WAN Design with Frame Relay

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Abstract
This paper gives a high-level overview of how to design a Wide Area Network (WAN) using Frame Relay technology. Aspects of the WAN design process are explored through the use of a fictitious manufacturing company called Zippy's Chips. The Zippy's WAN design covers the topics of weighing alternative technologies, setting up basic Frame Relay Permanent Virtual Circuit (PVC) connections, adding redundant links and scaling the network for future growth.

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Frame Relay in a Nutshell

Frame Relay is a layer-2 protocol used in wide area networking. It uses the telecommunications provider's packet-switching infrastructure to move data. Frame Relay can provide speeds from 56kbps DS0 up to 43Mbps DS3 connections depending on the capability of the service provider's network. [1]

Terminology

There are many terms used to describe Frame Relay, and Wide Area Networking (WAN) in general, that may be foreign to those who are familiar only with Local Area Network design. Some of the more common Frame Relay terms are briefly described below. [2]

Table 1 – Frame Relay Terms

CIR	Committed Information Rate – the minimum level of throughput as guaranteed by the service provider.
DCE	Data Circuit-terminating Equipment – a device on the service provider's network that connects to the customer's DTE.
DTE	Data Terminal Equipment – a device at the customer's site that connects to the service provider's DCE.
DLCI	Data Link Connection Identifier – a 10-bit number used to uniquely identify a virtual circuit end-point on the customer's Frame Relay network.
HDLC	High-level Data Link Control – a layer-2 protocol used to control data flow and provide error detection.
LMI	Line Management Interface – a protocol that provides line status and other management information to the end user of a Frame Relay connection.
PPP	Point-to-Point Protocol – an alternative to HDLC.
PVC	Permanent Virtual Circuit – a connection between two nodes on a Frame Relay cloud that allows the exchange of data.

Basic Concepts

When using Frame Relay for WAN connectivity a business customer purchases Frame Relay service from a service provider. The connection to the Frame Relay network is done by attaching a point-to-point link from the customer's DTE to the provider's DCE.

This connects the customer to the provider's Frame Cloud. Once the connection to the Frame Cloud is in place at two or more of the the customer's sites PVC's can be set up to allow communication between the sites. The PVC's endpoints are identified with a DLCI. Once the connection is up the customer can monitor the status of the line using the functionality provided by the LMI.

A Sample Design

To solidify a basic understanding of Frame Relay consider the example of a fictional company called Zippy's Chips. Zippy's is a nationwide company that makes potato chips and corn chips for sale in vending machines across the country. They have supply offices in Boise, Idaho and Des Moines, Iowa as well as manufacturing centers in Dallas, Texas; Portland, Oregon and Chicago, Illinois. The Zippy's corporate office is located in Schaumburg, Illinois. Distribution of Zippy's products is handled by its business partner, Vend-O-Land Systems, headquartered in St. Louis, Missouri.

Zippy's needs to communicate effectively with all of its offices across the country as well as with its business partner in St. Louis. To meet their business needs Zippy's has decided to purchase Frame Relay services from their telecom provider Fat Data Pipe (FDP) Incorporated. To connect its offices to the Frame Relay cloud Zippy's has purchased a mixture of full and fractional T-1 lines. A full T-1 line connects its Schaumburg headquarters to the frame cloud and fractional T-1 lines connect each of its supply and manufacturing offices across the country. In addition to this Zippy's shares the cost of a fractional T-1 for the Vend-O-Land main office in St. Louis.

