"High-speed Data Communications
for Business"

FRAME TRANSPORT SERVICE SALES TRAINING

VERSION I
JUNE 24, 1994

Created By:

Marketing Services Department

Karen Faleskie - Lisa Lennon - Ted Rozolis

Bob Barbour

"High-speed Data Communications
for Business"

FRAME TRANSPORT SERVICE
SALES TRAINING

VERSION 1
JUNE 24, 1994

Created By:

Marketing Services Department

Karen Galeotte - Lisa Lorenzo - Teri Parella
Bob Barbour

NEWS RELEASE

MFS COMMUNICATIONS COMPANY, INC.
ONE TOWER LANE, SUITE 1600, OAKBROOK TERRACE, ILLINOIS 60181
(708) 218-7200 FAX (708) 218-1216

FOR MORE INFORMATION, CONTACT:
Steve Ingish or Claire Fennell
MFS Communications Company
708/218-7200

MFS DATANET FIRST TO SUPPORT FRAME RELAY OVER ATM
New Frame Transport Service Provides Frame Relay Connectivity over MFS' Fiber Optic ATM network

SAN JOSE, Calif., June 21, 1994 -- MFS Datanet, Inc., an operating company of MFS Communications Company, Inc. (MFS), today launched its Frame Transport Service, the first service to provide frame relay over an Asynchronous Transfer Mode (ATM) network, providing business and government customers with reliable data transmission at a cost approximately 5 - 15 percent lower than competing frame relay services.

As the latest addition to MFS Datanet's family of ATM-based products called High-speed LAN Interconnect (HLI) services, Frame Transport Service offers scalable, high-speed access to its ATM network. This allows companies to cost-effectively connect geographically dispersed LANs using frame relay while realizing the advantages of ATM technology, including the ability to upgrade to high-speed LAN internetworking at native speeds, plus the capability to accommodate high-bandwidth applications such as multimedia.

Frame Transport Service is being offered in all MFS Datanet cities throughout the U.S. and abroad.

"Our Frame Transport Service is ideal for customers who have made a commitment to frame relay services yet want a smooth, easy and investment-free migration path to ATM technology as user applications and traffic requirements expand," said Al Fenn, president of MFS Datanet.

Traditional frame relay networks are limited to backbone

-more-

speeds of 1.544 Mbps, and access speeds from 56/64 Kbps to1.544/2.048 Mbps. MFS Datanet uses a 45 Mbps ATM backbone and supports scalable access and hub speeds from 56/64 Kbps to 6 Mbps, accommodating a far wider range of applications. As a result, users experience lower latency and fewer congestion management problems than typically occur on the lower-speed backbones of other frame relay networks.

MFS Datanet carefully chose a platform for Frame Transport Service that provides maximum reliability and cost efficiency. The new service is based on the Cascade B-SDTX 9000 Multiservice WAN platform, with Newbridge 36150 MainStreet ATM and GDC APEX ATM switches on the backbone.

MFS Datanet launched the first national ATM network service on August 4, 1993, and the first international ATM service on February 9, 1994. The company offers ATM-based services on a global, national and metropolitan basis in the U.S. and abroad over its fiber-topic network. ATM also serves as the backbone technology for the entire family of MFS Datanet's High-speed LAN Interconnect (HLI) services, providing the ability to connect LANs in a single metropolitan area, the nation or the world as easily as if they were in the same building.

MFS Communications Company, Inc. (MFS) is a leading provider of communication services for business. The company operates in two segments: Telecommunications Services; and Network Systems Integration and Facilities Management Services. Through its operating companies, MFS provides a wide range of high quality voice, data and other enhanced services and systems specifically designed to meet the requirements of business and government customers. MFS' common stock is traded on the Nasdaq National Market under the symbol MFST. MFS is headquartered in Omaha, Neb.

Frame Transport Service

HIGH-SPEED LAN INTERCONNECT (HLI) SERVICES

MFS Datanet's Frame Transport Service

Offers scalable access and hub speeds ranging from 56/64 Kbps to 6 Mbps for interconnecting multiple, geographically dispersed local area networks. Includes wide area network management, maintenance and customer services.

Frame Transport Service from MFS Datanet utilizes a 45 Mbps ATM-based backbone allowing lower latency and less congestion than traditional frame relay networks. With Frame Transport, an easy, cost-effective migration path to ATM is ensured as user applications and traffic requirements increase.

- Frame Transport Service is offered in all MFS Datanet cities throughout the U.S., UK, and Europe.
- A V.35 interface connects directly with MFS Datanet's Frame Transport Service.
- Complies with CCITT Q.922 and I.363 specification standards.

MFS DATANET

FRAME TRANSPORT SERVICE

Technical Specifications

- Compatibility with certified customer's equipment. The customer supplies a frame relay interface to MFS Datanet's service at each building location and MFS does the rest.
- International, National and Metropolitan services. Customers have the ability to interconnect between buildings within a city, and between buildings in different cities over MFS Datanet's ATM-based network.
- Interconnectivity options. This allows the customer to interconnect diverse LANs from 56/64 Kbps up to 6 Mbps for high-bandwidth applications and sharing of data between workstations.
- High-performance digital transmission over a fiber optic based network. MFS' metropolitan area networks are built with high-quality fiber optic facilities. Superior service features include: reliability, redundancy, route diversity and responsiveness.
- Extends the life of current frame relay investment. MFS Datanet adopts the latest proven technologies in order to provide premium levels of performance and quality with speeds above 1.544 Mbps. Users receive the benefits of the latest innovations without the associated risks: hardware incompatibility, a short equipment life cycle, excessive capital expenditures and high implementation and training costs.
- Network flexibility. Customized network configurations allow customers to implement new sites with little disruption to existing services.
- Network security. MFS Datanet provides a physically secure point-of-presence in each of its buildings.
- 24-hour network monitoring. MFS Datanet offers management and maintenance of local loop, interexchange facilities and data equipment.

MFS DATANET

Corporate Headquarters
55 South Market St., Suite 1250
San Jose, California 95113
(408) 975-2200
1-800-MFS-4USA

Today's Agenda

MFS DATANET

8:30	Continental Breakfast
9:00	Introduction - Overview of Day
	Overview of Frame Relay Market
	Description of MFS Datanet's FTS
	Features and Benefits
	How FTS differs from Fractional HLI
	Pricing - Exercises w/various network topologies
	Support Materials (Data Sheets, Presentations, etc.)
	COMPETITIVE OVERVIEW
	Compare and Contrast FTS w/other carriers services
	Selling against the Competition
	Future Product Enhancements
	Q & A
12:00	END

MFS DATANET

Frame Relay Services Market Overview

Market Environment & Trends

Market Opportunity

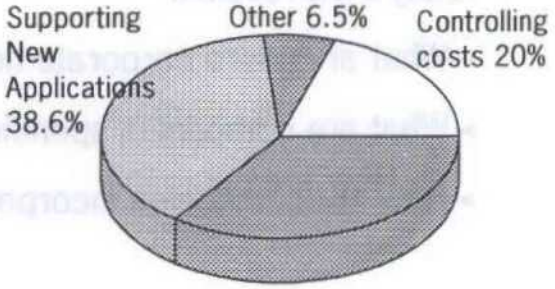
Corporate Network Strategies Aimed At Increased Competitiveness

MFS DATANET

Strategies → Spending → Technologies

- Centralized corporate backbone management supports distributed applications requirements
- Shift in relationship between information systems and business processes
- New focus is on running business more competitively

Primary objective for enterprise internetwork strategy:



Source: IDC Directions '94 Conference Notes

Part of Business Strategy by Non-Network Guys.

Must Go beyond MIS. Key business advantage

MFS DATANET

Market Environment & Trends

- Today's discussion:
  - What are users corporate networking strategies?
  - What are companies spending on networking?
  - How are companies incorporating new technologies?

MFS DATANET

A look at the Market

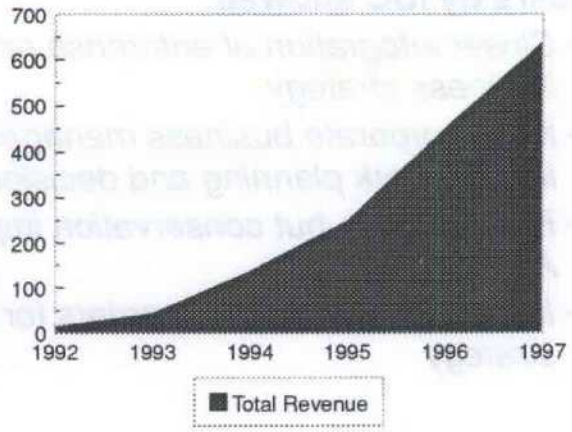
- **A sample of the 500 most sophisticated networking users by IDC showed:**
  - *Closer integration of enterprise network development and business strategy*
  - *More corporate business management involvement in internetwork planning and decision making*
  - *High interest, but conservation implementation plans for ATM*
  - *Increasing reliance on carriers for enterprise networking strategy*

MFS DATANET

Frame Relay Spending

Strategies → Spending → Technologies

- Total worldwide revenues will grow from $43 million in 1993 to $636 million by 1997
- CAGR = 118%
- Total number of frame relay ports will grow from 3,825 in 1993 to 63,350 by 1997
- Total number of customers using frame relay will grow from 425 in 1993 to 4,525 by 1997



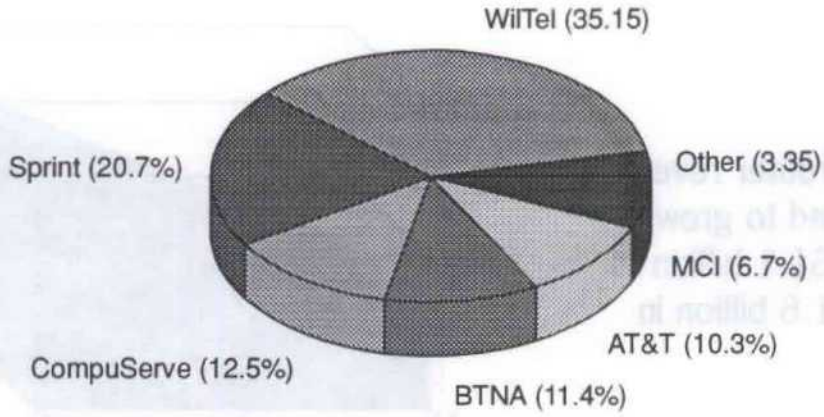
Source: IDC Directions '94 Conference Notes

RBOC's Going crazy.
U.S. West expanding to Non US west areas.
- Staying away from MFS Cities
- L.A. Costa 125.00/mo + PVC 5 → 15
128Kb ~~1.03 T1~~ 1ch Term.
56K - 50.00/mo
Port - 56K - 75.00 + PVC
- 128 150 15 Feature
- T1 500 Next tone 15.00 ea
- ~~512~~ 250
- 384 200

MFS DATANET

Competitive Market Share

U.S.-Based Carriers' Market Share of Worldwide Frame Relay Services Revenues, 1992



(Total = $13.1M)

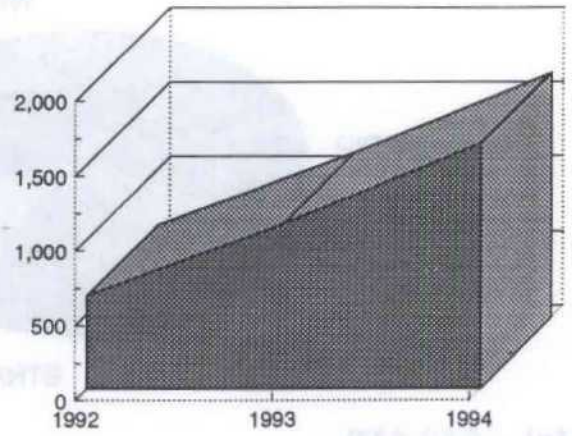
Source: International Data Corporation, 1993

MFS DATANET

Router Spending

Strategies → Spending → Technologies

- In the US, router revenues are expected to grow 48% from $1.1 billion in 1993 to $1.6 billion in 1994



Source: IDC Directions '94 Conference Notes

MFS DATANET

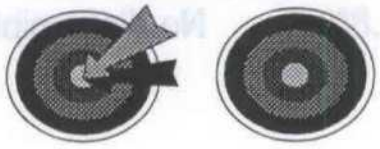
LAN Bandwidths Currently Adequate?

- More than 80% of frame relay ports today are connected at speeds of 56 Kbps.....Why?
- Users are limited by T1 backbones of traditional frame relay providers
- Users are planning migration to higher speed LANs

LAN bandwidth constraints

Yes: 38.8%
No: 61.2%

Migrating to high-speed LANs



Yes: 72.8%
No: 27.2%

Source: IDC Directions '94 Conference Notes

MFS DATANET

Network Strategy is Key to Corporate Business Strategy

- 60.8% Key element of business strategy
- 27.1% Primarily facilitates IT objectives
- 10.2% Minor role in achieving business objectives
- 1.8% No discernible impact on business objective

Source: IDC Directions '94 Conference Notes

MFS DATANET

Growing Application Portfolio Will Drive Migration to High-Speed LANs

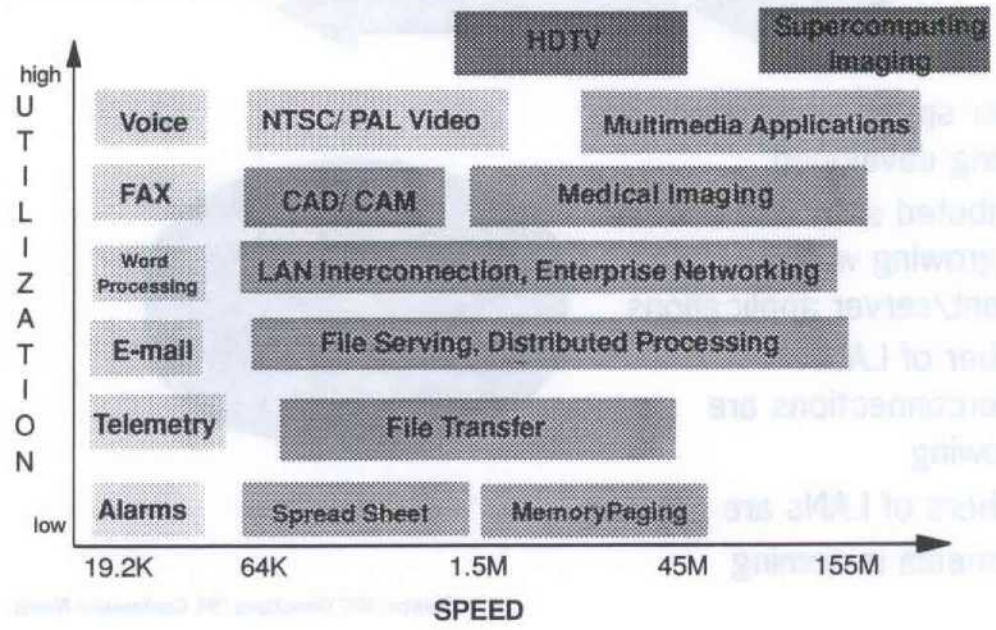
Strategies → Spending → Technologies

- Higher speed applications are being developed
- Distributed database access is growing with client/server applications
- Number of LAN interconnections are growing
- Numbers of LANs are growing
- Mulitmedia is coming

Source: IDC Directions '94 Conference Notes

MFS DATANET

Different Applications have a Diversity of Speed and Utilization Requirements

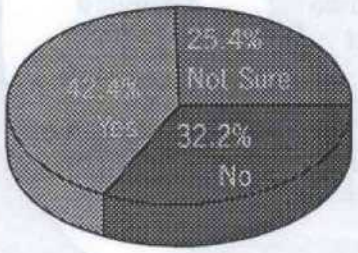


MFS DATANET

Carriers Gain Significant Mindshare in 1994...

Strategies → Spending → Technologies

Will carriers become more important to internetwork strategy as they roll out advanced data transmission services?



