office where the channel groups are directed to the appropriate service platform.

GRAPHIC BY SUSAN SLATER

SOURCE: TELECHOICE, INC., VERONA, N.J.

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port charges. Interexchange carriers charge a flat port connection fee and add a small charge for each PVC that uses that port.

Another distinction is that carriers charge for the CIR ordered on PVCs. CIR can be loosely defined as the amount of bandwidth guaranteed to be available under noncatastrophic network operating conditions.

The frame relay standard specifies that any data sent at a rate exceeding CIR is to be marked discard eligible. When network circuits supporting multiple PVCs become congested, all traffic marked discard eligible is thrown away in order to maintain the CIR on each PVC.

Most carriers offer CIR for a fixed per-month price. In other words, users can pump as much data as they can across a PVC for one fee, a similarity to private-line pricing. Only MCI and Sprint offer a usage-based CIR, which can be attractive for sites that don't have enough traffic to justify a fixed-rate CIR.

CIR is offered in many different increments ranging from zero to the full speed of the access port, which usually tops out at T-1. And net managers are sure to be confronted by conflicting views from carriers about if and when they need to allocate CIR on a particular PVC.

Currently only offered by MCI, Sprint and US West, zero CIR does not promise any particular sustained transmission rate, and, therefore, does not necessarily afford the user with any consistent level of network performance. Information transmitted across a PVC with a zero CIR is the first to be discarded in times of abnormal network congestion.

Nearly all carriers are now offering incremental CIR. For instance, BT offers CIR in 16K bit/sec increments. This means net managers can assign bandwidth to PVCs in blocks of 16K bit/sec up to the full port speed. Other carriers such as CompuServe offer CIR in 4K bit/sec increments.

Net managers selecting CIR at anything less than full port speed should know that most carriers allow PVCs to send bursts of data that exceed CIR as long as the bandwidth is available.

The duration of bursting is largely a function of network congestion. Some carriers set a specific time limit on bursts in order to make sure bandwidth is available for other customers. Other carriers say they will allow users to burst for any amount of time until the network starts getting congested and traffic marked discard eligible starts getting tossed.

The bursting allowance shows that each carrier has its own interpretation and implementation of CIR that is based on the frame relay switching platform it uses and its networking philosophy. This means users do not necessarily need to purchase the same amount of CIR to achieve similar performance on different carrier networks.

In the past, most carriers used a StrataCom IPX-based switching platform that did not allow bursting above CIR for anything longer than a few milliseconds. This forced customers into buying some amount of CIR for all connections.

In early frame relay networks, Sprint's TP4900 — which is now called the TPX 1100 and is a joint effort of Alcatel Data Networks and Sprint — allowed for extended continuous bursting above CIR. Sprint leveraged this advantage by pioneering the use of a zero CIR PVC.

Coupling zero CIR with Sprint's usage-based option may provide a less expensive alternative to buying CIR for all network links. "The usage-based option is ideal for companies with field offices which have sporadic usage patterns," says John Lee, manager of information technology at Falcon Microsystems of Landover, Md. Availability of zero CIR and usage-based pricing was a big factor in Lee's selection of Sprint.

Recently, StrataCom introduced its Foresight software, which allows carriers using the IPX to support the same type of extended burst capability as Sprint. Foresight enables the IPX to use a unique, closed-loop congestion management system. Of course, Foresight is only a tool and each carrier using the software can choose how it will offer the new feature to their end users. Since Foresight is really a congestion management solution, users should ask carriers to provide an in-depth description of both their sustained burst options and their approach to congestion management.

Carriers that use other switching platforms also have different performance characteristics and management schemes. The end result is that CIR, while meaningful, is not going to be an absolute measure of performance.

Another option some carriers provide is an oversubscription allowance. Oversubscription enables users to assign full port speed to each PVC terminating into a single port. This enables one PVC to operate at full CIR when all others are idle. When more than one PVC is transmitting, they contend for bandwidth.

Network managers may want to consider the possible impact of sustained bursts on applications, which are sensitive to variations in network performance, and on the expectations of network users.