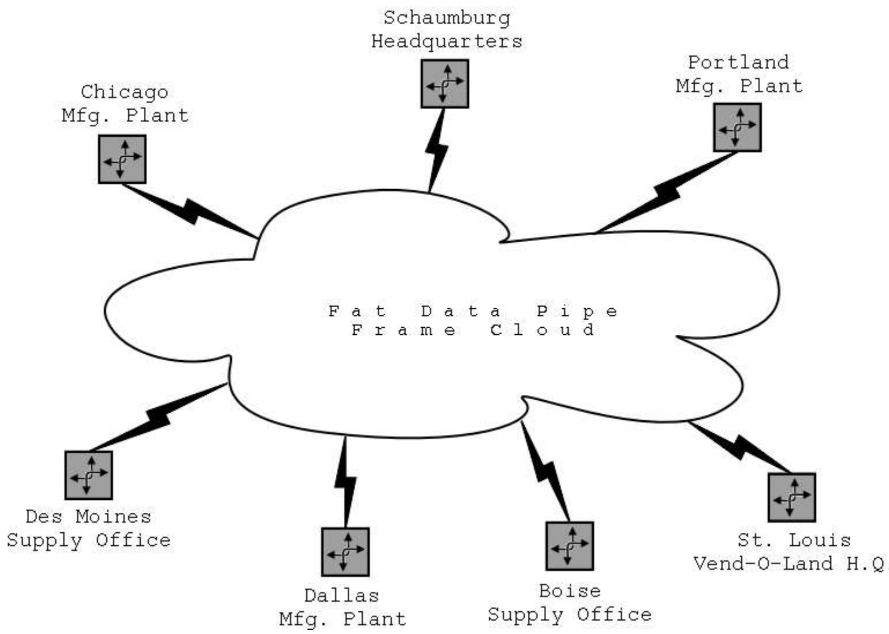

Figure 1 – Connections to the Frame Cloud

So how did Zippy's know that Frame Relay was the best solution for their network? Did they make an arbitrary decision based on colorful sales literature given to them by FDP or did they carefully weigh the available options and make an informed decision. Hopefully the latter is the case for Zippy's and for any company considering an investment in Wide Area Networking technology. This decision making process will be explored in the next section.

Deciding if Frame Relay is Right for the Network

In order to make an informed decision about wide area connectivity Zippy's has to know the requirements of their network as well as the capabilities of FDP's Frame Relay service.

Advantages of Frame Relay

The main advantage of Frame Relay over point-to-point leased lines is cost. Frame Relay can provide performance similar to that of a leased line, but with significantly less cost over long distances. The reason is because the customer only has to make a dedicated point-to-point connection to the provider's nearest frame switch. From there the data travels over the provider's shared network. The price of leased lines generally increases based on distance. So, this short-haul point-to-point connection is significantly less expensive than making a dedicated point-to-point connection over a long distance. [2]

Lower cost over distance makes Frame Relay is a good choice for Zippy's Chips since it has offices located across the country. However, if Zippy's only needed to send data between its Schaumburg headquarters and the Chicago manufacturing plant it might make sense to consider a dedicated circuit since the two locations are in the same metropolitan area.

Disadvantages of Frame Relay

The two main disadvantages of Frame Relay are slow downs due to network congestion and difficulty ensuring Quality of Service (QoS). Because all of a provider's Frame Relay customers use a common network there can be times when data transmission exceeds network capacity. The difficulty ensuring QoS is due to the fact that Frame Relay uses variable-length packets. It is easier to guarantee QoS when using a fixed-length packet. Zippy's needs to decide how significant these disadvantages are to the needs of their network and how to mitigate against them.

To address the issue of potential congestion, Zippy's should be sure that Fat Data Pipe's Committed Information Rate (CIR) is sufficient to meet the needs of their network. CIR is the minimum level of throughput that the provider guarantees and FDP should be delivering at least this amount of throughput even in times of heavy network load. Zippy's should also carefully examine their present and future quality of service needs. Is voice or video conferencing between sites is something on the horizon? If so, Zippy's may want to examine the ways in which Frame Relay equipment can prioritize traffic and determine if these mechanisms are sufficient for to meet their needs. If not, Zippy's may want to consider an alternative like ATM.

Alternatives to Frame Relay

There are other WAN protocols that can be used in place of Frame Relay. A good network designer should always look at the alternatives before making a final decision.

X.25

X.25 is an older technology that is similar to Frame Relay, but not as efficient. The reasons for its inefficiency are due to the fact that it is an older designed conceived when most telecommunications lines were analog. Since analog lines are inherently noisy X.25 loses a large percentage of throughput to error checking overhead when compared to Frame Relay. [3] For modern, digital lines X.25 offers no advantages over Frame Relay and should not be used unless there are no other alternatives available.

