Payoff

Frame relay connections are relatively affordable and support multiple applications. The application scenarios in this article should help network managers design, procure, and operate their own frame relay network.

Problems Addressed

There are many applications for frame relay in wide area networking. Frame relay connections are in some ways like logical leased lines with special properties—namely, they cost less, support multiple applications, or allow traffic to temporarily burst at high rates. This article discusses a few applications that should help network managers understand how Frame relay can benefit their networking situations.

The Beginning: Lan Internetworking

The first widespread application for frame relay was the interconnection of routers. Before the advent of Frame relay, router networks typically used leased lines and Point-to-Point Protocol, or perhaps X.25, to carry traffic between sites. A dedicated leased line was necessary between locations for which a one-hop connection was desired, but as networks grew, more and more ports and leased lines were required in every router in the network, thereby increasing cost. In addition, leased lines often cost more for installation and in per-month charges than Frame relay connections do today.

When Frame relay is used for LAN internetworking, savings can be realized in several areas, including equipment, installation, local loop, and wide area charges. If a smaller router chassis or less expensive port card can be used, additional savings can be realized.

Newer Frame Relay Access Devices (FRADs) from several vendors provide an alternative to routers in some internetworking applications. FRADs offer one or both of the following advantages:

- Equipment cost savings, as compared with access routers.

- The ability to share the Frame relay network with non-LAN applications.

Training costs are usually minimal as communications or IT personnel learn to manage Frame relay as Data Link Connections (DLCs), in a fashion similar to how they have managed leased lines; virtual circuit replace physical circuits when packet-switching techniques are used.

Workstations and workgroups can send mail and access servers over the internetwork riding over Frame relay (see Exhibit 1). As shown in this exhibit, only four physical connections are required to link all sites (using as many data link connections as required for the desired logical topology).
LAN Internetworking over Frame Relay

An area to be aware of in this application concerns dynamic-routing updates. All of the various routing update protocols (e.g., OSPF [open shortest path first]) generate some traffic over the wide area.

The application in Exhibit 1 applies to NetWare Internet Protocol Exchange (IPX) as well as Internet Protocol (IP) environments. With NetWare, some tuning may be required for optimal performance over wide area links, such as Frame relay.

Sna/Sdlc Communications

One application—the replacement of leased lines carrying Synchronous Data Link Control traffic by frame relay DLCs—provides Systems Network Architecture (SNA) users with the opportunity to save twice and improve performance. Users save first by replacing a leased line (typically 19.2K or 56K bps) with a lower-cost Frame relay connection and, second, by sharing the Frame relay connection with another application (see the section on LAN and Legacy Transport). When the Frame relay connection provides more bandwidth to the application than was previously available, performance can be improved as well.

This application has picked up steam more slowly than LAN internetworking over Frame relay, probably because of the conservatism of most System Network Architecture network managers compared with LAN designers. However, the maturing of Frame relay technology in IBM front end processors (FEPs) and AS/400s in early to mid-1994 has cemented the practicality of Frame relay in the IBM environment.

The task of connecting remote SDLC controllers to Front-End Processor and AS/400 midrange computers can be accomplished in two ways:

- By using a FRAD at both ends of the connection and transporting SDLC over Frame relay (usually by spoofing the protocol—that is, by locally acknowledging the polls and sending only data to the other end). Network managers may also use a FRAD or router as the remote end only and communicate directly with the Front-End Processor or AS/400 by using logical link connection type 2 (LLC2) encapsulated in Frame relay using the Regional Financial Center 1490 standard. Some FRADs and routers support this direct connection with IBM gear.

- By using a router or FRAD at both ends that supports data link switching, which encapsulates the SDLC/LLC2 traffic into IP.

Both of these methods can use a Frame relay network for long-distance communications. Each technique offers the possibility of sharing the Frame relay connections with other traffic—either with LAN or other legacy applications in the case of most FRADs and with other LAN applications only in the case of most routers—and thus achieving further cost savings.

Token Ring Connectivity.

Token Ring has widespread acceptance in the IBM environment, of course. When connecting routers or bridges over Frame relay to support source route bridging (SRB), Data Link Connections are used to replace leased lines. Care must be taken in network design to account for the traffic generated with SRB. Sometimes Token Ring is used only at the host end, whereas some or all of the remote ends use SDLC serial connections.

The latter solution is popular when there are many remote sites, but the expense of Token Ring cannot be justified at these sites the way it is at the host (i.e., for the savings gained using a single Token Ring versus supporting a large number of serial SDLC ports).
This application variant also fits the model previously described when a FRAD or router at the host site that supports Token Ring connectivity is used.