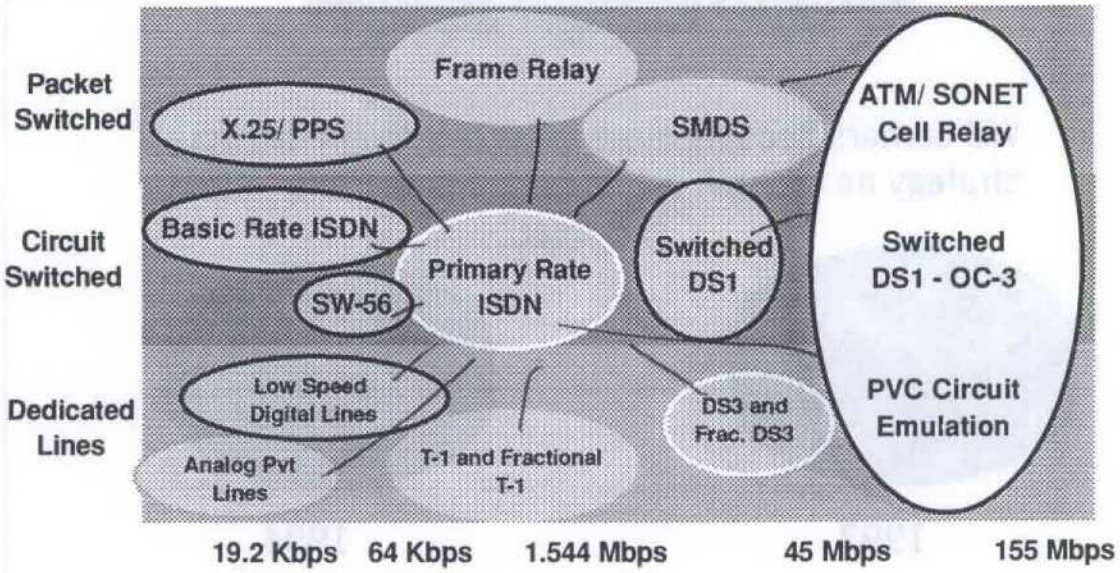
1993

1994

Source: IDC Directions '94 Conference Notes

MFS DATANET

Carriers support a wide range of data transport products

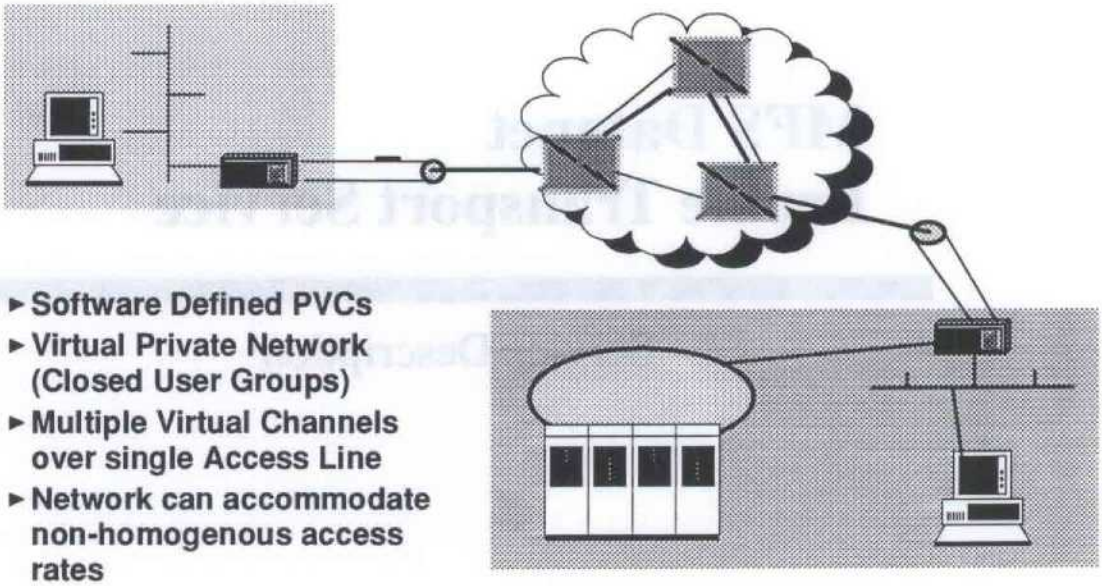


MFS DATANET

MFS Datanet
Frame Transport Service

Service Description

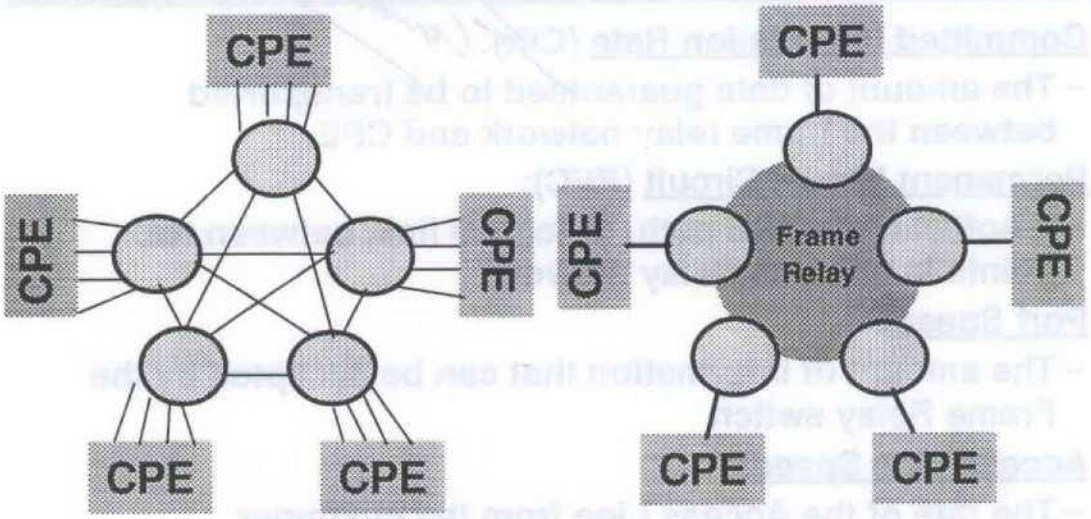
Frame Relay is a Connection-Oriented Service Provided Over Pre-defined PVCs



- Software Defined PVCs
- Virtual Private Network (Closed User Groups)
- Multiple Virtual Channels over single Access Line
- Network can accommodate non-homogenous access rates

MFS DATANET

Frame Relay offers cost savings over fully meshed dedicated line networks



Private Line Network

Frame Relay Network

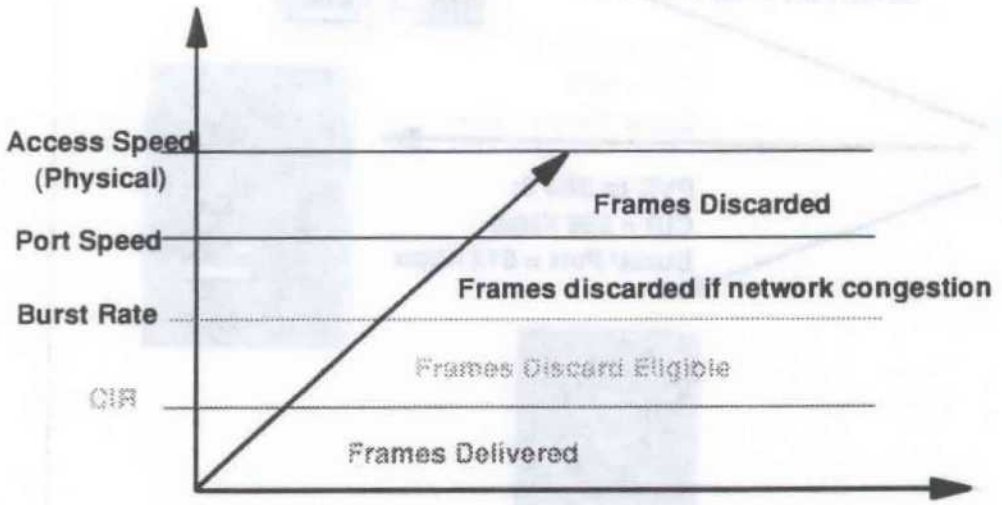
MFS DATANET

Frame Relay Terminology

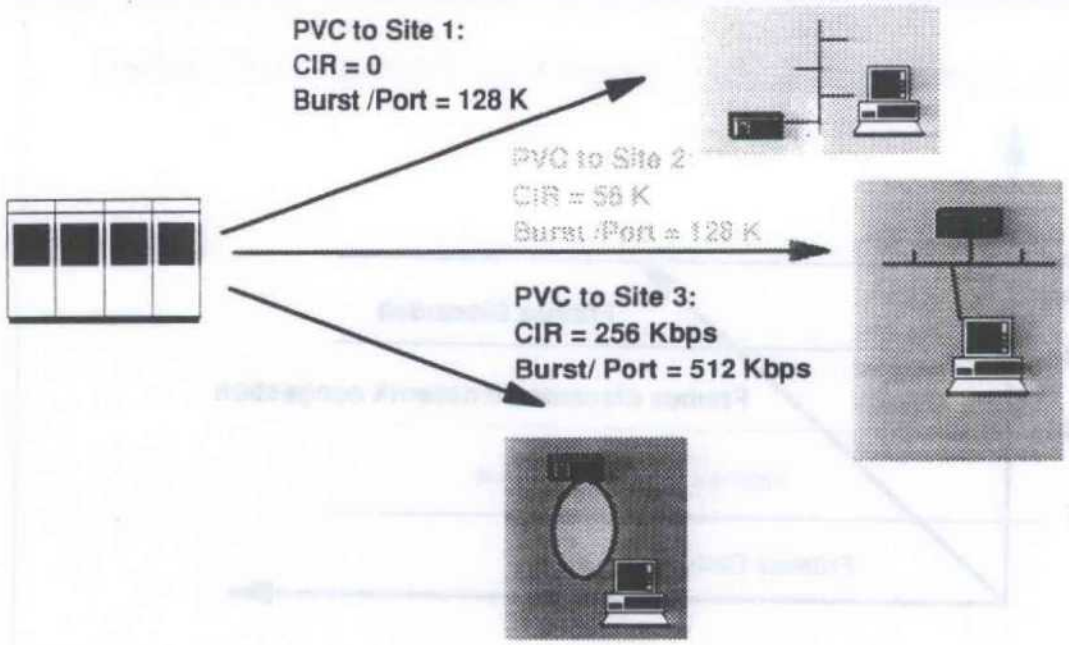
- Committed Information Rate (CIR):
  - The amount of data guaranteed to be transported between the frame relay network and CPE
- Permanent Virtual Circuit (PVC):
  - A software defined path, or logical link, between two points in a Frame Relay network
- Port Speed:
  - The amount of information that can be accepted by the Frame Relay switch
- Access Line Speed:
  - The rate of the Access Line from the customer premises to the frame relay switch. This speed may be different from the Port Speed.

Relationship between CIR and Physical Interface Speeds

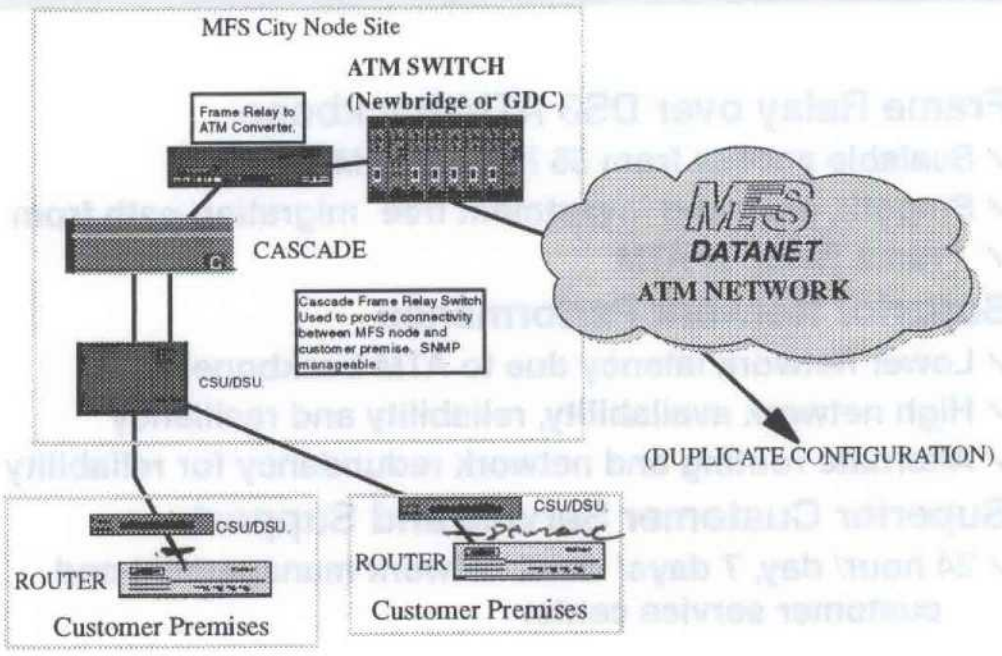
CIR< Burst Rate < Port Speed < Access Line Speed



Each PVC can have its own CIR and Burst Parameters



Frame Transport Service Configuration



MFS DATANET

Frame Transport Features

- **Frame Relay over DS3 ATM Backbone**
  - ✓ Scalable access from 56 Kbps to 6 Mbps
  - ✓ Smooth, easy and investment free migration path from
  - ✓ Frame Relay to ATM
- **Superior Network Performance**
  - ✓ Lower network latency due to ATM backbone
  - ✓ High network availability, reliability and resiliency
  - ✓ Alternate routing and network redundancy for reliability
- **Superior Customer Service and Support**
  - ✓ 24 hour/ day, 7 days/ week network management and customer service center

MFS DATANET

Frame Transport Service Features

- **Standards Based**
  - ✓ CCITT and ANSI standards for Frame Relay and ATM
  - ✓ Frame Relay over ATM Implementation Agreement by the ATM and Frame Relay Forums
  - ✓ Allows for interoperability of equipment across the network
- **Simple, Flexible Pricing Options**
  - ✓ Cost effective compared to leased line options
  - ✓ Aggressively priced over competing services

MFS DATANET

How Does Frame Transport Compare to HLI?

Feature	HLI	Frame Transport
Interface Protocol	Ethernet, Token Ring, FDDI	Frame Relay
Port Speeds	Fractional T1 and T1 4, 10, 16 and 100 Mbps	Standard: Fract. T1 and T1 ICB: 1.9 (E1), 3, 4.5 and 6 Mbps
Configurations	Mesh, Ring and Star	Standard: Star (other configurations possible)
LAN Interface	AUI, MAU, MIC	V.35, X.21, RS 449, DSX 1
Network Management	LAN Interface to LAN Interface	Up to CPE (V.35 interface)
Router	Optional	Customer supplies
Customer Solution	For customers who want end-to-end network service and management	For customers who understand WAN concepts and are committed to FR technology

MFS DATANET

Frame Transport Service offers the broadest range of port speeds available

Standard:

- 56 Kbps
- 128 Kbps
- 256 Kbps
- 512 Kbps
- 1.536 Mbps

ICB:

- 1.920 Mbps (E1)
- 3 Mbps
- 4.5 Mbps
- 6 Mbps

MFS Datanet
Frame Transport Services

Pricing

MFS DATANET

FTS Pricing Overview

- ✓ Goal is **Simplicity**
- ✓ All Frame Transport is **STAR** configured
  (MESH Frame Transport is ICB)
- ✓ All Prices are **10% below MCI** pricing
  since MCI is the "relative" low price leader
  - ➡ This price position avoids a price war
- ✓ Margins are **very small**
- ✓ Frame Transport will *not necessarily be* always
  lower priced than HLI (exception is at 1.5 Mbps)

MFS DATANET

Service Positioning

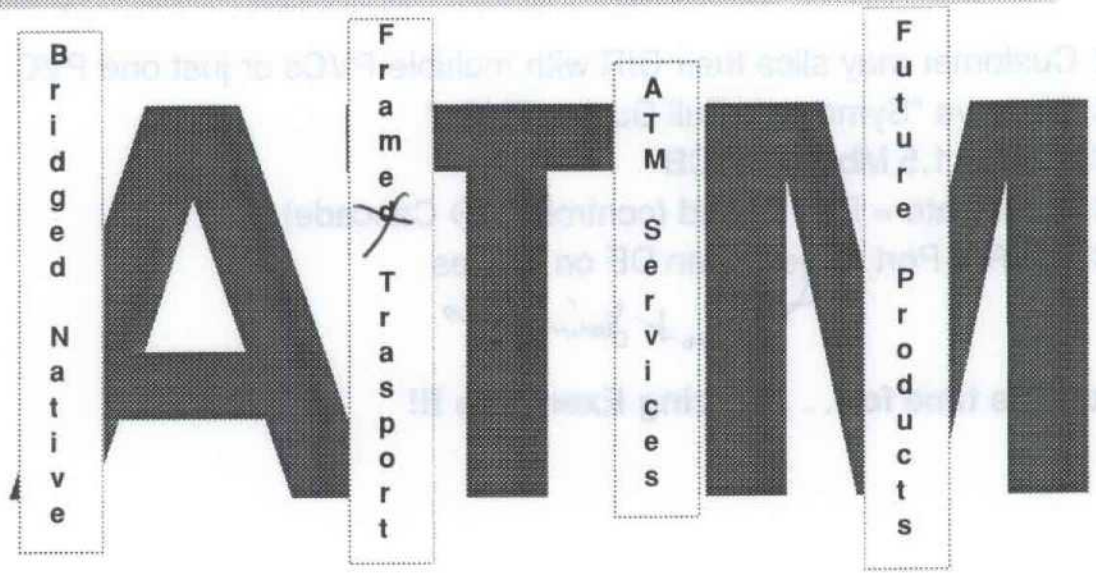
- ► Frame Transport is "low end" of the HLI portfolio
- ► Price Overlap is due to different buyers and different environments
  - 1.5 Mbps HLI = $900 + Backbone
  - 1.5 Mbps FTS = $1440

  (which is the lowest 1.5M port in the market)
- ► HLI Family of Services Graphic

MFS DATANET

HLI Service - Family of Products

High-speed LAN Interconnect Services - Family of Products



MFS DATANET — Various Facts about Frame Transport

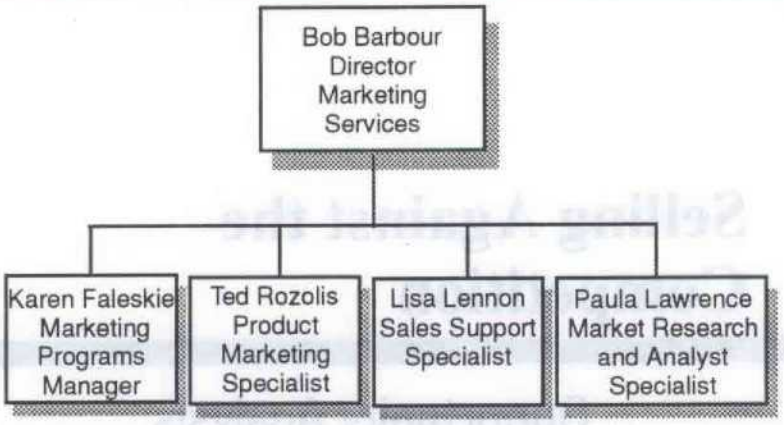
- ✖ Customer may slice their CIR with multiple PVCs or just one PVC
- ✖ We have "Symmetric Full Duplex PVCs"
- ✖ Ports > 1.5 Mbps are ICB
- ✖ Burst Rate = Port Speed (controlled @ Cascade)
- ✖ If CIR > Port Speed, then DE on frames

not doing this

Now it's time for . . . Pricing Exercises !!!