ATM

The main differences between ATM and Frame Relay is that ATM uses a fixed-length packet (called a cell in ATM terminology) where Frame Relay uses variable-length packets. [4] Using fixed-length cells makes quality of service (QoS) calculations much more straightforward. Good QoS is important in applications like voice and video conferencing that cannot tolerate significant network delays. The choice to use ATM rather than Frame Relay should be based on the use of these applications as well as pricing and availability.

Designing a Network with Frame Relay

Zippy's has examined all of the alternatives and decided that Frame Relay offers the best combination of price and performance for their Wide Area Network needs. The next step is to design the network to efficiently connect the various sites across the country.

Choosing the Topology

Since Zippy's will be connecting more than two sites they can choose to use a mesh topology to provide some redundancy in communications links. This redundant arrangement can be either full-mesh, where every site has a connection to every other site on the network, or a partial-mesh, where sites have connections to one or two other sites, but not all. [5] It might seem like full-mesh is the best way to connect since it features the most redundancy, however this is rarely the case in larger networks. The problem is one of management. Full redundancy means more virtual circuits and more virtual circuit connections means more time spent for setting up and monitoring the network.

Connecting the Sites

Zippy's needs to decide how much redundancy, if any, is needed between site and how to best set this up.

Basic Connectivity

Zippy's headquarters is located in Schaumburg, Illinois and is the central clearinghouse for all of the company's data. Given this fact, the WAN design can start as a simple hub-and-spoke network with the Schaumburg HQ in the center. Each supply office and manufacturing site will have a virtual circuit connected to Schaumburg. Additionally there needs to be a virtual circuit between Zippy's headquarters and Vend-O-Land headquarters. This simple design solves the basic connectivity issue. All sites can communicate with headquarters and all sites may also communicate with each other by routing layer-3 data through headquarters.

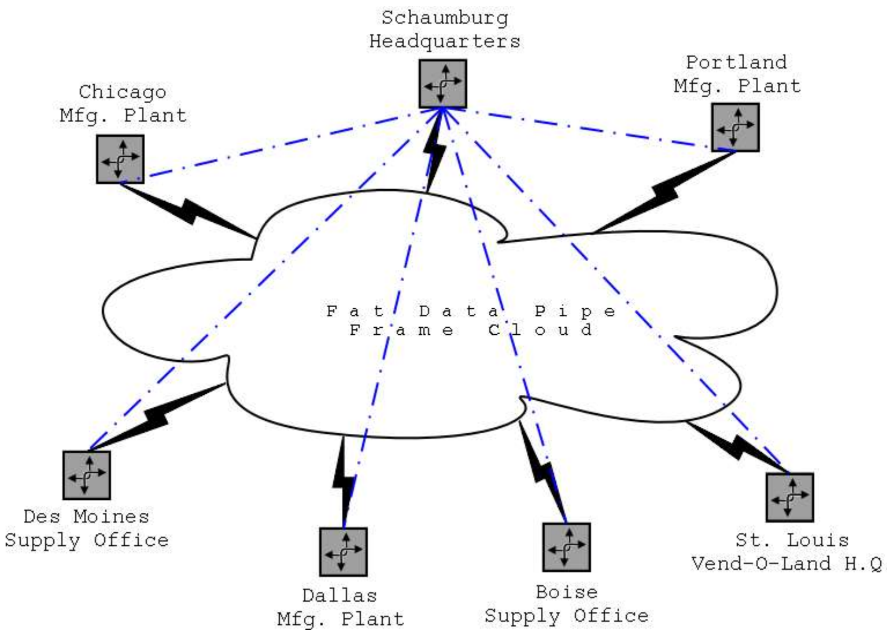

Figure 2 – Hub and Spoke Virtual Circuit Connections

Redundant Links

The basic hub-and-spoke design has one fatal flaw in that it relies entirely upon the Schaumburg office for inter-site communications. If a fire, flood or other disaster should knock out communications at headquarters all of the other sites would be unable to communicate with each other and business would grind to a halt. Even though management would prefer to have all data route through headquarters, it is possible to continue business operations in a less centralized fashion. Providing redundant links between key locations will help ensure business continuity in the event of an unplanned outage.