Additional information on SNA over Frame relay support should become available as IBM and others introduce products that support IBM's High-Performance Routing (HPR) capability under the Advanced Peer-to-Peer Networking (APPN) umbrella. Until then, the types of solutions indicated in this application example (and illustrated in Exhibit 2) can be used to provide practical SNA over Frame relay solutions.

**SNA/SDLC Communications over Frame Relay**

**Internet Access Over Frame Relay**

With the increasing popularity of the Internet, the need for cost-effective network access by both businesses and consumers has increased. The issue faced by small and medium-sized businesses—and by branch or regional offices of larger businesses—is that the monthly cost of dedicated access may still be prohibitive, yet the performance of more affordable dialup connections is somewhat disappointing.

Dialup performance is exacerbated by the use of powerful information tools such as Mosaic, from the National Center for Supercomputing Applications (NCSA) at the University of Illinois, or its cousin Netscape, from Netscape Communications Corp., both of which are among the popular tools used to access the World Wide Web. With these tools regularly transferring thousands of characters of text and perhaps millions of bytes of graphics to and from users' PCs each session, 14.4kilo-bps or even 28.8 K-bps modems quickly become a bottleneck.

Frame relay offers a unique solution to this problem. Dedicated access to the user's Internet service provider is supplied through a 56K-bps, Fractional T1, or full T1 link (or from Nx64 to E1), depending on the performance required and budgetary constraints. This connection is usually less expensive than the equivalent leased line service. (If it is not, some users may choose to acquire a leased line to another one of their offices, where the service is more affordable, or to set up a private frame relay network of their own.) A FRAD or router is then used to connect to the Internet service (often associated with a firewall server or bastion host for security).

Savings are realized in any or all of the following areas: equipment, installation, local loop, and Internet service charges. If a small FRAD or smaller router can be used, additional savings are realized. FRADs from several vendors provide an alternative to routers in some applications, making it possible to reap some equipment cost savings and to share the Frame relay network with non-LAN applications. For a single workstation, a PC card providing the required serial interface can be used (remembering to include the Data Service Unit/Channel Service Unit, however). Training costs are usually minimal; communications personnel become accustomed to managing Data Link Connections much as they have managed leased lines.

Exhibit 3 illustrates Internet access over Frame relay. Frame relay can also be used for private internetworks and for networking NetWare LANs (IPX).
Internet Access over Frame Relay

LAN and Legacy Transport

For some users, it is possible to share the Frame relay line for multiple applications. This solution allows the multiple leased lines required for, say, NetWare LAN-to-LAN communications along with simultaneous Burroughs terminal/host communications to be collapsed into a single Frame relay access line. How the applications share the line depends on several factors, including:

- How the network is designed (e.g., the price/performance criteria).
- What Frame relay access equipment is selected.
- What the selected Frame relay access equipment offers in terms of applications support and for Data Link Connections sharing.

The third factor is often ill-understood by network designers unfamiliar with either Frame relay or X.25. The ability of the Frame relay equipment to share a data link connections with multiple applications means that, in some cases, a single data link connections can serve as a pipe to send more than one application through to a common destination, as is often seen with both hub-and-spoke and hierarchical networks.

Not all Frame relay equipment lends itself to supporting the data link connections-sharing feature. In the case of SNA/SDLC, routers more commonly support SNA/SDLC transport through data link switching (DLSw). Some routers offer some X.25 support as well, but it is usually limited to routing IP over X.25. asynchronous support may be available but limited to Telnet (i.e., Asynchronous over IP). That is, routers can share a data link connections (acting as a logical leased line) with multiple IP applications. This feature is not surprising, however, because routers were designed for IP applications and use IP as a backbone transport protocol.

Client/Server Migrations.

In the case of a mixed LAN and legacy situation, most FRADs offer a larger degree of legacy application support, adding bisynchronous, Burroughs Poll/Select, Uniscope, asynchronous, and X.25 support to SNA/SDLC, as already discussed. Again, not surprisingly, most FRADs offer less in the way of IP and Internetwork Packet eXchange support than routers; some support only serial line IP (SLIP) and Point-to-Point Protocol, for example. There are, however, several notable exceptions to this rule.

Some FRADs offer the ability to share a single data link connections with heterogeneous applications (e.g., Internetwork Packet eXchange plus Burroughgs). These cases arise out of the desire to migrate applications gradually to LAN client/server arrangements or often simply to take advantage of the lower cost of Frame relay versus leased lines (perhaps by merging two leased connections into a single Frame relay line) while avoiding complete reengineering of the applications for an IP client/server arrangement.

Priority Algorithm.