MFS DATANET

Headquarters Marketing Support



Telemarketing
Lead Generation
Sales Support
Collateral Materials
Presentations

Product Launch
Training
Competitive Information
Trade Show Support
Sales Handbook

Press Releases
Press Contacts
Analysts Contacts
Demonstrations
Vertical Market Analysis

MFS DATANET

Selling Against the Competition

Opportunity Analysis

Selling Against the Competition

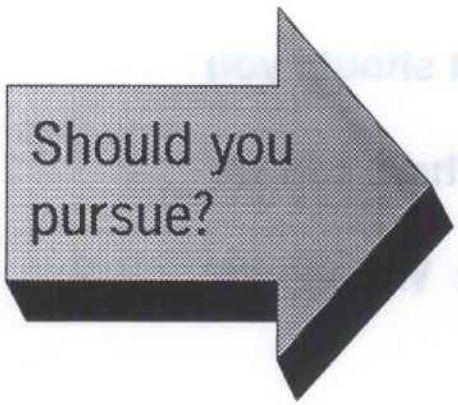
MFS DATANET

Opportunity Analysis

- **Business Potential: What should you pursue?**
- **Customer Resistance: Where can we compete?**
- **Competitive Opportunity: Where can we win?**

MFS DATANET

Business Potential



YES, if customer has:

- Understands WAN concepts
- Five or more geographically dispersed LANs sites that need interconnection
- Committed to Frame Relay technology
- An installed router network and wants to protect his/her investment
- IBM legacy system migrating to client/server environment
- Bandwidth constraints with existing frame relay provider

MFS DATANET

Customer Resistance

YES, if:

- More than ___% of his sites located "on-net"
- Planning migration to higher speed LANs
- Migration strategy to higher speed services like ATM is under consideration
- Networking strategy is seen as a critically important element of overall corporate strategy
- Customer needs to implement a frame relay network in less than 60 days from order date

MFS DATANET

Competitive Opportunity

YES, if:

- You are able to empower the customer to respond to their market (using MFS Datanet Services) in ways they haven't considered.
- You are able to position Frame Transport in terms that address mission critical concerns of customer.
- You understand and sell to the decision maker, and strategic influencer in your account.
- You influence the evaluation and purchase criteria to reflect MFS Datanet competencies

MFS DATANET

Selling Against The Competition

- What's wrong with competing frame relay services?
  - Platform
  - Limited backbone & access speeds
  - Long service delivery lead times
  - No immediate ATM migration path

MFS DATANET

Platform

- Four of the seven leading Frame Relay providers use the Stratacom IPX switch
  - ***Architecture of the IPX is nearly 10 years old, and was built to optimize voice/circuit switching not data, and is burdened by significantly higher manufacturing costs***
  - ***Stratacom BPX (ATM switch) configurations require an IPX interface for low speed traffic***
  - ***IPX & BPX is twice as expensive as Cascade's 6000/9000***
  - ***BPX switch is only in beta test with carrier "customers"***
  - ***No native network management support for SNMP***
  - ***Call Marketing for Cascade/Stratacom competitive comparison chart***

MFS DATANET

Limited Backbone & Access Speeds

- Datanet's backbone transmission uses DS3 trunking with 45 Mbps throughput
- Most frame relay switches are limited to backbone transmission using DS1 trunking with 1.5 Mbps throughput
- Datanet offers the broadest range of port speeds available---56 Kbps up to 6 Mbps
- Traditional frame relay providers are limited to port speeds of 56 Kbps up to 1.5 Mbps
- Datanet ATM backbone won't encounter the congestion problems that usually occur on limited speed backbones
- Low latency compared to traditional frame relay providers

MFS DATANET

Service Delivery Lead Times

Carrier	New Access/PVCs	New/Modify PVCs
MFS Datanet "On-net"	20 days	1 day
MFS Datanet "Off-net"	20-60 days	1 day
MCI	34 days	1 day
AT&T	36 days	NA
Sprint	60 days	7 days
WilTel	60 days	1 day

MFS DATANET

Migration Path To ATM

- Users want assurance that their networks will not become obsolete
- Users want to preserve their network investments
- Users want to see a migration path to ATM and interoperability with frame relay---and traditional providers aren't providing this!
- Datanet's Frame Transport extends the capabilities for which ATM is used, because it is:
  - Easy and inexpensive to implement
  - Preserves the investment in current technologies
  - Provides a ready migration path to ATM

MFS DATANET

Enhancements Under Consideration

- Usage based pricing
- Network Management Reports
  - Utilization Info
  - Frames marked DE
  - Traffic by location
  - Traffic by PVC
- Gateways
  - PPP to Frame Relay
  - Dial-up to PPP to Frame Relay
- Priority Levels on Discard

MFS DATANET

Frame Relay vs. SMDS

Consider either Frame Relay or SMDS when:

- ✓ 4 or more sites have significant LAN traffic
- ✓ Apps need quick response, are bursty or otherwise require high speeds
- ✓ Site-to-site traffic has outgrown private lines
- ✓ Organization will not invest in LAN-to-LAN technology or the staff to support it

source: Comm Week

MFS DATANET

Frame Relay vs. SMDS

Consider Frame Relay when:

- ✓ Speeds from 56 Kbps to 1.5 Mbps are needed
- ✓ Site-to-Site communications require upgrade from sub-56 Kbps speeds to 56 Kbps
- ✓ Most communications are intracompany
- ✓ Non-time-sensitive imaging or stored video is involved

source: Comm Week

MFS DATANET

Frame Relay vs. SMDS

Consider SMDS when:

- ✓ Company-to-Company communications are needed
- ✓ Apps require speeds greater than 1.5 Mbps
- ✓ Access to a large number of sites is required
- ✓ Processing will be distributed
- ✓ Time-sensitive videoconferencing is involved

source: Comm Week

Port Charges/month	
Speed	Port Cost
1536000	$ 1,440
512000	$ 675
256000	$ 360
128000	$ 300
56000	$ 165
Zero CIR :	$ 40 Per Leg

Non-Zero CIR :

City Pair	1.544 Mbps	512 Kbps	256 Kbps	128 Kbps	56 Kbps
Atlanta-Baltimore	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
Atlanta-Boston	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Atlanta-Chicago	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
Atlanta-Dallas	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
Atlanta-Houston	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
Atlanta-Los Angeles	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Atlanta-Minneapolis	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Atlanta-New York	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Atlanta-Philadelphia	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
Atlanta-Pittsburgh	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
Atlanta-San Francisco	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
Atlanta-Washington D. C.	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
Baltimore-Boston	$ 2,479	$ 1,224	$ 617	$ 280	$ 167
Baltimore-Chicago	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
Baltimore-Dallas	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Baltimore-Houston	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Baltimore-Los Angeles	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
Baltimore-Minneapolis	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Baltimore-New York	$ 1,978	$ 994	$ 504	$ 229	$ 136
Baltimore-Philadelphia	$ 1,978	$ 994	$ 504	$ 229	$ 136
Baltimore-Pittsburgh	$ 1,978	$ 994	$ 504	$ 229	$ 136
Baltimore-San Francisco	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
Baltimore-Washington D. C.	$ 1,978	$ 994	$ 504	$ 229	$ 136
Boston-Chicago	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Boston-Dallas	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Boston-Houston	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Boston-Los Angeles	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
Boston-Minneapolis	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Boston-New York	$ 1,978	$ 994	$ 504	$ 229	$ 136
Boston-Philadelphia	$ 2,479	$ 1,224	$ 617	$ 280	$ 167
Boston-Pittsburgh	$ 2,479	$ 1,224	$ 617	$ 280	$ 167
Boston-San Francisco	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
Boston-Washington D. C.	$ 2,479	$ 1,224	$ 617	$ 280	$ 167
Chicago-Dallas	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Chicago-Houston	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Chicago-Los Angeles	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290

Chicago-Minneapolis	$ 2,479	$ 1,224	$ 617	$ 280	$ 167
Chicago-New York	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
Chicago-Philadelphia	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
Chicago-Pittsburgh	$ 2,479	$ 1,224	$ 617	$ 280	$ 167
Chicago-San Francisco	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Chicago-Washington D. C.	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
Dallas-Houston	$ 1,978	$ 994	$ 504	$ 229	$ 136
Dallas-Los Angeles	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Dallas-Minneapolis	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Dallas-New York	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Dallas-Philadelphia	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Dallas-Pittsburgh	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Dallas-San Francisco	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Dallas-Washington D. C.	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Denver-Atlanta	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Denver-Baltimore	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Denver-Boston	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Denver-Chicago	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Denver-Dallas	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
Denver-Houston	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Denver-Los Angeles	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Denver-Minneapolis	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
Denver-New York	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Denver-Newark, NJ	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Denver-Philadelphia	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Denver-Phoenix	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
Denver-Pittsburgh	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Denver-San Francisco	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Denver-San Jose	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Denver-Washington D. C.	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Houston-Los Angeles	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Houston-Minneapolis	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Houston-New York	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Houston-Philadelphia	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Houston-Pittsburgh	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Houston-San Francisco	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Houston-Washington D. C.	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Los Angeles-Minneapolis	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Los Angeles-New York	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
Los Angeles-Philadelphia	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
Los Angeles-Pittsburgh	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
Los Angeles-San Francisco	$ 2,479	$ 1,224	$ 617	$ 280	$ 167
Los Angeles-Washington D. C.	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
Minneapolis-New York	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Minneapolis-Philadelphia	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Minneapolis-Pittsburgh	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
Minneapolis-San Francisco	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
Minneapolis-Washington D. C.	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
New York-Philadelphia	$ 1,978	$ 994	$ 504	$ 229	$ 136
New York-Pittsburgh	$ 1,978	$ 994	$ 504	$ 229	$ 136
New York-San Francisco	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352

		New York-Washington D. C.	$ 1,978	$ 994	$ 504	$ 229	$ 136
		Newark, NJ-Atlanta	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
		Newark, NJ-Baltimore	$ 1,978	$ 994	$ 504	$ 229	$ 136
		Newark, NJ-Boston	$ 1,978	$ 994	$ 504	$ 229	$ 136
		Newark, NJ-Chicago	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
		Newark, NJ-Dallas	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
		Newark, NJ-Houston	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
		Newark, NJ-Los Angeles	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		Newark, NJ-Minneapolis	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
		Newark, NJ-New York	$ 1,978	$ 994	$ 504	$ 229	$ 136
		Newark, NJ-Philadelphia	$ 1,978	$ 994	$ 504	$ 229	$ 136
		Newark, NJ-Pittsburgh	$ 2,479	$ 1,224	$ 617	$ 280	$ 167
		Newark, NJ-San Francisco	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		Newark, NJ-Washington D. C.	$ 1,978	$ 994	$ 504	$ 229	$ 136
		Philadelphia-Pittsburgh	$ 2,479	$ 1,224	$ 617	$ 280	$ 167
		Philadelphia-San Francisco	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		Philadelphia-Washington D. C.	$ 1,978	$ 994	$ 504	$ 229	$ 136
		Phoenix-Atlanta	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
		Phoenix-Baltimore	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		Phoenix-Boston	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		Phoenix-Chicago	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
		Phoenix-Dallas	$ 3,479	$ 1,683	$ 846	$ 384	$ 229
		Phoenix-Houston	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
		Phoenix-Los Angeles	$ 2,479	$ 1,224	$ 617	$ 280	$ 167
		Phoenix-Minneapolis	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
		Phoenix-New York	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		Phoenix-Newark, NJ	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		Phoenix-Philadelphia	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		Phoenix-Pittsburgh	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
		Phoenix-San Francisco	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
		Phoenix-San Jose	$ 2,979	$ 1,454	$ 733	$ 332	$ 198
		Phoenix-Washington D. C.	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		Pittsburgh-San Francisco	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		Pittsburgh-Washington D. C.	$ 1,978	$ 994	$ 504	$ 229	$ 136
		San Francisco-Washington D. C.	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		San Jose-Atlanta	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		San Jose-Baltimore	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		San Jose-Boston	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		San Jose-Chicago	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
		San Jose-Dallas	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
		San Jose-Houston	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
		San Jose-Los Angeles	$ 2,479	$ 1,224	$ 617	$ 280	$ 167
		San Jose-Minneapolis	$ 4,480	$ 2,144	$ 1,075	$ 488	$ 290
		San Jose-New York	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		San Jose-Newark, NJ	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		San Jose-Philadelphia	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		San Jose-Pittsburgh	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352
		San Jose-San Francisco	$ 1,978	$ 994	$ 504	$ 229	$ 136
		San Jose-Washington D. C.	$ 5,479	$ 2,603	$ 1,303	$ 591	$ 352

Example 1: Customer wants a zero CIR between each of the 3 locations below and the hub site in NYC. All sites have a 1.5M port speed.

Port Charge

➢ *NYC: 1.5M Port Charge (hub):*	*$1440/mo*
➢ *ORD: 1.5M Port Charge*	*$1440/mo*
➢ *LAX: 1.5M Port Charge*	*$1440/mo*
➢ *ATL: 1.5M Port Charge*	*$1440/mo*

Zero CIR charge:

➢ *NYC-ORD*	*$40/mo*
➢ *NYC-LAX*	*$40/mo*
➢ *NYC-ATL*	*$40/mo*

Example 2: Customer wants a 56k CIR between each of the 3 locations below and the hub site with a port speed at 256k in NYC.

Port Charge

➢ *NYC: 256k Port Charge (hub):*	*$360/mo*
➢ *ORD: 56k Port Charge*	*$165/mo*
➢ *LAX: 56k Port Charge*	*$165/mo*
➢ *ATL: 56k Port Charge*	*$165/mo*

56K CIR Charge:

➢ *NYC-ORD*	*$198/mo*
➢ *NYC-LAX*	*$352/mo*
➢ *NYC-ATL*	*$229/mo*

Example 3: Customer wants a 56k CIR between each of the 3 locations below, 256k burst capabilities, and the hub site with a port speed at 256k in NYC.

Port Charge:

➢ *NYC: 256k Port Charge (hub):*	*$360/mo*
➢ *ORD: 256k Port Charge*	*$360/mo*
➢ *LAX: 256k Port Charge*	*$360/mo*
➢ *ATL: 256k Port Charge*	*$360/mo*

56K CIR Charge:

➢ *NYC-ORD*	*$198/mo*
➢ *NYC-LAX*	*$352/mo*
➢ *NYC-ATL*	*$229/mo*

Example 4: Customer wants a 512k CIR between each of the 3 locations below, 1.5M burst capabilities, and the hub site with a port speed at 1.5M in NYC.