Some applications and protocols perform best in an environment where network delay is predictable. For example, in an order entry environment, order takers develop a rhythm for filling in information on terminal screens — typically traditional SNA terminals — and will appreciate consistency in screen delays and updates.

It matters less that a few seconds are saved in transmission and more that the rhythm is maintained for such an application. A sustained burst capability may actually reduce overall user productivity because the order taker can get distracted by screen updates that are too quick or may need to call back screens that disappeared too quickly. In this case, it may be optimal that the frame relay PVC emulate a dedicated connection and not allow sustained bursts.

Other applications and protocols may not have a sophisticated recovery system that can detect when frames that exceed CIR have been discarded. Without the ability to detect and regenerate these missing frames, it may be better to proactively avoid the event by ensuring that transmission speed on PVCs supporting such applications and protocols never goes beyond CIR.

Additional forms of pricing net managers can expect to encounter include:

- **SVCs.** Now that the frame relay forum has released specifications for an SVC, net managers can expect frame relay switch vendors to start implementing that capability in their hardware. Once the hardware implementation is done, which should take about a year, carriers can start rolling out SVC services.
- **Asymmetrical PVCs.** Offered by WilTel, MCI and AT&T, this form of pricing offers a more flexible way to handle varying network requirements. Asymmetrical PVCs enable users to assign different CIR speeds on a PVC based on the direction of traffic. For instance, small frames of data requesting information from a remote server can be transmitted at low speed. The server can then transmit the large frames of data needed to satisfy those requests at a higher speed.

BEGINNING AT THE END

Aside from cost, a critical area that should be considered when selecting PVC and CIR speeds is the expectations of end users. SNA managers have long been proactive in engineering the network so that performance over time, even as more and more users are brought onto the net, is consistent.

Take, for example, a network manager that deploys frame relay to support several remote work groups consisting of an engineering and development team, several remote sales offices and a remote data processing site.

Because the number of users in the initial network configuration is relatively low at each site — only those work groups connected to LANs and screaming the loudest for connectivity — a conservative CIR is provided. A relatively low initial network utilization enables users to consistently enjoy transmissions above CIR. All the users get accustomed to very rapid file transfer time and quick network response.

The net manager is happy because the network is performing better than what was set out in the contract. The end users are happy because the network is delivering outstanding performance. However, the network manager begins to provide connectivity to more and more user groups and applications. Even though those groups and applications are added in a cost-effective and easy manner, the original network users are no longer happy because they perceive network performance is starting to drag.

More users means more contention for network capacity. More PVCs are active simultaneously, meaning that less and less excess port capacity is available for allocation to PVC bursts. The network may still be consistently delivering a transfer rate slightly in excess of the CIR that was purchased, but the actual performance from the end user's perspective has decreased over time.

These original users are no longer satisfied with the network's performance because their expectations have been set by past performance and those expectations are no longer being met. The network manager begins receiving complaints. End users are demanding to know why the network is no longer providing the level of performance and response to which they have grown accustomed. The manager is no longer happy because either more CIR must be purchased or a service that is now considered unsatisfactory must be maintained.

Therefore, the proactive management of these end-user expectations should be considered. Depending on the planned growth, the user applications and the expected network performance, it may once again be more appropriate to provide consistent network perfor-

Frame relay switching platform used

Carrier	Switch vendor	Model
Ameritech	AT&T	Broadband Networking Switch-2000
AT&T	StrataCom, Inc.	IPX
Bell Atlantic Corp.	Siemens Stromberg-Carlson	EWSM
	Cascade Communications Corp.	STDX 6000
BellSouth Telecommunications, Inc.	AT&T	*
BT North America, Inc.	Cascade Communications	*
Cable & Wireless Communications, Inc.	StrataCom	IPX
CompuServe, Inc.	Northern Telecom, Inc.	DPN 100 series
EMI Communications Corp.	StrataCom	IPX
MCI Communications Corp.	StrataCom	IPX
	Siemens Stromberg-Carlson	EWSM
NYNEX Corp.	Wellfleet Communications Corp.	Backbone Node Switch
Pacific Bell	Northern Telecom	*
PacNet, Inc.	Newbridge Networks, Inc.	3612 Main Street
Southwestern Bell Corp.	Cascade Communications	STDX 6000-B STDX 9000
Sprint Corp.	Northern Telecom	DMS-100
US West Communications, Inc.	Alcatel Data Networks/Sprint	TPX 1100
	AT&T	Broadband Networking Switch-2000 and Datakit
WilTel	Cascade Communications	STDX 3000/6000
	StrataCom	IPX

* Model not provided

mance over time.