No matter how the data link connections is being shared, a key factor is the ability of the FRAD or router to keep one of the applications from overwhelming the other. This is
accomplished by way of a fairness or priority algorithm. More and more FRADs and routers offer this capability, which is required when a line is being shared for multiple applications over the same data link connections or over separate data link connections. When the applications have different destinations (e.g., different hosts or servers in distant facilities), the applications can share the Frame relay access line, but not the same data link connections. It may also be advantageous from a network management point of view to have all LAN traffic from a site travel over one data link connections and all legacy traffic travel over another (see Exhibit 4). That way, priority assignment or tuning can be done in a way somewhat similar to using separate leased lines. The disadvantage is, of course, the incremental cost of additional data link connections.

**LAN and Legacy Traffic Networked over Frame Relay**

**Sharing Wide Area Links: Bandwidth On Demand**

An overwhelming reason to use frame relay is the ability to send a burst of data at rates above the committed information rate (CIR)—the guaranteed service a customer has contracted for with the Frame relay carrier—when the offered traffic from one or a combination of user applications exceeds the Committed Information Rates. For example, a customer's original application runs on a 56K-bps leased line. The average traffic is 14.4K bps. However, at certain times, the instantaneous demand is much higher. The leased line could support 56K bps maximum. A 56K-bps frame relay line can offer approximately the same transmission (actually slightly less, because of a small amount of overhead). But the customer would not necessarily have to pay for a 56K-bps CIR when using Frame relay, given that the average traffic is lower. The customer could select a typical 16K-bps CIR offering, for example, to deal with the average traffic rate and allow the traffic to burst up to 56K bps. The disadvantage is that the traffic above the CIR (16K bps in this example) can be discarded by the carrier if the network is in congestion at the time the extra data is sent.

**Burst Rates.**

This arrangement is even more advantageous when the customer considers a T1 Frame relay connection versus the original 56K-bps leased line. The burst rate could then approach 1.536M bps, or whatever Fractional T1 rate (e.g., 768K bps) was contracted for with the carrier.

The Frame relay carrier can accommodate these bursts up to the line rate, or more typically, up to another limit known as the burst rate, as long as there is excess bandwidth available in the Frame relay network at the time it is needed. If the bandwidth is not available, the excess traffic (i.e., the amount over the CIR) is discarded. If there is a burst rate limit set below the line rate, any traffic above the burst rate is automatically discarded. (The speed the traffic can burst to can never be higher than the line rate, of course, unless some form of data compression is being used.)

Although there are some pitfalls (which are discussed later), overall, the ability of the Frame relay connection to accommodate bursts of traffic becomes even more compelling when users combine multiple applications onto the line. With two applications whose combined average traffic rate is less than or equal to the CIR chosen, the ability to send a burst of data allows more traffic to get through for those instances it is required, while the customer pays only for the average rate. Because most carriers design their
Frame relay networks to allow for a reasonable level of instantaneous bursting by their customers, the situation should work in the customer's favor.

**Congestion Control.**
A related issue is congestion control. The router or FRAD the network uses should be able to deal with congestion caused by oversubscription at the user side of the device or from the network side, if the carrier's network becomes overloaded either transiently or over the long term.

When network managers measure their traffic throughput, they should be getting at least as much as their CIR. If not, something is wrong, either because of errors or congestion somewhere in the network or in the attached equipment.

Sharing of bandwidth, which is accomplished through statistical multiplexing, is illustrated in Exhibit 5.

### Sharing Bandwidth over Frame Relay

**Pointers On Frame Relay Network Design**

Although this section is not intended to give blanket guidance on network design, it does offer a few pointers on frame relay network design.

**Frame relay DLCs can be thought of as specialized leased lines.**
Cost and performance characteristics of Data Link Connections are predictable (or at least estimable). Network managers should size their traffic and choose their Committed Information Rates appropriately. Zero (0) CIR service may be priced attractively, but it may not offer the throughput desired when it is really needed. (As always, when negotiating a contract, network managers should make sure they have service guarantees.)

**A frame relay connection should have slightly higher latency than the same-speed leased line.**
This is especially true over long distances that may route traffic through several switches. Network managers should investigate costs to find out where frame relay's savings provide the opportunity to use a higher-speed connection (as opposed to the CIR) in order to reduce latency.

**When a leased line network is compared with frame relay, significant cost savings may be apparent.**
Customers typically see a small savings with most Frame relay service offerings, but not all. Some frame relay offerings are actually more expensive when compared one-to-one with leased lines, often where the leased line bit rate and the CIR are the same. The largest savings occur when customers build a network of data link connections using fewer physical connections than required by the original leased line topology and size these connections—clock speed and CIR—appropriately.