Port Charge:

➢ *NYC: 1.536M Port Charge (hub):*	$ 1,440 */mo*
➢ *ORD: 512k Port Charge*	$ 675 */mo*
➢ *LAX: 512k Port Charge*	$ 675 */mo*
➢ *ATL: 512k Port Charge*	$ 675 */mo*

512K CIR Charge:

➢ *NYC-ORD*	$ 1,454 */mo*
➢ *NYC-LAX*	$ 2,144 */mo*
➢ *NYC-ATL*	$ 2,144 */mo*

Table 3
SNA Network—256-kbps Central Site with 16-kbps CIRS List Pricing

Location	Rate Element	AT&T[1]	BT	CompuServe	C&W[2]	MCI	Sprint[1,2]	WilTel
New York	Port at 256 kbps	$435	$750	$155	$190	$400	$495	—
	PVC to Boston (16 kbps)	$125	$22	$35	$45	$46	$195	—
	PVC to Wash DC (16 kbps)	$125	$22	$35	$45	$46	$195	—
	PVC to Atlanta (16 kbps)	$125	$22	$35	$45	$78	$195	—
	PVC to Houston (16 kbps)	$125	$22	$35	$45	$105	$195	—
	PVC to Dallas (16 kbps)	$125	$22	$35	$45	$105	$195	—
	PVC to LA (16 kbps)	$125	$22	$50	$45	$132	$195	—
	PVC to SF (16 kbps)	$125	$22	$50	$45	$132	$195	—
	PVC to St. Louis (16 kbps)	$125	$22	$35	$45	$78	$195	—
	PVC to Denver (16 kbps)	$125	$22	$35	$45	$105	$195	—
	PVC to Chicago (16 kbps)	$125	$22	$35	$45	$67	$195	—
	PVC to Detroit (16 kbps)	$125	$22	$35	$45	$67	$195	—
	Location Total	$1,810	$992	$570	$685	$1,361	$2,640	$681
Boston	Port at 56 kbps	$165	$400	$145	$145	$180	$160	—
	PVC to NY (16 kbps)	$0	$22	$35	$45	$46	$0	—
	Location Total	$165	$422	$180	$190	$226	$160	$300
Washington DC	Port at 56 kbps	$165	$400	$145	$145	$180	$160	—
	PVC to NY (16 kbps)	$0	$22	$35	$45	$46	$0	—
	Location Total	$165	$422	$180	$190	$226	$160	$300
Atlanta	Port at 56 kbps	$165	$400	$145	$145	$180	$160	—
	PVC to NY (16 kbps)	$0	$22	$35	$45	$78	$0	—
	Location Total	$165	$422	$180	$190	$258	$160	$300
Houston	Port at 56 kbps	$165	$400	$145	$145	$180	$160	—
	PVC to NY (16 kbps)	$0	$22	$35	$45	$105	$0	—
	Location Total	$165	$422	$180	$190	$285	$160	$300
Dallas	Port at 56 kbps	$165	$400	$145	$145	$180	$160	—
	PVC to NY (16 kbps)	$0	$22	$35	$45	$105	$0	—
	Location Total	$165	$422	$180	$190	$285	$160	$300
Los Angeles	Port at 56 kbps	$165	$400	$145	$145	$180	$160	—
	PVC to NY (16 kbps)	$0	$22	$50	$45	$132	$0	—
	Location Total	$165	$422	$195	$190	$312	$160	$300
San Francisco	Port at 56 kbps	$165	$400	$145	$145	$180	$160	—
	PVC to NY (16 kbps)	$0	$22	$50	$45	$132	$0	—
	Location Total	$165	$422	$195	$190	$312	$160	$300
St. Louis	Port at 56 kbps	$165	$400	$145	$145	$180	$160	—
	PVC to NY (16 kbps)	$0	$22	$35	$45	$78	$0	—
	Location Total	$165	$422	$180	$190	$258	$160	$300
Denver	Port at 56 kbps	$165	$400	$145	$145	$180	$160	—
	PVC to NY (16 kbps)	$0	$22	$35	$45	$105	$0	—
	Location Total	$165	$422	$180	$190	$285	$160	$300
Chicago	Port at 56 kbps	$165	$400	$145	$145	$180	$160	—
	PVC to NY (16 kbps)	$0	$22	$35	$45	$67	$0	—
	Location Total	$165	$422	$180	$190	$247	$160	$300
Detroit	Port at 56 kbps	$165	$400	$145	$145	$180	$160	—
	PVC to NY (16 kbps)	$0	$22	$35	$45	$67	$0	—
	Location Total	$165	$422	$180	$190	$247	$160	$300
	Total	$3,625	$5,634	$2,650	$2,775	$4,302	$4,400	$3,981

Note: [1]AT&T and Sprint pricing includes bidirectional CIRs; [2]Cable & Wireless and Sprint pricing include PVCs in 19.2 kbps CIR granularity.

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.: Inband	On-line mgmt.: Dialout	POPs	Gateways (A = ATM, B = 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/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) 832-8328	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-$875	$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)		✔	✔		✔
MFS Datanet	Frame Transport	C	L	(1)	✔	✔	1	R,S,T,U T.B.A.	✔	✔	1900+	T.B.A.	1		✔	@165	@300	@360	ICB	@675	ICB	ICB	@1440	✔	✔	✔	TBA	✔

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

Chart compiled by Cheri Paquet

Each pilot ATM node will have VP cross connection capability and will comply with ITU-T (formerly CCITT) and European Telecom-munications Standards Institute (ETSI) standards on ATM. There will be 256 VP per access and 16 ports per node. The pilot will also make use of Eurescom deliverables such as ATM VP equipment specifications.

With the trial only months away, the majority of public network operators involved have placed orders for ATM cross connects. In many cases, installation and local testing is underway. Suppliers who have successfully bid for these contracts include: Alcatel Bell, Alcatel Network Systems, GPT-Siemens, AT&T and Netcomm. Network planning for Operation and Maintenance (OAM) features and functions is reported to be well-advanced.

By March 1994, the transmission links for the preliminary ring structure are scheduled to be ready. These will start off as bi-directional 34 Mbps Plesiochronous Digital Hierarchy (PDH) connections and will be logically fully meshed. The PDH interfaces will be consistent with the recently agreed G.804/ETSI TM 3007 standards for mapping ATM cells over the PDH at 34 Mbps and 140 Mbps.

"The ring will evolve to 140 Mbps PDH and 155 Mbps Synchronous Digital Hierarchy where practical in which case the structure may also need to change from a ring to a meshed or hybrid network. People expect 155 Mbps, but the network has to work with what exists now," said Perkins.

ATM testing will begin in March/April with interoperability testing at the ATM layer scheduled from April to June.

EUROPEAN ATM PILOT CONTACTS

Operator	Contact	Telephone
Austrian PTT	Mr Otto Freude	+43 1 51551 2211
Belgacom	Mr Wim de Meyer	+32 2 213 47 98
BT	Mr Bob Cuell	+44 71 492 3739
DBP Telekom	Mr Reinhard Latzel	+49 6151 83 5069
France Telecom	Mr Karim Jammal	+33 1 4444 5214
Helsinki Telephone Company	Mr Timo Tenhovuori	+358 0 606 5220
IRITEL & SIP	Mr VaccaroTommaso	+39 6 5494 5213
Norwegian Telecom International	Mr Jon Sjaavaag	+47 22 77 89 77
PTT Telecom-NL	Mr Hans Diefenbach	+31 70 3434 087
Swiss PTT Telecom	Mr Santo Filisetti	+41 31 62 7400
Telecom Denmark	Mr Helle Eliasen	+45 42 52 91 11
Telecom Eirann	Mr Barry Reynolds	+353 1 701 8299
Telecom Finland	Mr Eero Torri	+358 704 2973
Telecom Portugal	Mr Jaime Ferreira	+351 1 350 4720
Telefones de Lisboa e Porto (TLP)	Mr Zeferino Silva	+351 1 147796
Telefonica	Mr Luis Paneda	+34 1 542 07 57
Telia AB	Mrs Mona Salomonsson	+46 8 7133040

Frame Relay

CARRIERS PUT STOCK IN FRAME RELAY

While higher-speed technologies continue be on users' wish lists, technologies that provide real-world solutions today are gaining momentum. It is evident from the results of our frame relay survey on the following two pages that carriers are moving ahead with the technology.

While most carriers have been offering the frame relay service since 1992 and the infrastructure in place, analysts agree that users are starting to sign on. Most users note that they are interested in the technology because X.25 is not fast enough to carry local area network (LAN) traffic and higher speed. Meanwhile, dedicated lines are wasteful because bandwidth is paid for while the pipes are idle. In addition, users agree that SNA and LAN internetworks can be combined into one, elimating parallel networks and their associated costs.

Many users expect to buy public frame relay services for some, even all, of their network. They believe carrier-based services are less expensive than building and running a private network. However, there are other users that plan on building hybrids of public and private services.

	AT&T	British Telecom	MCI	NYNEX	South-western Bell	Sprint	Wiltel
Service Name/ Available Since When	InterSpan/ US July '92, Europe 1Q '93 Canada 3Q '93	GNS LAN Interconnect Phase-1 9/91 Phase-2 12/92	Hyper Stream Frame Relay Available 6/92	NYNEX Frame Relay April 1992	Frame Relay July 1992	Sprint Frame Relay 4Q 1991	WilPak 3/91
U.S. Locations	Available throughout	22 North American locations	390+	Available throughout	15 in U.S.	350+	175 cities+
Total U.S. Nodes	200 plus points of presence	22 North American nodes	None Available	49 nodes in NY Telephone area; 10 nodes in Mass.	13	41 Switches	1,000 as of 8/93
International Locations	Available in 16 European countries. Pac Rim & Australia 1Q '94	5-U.K. 9-Continental Europe 4 Asia Pacific	16	None	None Available	Canada, Australia, U.K. 8- Continental Europe 2- Asia Pacific	London & Frankfurt in 1994
International Nodes	Approx. 80	Approx. 18	None Available	None	None Available	18	Plan to interconnect with other FR providers
Platform/Back-bone Network	GCNS-2000 core switch with Stratacom IPX and BPX switches as edge vehicles	Stratacom IPX 16 and 32 Fastpacket switches	Wellfleet BCN /Siemens EWSM	Northern Telecom Link Peripheror Processor T1 Backbone	Northern Telecom DMS-100 Link Peripheror Processor(LPP)	TPX 1100 Alcatel Data Networks	Stratacom IPX-Cell Relay
CPE Certification	Conduct customized compatibility tests with customers	ACC, Cisco, Wellfleet, IBM, 3Com, Vitalink, Andrew, Proteon	Yes	Will test on customer request	None	Yes	Yes
U.S. Access Rates	2400 bps to 14.4 kbps using dial access; 56 kbps to 1.5 mbps using digital access	56 Kbps to T1	Per FCC #1-MCI	Up to T1	56, 384 Kbps 1.536 Mbps	Up to and including T1	56/64 Kbps, 128, 256, 384, 512, 768, 1.024, 1.536
International Access Rates	Canada 56 K & 1.5 Mbps, Europe 64 K, 2 Mpbs and E-1	64 Kbps to E1	Per PTT	None	None Available	64, 128, 256 Kbps	In development
Committed Information Rate (CIR) Support	Yes	Yes. Offer in 16 Kbps increments.	Yes	Equals to access line	No	Yes	Yes. 16 Kbps increments below 64 Kbps
Data Traffic Types	Anything packaged for frame transmission	Has certified: AppleTalk, TCP/IP, DECnet, Vines, Netware, XNS	No	No restrictions	Not Available	All	Not Available
Switched Virtual Circuits Offered	No SVC support; will support when standards are complete	No SVC support; will support when capability is integrated into industry switches and routers	Not Available	No SVC support; will be offering ISDN access to Frame Relay Parts in 1994	No SVC support	Offer as demand warrants	No; looking into providing it
Network Management Capabilities	SNMP support	Uses Stratacom's StrataView Plus system; uses SunNet Manager for SNMP management of BT provisioned routers (Cisco or ACC)	SNMP support	NOC monitors physical and logical aspects of customer networking	SNMP-based CNM under development	Network monitoring, data delivery analyses utilization analyses and capacity management.	Order tracking, trouble ticket tracking, entry alarm, monitoring, utilization reporting, SNMP capabilities

Utilize DE BIT?	No	No	Yes	Yes	Switch support in 2H94	Yes	Yes; only for data above CIR
Utilize FECN & BECN	Yes	Yes	Yes	Yes	Switch support in 2H94	Yes	Yes
Data Buffered or Discarded With Congestion	Uses a closed loop algorithm to monitor spare capacity; therefore does not allow	Engineered to avoid congestion. If it occurs, data is buffered within the IPX nodes	Yes but discarded when buffers are filled	Both	Both; depend on level of congestion	Buffered	Buffered
Price Structure	Access fee, Port PVC fixed price by speed, and usage for dial-in access. Customer network management and equipment fees are optional.	Access circuit, installation/deinstallation, monthly maintenance fee for telco circuit, monthly port fee, port installation /deinstallation and international connectivity charge	Monthly access and port charges with installation charges. Three PVCs offered and monthly charges based on type.	Three types of ports: 56 Kbps, 384 Kbps and 1.5. Pricing dependent on customer requirements. One example: FCC 1 Port Charge-Packet Switch Port (1.5 Mbps) month to-month $862, 3-year plan $865, 5-year plan $769.	Flat rate pricing varying by bandwidth. Key Service elements: Access Link, Port and Logical Links (PVC).	Domestic U.S.: Usage and fixed monthly rates International Service: Port Plus Fixed. Raise Traffic Charges	Non-linear, based on port connection speed & PVC subscription rate, simplex
Usage Pricing	For dial access	No	Yes	No	None	Yes (U.S.)	No
Distance Pricing	None: no additional charge for long distance	No	Yes	Access line only	Mileage pricing may apply to locations outside of metropolitan areas.	No	No
Over Subscribe Access Line	Configuration dependent	200% of the access port speed	Unlimited oversubscription	No	Yes	Yes	400% for 56/64 Kbps, 200% for port connections
Asymmetrical Pricing	Yes	Asymmetrical CIR provisioning	Yes		N/A	No	Yes
Recurring Charges	Port/PVC and access and options selected	Yes except for installation/ deinstallation	Yes	Yes	Access Link, Port, and Logical Link(PVC)	Yes (Port & PVE)	Flat rate per node
Package/Discount	Yes	Yes for significant implementations on a case-by-case basis	Yes	3 and 5 year discounts	3 and 5 year contract pricing under development	Volume Discounts	Via promotions
Number of Customers	NA	NA	NA	Approx. 30	11 with 76 ports as of 10/92	385	100 as of 8/93
Customer Name	LSI Logic, NIKE, Prudential, Healthcare Systems, Halliburton, Minnesota Mutual	Will provide upon individual requests	N/A	N/A	N/A	Ernst & Young, Dyn Corp., Legent, General Electric	Convex Computers, RW Blek, Sequent Computers, Novell
Marketing Contact	1-800-247-1212	Debra Mielke (408) 922-7186	Joseph McKernan (214) 701-1267	Jim Hines (914) 644-5470	Tom Prost (314) 235-8535	U.S.: Katherine Waldron (703) 689-2209 Intl.: Leigh Saunders (703) 689-6000	Leslie Nelson and David Soares (918) 588 5054

Q1. **What type of Frame Relay switches are used?**
A1. *Cascade 6000 & 9000 B-STDX Multiservice WAN Platform switches at the network edges with current backbone based on Newbridge 36150 MainStreet ATM and GDC APEX ATM switches.*

Q2. **What is the minimum switch latency?**
A2. *Use caution when answering questions regarding latency. There are many elements involved with network latency, one of which is switch latency. The Cascade 9000 B-STDX has a minimum switch latency of less than, or equal to 1 (one) millisecond. Of all the elements involved in network latency,however, propagation delay will be more significant than switch latency. In our network, propagation delay is approximately equal to 0.865 milliseconds per 100 miles.*

Q3. **What access speeds are supported?**
A3. *56 Kbps up to 6 Mbps. Refer to Frame Transport service description for details.*

Q4. **What committed information rates are supported?**
A3. *Standard CIR options are available at zero, 56 Kbps, 128 Kbps, 256 Kbps, 512 Kbps, and 1.5 Mbps. Individually priced CIR options are available in additional increments of N x 64 Kbps.*

Q5. **What trunk speeds are supported?**
A5. *T3.*

Q6. **What is the maximum frame size supported from the customer equipment?**
A6. *4096 byte frames are supported. We can accommodate larger frame sizes if requested by a customer, however, we don't recommend it because it could reduce performance.*

Q7. **What is the maximum number of PVCs supported by the Cascade 6000 & 9000?**
A7. *400.*

Q8. **What is the maximum number of PVCs supported per access port?**
A8. *Hundreds of PVCs can be supported per access port, however, an exact number was not available at the time this document when to printing.*

Q9. **What is trunk method is used between frame relay switches?**
A9. *ATM.*

Q10. **Are the frame switches we use fully redundant?**
A10. *The Cascade 6000 and 9000 used by MFS Datanet are capable of full redundancy, however, there are some components of the switch (in the way we purchase them) that are not redundant. The power supply, central processors and individual port cards are all independent of each other and a failure on one I/O card will not impact others around it.*

Q12. **What communication protocol is used on the trunk portion of the network?**
A12. *ATM.*

Q13. **How are routes selected?**
A13. *Routes through the network are selected using "Open Shortest Path First" (OSPF).*

Q14. **Are PVCs maintained if a trunk fails?**
A14. *Yes. PVCs are automatically rerouted around a trunk that has failed in the network. The network is configured with multiple paths, so in the event that an alternative path is unavailable, a PVC will be automatically restored as soon as a path is available.*

Q15. **Does the network allow for different PVC speeds in each direction?**
A15. *No.*

Q16. **Does the backbone handle different priority schemes.**
A16. *No.*

Q17. **Is the network fully diverse?**
A17. *Yes, except for a few cities (like Boston) that currently being scheduled.*

Q18. **Is the routing of PVCs done by the nodes, network management system or by network operators?**
A18. *By nodes.*

Q19. **Does the network support SNA traffic?**
A19. *Customers may chose to use a FRAD device to connect SNA traffic to the network for use with Frame Transport. Presently we do not natively support SNA, but may chose to in the future.*

Q20. **Is Link Maintenance Interface (LMI) supported?**
A20. *Yes and conforms to Revision 1.0 of the original Frame Relay Forum specification, as well as to ANSI T.617 Annex D.*

INTRODUCTION

A Report from Users and Experts on Frame Relay

Welcome to "Frame Relay, 1994 and Beyond." This report presents a current view of frame relay's business benefits through interviews with frame relay users and industry experts. The report also evaluates the ongoing role of frame relay in the developing Asynchronous Transfer Mode (ATM) environment. The results offer compelling reasons to consider a frame relay solution for your wide area data networking needs today.

The articles that follow address these questions:

- What are current users experiences with frame relay? What benefits have they received, and what is frame relay's applicability to everyday business needs?
- Where does frame relay stand in the market today? What are the primary drivers behind frame relay's current rapid growth?
- What about ATM—will it interoperate with frame relay ? What is frame relay's role in an ATM network?

The answers are overwhelmingly positive. Users resoundingly endorse frame relay solutions for their wide area data networking needs. They are saving money, improving performance, enhancing corporate productivity, and easing implementation and network management concerns. The frame relay market is taking off with over 700 corporate and public service users in the U.S. alone by the end of 1993.