Coyne Gibson, telecom manager at Convex Computer Corp. of Richardson, Texas, says one of the single overriding objectives in his network design is to ensure that any user accessing the network from any location worldwide at any time of the day or night will experience a constant look and feel to the system and the network performance.

If predictable and consistent network performance is a critical factor, then managers may want to consider a frame relay network design that optimizes around this objective.

WilTel, for example, allows users to set the sustained burst rate of each PVC at any level between the PVC's CIR and the port connection speed. This allows each PVC to be optimally designed to support the end users and applications that will utilize it. If the sustained burst rate — called the maximum sustained transmission rate — is set equal to the CIR, then the PVC will function like a dedicated connection, while still maintaining its ability to automatically route around network failures.

NEW ACCESS OPTIONS

To go along with design alternatives, carriers are rolling out new access options. As late as a year ago, customers used a dedicated T-1 or 56K bit/sec line to reach an interexchange carrier service.

As anyone running an enterprise network knows, dedicated connections have limitations, particularly when it is becoming increasingly important to support network access for mobile and remote workers as well as sites with low usage.

Most carriers are planning to offer high-speed dial-up access to frame relay, but currently only AT&T and Sprint support analog dial-up access. Sprint also offers access to frame relay via dial-up circuits that support the Internet Protocol at up to 14.4K bit/sec.

The rest of the carriers are still involved in pilot programs and have yet to roll out dial-up service. But net managers can expect to see a variety of dial-up options emerging over the next year or two. Those options include dial-up X.25 access to frame relay, as well as access via asynchronous links, Integrated Services Digital Network circuits and dial-up facilities that support the Point-to-Point Protocol.

Another new form of access will provide disaster recovery options. While a public frame relay network provides excellent redundancy, the customer's dedicated access line still represents a single point of failure. Carriers are now helping their customers figure out and install backup access arrangements.

The basic issue is that any backup circuit must terminate to the same port on the frame relay switch in order for network traffic to reach users at the affected site, and vice versa. The reason for this is that the frame relay interface on routers at the customer site only read the wide-area portion — the Data Link Control Identifier — of the frame relay address, which denotes a particular port.

It is possible to provide alternate routing through the use of dual access lines connected to a single router. If two local loops are used at one location to provide local access redundancy, then three alternative architectures are possible.

First, each loop can terminate into a separate port connection and each port can have its own set of PVCs.

In this first architecture, each remote site has two PVCs back to the central site. However, each PVC has only half the CIR it would otherwise require and the port speeds at the central site — where two access circuits and two ports are being used for redundancy — are only half the speed. The router then load balances the traffic between the PVCs. If one access line at the central site should fail, all connectivity to remote locations is maintained but at half of the normal speed.

Sprint, WilTel and MCI have customers utilizing this first architecture with success. WilTel calls this configuration dual-homing. The two port connections can even be in different cities or on different backbone switches, which provides further protection against single points of failure.

The second option entails the use of an A/B switch placed in front of the port on the frame relay switch within the carrier's POP. The A/B switch supports two local loops, each terminating into the same router at the customer site. In the event of a local loop outage, the user can dial directly into the A/B switch and manually activate the backup loop. The router must then be configured to transmit all traffic over the back up loop.

The last option is a variation on the A/B switch theme. For instance, net managers can install automatic protection switches in front of the router and ask the carrier to do the same in front of the port on the frame relay switch at the POP. In theory, this solution would provide real-time monitoring of the primary access line and automatic switching to the backup line. In practice, it would also add two additional single points of failure.