**Factor in Other Charges.**
When comparing Frame relay dedicated access to switched connectivity options such as Integrated Services Digital Network, switched 56 service (“dial” Digital Dataphone Service at 56K bps), and analog modems, the network manager should bear in mind that these options typically entail a per-minute charge—at least for long-distance traffic, though sometimes for all traffic—in the same ways that X.25 services typically have per-packet charges on the amount of traffic sent. These charges can add up quickly. Network
managers should do the math for the connect times that their applications require, at least for an estimate of the average times. Usually, they will find a crossover point in terms of minutes or hours of connect time for their applications that may make dedicated services such as frame relay a better choice. Often this is on the order of only several solid hours of connectivity per day. (In addition, users may need to disconnect from switched services when they are done working or doing work offline. They will then experience a call setup delay when reconnecting. This situation does not occur with dedicated access.)

**Frame relay services are typically priced as fixed costs based on local loop, number of DLCs, and CIR chosen.**
A few services charge in regard to distance, too. Nevertheless, a fixed amount can be budgeted that will not vary for the term of the contract. This pricing can be a major advantage in controlling costs when compared with switched services.

**A hybrid approach should be considered.**
Several carriers offer (or are planning to offer) integrated services digital network (ISDN) to Frame relay interworking in their networks, with integrated services digital network (ISDN) used as a switched, cost-effective local loop alternative. Some regional carriers may drop or significantly reduce per-minute charges (at least for local calls within their service region), making integrated services digital network (ISDN) the best choice for the local loop. Therefore, some hybrid approaches might be considered, including:

- Dedicated or switched remote connections, chosen depending on the application served, connect-time estimates, and service available (e.g., integrated services digital network (ISDN)).
- Dedicated service at the host/server site, where connect time will be high, easily justifying dedicated service that is sized for predicted average and peak traffic.

**Standard facets of connectivity or performance should not be overlooked.**
Frame relay will not magically supercharge an application. Businesses should design their distributed applications with networking in mind.

- Using higher-speed connections (Frame relay or not) or improving the organization’s applications are the factors that make the bits travel faster (data compression is another option). What Frame relay can do for the corporate network, however, is provide higher-speed connectivity more affordably.

**The Economics: When Does Frame Relay Make Sense?**
The flowchart in Exhibit 6 is intended to be used as an quick guide for determining when frame relay may be appropriate for a particular networking application. Network managers need to carefully examine and consider several key factors before making a final determination about whether it makes sense to use Frame relay. These factors include:

- What is the network topology (e.g., hub and spoke, hierarchical, mesh, or hybrid)?
- What performance criteria do the network use (e.g., transfer times, latency, or response time)?
- What is the networking budget (e.g., for circuits, people, and equipment)?
A Rule of Thumb for Frame Relay

Cost Components

The following is a summary of cost components in Frame relay network design. Readers should use this list as a basis for their own evaluation checklist, adding those items that apply to their unique situation. Each item on the network manager's checklist can be assigned a weight according to its importance or impact for the particular networking scenario. This method can help the network professional in making a thorough evaluation and decision.

The chief Frame relay costs are for communications, personnel, and equipment. Communications costs cover Frame relay service, which includes:

- Access speeds (e.g., 56K bps, T1).
- Burst rate (which may be fixed).
- Distance charges (usually do not apply).
- DLC and Committed Information Rates (although costs should be less for Data Link Connections after the first, charges for succeeding data link connections vary significantly, depending on the carrier).
- Local access (e.g., per month to Regional Bell operating company or interexchange carrier service; these costs may be bundled).
- Installation (a one-time charge).

Personnel costs include:

- Salaries.
- Training (e.g., costs for training personnel on Frame relay technology, Simple Network Management Protocol, the chosen equipment, and the carrier management interface).

Equipment costs include:

- FRAD or router or PC card (e.g., one-time cost plus maintenance).
- DSU/CSU, Terminal Adapter, Integrated Services Digital Network terminal adapter (TA), modems, or other line termination and cable (unless equipment with integral line termination is selected).
- Management station and software (unless already available; maintenance costs must also be factored in).

Contracting For Frame Relay Services

Users may encounter several potential problem situations when trying to implement or operate a frame relay network. Some of the issues to anticipate are discussed next.
The Carrier Does Not Have Any Circuits Available. This situation has occurred from time to time with many carriers over the past few years as demand for Frame relay services has increased. Although this problem is usually rectified by the purchase of more Frame relay switches by the carrier, delays can be significant—as long as 12 to 16 weeks—while the new switches are installed. Many options are available to customers in this situation, including:

- **Waiting.** Depending on the situation, the time can be filled with other project activities, such as the selection of Customer Premises Equipment.