Analysts and users have concluded that frame relay and ATM are complementary technologies. Frame relay and ATM will work together, bolstered by broad industry support for frame relay-to-ATM interworking. These technologies will continue to work together into the next century.

This report would not have been possible without the cooperation and support of the Forum members as well as that of numerous experts in wide area networking technologies. I would also like to express my gratitude to the many users who were interviewed for these articles. They willingly shared their thoughts about the measurable improvement frame relay has made in their business.

Laura Capaldini
Northpoint Consulting

About This Report

This report was commissioned by The Frame Relay Forum and produced with the cooperation of CommunicationsWeek and Data Communications, among other with the new Frame Relay Interexchange and Local Service (see Page 11), is part of an overall program dedicated to the Frame Relay Forum to promote the understanding of frame relay and its current use in the marketplace. This research and writing for this report was done by Laura Capaldini of Northpoint Consulting. The overall program was developed and managed on behalf of the Forum by Strategic Directions, Inc.

FEATURES

Biographies

Laura Capaldini is a principal at Northpoint Consulting in Ithaca, N.Y. She specializes in strategic marketing and business planning for emerging data and voice services. Her focus is on broadband networking, packet-based data services including frame relay, and wireless communications including PCS. She is a member of the Frame Relay Forum. Laura may be reached on MCI Mail at 493-8893, or by phone at (607) 257-4240.

Thomas H. Jones is President of New Venture Directions, Inc., of McLean, Va., a management consulting firm specializing in strategic planning and marketing for companies in the data communications and networking industry. Tom was active in the founding of The Frame Relay Forum and served as its first President and Chairman of the Board. He can be reached by phone at (703) 442-8995 or via the Internet at wk02143@worldlink.com.

ILLUSTRATIONS BY ALEXANDER BARSKY

Frame Relay Enters Business Mainstream

Users from all industries are finding that frame relay saves money, improves performance and is easy to implement.

In the evolution of any new technology, there comes a point when the focus shifts from a debate over technical capabilities to a discussion of actual experiences of users. Frame relay has passed this milestone, and there is now a growing body of users ready to speak out. With several years of operating experience, these frame relay users have overwhelmingly positive reports to make about frame relay's impact on their business. Based on their first-hand accounts, frame relay is here to stay.

What are some of the reasons users choose frame relay solutions? Users are reaping numerous business benefits, including improved corporate productivity, enhanced competitive advantage, and responsiveness to rapidly changing business environments. Plus, they are doing so with a technology that they say is simple to use, improves performance, and saves money.

The frame relay-based solutions discussed below include public network services, private frame relay networks, and "hybrid" networks of both public and private solutions. They represent mainstream network users of different sizes and from different industries. All the networks discussed in this article are installed and working today in full production.

"We were amazed at how easy it was to implement frame relay—it took only six weeks."

—Phil Marzullo, REN Corp.—USA

"Frame relay has made the whole network so simple and incredibly flexible. We literally could move the whole corporate office to another city and it wouldn't make a big difference," says Phil Marzullo, Vice President and Chief Information Officer of REN Corp.—USA, based in Nashville, Tenn. Marzullo says that frame relay has enhanced his company's ability to grow, while simplifying the installation and management of the network. "We are very happy," adds Marzullo. "The phone doesn't ring as often as it used to in the user support area. The network is very stable."

REN Corp.'s network is the backbone of its business. REN Corp. builds and operates kidney dialysis centers throughout the U.S., with recent expansion to Mexico. Each center is linked to a centralized patient information database. Vital data about the patient is recorded in the system, including treatment plans, lab results, and medical history. The network links patient information to the billing system and to a centralized lab.

"Our bandwidth increased from 9.6 to 56 Kbps and our monthly line costs dropped in half."

—Jerry Johnson Abco Foods

Easing Implementation

With over 50 U.S. locations, and plans for more, REN Corp. needed to easily bring up new sites. "We were amazed at how easy it was to implement frame relay," reports Marzullo. He adds that, "remarkably, the entire changeover to frame relay from the previous leased line network took only six weeks." New locations are brought on-line by simply adding an access port and configuring the permanent virtual circuits (PVCs). As new applications arise, Marzullo notes, "frame relay gives us the ability to expand the bandwidth without expanding the whole network."

REN Corp. has seen other benefits. "Implementing frame relay was a no-brainer from a cost-effectiveness point of view," says Marzullo. Using an interexchange carrier's public frame relay service, REN Corp. was able to upgrade network access to 56 Kbps (from 9.6 Kbps leased lines), and save 20-to-25 percent over its pre-

ILLUSTRATIONS BY ALEXANDER BARSKY

vious network configuration.

Frame relay simplified REN Corp.'s disaster recovery plans. "On just an hour or two notice, we can switch the entire network over to utilize the back-up data center, keeping the patient information system available to clinics nationwide," says Marzullo.

Marzullo sums up his satisfaction with frame relay: "There is nothing that we would do differently about our move to frame relay. Thus far, we are very happy. Frame relay is definitely living up to our expectations."

Cutting Costs

Success in the retail grocery industry is measured on the slimmest of profit margins, where a one percent improvement in profit is significant. Abco Foods, an operator of retail grocery stores in Phoenix, needed to improve its networking capabilities while keeping costs down.

Frame relay expanded Abco's network bandwidth and improved response time while saving 30 percent per month. "Moving to frame relay is one of the smarter decisions we've made," declares Jerry Johnson, Vice President of MIS.

Growing application requirements at Abco saturated the existing network of 9.6 Kbps multidrop lines. The network initially supported electronic funds transfer as well as credit check applications from each of Abco's 76 stores in Tucson, Yuma, and Phoenix. Later, price change, time and attendance records, and other administrative applications were added.

Abco considered upgrading to 56 Kbps leased lines, but the monthly line costs would have almost tripled from $12,000 per month to $35,000. Abco's solution was to use a public frame relay service offered by its local exchange carrier.

Frame relay delivered on cost and performance improvements. "Our bandwidth increased to 56 Kbps to each site, and our monthly line costs dropped in half to $6,000," states Johnson. "We ran our own T1s between the two Local Access Transport Areas (LATAs) where our stores are located. Even with that cost, we are saving 30 percent every month compared to the previous network."

Abco also saw dramatic performance improvements. "The new network has given us a big boost in response time, for both check verification and electronic funds transfer (EFT)," relates Johnson. Faster response times mean more customers served and greater customer satisfaction.

Abco's confidence in frame relay and its vendor was demonstrated by its aggressive network deployment. "We had everything installed, pretested, and ready to go," relates Johnson. "So we cut over four stores per night to frame relay. The entire network was done in three-to-four weeks."

Frame relay provides application independence for Abco's network. "We are firm believers in frame relay because we only want one communications platform in each store," says Johnson. "We need an open architecture that can support TCP/IP, NetBIOS, SNA and other protocols, all of which we can support with frame relay.

> *"Network response time improved to less than one second from its previous range of three-to-five seconds."*
>
> —Brian Spears
> Konica

> *"Parsons looked at putting up a private line network but it would have cost three-to-five times more."*
>
> —Kevin Hendrickson
> The Parsons Corp.

And we will be putting up new applications in the future."

Changing Business Needs

"One of frame relay's biggest selling points is its flexibility," says Kevin Hendrickson, Manager of Technology Services for The Parsons Corporation, Pasadena, Calif. "In an engineering company, projects get staffed up and staffed down. Once frame relay is implemented in a site, we can quickly adjust the bandwidth and connections for optimal performance. So we're really paying only for the services and the bandwidth we need."

Parsons is one of the country's largest engineering and construction companies. Until recently, different subsidiaries each had their own business support systems. After consolidating these functions, Parsons added public frame relay service from an interexchange carrier.

The frame relay network links LANs in 30 offices across the U.S. back to three data center sites, one of which is in London. "Given that we were going to have everybody use the same financial, job cost, human resources, and payroll systems, we had an urgent need to link everyone to the same data center sites," says Hendrickson.

Using a public frame relay service provided the cost-effective flexibility Parsons required. "Parsons looked at putting up a private line network, but an equivalent network would have cost three-to-five times more," says Hendrickson. As well, a leased line network lacks the flexibility to change readily as business needs change. "The ability to phase-in changes incrementally is one of the major benefits of

frame relay," says Hendrickson.

With two years of experience with frame relay, Parsons is ready to add more sites, particularly overseas. Having met its original need to consolidate existing applications and protocols over one network, Parsons is ready for expansion. "With the frame relay network now in place," Hendrickson reports, "we're seeing lots of other possible applications for the network bandwidth."

Reducing Response Time

Enhancing productivity through improved performance was a critical decision factor in a move to frame relay for Konica Business Machines USA Inc. Konica, based in Windsor, Conn., needed to migrate from a pure SNA network to a LAN based environment to meet changing business requirements.

Konica chose an interexchange carrier's public frame relay service to link its LANs across the U.S. "On the basis of a price/performance analysis, frame relay was clearly the best decision," reports Brian Spears, Manager of Information Technology.

The decision has paid off. Branch officers were upgraded from the 9.6 Kbps point-to-point and multidrop line network to 56 Kbps access. As a result, according to Spears, "network response time improved to less than one second from its previous range of three-to-five seconds."

In addition, "strictly on the basis of line charges, Konica is saving about $120,000 per year or 15-to-20 percent over what we were previously paying for the 9.6 Kbps network," says Spears.

Konica's network connects 50 branch sales offices with headquarters for wholesale and retail office equipment sales operations. Applications include: customer inquiry, billing, order placements, order inquiry, and service records. Timely response has improved sales force productivity and customer satisfaction. New local area network-based applications are proliferating throughout the company.

Using a frame relay service has also improved network reliability for Konica. With frame relay's automatic re-routing capabilities, line outages have not been a problem. "Previously, outages were an issue, and we had implemented dial backup capabilities for our network lines," reports Spears. "These capabilities have not been needed with the frame relay network."

Superior Network Reliability

Corporate mergers may enhance a company's strategic positioning but they often wreak havoc on the corporate networking environment.

Legent Corporation, based in Herndon, Va., was formed through a series of mergers and consolidations among software companies. In 1992, it doubled in size through a merger with Goal Systems, forming the third largest mainframe software company in the world.

"We needed a network that could carry a mix of data protocols such as TCP/IP, SNA, SDLC, IPX and XNS reliably over a single company highway," reports George Photakis, Director of Corporate Telecommunications.

Legent's business requires superior network reliability. "It was absolutely critical that the network be available at all times, around the clock," notes Photakis. "Almost 80 percent of the network use is pure interactive traffic to the mainframe or a file server. For example, our customer support personnel are spread all over the world, needing access to centralized data bases as they work in real time with customers." The network supports other applications including e-mail and Lotus Notes; access to development computers, imaging and file transfers for software development; and on-line sales tools.

"We needed a network to carry a mix of data protocols—TCP/IP, SNA, SDLC, IPX and XNS."

—George Photakis
Legent Corporation

Legent is combining public and private frame relay capabilities into one reliable corporate network. "Frame relay gives us a self-healing network," reports Photakis. "With 30-to-35 sites in the U.S. and an equal amount abroad, leased lines would be impossible to maintain."

The major U.S. sites plus a site in Japan are connected and working through an interexchange carrier's public frame relay service. Starting in 1994, Legent plans to add its European sites, plus Australia and the Pacific Rim, to the frame relay network.

A private network of dedicated T1s between major development sites will become a multiplexer-based private frame relay network for high volume applications.

Legent likes the results. "We're seeing approximately 35 percent savings on average over the previous 56 Kbps leased line network. We're also saving on access costs at the host computer," reports Pho-

"We can transmit a printing document from New York to London in one-fifth the time it took before."

—John Robinson
R.R. Donnelley & Sons

takis. Photakis concludes, "We must be able to plan for the unexpected, particularly in terms of new applications. Frame relay gives us flexibility and reliability, without the cost and maintenance issues of a leased line network."

Enhanced Competitive Advantage

In the highly competitive printing industry, the time it takes to deliver the final document is often the deciding factor in the ability to win the business.

At R.R. Donnelley & Sons, communication networks provide mission critical connectivity for business applications. Donnelley, with headquarters in Chicago, relies on the network to distribute text and color images to printing plants around the world. The network also distributes diskette masters and files for the information replication business.

"These applications are at the core of our business," states John Robinson, Manager of Data Communications at Donnelley. "Our product is going through the network, and our deadlines simply can't be missed." Other applications such as e-mail and financial reporting also flow through the networks.

Over two years ago, Donnelley knew that its networks were becoming outdated. Donnelley replaced multiple discrete networks with a private frame relay network. The network uses switches supporting frame relay and X.25 in the same switching fabric. "The decision to move to frame relay gave us the ability to encompass all the applications we could foresee at a cost that was advantageous compared to the alternatives," states Robinson.

These applications now work together on a single network. "The internetworking that frame relay gives us provides a strategic advantage versus our previous discrete networks," reports Robinson. "By using a single network, our applications are better able to talk to each other," he says.

"Frame relay gives us a competitive edge in our business," relates Robinson. "In a broad view, we manage a network of printing plants." The new frame relay network cuts the time required to distribute documents to the printing plants, improving Donnelley's ability to compete.

"For example, our financial printing business has seen a five times increase in throughput," reports Robinson. "We can transmit a financial printing document from New York to Los Angeles or London in one-fifth the time it took before. In this business, days are worth dollars."

Conclusion

Users of frame relay equipment and services are vocal supporters of the technology. Network managers report measurable improvements in networking costs, performance, reliability, manageability, and ease of implementation. Corporations are pleased with the resulting improvements in productivity, customer satisfaction, and profits. The message is clear—frame relay provides a proven, cost-effective solution for wide area data networking in the '90s.

The International Outlook

While the user experiences highlighted in this report have focused on frame relay networking in the U.S., international usage of frame relay is also growing strongly. Over 18 international operators offered frame relay services in 1993, and at least eight additional national frame relay networks are planned for 1994. The networks span every region of the world. In addition, U.S.-based carriers are aggressively expanding internationally, often in response to requirements from major multinational customers.

The rise in demand for international frame relay has been somewhat slower to materialize than in the U.S. While the reasons vary from country-to-country, several general explanations may be noted.

First, international LAN-to-LAN connectivity requirements are still less than in the U.S. "The number of LAN installations in all of Europe is still less than that in the States," reports Jeffrey Gould, Principal of DataStrategies SA (Paris). But demand for LAN connectivity is growing and is expected to catch up with U.S. levels sometime in the next two-to-three years.

The second reason is the popularity in Europe of X.25 networks for LAN-to-LAN and SNA transport applications. However, frame relay's lower delay, higher performance, and lower line overhead are beginning to sway users and service providers alike.

Third, in some countries, there were concerns that the underlying transmission lines did not have the low error rates needed for good frame relay performance. Such error-free transmission lines are already available in many countries. Other countries have aggressive network upgrade plans underway to allow high speed digital transmission.

As frame relay's benefits are better understood and as LAN-to-LAN networking has expanded, international use of frame relay has grown. Telecom Finland operates one of the largest frame relay networks in the world. Juha Heinonen, Manager of the network, reports that Telecom Finland uses a frame relay backbone as part of an end-to-end LAN internetworking service offering. "While we are heavily using frame relay, we don't sell 'frame relay' to our customers. Many don't even know they're using frame relay," he adds.

Users of international private frame relay networks are reaping the same benefits as their stateside counterparts. Britvic, a Birmingham, England-based soft drinks manufacturer and distributor, combined existing X.25 traffic with growing LAN-to-LAN connectivity needs into one private router-based frame relay network. National networks are in place in countries across Europe, in the Far East in Hong Kong, Japan, Australia, New Zealand, and elsewhere including Israel, Canada, and South Africa.

The list keeps growing as users and carriers alike determine that frame relay offers the price and performance characteristics required by their changing connectivity needs.

Frame Relay Takes Off!

Industry experts note the rapidly growing use of frame relay for LAN-to-LAN and SNA networking.

A ground swell of support for frame relay has been quietly building among users and among wide area networking industry experts throughout the U.S. and abroad.

"Frame relay is the best kept secret in the industry," according to Rick Malone, a Principal of Vertical Systems Group, Dedham, Mass. "Two years ago there were a lot of naysayers regarding frame relay's growth. But users needed something easy to install, easy to understand, economical, that fits their environment. Frame relay meets these needs."

Price, Performance, and Manageability

"People are looking for a combination of cost savings, ease of management, and level of performance," explains Robbie Forkish, President of RFTC, Inc., a consulting firm based in Eugene, Ore. He adds, "Improvements in price and performance are definitely the measure by which users judge a technology."

Frame relay's combination of price and performance is a primary reason for frame relay's growing success. "We've reviewed case studies and found that frame relay users have the opportunity for tremendous savings," reports Steve Taylor, President of Distributed Networking Associates, Greensboro, N.C. In addition to savings, Taylor adds, "users are getting the redundancy and performance of a meshed network that they couldn't otherwise afford to have."

Other analysts agree. "A primary benefit of frame relay is cost savings," says Tom Nolle, President of CIMI Corp., a Voorhees, N. J., consulting firm. "Our clients have seen an average 32 percent savings overall." Nolle estimates that at least three-quarters of these clients are replacing existing leased line networks.