There are other disaster recovery options aside from providing dual dedicated access lines. For instance, MCI supports dial-up 56K bit/sec access to the A/B switch so that a dedicated local loop does not need to be purchased. This can provide significant cost savings if the location can be adequately backed up with a 56K bit/sec connection. Sprint offers switched digital access to a backup switch and port in the case of switch outage.

Another issue of access is the ability to get onto the Internet. AT&T, Sprint, WilTel and EMI Communications all offer the option of dedicated access to the Internet via frame relay. This is typically done by providing a connection from the carrier's frame relay network to a port on an Internet access provider's

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Carriers march to user's beat

When setting out to acquire a frame relay service, Cadence Design Systems, Inc. did everything it could to get carriers to provide what it wanted.

"Set defined values and make the carriers measure up to them," advises Edward Bowden, senior manager of telecommunications at Cadence, a leading provider of automation software for integrated circuits and accelerated electronic systems design in San Jose, Calif.

Bowden knows whereof he speaks, having evaluated frame relay carrier services twice during the past three years. Bowden conducted his initial evaluation in 1991, when the need became clear for higher speed dial-in capabilities for electronic mail and sales order entry. In 1993, he spent three months reevaluating frame relay services to identify a carrier that could meet his firm's international networking needs.

Bowden based his carrier selection on two key criteria: outsourcing routing operations and adherence to price targets. He launched his first investigation into frame relay services by visiting four prospective carriers several times to gain an understanding of their data networking strategies. He came out of that fact-finding mission with a feeling that there were two camps of carriers: those that were used to selling circuits and viewed frame relay service as base transmission, and the traditional value-added network carriers that were offering a more complete package.

"We told everybody that we did not want to buy or maintain our own routers, and the carriers who were responsive to that remained under consideration," Bowden says.

He was equally successful in meeting his cost objective. "We figured [the cost should be] about $1,000 to $1,200 per site per month, and by the end of the negotiations, we had achieved that figure," Bowden said. He reached that cost range by reviewing all available price quotes and applying them to his company's situation.

The end result was a domestic 20-node CompuServe, Inc. Frame-Net internetwork that was implemented in about 10 weeks and cost about two-thirds that of an equivalent private-line network.

When it came time to expand internationally, "We set the same kind of benchmarks for cost savings as we did for the domestic net," Bowden says. But he went beyond pricing and routing outsourcing when examining carriers' global net plans. For instance, Bowden wrestled for three months to evaluate carriers' international net management capabilities to his firm's overseas site and chose CompuServe to install links to locations in France and Germany.

While he twice gave the nod to CompuServe, Bowden points out that the choice of an international provider can be totally unrelated to the domestic choice. "Support issues are far more important for international than domestic service, as is experience in providing an end-to-end service," he says.

Interestingly, Bowden found that international frame relay can be easier to administrate than international private lines because it avoids local taxation issues. Basically, this means U.S. companies that order a frame relay circuit in a foreign country do not have to pay local taxes on those circuits.

C. Finn

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router.

Users of a carrier's frame relay service can assign a PVC that defines a path to the Internet provider's port. Doing so establishes connectivity to the Internet without incurring the cost of a separate router, Internet access loop or port connection. WilTel partners with several Internet access providers, giving end users a choice. AT&T and Sprint offer dedicated links to Internet providers.

NETWORK MANAGEMENT

The ability to manage a frame relay network is also a critical decision-making factor, especially for users migrating from private-line arenas. A well-implemented network management system can decrease network operation costs by improving the ability of the network manager to remotely identify, isolate and resolve network problems.

Carriers have been forced to develop a unique set of management options for frame relay. Service management designers have bowed to the standards and needs of the LAN environment in creating solutions. For instance, the Simple Network Management Protocol is the widely supported choice today. Carriers are offering SNMP applications that run on various SNMP-based management consoles. They are also offering fully configured SNMP workstations and centralized management of their frame relay hardware via SNMP.