- **Looking for another carrier.** Sometimes even the initiation of a search can get a customer moved up the waiting list.

- **Choosing another networking option.** If the choice of Frame relay is marginal for an application (e.g., remote asynchronous access for PCs and laptops accessing E-mail or files at low speeds or for less than an hour a day), another technology might be appropriate.

- **Beginning installation of a portion of the network that does not use frame relay.** For example, this might include a defined portion of the network in which leased line service is less expensive than Frame relay, or at the central site where LAN connections must be installed.

- **Building a private frame relay network.** After doing the math on the purchased, financed, or leased equipment, network managers can use the results as a guide that might dictate the construction of a hybrid public/private network.

**Performance: What to Expect.**
Network managers should negotiate clear performance guarantees or warranties with the carrier. Several important items for a contract checklist are outlined in Exhibit 7. Readers can add their own requirements to customize the checklist for their situation.

**Frame Relay Contract Checklist**
Communications Circuits
-------------------------------
- Does the carrier offer the access speed desired (e.g., 56K bps, fractional T/1)?
- Do distance charges apply? To answer this question, always draw the geographic network and ask the chosen carriers to price it.
- What are the charges for the first DLC (by CIR)? What are the charges for succeeding DLCs?*
- What are the options for burst rate, for the access speeds chosen? How fast can the network react to bursts—immediately or over some time? What happens to frames that are sent above the CIR—are they tagged DE or not?**
- What guarantees are there for availability? Are these guarantees in writing? How will they be monitored?
- What are the problem escalation procedures? Has the carrier explained how its procedures work?
- What are the local access charges—are they per month to the regional Bell operating company or IXC service? Are they bundled with the IXC service?
- Are there one-time charges for providing and installing the communications circuits? Are installation dates and guarantees in writing?
- What is the length of the contract (in months or years)? How long are the selections guaranteed at the specified costs?

Personnel
---------
- Is training on equipment (including the carrier management interface, if necessary) provided by the carrier?

Equipment
---------
- Does the carrier offer frame relay access devices (FRADs) or routers? Does the carrier recommend equipment? If recommended equipment is used, are installation, warranty, and maintenance explained?
- If carrier-recommended equipment is not used, is the equipment chosen approved for use on the carrier's frame relay service? (It should be.)
- What are the problem escalation procedures?
- Does the equipment provided/selected support a fairness or priority algorithm? Offer congestion control? Support enough LAN and serial ports, and protocols, required now and in the future?
- Is the equipment SNMP manageable?
- Does the equipment provide the DSU/CSU, TA, or other line termination? If it does not, is a cable provided?

* Charges should be less for DLCs after the first, but charges for succeeding DLCs vary significantly among the carriers.
** DE, or discard eligible, refers to frames to be discarded during congestion.

Managing the Packet-Switched Network

Management of a frame relay, IP, or any packet-switched network is difficult to imagine for those who have not done it before. It is often helpful to think in terms of managing the virtual circuit (i.e., the Data Link Connections in the case of Frame relay) rather than the frames or packets. Each data link connections can be thought of as a leased line. The FRAD or a router should offer information on frames transmitted and received, errored frames, and a number of other statistics. Likewise, carriers may offer statistics to their customers (the carrier should have statistics available from the switches used to provision the service—that is how the carrier’s equipment polices the Committed Information Rates...
and burst rate activity). Anyone who has managed a Time-Division Multiplexing network that supported multiple connections on a T1 (e.g., DS0s or fractional connections) will have done something conceptually similar. Those with Integrated Services Digital Network or X.25 experience will also have worked with similar concepts.

Most Frame relay equipment available today supports Local Management Interface or American National Standards Institute Annex D, both of which are standards governing the management and status of active and inactive data link connections. Another version of this specification is the Telecommunications Standardization Sector's (ITU-TSS’s) version of Frame relay called Annex A, which is used internationally. Frame relay service typically requires that the network support at least one of these options, though usually Annex D. When problems occur with data link connections, customers should first look at the status available from the Frame relay access equipment before contacting the carrier.

### Installation and Configuration

There are several places things could go wrong during installation of Frame relay. The most typical problem occurs with the configuration of data link connections in the Frame relay access equipment. When the wrong Data Link Connections are configured, the network will not be able to pass data traffic. Because the wrong data link connections may be configured because of human error on the customer side or on the carrier side, customers need always check the access equipment's configuration versus the one the configuration carrier has made in its switch. Because data link connections identifiers (DLCIs) have local significance only, it is easy to accidentally configure the local side with Data Link Connection Identifier associated with the other side of the connection, which may or may not be the same as the local one.