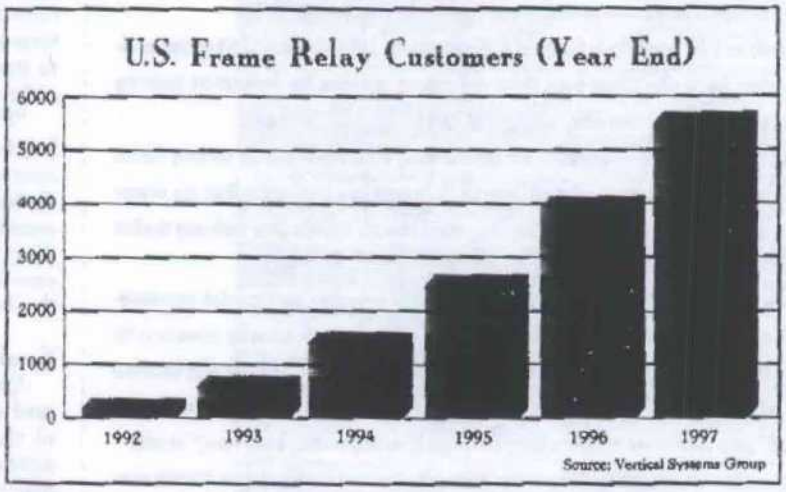
Frame relay users are learning that, with no increase in cost, performance can improve dramatically over previous network configurations. "We have seen up to a five times performance improvement while still paying the same as before," reports Malone.

Manageability is also a critical consideration. "Users want to be able to hand off the management of their networks to carriers," says Paul Callahan, Senior Analyst, Network Strategy for Forrester Research Inc., Cambridge, Mass., a user-focused market research firm. "They don't want to have to build and manage complex mesh networks. Frame relay solves that problem for them."

Multiprotocol Networking

Functionally, the requirement to support multiprotocol networking, particularly LAN protocols, drives frame relay's growth. In particular, the integration of LANs into SNA environments has caused many users to evaluate frame relay. "We're seeing an extraordinary transformation of branch offices from traditional SNA into LAN-based networks," reports Callahan.

"We work with people who are struggling with the migration of dedicated SNA networks into decentralized, multiprotocol environments," states Donald Czubek, President of Gen2 Ventures, Saratoga, Calif., a firm that consults on IBM networking. "Frame relay fits well. In the original SNA world, WAN connections were primarily dedicated data links which handled only SNA and SDLC. Now, frame relay supports a mix of protocols—the direction in which everyone is going."



The unpredictable nature of LAN traffic has also served as a driver for frame relay acceptance. "An increasing percentage of traffic is LAN-to-LAN," relates Czubek. "This is true across the industry. In the new enterprise networks, data traffic patterns are less predictable. LAN traffic also tends to be bursty and needs greater bandwidth. Even with a single protocol, it is still diffi-

cult to configure networks."

With support for multiple protocols and applications, the network must be resilient enough to withstand rapidly changing traffic loads. "It's often the case that end users can't tell you which new applications are running from day to day," says RFTC's Forkish. Traffic analysis and management are increasingly difficult. Frame relay meets these challenges.

U.S. Frame Relay Market Revenue In Millions

	Services	Equipment	Total
1992	14.6	36.2	50.8
1993	57.1	132.9	190.0
1994	153.5	251.3	404.8
1995	332.1	435.5	767.6
1996	618.1	656.9	1275.0
1997	1027.7	916.4	1944.1

Source: Vertical Systems Group

Frame Relay in IBM Networks

IBM networking represents a growing segment of the frame relay market, not only with the migration to LANs, but within the SNA environment as well. Frame relay technology provides a robust alternative to the traditional wide area leased line networks of the IBM networking environment.

"IBM realizes that it must provide an open environment. While X.25 was supposed to offer that environment, IBM never really got behind X.25," says Anura Guruge, an independent consultant in New Ipswich, N.H., specializing in IBM networking. "Frame relay provides IBM with a fairly smooth transition—customers can use existing hardware to support frame relay."

In early 1994, IBM released a new version of its Network Control Protocol (NCP Version 7.1) allowing SNA networks to fully utilize frame relay. "Frame relay has some significant benefits for the SNA community—link consolidation being one of them," reports Guruge. "Frame relay will support, theoretically, hundreds of virtual circuits on each access link, significantly reducing user access port needs."

IBM networking users also receive the benefit of higher access speeds and redundant routing. With connections generally at 56 Kbps and above, frame relay significantly improves performance over the traditional 9.6 Kbps leased line and multidrop networks prevalent in the IBM environment. Frame relay's automatic rerouting capabilities and network robustness minimize the possibility of major line outages.

The use of frame relay in IBM networks is on the upswing. "People are still in the early stages of the migration," reports Czubek. He adds, "IBM has thrown a lot of support behind frame relay. And IBM's support of frame relay makes the traditional IBM customers more comfortable."

Continued Growth

Future growth of frame relay will be nurtured by the development of new applications. "Frame relay is still in the replacement stage, replacing existing networks," says Taylor from Distributed Networking Associates. "This will change over time. As we replace existing networks, it will give us the infrastructure that will allow tremendous growth in new applications."

Nolle agrees. "Today, frame relay enables a network expansion that otherwise would have been cost-prohibitive," relates Nolle. "By the end of 1994, we expect to see the first stream of new applications driving frame relay growth."

Additional growth will develop as frame relay moves into international markets. "Users are extending their networks globally," says Malone. "There's tremendous interest in bringing on European and Asian sites. Carriers are having to accelerate their plans."

"People are buying frame relay," reports Callahan. "They have awakened to the fact that they can't go forward without LAN internetworking. The best way to do that is with frame relay."

The secret is out.

Growing User Acceptance

Installations of public and private frame relay networks in the U.S. are rapidly accelerating. Industry experts project a market size of almost $400 million in 1994, growing to over $1.2 billion in 1996.

User acceptance of frame relay technology took off dramatically in 1993. According to a study by Vertical Systems Group (see Page 7), an estimated 590 corporate, educational, and institutional customers were using public frame relay services in the U.S. by the end of 1993. A more recent survey by Distributed Networking Associates put that number at over 700. In 1994, the number is expected to almost triple.

User acceptance of frame relay services is driving growth in the market for frame relay customer premises equipment (CPE) and service provider equipment. The market for private network switches is growing as well, since private network users are looking to upgrade to the benefits of frame relay technology (see chart above).

Frame relay users represent a range of industries, company sizes, and network configurations. However, they have all found that frame relay meets their critical wide area data networking needs. "By 1998-99, frame relay will be the most important data service, with the largest worldwide market share—greater than X.25 or any other service," predicts Tom Nolle, President of CMG Corporation, a Voorhees, N.J., consulting firm.

When Frame Relay Meets ATM

A broad consensus sees frame relay's integral role in ATM networks.

In making the major financial and time commitment to upgrade network technology, users want assurance that their networks will last. "The biggest hesitation in networking that we're still seeing is uncertainty among the choice of frame relay, SMDS (Switched Multimegabit Data Service), and ATM technologies," reports Steve Taylor, President of Distributed Networking Associates, Greensboro, N.C. "People are not clearly seeing the migration paths or that full interoperability will be available. But these technologies absolutely will coexist," he adds.

Industry experts believe that frame relay and ATM are entirely compatible and complementary. "From an ATM perspective, frame relay is great," says Steve Walters, Executive Director—Broadband Product Line Management for Bellcore, and a Vice President of the ATM Forum. "Frame relay extends the range of capabilities for which ATM is used."

Optional Interface

This includes supporting a lower speed interface particularly well suited for data applications. Walters adds, "There will be situations based on specific applications and economics where either a frame relay or ATM interface will be the right choice for the customer."

Other experts agree. "Many people have the misconception that ATM and frame relay are mutually exclusive, but that's not true," states Donald Czubek, President of Gen2 Ventures, Saratoga, Calif., a consulting firm specializing in IBM networking. He cites IBM's plans for ATM access: "For most of the IBM architecture, frame relay will be one of the interface options for ATM networks."

Compatibility between frame relay and ATM will benefit both technologies. "ATM's issue is where will that traffic come from," reports Robbie Forkish, President of RFTC Inc., Eugene, Ore., an original co-founder of Network Equipment Technologies and a leading expert on broadband technologies.

> *"From an ATM perspective, frame relay is great. [It] extends the capabilities for which ATM is used."*
>
> —Steve Walters
> Bellcore
> VP ATM Forum

While frame relay and ATM networks may initially coexist as separate networks, Forkish says that eventually frame relay and other access technologies will feed traffic into the multimedia ATM networks. "We expect to see most new networks being ATM-based and supporting frame relay access as well," he adds. "Over time, the predominance of LAN interconnect will be frame relay going to ATM networks."

Why does frame relay work well as an access interface for ATM? First, there are remarkable similarities in the protocols. Frame relay and ATM evolved from the broadband Integrated Services Digital Network (ISDN) standards developed during the 1980s.

"If you look at the basic technology, the only real difference between frame relay and ATM is the variable length versus the fixed length packets (or cells)," reports Taylor. "That's where all the differences stem from in terms of bandwidth efficiency and ability to support very delay-sensitive applications like voice and video."

Second, frame relay is easy and inexpensive to implement. Frame relay is readily supported in software, and for many users simply requires a software upgrade to existing equipment, minimizing network investment. A wide range of vendors support software-based frame relay interfaces on their equipment.

Third, frame relay's relatively low overhead and variable packet size makes it an efficient protocol for transmitting data. With frame relay, the default overhead on a 128 byte frame is approximately 4 percent of the frame. As the frame size increases, the overhead percentage decreas-

es dramatically. For example, with a 1600 byte frame, a size common with LAN protocols, the overhead drops to less than one-third of a percent.

ATM's 53 byte fixed cell is optimized for handling multimedia traffic at high speeds. However, with ATM, approximately 10 percent of each full cell is overhead. In very short transactions, where cells are not full, an even greater percentage of bandwidth carries no user data.

"As a general rule, the lower the speed (e.g., T1 and sub T1), the more concerned you are with overhead for data applications," relates Taylor. At levels of T3 and above, the benefits of ATM outweigh the efficiency considerations. At relatively lower speeds (T1 and below), frame relay more efficiently transports data.

"Frame relay is a good approach for data," asserts Ken Miller, President of Prism Networks Inc., a Waltham, Mass., network services consulting and integration firm. "The rationale for using ATM is to tie together multiple sources of traffic with different characteristics. Even if you have ATM, the interface into the ATM network will continue over time to be frame relay."

Industry-wide Agreement

Frame relay's success as an access interface to ATM will be enhanced by an industry-wide agreement on the interworking between frame relay and ATM. The Frame Relay Forum and the ATM Forum have been working on just such an agreement.

These two industry organizations represent companies ranging from wide area networking service providers, to equipment vendors of CPE, switches, computers, and multiplexers, and to major networking software vendors. With this formidable array of networking talent, the industry has actively taken charge of ensuring broad-based interoperability between these two technologies.

The goal of these interworking activities is to develop specifications for two different interworking scenarios. "The first scenario allows frame relay transport from end-to-end across an ATM network," reports Walters.

The frame relay emulation may take place in the ATM network itself, or in the customer premises equipment at either end of the connection.

Walters continues, "The second scenario is to support frame relay at one end of the connection and ATM at the other end." This may be attractive to users who want to aggregate lower speed data over the network into one higher speed ATM interface to a mainframe or centralized server. Commonly known as "service interworking," this scenario requires that a protocol conversion function take place between frame relay and ATM.

> *"Even if you have ATM, the interface into the network will continue to be frame relay."*
>
> —Ken Miller
> Prism Networks

In early 1994, The Frame Relay Forum in cooperation with the ATM Forum, released the "Frame Relay/ATM Network Interworking Implementation Agreement" for final approval. Both groups endorse the Agreement as the industry-accepted specification for frame relay-to-ATM network interworking. The Agreement is expected to be widely implemented by both frame relay and ATM equipment vendors and service providers.

Joint work is also underway by The Frame Relay Forum and the ATM Forum on the second interworking scenario, service interoperability, supporting frame relay-to-ATM protocol conversion.

Frame Relay User Confidence

Current frame relay users are confident that frame relay satisfies today's needs and offers a migration path to future networks. "We don't even expect to see the migration to ATM—that's how seamless it should be," says Kevin Hendrickson, Manager of Technology Services for The Parsons Corporation. Hendrickson doesn't anticipate that ATM will replace frame relay entirely. "We expect to continue to support a mix of WAN technologies based on application needs."

Other users already plan to use frame relay as an access interface to ATM. Continental Insurance, based in New York, moved from a leased line-based bridged network onto a public frame relay service. Walter Parezo, Continental's Network Project Manager says, "We've been watching ATM develop. We fully expect to be able to plug our frame relay capabilities into the ATM switch transparently. In fact, many ATM switches already support frame relay as an interface."

Roy F. Weston, an environmental engineering firm in West Chester, Pa., sees that computer-based training and document imaging applications may require ATM. "Sometime in the next two-to-three years, we will implement ATM in our headquarters as a metropolitan area network," says Robert Lewis, Weston's Technical Manager of Networks. "Frame relay will continue to offer us access into a carrier-based ATM wide area backbone."

Meeting Office Needs

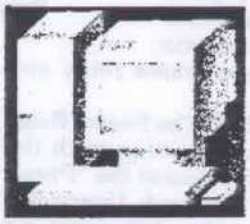
For users that are just now upgrading to 56 Kbps or fractional T1 lines from 9.6 Kbps, T3 (and even T1) access requirements are a long way off. "I don't need DS3 to an office with 10 people," states George Photakis, Director of Corporate Telecommunications for Legent Corporation, a mainframe software development company. "At that office, even T1 may still be too much." At these lower speeds, frame relay will be more efficient and cost-effective.

Frame relay is available today, broadly implemented in hardware and service offerings, and cost-effectively meeting existing user and applications needs. Industry efforts to make sure that frame relay and ATM interoperate have already achieved important successes. Frame relay will continue to be available in the future, working in concert with ATM and other technologies to support wide area networking needs well into the 21st century.

New! On-Line Information About Frame Relay

Users can get free information by simply using a PC or a fax.

In order to make it easy for end users to investigate frame relay, the Frame Relay Forum has developed on-line information services to provide end users with information about frame relay and its applications. The on-line services are co-sponsored by CommunicationsWeek and Data Communications.



The on-line services consist of two parts: the Frame Relay InfoExchange℠, an electronic bulletin board; and Frame Relay Facts-by-Fax℠, a fax-on-demand service. Both services are available with NO usage or connect-time charges.

FR InfoExchange

Inspired by the growing use of on-line services and the Internet to access a wealth of information, the Frame Relay InfoExchange has two parts: a library of various information that users can copy, and an interactive message section. The library contains electronic copies of documents such as the following:

- An overview of frame relay.
- Bibliography of recent articles regarding frame relay, with complete text of selected articles.
- Copies of Frame Relay Forum Newsletters.
- Directory of standards related to frame relay, including proposals in the draft stage and full copies of selected standards.
- Directory of Frame Relay Forum member companies, with contact information.
- Information on Frame Relay Forum activities.

The message section of the InfoExchange offers perhaps the greatest potential benefit for users. It enables direct interaction among frame relay users and prospective users, sharing the information gained from actual implementations about frame relay in greater detail than could ever be covered in a published article. The InfoExchange allows users to ask questions, receive answers, post useful information, and browse through messages posted by other users. For example, a user considering frame relay might want to know how a particular application behaves when connected with frame relay instead of multipoint leased lines. By posting a message, the user can determine if any other Frame Relay InfoExchange users have already implemented frame relay with that application. Users considering frame relay can capitalize on the experience of others regarding how to get the greatest performance and savings from frame relay when operating with specific protocols, vendor equipment, and carrier services.

How to Get On-Line

In effect, the InfoExchange becomes a frame relay users group, without the need for travel to on-site meetings.

The Frame Relay InfoExchange is operated in cooperation with CompuServe, which has agreed to provide the facilities, maintenance, and access for the InfoExchange free of any connect-time charges. Users who already have a CompuServe account can access the InfoExchange by typing GO FRAME. Users who do not already have a CompuServe account, or Internet users who wish to access the InfoExchange via the Internet, can obtain information on how to connect to the InfoExchange by contacting The Frame Relay Forum using the fax, Internet, or telephone number listed on the last page of this report, and include your name, company, mailing address, telephone, and fax number.

Frame Relay Facts-by-Fax

The other element of the Forum's on-line services is Facts-by-Fax℠. The documents available from Facts-by-Fax include a subset of the materials in the library portion of the InfoExchange. This is an expansion of the service which the Forum has had since 1992. To access this service, a user dials Facts-by-Fax from the telephone handset of a fax machine. The user will hear instructions and can respond with touch-tone entries to request a listing of available documents or to request one or more specific documents. Facts-by-Fax will then automatically fax the requested information immediately to the user's fax machine. There is no charge for Facts-by-Fax. The Frame Relay Facts-by-Fax service may be reached by dialing (415) 688-4317 from any fax machine.

Frame Relay Forum

The Frame Relay Forum

The Frame Relay Forum is a non-profit organization dedicated to promoting the acceptance and implementation of frame relay based on national and international standards. Established in 1991, the Forum has more than 100 member companies in North America, Europe, Australia and New Zealand. In addition, another 120 companies are members of the Japan Frame Relay Forum, an independent organization established and operated in cooperation with The Frame Relay Forum.

The Forum works to ensure frame relay interoperability by developing and approving Implementation Agreements which define how national and international standards will be applied for common support of the frame relay protocol. The Forum also furthers the growth of the worldwide market for frame relay by promoting an understanding of frame relay's benefits, applications, and user experiences.