Carrier plans for supporting frame relay over ATM

Carrier	Date
Ameritech	4Q 1994
AT&T	2Q 1994
Bell Atlantic Corp.	*
BellSouth Telecommunications, Inc.	2Q 1994
BT North America, Inc.	1994/1995
Cable & Wireless Communications, Inc.	1Q 1995
CompuServe, Inc.	1Q-2Q 1994
EMI Communications Corp.	1Q 1995
MCI Communications Corp.	**
NYNEX Corp.	3Q 1994
Pacific Bell	1Q 1995
PacNet, Inc.	2Q 1994
Southwestern Bell Corp.	1Q-2Q 1996
Sprint Corp.	4Q 1994
US West Communications, Inc.	3Q 1995
WilTel	Dec. 1993

*To be determined possibly by 1Q-2Q 1995
**To be determined
ATM = Asynchronous Transfer Mode

The chart on page 34 notes that 10 of the 16 carriers listed enable customers to manage their frame relay services via SNMP. While the use of SNMP makes management capabilities roughly equal among the carriers, there are differences in the platforms supported and whether the carrier provides the SNMP management and workstation application. AT&T and MCI, for instance, offer a prepackaged SNMP workstation with their SNMP-based frame relay service management application.

However, most network managers already have their own management system in operation. SunConnect's SunNet Manager, Hewlett-Packard Co.'s HP OpenView and IBM's NetView are the most common. It is important to be able to manage the frame relay network by being able to receive such information as alarms and gain access to such data as performance statistics from existing tools. Carriers that support an SNMP agent in the frame relay equipment within their network cloud allow such management information to be obtained without forcing customers to invest in new hardware and software.

Carriers have also installed SNMP-based management internally and can offer outsourced SNMP-based management of customer premises equipment, such as data service units/channel service units (DSU/CSU) and routers.

AT&T will provide customers with Cisco Systems, Inc. routers and Verilink Corp. CSUs, and manage that equipment as part of its Extended Connectivity Option. WilTel likewise provides and manages 3Com Corp., Cisco or Wellfleet Communications, Inc. routers as part of its LAN internetworking service, while Sprint offers SNMP-based management of ADC Kentrox DSU/CSUs and either Cisco or Wellfleet routers. CompuServe provides managed Verilink CSUs.

Net managers preferring to stay away from SNMP can still receive reports of network utilization and performance. Several carriers will supply these reports on paper or via a terminal attached to the carrier management system. These reports can provide insight into the level of utilization of a PVC over a given time period as well as information that is useful in fine-tuning the network configuration.

Some carriers such as WilTel are beginning to offer net managers the ability to use a terminal that taps into the carrier frame relay management system to order new PVCs or request configuration changes. Real-time network reconfiguration is probably not far behind.

NEGOTIATING FOR FRAME RELAY

After poring over all the differing service options, the last thing net managers have to do for a frame relay service is negotiate with the carriers. While carriers are still a little sheepish about quoting prices publicly, they have no problem providing a quote within the confines of a request for proposal. In fact, net managers will find the prices quoted in an RFP are often better than the ones stated publicly.

In preparing an RFP, users should make the carriers put pricing information into a common format with a detailed summary of per location charges and PVC charges.

Companies putting up entirely new networks or moving from dedicated circuits to frame relay will probably have difficulty in sizing access ports and PVCs. The first reason for this is that they may not have a functioning network to use as a baseline, and the second is that users do not get any traffic statistics from private-line networks unless they use a protocol analyzer on each circuit.

As a result, it is not really possible to take a snapshot of the entire enterprise network at once. Users need to ask carriers to provide pricing on a range of scenarios and invite them to provide as much analysis of the potential network needs as possible. This will not only help in the implementation, but it will also give a good view of the carrier's expertise.

Although net managers will be putting an entire network out to bid, they should require the option of installing one or two test links before committing to full installation. This is especially important for those with no frame relay experience. Really, there is no sure way to know how a particular service will support specific applications unless the net manager does a little experimenting first.

As mentioned, frame relay networks, unlike digital private lines, have individual performance characteristics that can be tuned down to the individual PVC level. No longer can you generalize about carriers by platform switch. The switch is now akin to a musical instrument; there are good and bad instruments, but the true difference depends on who is the musician.

When putting a net out for bid, there is no right configuration and sizing. This is another reason why it is important to go through a trial stage before full implementation.