If the network is configured correctly according to the information the carrier has provided, it is still possible that the customer received incorrect information from the carrier. Therefore, it is prudent to contact the carrier and have it verify the data link connections numbers it has provided. If they are correct, the data link connections will come up after the carrier checks on them (perhaps they were not already activated or the carrier’s port required initialization). As a last resort, if the data link connections is the first or only one at this connection, the user might try configuring from DLCIs 16, because many connections start from this number. It always helps to have a datascope available to check on the circuit or to have sufficient status display ability in the chosen frame relay equipment.

Exhibit 8 is an installation checklist for Frame relay networks. Once again, the checklist considers three cost factors: communications circuits, personnel, and equipment.

**Frame Relay Installation Checklist**
## Communications

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- Is frame relay service ordered and are installation date and DLCs confirmed in writing?
- Is local access ordered and the installation date confirmed? (It may be bundled with frame relay service.)
- Are installation charges know and purchase-order numbers issued?

## Personnel

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- Have installation or operations staff been trained? Is the carrier or systems integrator providing installation personnel? (All relevant parties must be trained in the equipment, frame relay, and the management system. Even if another group is doing the installation, the customer should participate.)

## Equipment

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- Are the FRAD, router, and other equipment available and configured for frame relay and application interfaces in order to test?
- Have DSU/CSU, TA, or other line termination cable been configured?
- Have relevant loopback or other "sanity check" tests been run?
- Are data scopes, breakout boxes, or other equipment available to verify frame relay connection and DLC numbering and status?
- Are equipment management and control procedures ready and working?
- Has problem escalation been worked out?

## Keeping Costs Under Control

The key to maintaining control over costs is effective management of network resources. Proper network design is a good start. Monitoring of activity and errors will reveal how to maintain and grow the network as required. Establishing a good relationship with the carrier will give the customer a leg up when dealing with service problems or when it is time to renegotiate the contract.

Provided that the chosen Frame relay carrier is giving proper service based on the contracted CIR and burst rate, the most typical problem stems from the CIR chosen and the actual traffic rate. If the amount of traffic actually being offered to the network is higher than the CIR, there is a chance that this traffic will be discarded. If this is the case, throughput could suffer, even when higher-level protocols such as Transmission Control Protocol adapt to the seemingly high error line, as a result of the discarded traffic. Customers must then revisit their traffic calculations and adjust the CIR to be contracted from the carrier appropriately. If the monthly cost of the increased CIR is not within budget, a customer might consider adding equipment or software that compresses data. This option generally requires only a one-time charge, as opposed to monthly, recurring fees.

## Planning For Backup

The most likely backup problems occur in the local loop. Backup scenarios include:

- Having a modem, switched 56, or Integrated Services Digital Network dial backup scheme that dials around the frame relay network.
- Having an alternate Frame relay connection at 0 kilobits per second for low cost, if available (this strategy is not recommended, however, because all data may be
discarded by the carrier) or at the same Committed Information Rates for highest availability. From a network design standpoint, use of another carrier (in particular another local loop connection) or perhaps a non-frame relay leased line should be available as an alternate path if the primary one goes down.

- Obtaining switched access or switched backup from the carrier. Carriers most likely use V.34 modem or integrated services digital network (ISDN) Basic Rate Interface BRI service through their Frame relay service (as opposed to around it).

- Never putting backup connections over the same conduit or local loop as the primary, if at all possible. If the local loop is affected by the proverbial backhoe, all associated links may be affected adversely. Over the long haul, diverse routing is recommended.

Another problem that may become more visible in coming years is network congestion. It is important for Frame relay customers to monitor their service using available statistics and reports. When carriers see on their own that service is not being maintained or when customers complain, the carriers typically add or upgrade equipment in order to return to appropriate service levels.

**Recommended Course of Action**

As a high-speed packet-switching protocol, frame relay is an efficient technology designed for today's reliable circuits. Corporate network managers should find that Frame relay, when properly applied, offers high value and predictable costs. Nonetheless, there are some items to watch for when an organization is designing and implementing a Frame relay application. Not all potential pitfalls and suggested solutions are listed in this section, but after reviewing the applications discussed in this article, network managers should be able to let their common sense guide their network design and debugging procedures.

**Problem.**
Some or all Frame relay connections are more expensive than a leased line.

**Solution.**
The network manager can run Frame relay, X.25, or Point-to-Point Protocol over a leased or switched line for these connections. Private Frame relay networking is an option that is especially practical when Frame relay makes sense overall. If the network is a small hub-and-spoke configuration, some carriers have a special service in which they groom leased lines into a T1—that is, the carrier routes multiple Dataphone Digital Service lines into DS0s on a single T1 and presents the customer with the T1 interface. Exhibit 9 illustrates this solution using equipment from FastComm Communications Corp. Running Frame relay over the user's own leased lines is not a problem. This is essentially how the carriers get Frame relay traffic over the local loop to the customer from wherever their closest Frame relay switch is.