More information on The Frame Relay Forum may be obtained via the Frame Relay Facts-by-Fax service or the on-line Frame Relay InfoExchange (see Page 11 for details), or by contacting the Forum at the addresses below:

North American Office
The Frame Relay Forum
303 Vintage Park Drive
Foster City, CA 94404-1138
USA
Telephone: +415.578.6980
Fax: +415.525.0182
Internet ID: FRF@INTEROP.COM

European Office
The Frame Relay Forum
c/o OST, BP 158
Z1 Sud Est rue du bas Village
35510 Cesson Sevigne cedex,
FRANCE
Telephone: +33.99.51.76.55
Fax: +33.99.41.71.75

Australian Office
The Frame Relay Forum
c/o Interlink Communications
Unit #4
14 Aquatic Drive
Frenchs Forest, NSW 2086
AUSTRALIA
Telephone: +61.2.975.2577
Fax: +61.2.452.5397

Japan Office
The Frame Relay Forum
c/o The Foundation for Promotion
of Telecommunications Studies
Nisso-Building 5F
1-11-10
Azabudai Minato-ku, Tokyo 106
JAPAN
Telephone: +81.3.3583.5811
Fax: +81.3.3583.5813

Frame
Relay
Forum

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-

Continued on page 35

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	CPE financing	Oversubscription	Bursting			Paper reports	On-line mgmt.		POPs	Gateways	Extended capabilities			Port speeds (bit/sec) and monthly cost							CIR				
		B = Bridges C = CSUs R = Routers	C = Carrier financing L = Leasing P = Purchase option	Percent allowed	Up to access speed	Up to port speed	Duration (seconds)	R = Raw traffic statistics S = Statistics on frames marked "Discard Eligible" T = Traffic by location U = Utilization by PVC	SNMP	Terminal		A = ATM B = BNA T = TCP/IP X = X.25 O = Other	International availability (no. of countries)	Integrated access	Disaster recovery	56K/64K	112K/128K	256K	384K	512K	768K	1.024M	1.536M	Zero	Incremental	Port speed	Usage-based pricing	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)		✔	✔		✔

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

Chart compiled by Cheri Paquet

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.

C. Heckart

Continued from page 33

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

Continued on page 38

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.

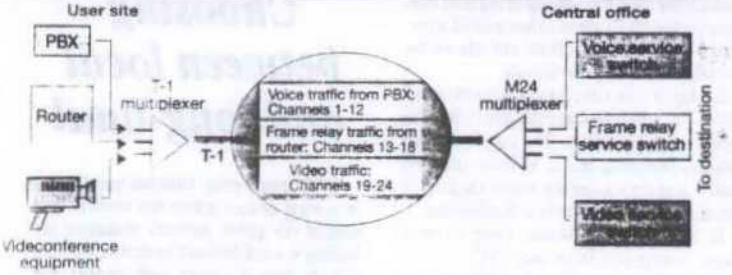
Currently, most international frame relay connections are extensions of U.S. networks. One point to note is that many users have experienced mixed results with transcontinental frame relay links.

"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.

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

ontinued from page 35

ort charges. Interexchange carriers charge a at port connection fee and add a small charge r each PVC that uses that port.

Another distinction is that carriers charge r the CIR ordered on PVCs. CIR can be osely defined as the amount of bandwidth uaranteed to be available under noncatasophic network operating conditions.

The frame relay standard specifies that any ata sent at a rate exceeding CIR is to be arked discard eligible. When network ciruits supporting multiple PVCs become conested, all traffic marked discard eligible is hrown away in order to maintain the CIR on ach PVC.

Most carriers offer CIR for a fixed permonth price. In other words, users can pump s much data as they can across a PVC for one ee, a similarity to private-line pricing. Only ICI and Sprint offer a usage-based CIR, hich can be attractive for sites that don't have ough traffic to justify a fixed-rate CIR.

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

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

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

Net managers selecting CIR at anything less han 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 pecific time limit on bursts in order to make ure 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 arrier has its own interpretation and implementation of CIR that is based on the frame elay 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	*
	Cascade Communications	*
BT North America, Inc.	StrataCom	IPX
Cable & Wireless Communications, Inc.	Northern Telecom, Inc.	DPN 100 series
CompuServe, Inc.	StrataCom	IPX
EMI Communications Corp.	StrataCom	IPX
MCI Communications Corp.	Siemens Stromberg-Carlson	EWSM
	Wellfleet Communications Corp.	Backbone Node Switch
NYNEX Corp.	Northern Telecom	*
Pacific Bell	Newbridge Networks, Inc.	3612 Main Street
PacNet, Inc.	Cascade Communications	STDX 6000-B STDX 9000
Southwestern Bell Corp.	Northern Telecom	DMS-100
Sprint Corp.	Alcatel Data Networks/Sprint	TPX 1100
US West Communications, Inc.	AT&T	Broadband Networking Switch-2000 and Datakit
	Cascade Communications	STDX 3000/6000
WilTel	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

Continued on page 40

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

Continued from page 39

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 masks 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 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 now may end up that much farther away.

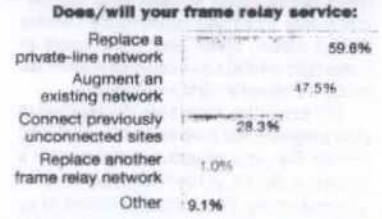
"Sooner or later, [upper] management is going to ask what you are waiting for," says PMI Mortgage Insurance Co.'s Fey.

**Finn and Heckart are senior analysts with TeleChoice, Inc., a Verona, N.J., consultancy specializing in strategic planning and analysis of intelligent networks, services and applications. They can be reached at (201) 239-0700 or via MCI Mail at 445-1600.

Reader views on frame relay services

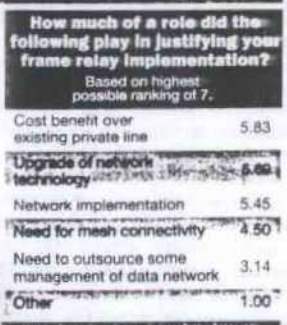
Based on 100 interviews.

Does/will your frame relay service:

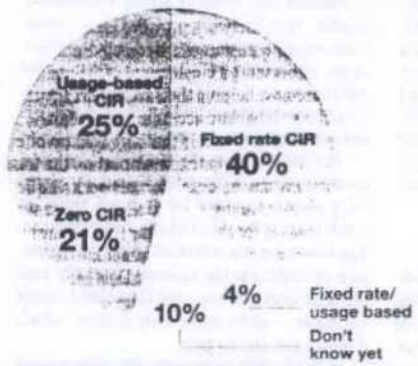


How much of a role did the following play in justifying your frame relay implementation?

Based on highest possible ranking of 7.

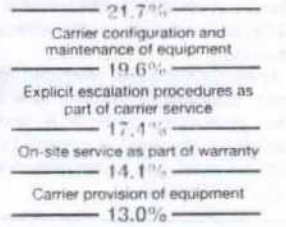


What frame relay permanent virtual circuit committed information rate (CIR) options do/will you use?

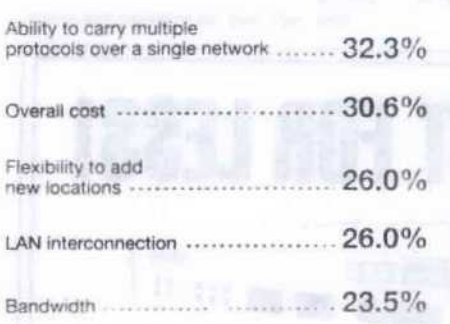


What are your top business applications that use/will use frame relay?

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

The Top Ten Frame Relay Headaches

Frame relay services have finally gotten beyond the magazine-article stage and are beginning to settle down and provide a functional option for LAN/WAN and other data communications applications. Now that vendors, consultants and corporate users have a base of experience, they are realizing what frame relay can do and what sorts of communication requirements it can realistically handle.

While this article is about the headaches you can expect in a frame relay project, I want to stress at the outset that frame relay works. I feel compelled to mention this fact because the service has taken a real battering in the trade press. This treatment seems to be the result of a decided emphasis on the negative features of frame relay technology, coupled with a bad case of "ATM Overhang."

Things began to got rocky when news of some of frame relay's seamy technical details began to get around. When corporate network planners heard that frame relay networks could actually throw frames away if the network got congested, the technology seemed to have the same appeal as a parachute that works most of the time.

Of course, the reality was not nearly so bad. While a frame relay network could lose frames, the overwhelming majority wind up being delivered. In fact, with most networks you can actually send more traffic than you had actually bought capacity for and everything still would get delivered.

Clearly, the frame relay market is growing. At the end of 1992, there were about 1,000 public frame relay ports installed, and by the end of 1993, that number had grown to more than 5,000 ports (some estimates run as high as 8,000). With vendors responding to bids for frame relay networks that have 1,000 and even 5,000 ports, the total number of ports is likely to increase 300 to 400 percent during 1994.

Customers are buying because they have found frame relay to be a reliable network alternative, and it has the potential to save money. Most initial applications were LAN/WAN-oriented and typically ran over 56-kbps services. The next big application that is being recognized is upgrading existing private line networks with IBM 3270 terminals operating at 9600 bps. So while ATM might be the darling of the trade show set, frame relay can be installed now and can immediately cut cost and improve service.

The Headaches

However, a frame relay installation is not a walk in the park. While network managers are not jumping off bridges because of their decision to implement frame relay, just doing a project analysis may have brought some close to the edge.

Some buyers fell into the classic trap of believing that frame relay works as the vendors say in their brochures. The reality is that frame relay is a developing market. Today's headaches may turn into fond memories six or 12 months from now, but there is no generic frame relay service available today. What "frame relay" means and how it works is defined by each carrier.

1. Inconsistent Pricing: If you are going to be doing a financial analysis for a frame relay project, get new batteries for your calculator. A frame relay price typically comprises three parts: access line charges, monthly port charge and permanent virtual circuit (PVC) charges.

The access line and port charges cover the physical connection to the network, and the PVC charges cover the logical connections between user devices. Pricing from the carriers for these elements is all over the lot. The access line can be rolled into the port charge, or it can be priced separately. PVC pricing can be a major part of the cost, or, like some of the local frame relay networks, PVCs can be priced as low as $1 per month.

The pricing confusion is confounded by the variety of options and special arrangements available. It can be close to impossible to come up with a real apples-to-apples comparison of different service options.

Since some deals seem too good to be true, you need to be concerned about whether the carriers will change their pricing philosophies if they find they are losing money on the service. Initially, pricing was a closely guarded secret, and Tom Nolle did one of the first frame relay pricing comparisons back in 1992 (see *BCR*, May 1992, page 31–36; see also *BCR*, January 1993, pp. 27–31). While things are firming up, it will probably be another year until pricing policies really gel.

2. Variety of Service Configurations: If the pricing options for frame relay don't get you, the service configurations will. At face value, frame relay seems to be a fairly simple concept, but once you begin analyzing the offerings in detail, myriad possibilities emerge.

Different carriers offer different ranges of bit rates and granularity for PVCs. Most charges are flat rate, but some carriers offer usage-sensitive pricing. There are also networks that support asymmetrical PVCs, where the user can order different bit rates for each direction of transmission on a PVC. Other networks allow for "oversubscription," where a network can be configured with access links that support bit rates lower than the total PVC capacity from a location.

These variations are not just curiosities, they directly affect the cost of the network. Further, the option that is most cost effective for a small network may not be the best choice as the number of stations grows.

3. Shortage of Network Design Tools: While this problem is not limited to frame relay, there seem to be almost no design tools that enable a user to predict the performance a given network configuration will deliver. A frame relay network can carry either batch/file transfers or interactive traffic, but the performance measures vary with the two applications. In a file transfer job, the

performance measure is how long it will take to send a file of *x* bytes. In an interactive service, the measure is response time.

Let's take a look at an interactive application to get an idea of what's involved. The transaction typically is generated by a workstation on a LAN. It then must be carried over the LAN to a router, sent over an access connection to the frame relay network, through the network, out to another router and finally onto the host or application server over another LAN. When the server generates the response, it must make the same trip back.

That transaction shares resources on two LANs, two routers, two access connections, a frame relay network and a host. When you consider that those elements are also shared with other batch and interactive users whose transmission activity will vary throughout the day, you begin to appreciate the difficulty of the design task. Oh for the stability of an old fashioned IBM 3270 network, where there were a whole range of computerized response-time estimators that could be used to compute the performance prior to installation. While this problem is endemic to the entire LAN/WAN arena, frame relay introduces some new potential bottlenecks.

It may be years before we get around to designing frame relay's steering and brakes

The three headaches discussed above indicate that you should expect to encounter difficulties when trying to figure out some fundamental issues: How much will frame relay cost and, once the cost is determined, what level of performance can be delivered.

4. No Standard Service Definitions: While the overall performance a user receives from a frame relay network will be affected by a number of variables, the frame relay–specific element is often the most difficult to assess. We are just starting to see standard performance measures (e.g., average network delay and frame loss and errors) to compare frame relay services, but these are not universally employed.

In ATM, these parameters are called Quality of Service and define three major areas: network delay, transmission error and loss. In this area, the prognosis is fairly good. Bellcore and the Frame Relay Forum are formulating a series of network management definitions that will soon enable us to generate a real report card that compares the performance guarantees/objectives for the various services.

5. Congestion Control: Probably the most perplexing question about frame relay is congestion control. One of the fundamental design concepts of a frame relay network is dynamic allocation of transmission capacity. If there is more traffic offered than the network can carry, someone's transmissions may be sent off to the great bit bucket in the sky.

Frame relay networks are engineered on the assumption that not all stations need to transmit at the same time, so the total capacity of the trunks within the network is less than the total capacity of the access lines. Further, PVC connections through the network are priced and configured based on a transmission measure called a Committed Information Rate (CIR). After that, everyone heads off in a different direction.

All networks will allow a user to "burst"—or transmit information in excess of the CIR: if a user has a CIR of 64 kbps on a PVC and the access link operates at 1.544 Mbps, every time the user transmits, the traffic will be in excess of the CIR. Therefore, the first question you need to answer is: How long can you transmit in excess of the CIR, and what happens to the excess?

In most networks, excess traffic will be delivered as long as the capacity is available. However, the traffic sent in excess of the CIR has a higher probability of being discarded. There is a rudimentary flow-control mechanism defined for the frame relay access protocol that uses the Forward/Backward Explicit Congestion Notification (FECN/BECN) and Discard Eligibility (DE) bits in the frame relay header. If the network is experiencing congestion on a PVC, the network will alert the sending and receiving stations by setting the BECN and FECN bits in the headers of frames it delivers.

The transmitter can respond to that notification in one of three ways: (*1.*) keep sending and hope for the best, (2.) slow down the transmission rate, or (*3.*) keep sending but begin setting Discard Eligibility bits on frames the network has permission to discard. That last option is called "offering up frames for sacrifice."

The problem is that different carriers define transmission bursts differently and take different steps to clear congestion conditions. Further, few user devices can even set Discard Eligibility bits.

I chided a product manager from one of the router companies—since they write software, how come they can't set a crummy bit? He responded that they could set the bit, but they don't think it's the router's responsibility to make decisions about whose traffic is more important.

Indeed, congestion control goes to the heart of the frame relay conundrum. The very nature of the technology introduces the possibility of frames being discarded to clear congestion conditions, but there is no defined set of rules for how the decision to discard ought to be made. This is key, because the decision to discard affects the performance and suitability of the network.

Until now, congestion control has been more of a potential problem than a significant performance issue. Most networks are over-engineered to the point that even if you can send continuously in excess of the CIR, all of the traffic will be delivered. But unless the carriers transform themselves into charities, this deal won't last.

You need to know—ahead of time—how a change in your carrier's handling of congestion control will affect network service. Under what conditions would such a change force you to reconsider either your choice of carrier or frame relay as your network technology?

Of course, the issue of congestion control will have to be addressed by all of the fast-packet technologies. The issue comes up with regard to frame relay because it is the only fast-packet technology currently being implemented to any great degree.

6. Requirement for Switched Network Access: Currently, the only option for frame relay network access is a private line. The bit rates vary by carrier, and the range is from 56 kbps to 1.544 Mbps.

The ability to support dial-up access to a frame relay network would be important for at least two applications. With a dial-up service, low-volume sites would not have to foot the bill for underutilized private lines. For backup applications, it would be ideal to have a bank of shared dial-in ports that could be immediately configured with all of the PVCs from a location that failed.

The signaling standard for frame relay Switched Virtual Circuits (SVCs) is essentially complete, and the Frame Relay Forum is now working on SVC implementation agreements. SVCs should begin to be offered within a year.

While dial-up access might be provided using an analog connection with modems, H0 (384 kbps) and H11 (1.536 Mbps) would be needed to provide the required transmission rates through Switched 56 or ISDN (64-kbps B-channel). This requirement is fairly well recognized throughout the frame relay community, and ISDN access to frame relay should be available within a year. In the interim, dial-backup arrangements for failed access links can be provided, but they can be costly and/or inconvenient.

7. Network-to-Network Connectivity: Another soft spot with frame relay is network-to-network connections. Today, most frame relay networks involve only one local or long distance carrier, but it is obvious that there will be occasions where data have to be shipped through a local frame relay to a long distance network, or from a private network to a public network.

While the CCITT has developed a network-to-network interface (NNI) standard and the Frame Relay Forum has produced an implementation agreement, a number of thorny issues remain unresolved. Network-to-network connections exist, but via vendor-specific implementations. Further, there are questions about how the service will be defined if the different networks support different options—e.g., level of granularity and asymmetrical PVCs.