Lastly, net managers should make the carrier commit to network and service support performance levels and back them up with service rebates. This once strictly European custom is becoming more common in the U.S., and carriers are more or less amenable to it based on contract size.

FRAME RELAY FOR THE MASSES

As is becoming evident, frame relay is the first of many high-speed internetworking services to be offered successfully by carriers. Customers will be able to choose the correct service for their needs, and, as distributed computing hits the mainstream, customers will be able to plug new sites into the carrier's high-speed backbone through their selected interface mechanisms.

Further, carriers are making it extremely inexpensive to make connections from one enterprise to another. Imagine calling a carrier and ordering a link to a new trading partner without having to make any physical changes to either network. The carrier simply installs PVCs between the two virtual networks, and the customers make the appropriate changes in their routing tables. It does require that the two parties be subscribers to the same network.

While frame relay is not the sexiest of the new fast packet or cell services, it is providing exponential leaps in bandwidth for a lot of mainstream companies. Most frame relay users will testify that the service delivers on its promise of flexible bandwidth, but carriers have had to come a long way to offer an effective service.

Frame relay is a big step on the road to broadband services, and those who choose to wait rather than implementing frame relay just may end up that much farther away.

"Sooner or later, [upper] management is going to ask what you are waiting for," says PMI Mortgage Insurance Co.'s Fey.

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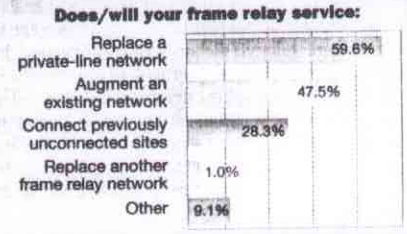
Reader views on frame relay services

Based on 100 interviews.

Does/will your frame relay service:

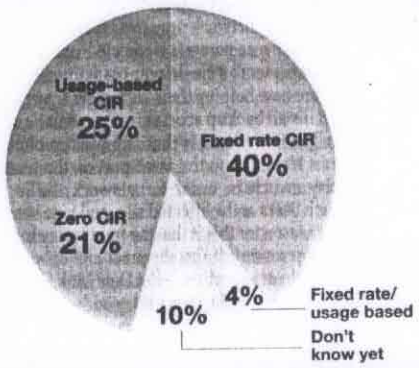


How much of a role did the following play in justifying your frame relay implementation?

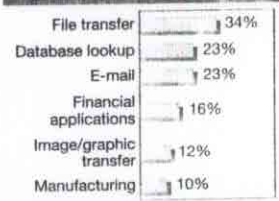
Based on highest possible ranking of 7.

Cost benefit over existing private line	5.83
Upgrade of network technology	5.69
Network implementation	5.45
Need for mesh connectivity	4.50
Need to outsource some management of data network	3.14
Other	1.00

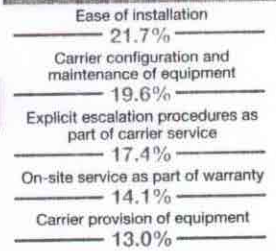
What frame relay permanent virtual circuit committed information rate (CIR) options do/will you use?



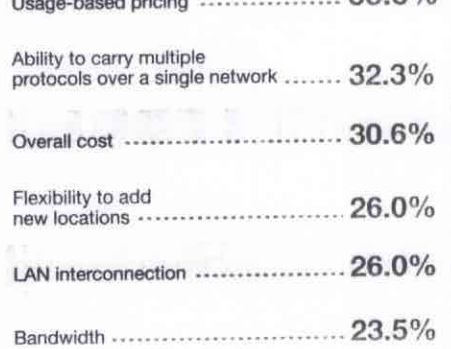
What are your key business applications that use/will use frame relay?



What are your key service and support issues?



What are your determining factors in selecting a frame relay service?



The information in this graphic illustrates key findings of a recent *Network World*/ Focus Data, Inc. reader survey. Focus Data, an independent market research firm in Framingham, Mass., conducted the survey and tabulated the results. For more information on Focus Data services, call (508) 626-2556.

GRAPHIC BY TERRI MITCHELL