**Running Frame Relay over Multiple DDS Lines from a T1**

**Problem.**
Configurations connect many remotes (e.g., more than 30) to a single router or FRAD with a T1/E1 port. Some routers and FRADs limit the number of Data Link Connections per port (usually when dynamic-routing updates are turned on), largely because of the need to do more processing associated with port handling and computing routing updates.
Customers may assume that they can bring 100 or more sites (DLCs) in over a single T1/E1 Frame relay connection, but this equipment configuration limit could prevent them from doing so.

**Solution.**

Turn off dynamic routing and use a Frame relay switch to break out the T1 into multiple serial connections (thus spreading out the data link connections over several ports), or chose a FRAD or another router that does not have the data link connections limitation. A related situation is the so-called split horizon problem. The problem arose because routers would not send routing updates back along the port from which they arrived (i.e., back over the horizon to avoid broadcast storms). With Frame relay private virtual circuit (i.e., data link connections), most routers would not send an update back along the same physical port the update arrived on, even though that port might now have several data link connections on it—one that delivered the routing update and the rest, which should receive their copy of it. This scenario, now solved in most routers, was never a problem in most FRADs and Frame relay switches, which were already used to dealing with Permanent Virtual Circuit and Switched Virtual Circuit.

Some tuning may be required for NetWare environments. NetWare users should check out burst mode operation for a significant increase in performance when routing Internetwork Packet eXchange over wide area connections (Frame relay and others). Without using all the features available in NetWare 3.X, performance will suffer as compared with IP over Frame relay, although it will undoubtedly be better than most dialup connections. The newer NLSP protocol in NetWare 4.X should offer some parity with TCP/IP environments. (Tunneling IPX through IP does not a ddress the windowing and other performance-related issues associated with IPX, originally intended for the LAN environment only. Therefore, use of IPX/IP gateways will not automatically result in increased performance over Frame relay or any other wide area link, unless tuning is done.)

**Problem.**

At one end of the spectrum, some carriers offer zero Committed Information Rates service with attractive pricing. At the other end, the price some carriers charge for more for lines where the CIR equals the line rate (e.g., 56K-bps CIR on a 56K-bps line), and the cost exceeds that of a 56K-bps leased line.

**Solution.**

If the data is not critical or can tolerate retransmission, customers can use a zero CIR connection. When the Frame relay network gets congested, however, all frames are eligible to be dropped. Therefore, this approach is not recommended for inexpensive backup lines. Customers who want a higher CIR to guarantee that peak bandwidth is available but who find the price is too high can try the following approaches:

- Using a lower CIR if the application can tolerate it (most can when they where not using all of the previously available bandwidth on average).

- Negotiating a lower rate with the carrier (Frame relay is not tariffed, so customers should negotiate).

- Choosing another carrier.
Using a leased line or switched service for that link, possibly in conjunction with data compression.

If the network is not able to sustain end-to-end traffic at the CIR that was contracted for or if the contract states that data cannot burst above the CIR, the carrier's network may be congested. The network manager should keep an eye on Frame relay statistics and contact the carrier in this situation. The contract should specify CIR and any upper limits (i.e., the burst rate).

**Problem.**
Configurations require a backup connection in the event that the primary Frame relay connection goes down.

**Solution.**
One solution is to have a modem, switched 56, or Integrated Services Digital Network dial backup scheme that dials around the Frame relay network and connects to the host or server of the original connection. This solution works well for LAN applications where TCP/IP and the dynamic address/routing functions take care of the new, switched connection so that traffic can be resumed with a minimum of fuss.

The second option is to have an alternate Frame relay connection (from zero kilobits per second for low cost if available and if the user can risk it, or at the same CIR for highest availability) over another carrier's line, but preferably over another local loop connection or a non-frame relay leased line, which is available as an alternate path if the primary path goes down. This approach is often more expensive but offers faster resumption of service if the networking equipment is able to automatically use the alternate line through or around the Frame relay services. Otherwise, a manual reconfiguration will be required. The network manager treats the Frame relay Data Link Connections as logical leased lines in this scenario.

Carriers may offer switched access or switched backup, most likely through 14.4K/28.8K-bps modem or integrated services digital network (ISDN) Basic Rate Interface service, through their Frame relay service. This solution will most likely be the best of both worlds by offering a low-cost, easy-to-use backup service.