8. Network Diagnostics and Performance Monitoring: Like any new technology, frame relay was designed around its engine and wheels, and it will be years before we get around to designing the steering and the brakes. Network management is and will remain among frame relay's biggest headaches.

While there are protocol analyzers to monitor a frame relay interface, the path a transaction takes can involve multiple LAN transmissions, routers and host elements, and one or more trips through the frame relay network cloud. Frame relay adds one more element to the already complex mix on which performance levels depend.

The other major area is fine-tuning network performance. As noted above, there are few network design tools that can be used to predict performance before a network is implemented, but in fairness, it would be difficult to make accurate predictions even if tools were available. The net result is that network managers have to begin with a "best guess" design and make adjustments as they go.

While carriers provide utilization information, there is a wide range of data available and there are some critical variables—like how often the information is provided (e.g., real time or monthly), how complete and accurate it is and whether it is in a form that assists in making a design adjustment that has a predictable result. If you increase the CIR capacity of a PVC, it will increase the cost of the network, but will it improve response time from 10 seconds to 2 seconds in the busy hour?

9. Can Frame Relay Ramp up to Scale: The average size of a frame relay network is around 10 ports, but the carriers are responding to bids for networks that involve thousands of ports. While frame relay seems to be providing more than adequate service for small configurations, will it support these larger configurations? Networking jobs become far more complex when you add two or three zeros to the number of stations that have to be supported.

Some carriers limit the number of PVCs on a 56-kbps access port to 28, and 63 per T1 link. If you are configuring a network to connect 1,000 remote sites to a host, you would need more than 35 ports to the host. The host interface might turn out to be far more expensive than with a traditional private line network.

Also, there is a basic question as to whether all the stations could be supported given the PVC rates and access connections that are provided. This question becomes most critical because many of the large network bids address SNA networks that are being converted from traditional private line services to frame relay.

10. Ignorance and Uncertainty: In the final analysis, frame relay serves up a whole range of perplexing questions and little in the way of secure answers. There are any number of configurations that could include frame relay with LANs, routers, frame relay access devices (FRADs), premises switches and even hybrid networks that connect a private frame relay network through one or more public network services. When coupled with the barrage of conflicting predictions and reports in the trade press, it's not surprising that some network managers are considering a career change into air conditioning repair.

On one hand, frame relay can provide a way to reduce costs and improve service in a variety of network applications. But designing the network and pricing all of the alternatives involves an awful lot of work for an uncertain payoff. As technical experts, we like to be able to guide our users through the shoals of new technology and guarantee the cost and performance impact these changes will have. This situation can lead to some unsettled feelings when it comes time to bet your career on a major project based on a frame relay network.

Conclusion

While the litany of potential frame relay headaches seems formidable, it should not discourage anyone from giving it a try. This discussion is meant to be a cautionary note—make sure that you embark on this adventure with a realistic attitude.

The reports from the front lines say clearly that frame relay can work and that it can substantially reduce the cost and improve the performance of data networks. It can be worth the effort, but you should proceed with caution. Telecom people seem to know intuitively that deals that appear too good to be true usually are, but you won't know for sure unless you try.

> As technical experts, we like to be able to guide our users through the shoals of new technology

Of course, there is no guarantee that frame relay won't be eclipsed by some other technology—SMDS, ATM or something as yet unknown. The business issue then becomes frame relay's payback period. If a frame relay investment can break even in six months, do it because none of the other technologies is going to be widely available by then.

ATM seems to be overhanging many frame relay decisions, but the first ATM services are just starting to come on line. Also, most of the same issues that have plagued frame relay—like inconsistent pricing and service configurations, congestion control and a lack of design tools—will also hamper ATM. Frame relay services have been around for over two years, and we are only now coming to grips with the major issues; what makes anyone think that the ATM experience will be any different? Deferring a decision until after the dust settles on ATM may mean pushing off the network until 1997.

We are at a juncture where traditional network tools can no longer meet the requirements of new applications. Something has to happen. The key is to avoid becoming so enamored of or confused by a technology that we fail to exercise good business judgment. In telecommunications, the only position worse than being the first to shift to a new technology is being the last.

Michael Finneran is president of dBrn Associates, Inc., an independent consulting firm in Hewlett Neck, NY, specializing in the design and installation of domestic and international networks. He is the instructor for several of BCR's data communications courses.

The BCR Business Review

A listing of companies appearing in this issue of Business Communications Review. Numbers indicate first page of article(s) in which each company is mentioned.

Frame Relay Glossary

Access Line

A communications line (e.g. circuit) interconnecting a frame-relay-compatible device(DTE) to a frame-relay switch (DCE). *See also* Trunk Line.

Access Rate (AR)

The data rate of the user access channel. The speed of the access channel determines how rapidly (maximum rate) the end user can inject data into a frame relay network.

American National Standards Institute (ANSI)

Devises and proposes recommendations for international communications standards. *See also* Comite Consultatif International Telegraphique et Telephonique (CCITT).

Backward Explicit Congestion Notification (BECN)

A bit set by a frame relay network to notify an interface device(DTE) that congestion avoidance procedures should be initiated by the sending device.

Bandwidth

The range of frequencies, expressed in Kilobits per second, that can pass over a given data transmission channel within a frame relay network. The bandwidth determines the rate at which information can be sent through a channel - the greater the bandwidth, the more information that can be sent in a given amount of time.

Bridge

A device that supports LAN-to-LAN communications. Bridges may be equipped to provide frame relay support to the LAN devices they serve. A frame-relay-capable bridge encapsulates LAN frames in frame relay frames and feeds those frame relay frames to a frame relay switch for transmission across the network. A frame-relay-capable bridge also receives frame relay frames from the network, strips the frame relay frame off each LAN frame, and passes the LAN frame on to the end device. Bridges are generally used to connect local area network (LAN) segments to other LAN segments or to a wide area network (WAN). They route traffic on the Level 2 LAN protocol (e.g., the Media Access Control address), which occupies the lower sub layer of the LAN OSI data link layer. *See also* Router.

Burstiness

In the context of a frame relay network, data that uses bandwidth only sporadically; that is, information that does not use the total bandwidth of a circuit 100 percent of the time. During pauses, channels are idle; and no traffic flows across them in either direction. Interactive and LAN-to-LAN data is bursty in nature, because it is sent intermittently, and in between data transmissions the channel experiences idle time waiting for the DTEs to respond to the transmitted data user's input of waiting for the user to send more data.

Channel

Generically refers to the user access channel across which frame relay data travels. Within a given T1 or E1 physical line, a channel can be one of the following, depending of how the line is configured.

Type of T1/E1 Channel	*Definition*
Unchannelized	The entire T1/E1 line is considered a channel, where:
	• The T1 line operates at speeds of 1.536 Mbps and is a single channel consisting of 24 T1 time slots. • The E1 line operates at speeds of 1.984 Mbps and is a single channel consisting of 20 E1 time slots.
Channelized	The channel is any one of N time slots within a given line, where:
	• The T1 line consists of any one or more channels. Each channel is any one of 24 time slots. The T1 line operates at speeds in multiples of 56/64 Kbps to 1.536 Mbps, with aggregate speed not exceeding 1.536 Mbps. • The E1 line consists of one or more channels. Each channel is any one of 31 time slots. The E1 line operates at speeds in multiples of 64 Kbps to 1.984 Mbps, with aggregate speed not exceeding 1.984 Mbps.
Fractional	The T1/E1 channel is one of the following groupings of consecutively or nonconsecutively assigned time slots:
	•*N* T/1 time slots (NX56/64Kbps where N = 1 to 23 T1 time slots per FT1 channel). •*N* E1 time slots (NX64Kbps, where N = 1 to 30 time slots per E1 channel).

Channel Service Unit (CSU)

An ancillary device needed to adapt the V.35 interface on a F.R. DTE to the T1 (or E1) interface on a frame relay switch. The T1 (or E1) signal format on the frame relay switch is not compatible with the V.35 interface on the DTE: therefore, a CSU or similar device, placed between the DTE and the frame relay switch, is needed to perform the required conversion.

Committed Burst Size (Bc)

The maximum amount of data (in bits) that the network agrees to transfer, under normal conditions, during a time interval Tc. *See also* Excess Burst Size (Be).

Comite Consultatif International Telegraphique et Telephonique (CCITT)

International Consultative Committee for Telegraphy and Telephony, a standards organization that devises and proposes recommendations for international communications. *See also* American National Standards Institute (ANSI).

Committed Information Rate (CIR)

The committed rate (in bits per second) at which the ingress access interface trunk interfaces, and egress access interface of a frame relay network transfer information to the destination frame relay end system under normal conditions. The rate is averaged over a minimum time interval Tc.

Committed Rate Measurement Interval (Tc)

The time interval during which the user can send only Bc-committed amount of data and Be excess amount of data. In general, the duration of Tc is proportional to the "burstiness" of the traffic. Tc is computed (from the subscription parameters of CIR and Bc) as Tc = Bc/CIR. Tc is not a periodic time interval. Instead, it is used only to measure incoming data, during which it acts like a sliding window. Incoming data triggers the Tc interval, which continues until it completes its commuted duration. *See also* Committed Information Rate (CIR) and committed Burst Size (Bc).

Cyclic Redundancy Check (CRC)

A computational means to ensure the accuracy of frames transmitted between devices in a frame relay network. The mathematical function is computed, before the frame is transmitted, at the originating device. Its numerical value is computed based on the content of the frame. This value is compared with a recomputed value of the function at the destination device. *See also* Frame Check Sequence (FCS).

Data Communications Equipment (DCE)

Term defined by both frame relay and X.25 committees, that applies to switching equipment and is distinguished from the devices that attach to the network (DTE). *Also see* DTE.

Data Link Connection Identifier (DLCI)

A unique number assigned to a PVC end point in a frame relay network. Identifies a particular PVC endpoint within a user's access channel in a frame relay network and has local significance only to that channel.

Discard Eligibility (DE)

A user-set bit indicating that a frame may be discarded in preference to other frames if congestion occurs, to maintain the committed quality of service within the network. Frames with the DE bit set are considered Be excess data. *See also* Excess burst Size (Be).

Egress

Frame relay frames leaving a frame relay network in the direction toward the destination device. *Contrast with* Ingress.

End Device

The ultimate source or destination of data flowing through a frame relay network sometime referred to as a Data Terminal Equipment (DTE). As a source device, it sends data to an interface device for encapsulation in a frame relay frame. As a destination device, it receives de-encapsulated data (i.e., the frame relay frame is stripped off, leaving only the user's data) from the interface device. Also see DCE

NOTE: An end device can be an application program or some operator-controlled device (e.g., workstation). In a LAN environment, the end device could be a file server or host.

Encapsulation

A process by which an interface device places an end device's protocol-specific frames inside a frame relay frame. The network accepts only frames formatted specifically for frame relay; hence, interface devices acting as interfaces to an frame relay network must perform encapsulation. *See also* Interface device or Frame-Relay-Capable Interface Device.

Excess Burst Size (Be)

The maximum amount of uncommitted data (in bits) in excess of Bc that a frame relay network can attempt to deliver during a time interval Tc. This data (Be) generally is delivered with a lower probability than Bc. The network treats Be data as discard eligible. *See also* Committed burst Size (Bc).

E1

Transmission rate of 2.048 Mbps on E1 communications lines. An E1 facility carriers a 2.048 Mbps digital signal. *See also* T1 and channel.

File Server

In the context of frame relay network supporting LAN-to-LAN communications, a device connecting a series of workstations within a given LAN. The device performs error recover and flow control functions as well as end-to-end acknowledgment of data during data transfer. thereby significantly reducing overhead within the frame relay network.

Forward Explicit Congestion Notification (FECN)

A bit set by a frame relay network to notify an interface device (DTE) that congestion avoidance procedures should be initiated by the receiving device. *See also* BECN.

Frame Check Sequence (FCS)

The standard 16-bit cyclic redundancy check used for HDLC and frame relay frames. The FCS detects bit errors occurring in the bits of the frame between the opening flag and the FCS, and is only effective in detecting errors in frames no larger than 4096 octets. *See also* Cyclic Redundancy Check (CRC).

Frame-Relay-Capable Interface Device

A communications device that performs encapsulation. Frame-relay-capable routers and bridges are examples of interface devices used to interface the customer's equipment to a frame relay network. *See also* Interface Device and Encapsulation.

Frame Relay Frame

A variable-length unit of data. in frame-relay format that is transmitted through a frame relay network as pure data. *Contrast with* Packet. *See also* Q.922A.

Frame Relay Network

A telecommunications network based on frame relay technology. Data is multiplexed. *Contrast with* Packet-Switching Network.

High Level Data Link control (HDLC)

A generic link-level communications protocol developed by the International Organization for Standardization (ISO). HDLC manages synchronous, code-transparent, serial information transfer over a link connection. *See also* Synchronous Data Link Control (SDLC).

Hop

A single trunk line between two switches in a frame relay network. An established PVC consists of a certain number of hops, spanning the distance from the ingress access interface to the egress access interface within the network.

Host Computer

A communications device that enables users to run applications programs to perform such functions as text editing, program execution, access to data bases, etc.

Ingress

Frame relay frames from an access device toward the frame relay network. *Contrast with* Egress.

Interface Device

Provides the interface between the end device(s) and a frame relay network by encapsulating the user's native protocol in frame relay frames and sending the frames across the frame relay backbone. *See also* Encapsulation and Frame-Relay-Capable Interface Device.

Link Access Procedure Balanced (LAPB)

The balanced-mode, enhanced, version of HDLC. Used in X.25 packet-switching networks. *Contrast with* LAPD.

Link Access Procedure on the D-channel (LAPD)

A protocol that operates at the data link layer (layer 2) of the OSI architecture. LAPD is used to convey information between layer 3 entities across the frame relay network. The D-channel carries signaling information for circuit switching. *Contrast with* LAPB.

Local Area Network (LAN)

A privately owned network that offers high-speed communications channels to connect information processing equipment in a limited geographic area.

LAN Protocols

A range of LAN protocols supported by a frame relay network, including Transmission Control Protocol/Internet Protocol (TCP/IP), Apple Talk, Xerox Network System (XNS), Internetwork Packet Exchange (IPX), and Common Operating System used by DOS-based PCs.

LAN Segment

In the context of a frame relay network supporting LAN-to-LAN communications, a LAN linked to another LAN by a bridge. Bridges enable two LANs to function like a single, large LAN by passing data from one LAN segment to another. To communicate with each other, the bridged LAN segments must use the same native protocol. *See also* Bridge.

Packet

A group of fixed-length binary digits, including the data and call control signals, that are transmitted through an X.25 packet-switching network as a composite whole. The data, call control signals, and possible error

control information are arranged in a predetermined format. Packets do not always travel the same pathway but are arranged in proper sequence at the destination side before forwarding the complete message to an addressee. *Contrast with* Frame Relay Frame.

Packet-Switching Network

A telecommunications network based on packet-switching technology, wherein a transmission channel is occupied only for the duration of the transmission of the packet. *Contrast with* Frame Relay Network.

Parameter

A numerical code that controls an aspect of terminal and/or network operation. Parameters control such aspects as page size, data transmission speed, and timing options.

Permanent virtual Circuit (PVC)

A frame relay logical link, whose endpoints and class of service are defined by network management. Analogous to an X.25 permanent virtual circuit, a PVC (often referred to as a PVC) consists of the originating frame relay network element address, originating data link control identifier, terminating frame relay network element address, and termination data link control identifier. Originating refers to the access interface from which the PVC is initiated. Terminating refers to the access interface at which the PVC stops. Many data network customers require a PVC between two points. Data terminating equipment with a need for continuous communication use PVCs. *See also* Data Link Connection Identifier (DLCI).

Q.922 Annex A (Q.922A)

The international draft standard that defines the structure of frame relay frames. Based on the Q.922A frame format developed by the CCITT. All frame relay frames entering a frame relay network automatically conform to this structure. *Contrast with* Link Access Procedure Balanced (LAPB).

Q.922A Frame

A variable-length unit of data, formatted in frame-relay (Q.922A) format, that is transmitted through a frame relay network as pure data (i.e., it contains no flow control information). *Contrast with* Packet. *See also* Frame Relay Frame.

Router

A device that supports LAN-to-LAN communications. Routers may be equipped to provide frame relay support to the LAN devices they serve. A frame-relay-capable router encapsulates LAN frames in frame relay frames and feeds those frame relay frames to a frame relay switch for transmission across the network. A frame-relay-capable router also receives frame relay frames from the network, strips the frame relay frame off each frame to product the original LAN frame, and passes the LAN frame on to the end device. Routers connect multiple LAN segments to

each other or to a WAN. Routers route traffic on the Level 3 LAN protocol (e.g., the Internet Protocol address). *See also* Bridge.

Statistical Multiplexing

Interleaving the data input of two or more devices on a single channel or access line for transmission through a frame relay network. Interleaving of data is accomplished using the DLCI.

Synchronous Data Link Control (SDLC)

A link-level communications protocol used in an International Business Machines (IBM) Systems Network Architecture (SNA) network that manages synchronous, code-transparent, serial information transfer over a link connection. SDLC is a subset of the more generic High-Level Data Link Control (HDLC) protocol developed by the International Organization for Standardization (ISO).

T1

Transmission rate of 1.544 Mbps on T1 communications lines. A T1 facility carriers a 1.544 Mbps digital signal. Also referred to as digital signal level 1 (DS-1). *See also* E1 and channel.

Trunk Line

A communications line connecting two frame relay switches to each other.