Of course, access security should be included as part of the dial backup scheme. At a minimum, password protection, authentication, or call control must be used to ensure that the unauthorized users are not able to get in through the backup links. The possibility of dropped frames scares some people, but it need not. Leased line and other networks also drop or damage frames when bit errors or line problems occur. This is why most protocols have a cyclic redundancy check (CRC) or other error detection at the link level and at other protocol levels.

Although some systems, such as the AS/400, are more sensitive to line problems than others, if there is an end-to-end error detection and retransmission mechanism in place in the system (e.g., Transmission Control Protocol, LLC2), dropped frames will affect only overall throughput, not data integrity. When Frame relay is used, the equipment chosen (and that the carrier uses) has error statistics at a number of protocol levels, so customers can tell if frames are being lost or damaged. If the error rate appears higher than it should be, contact the carrier (or the equipment vendor, if the cause is not the Frame relay network). The Frame relay nodes (backbone switches) the carrier uses most likely offer automatic rerouting of data link connections in the event an internodal link failure.

**Author Biographies**
Edward Bursk
Edward Bursk is the vice-president of marketing for FastComm Communications in Sterling VA. He has extensive experience designing and marketing innovative local and wide area networking solutions. Before joining FastComm, he held senior management or engineering positions with Dynatech Communications, NETRIX, Hughes Network Systems, E-Systems, and the MITRE Corp. Bursk holds a bachelor of science degree in electrical engineering from the University of Maryland and a master of science degree in computer science from Johns Hopkins University. He is a longstanding member of the Frame Relay Forum's market development and education committee.
NOTE:
SDLC traffic is sent over a frame relay service either as SDLC (using SDLC spooling) or using direct frame relay communications with the front end processor (top right). In the latter case, the FRADs on the left convert the SDLC traffic into LLC2. The LLC2 traffic is encapsulated in frame relay using RFC 1490. If Token Ring was used at the remote sites, the traffic would already be LLC2 based.
Numerous sites receive access to the Internet through single frame relay connection to an Internet service provider (ISP). The ISP then provides connectivity into the Internet through frame relay or other means.
NOTE:
Depending on the equipment used and the methods employed, traffic can ride over the same DLCs (for cost savings) or use a separate DLC for each application (for ease of management). All traffic is carried over frame relay, allowing only one physical line to be employed at each site. Management traffic, such as SNMP, may also ride over shared or separate DLCs.
Sharing of bandwidth is accomplished through statistical multiplexing. All frames associated with a particular DLC carry that number in the header. (Some control information was left out of the exhibit for simplicity.) Data for sites B and D is interleaved on the line. Data going to site B is sent on DLC 200. Data going to site D is sent on DLC 400. The line should be sized so that the line rate is higher than the aggregate rate required to support all applications, plus peaks. The CIR chosen should reflect the minimum throughput that can be tolerated for the applications sharing the line. Frame relay services can usually tolerate bursting for traffic above the CIR, accommodating the transient need to get higher throughput for peaks.
Can the data or IP video application use frame relay?

- Yes: Use a TDM- or ISDN-based solution.
- No: Does the application absolutely require a clear channel circuit?
  - Yes: Use an ATM- or TDM-based solution.
  - No: Does the application operate at T1 speeds or lower?
    - Yes: Use a switched or dialup solution.
    - No: Does the application stay connected all the time?
      - Yes: Evaluate frame relay for cost savings potential.
      - No: Does it stay connected for more than a few hours every day?
        - Yes: Will the application be able to share bandwidth with another?
          - Yes: Frame relay can still be evaluated for cost savings potential.
          - No: Frame relay can still be evaluated for cost savings potential.

**KEY:**
- ATM: Asynchronous transfer mode
- ISDN: Integrated services digital network
- TDM: Time division multiplexing
Communications

□ Is frame relay service ordered and are installation date and DLCs confirmed in writing?
□ Is local access ordered and the installation date confirmed? (It may be bundled with frame relay service.)
□ Are installation charges known and purchase-order numbers issued?

Personnel

□ Have installation or operations staff been trained? Is the carrier or systems integrator providing installation personnel? (All relevant parties must be trained in the equipment, frame relay, and the management system. Even if another group is doing the installation, the customer should participate.)

Equipment

□ Are the FRAD, router, and other equipment available and configured for frame relay and application interfaces in order to test?
□ Have DSU/CSU, TA, or other line termination cable been configured?
□ Have relevant loopback or other “sanity check” tests been run?
□ Are datastores, breakout boxes, or other equipment available to verify frame relay connection and DLC numbering and status?
□ Are equipment management and control procedures ready and working?
□ Has problem escalation been worked out?