Looking at the way Zippy's does business can help the network designer choose the best places to provide redundancy. The following is a basic outline of the manufacturing and delivery process:

1. Supply offices in Idaho and Iowa ship potatoes and corn to the manufacturing plants in Portland, Chicago and Dallas.
2. The manufacturing plants turn the raw potatoes and corn into bags of snack chips.
3. Vend-O-Land sends trucks to the manufacturing plants to pick up the bags of chips and deliver them to vending machines across the country.

Even this most basic understanding of Zippy's business gives the WAN designer a great deal of information to help plan the placement of redundant links. In particular there are two important facts that will influence the network design:

1. Supply offices must be able to communicate with manufacturing sites so that orders of raw materials arrive when needed.
2. Manufacturing plants must be able to communicate with Vend-O-Land's headquarters so that trucks are dispatched properly.

The basic hub-and-spoke design can be enhanced by adding three additional virtual circuits at each manufacturing site; one to the Idaho supplier, one to the Iowa supplier and one to Vend-O-Land headquarters in St. Louis. This partial mesh design takes care of the supply office to manufacturing plant redundancy as well as manufacturing plant to distributor redundancy. With redundant links, Zippy's business can continue to operate even if the headquarters should experience an outage.

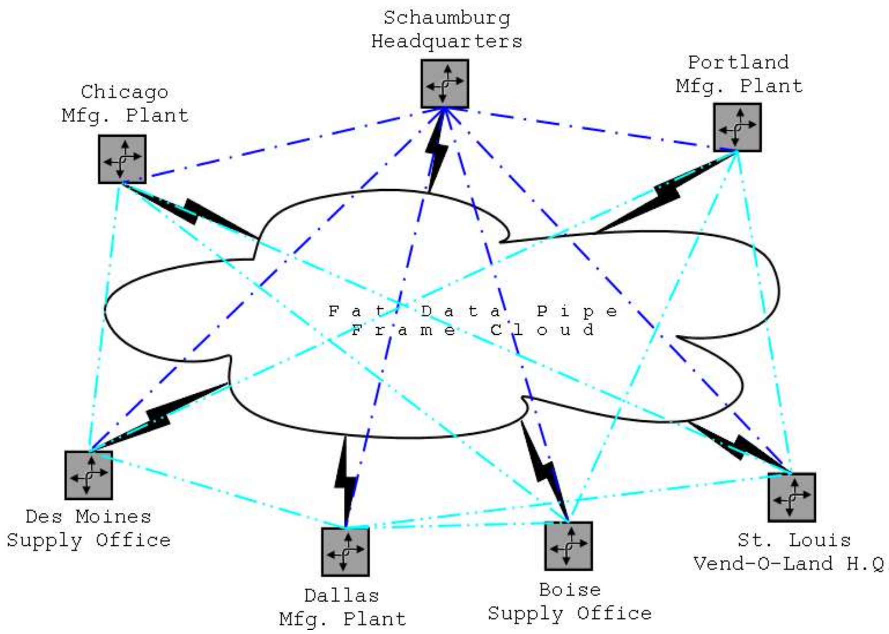

Figure 3 – Redundant Links forming Partial Mesh

Negotiating the Provider Contracts

Now that Zippy's has the topology design all worked out the next step is to take their requirements to Fat Data Pipe, their Frame Relay service provider. FDP will give Zippy's the prices and service level agreements for the frame bandwidth as well as prices and SLA's for the point-to-point links that connect Zippy's site's to FDP's local frame switches. Zippys' network designer can work with FDP to determine the most cost effective solution. The network designer should pay attention to the committed information rate (CIR) that the provider can give and make sure it fits the design. Zippy's should also be careful not to get locked into a contract that would be restrictive to future expansion of the network.

Choosing Equipment

Some Frame Relay providers will include customer equipment like DTE's and routers in the overall package price. If not, Zippy's should plan to purchase equipment from a reputable hardware vendor. The DTE and router can be purchased as separate pieces or as an integrated solution. An integrated package, like a router with a plug-in WAN Interface Card (WIC), can offer easier management, space savings and one point of contact for any service related issues.

Scaling the Network with Frame Relay

Every business has plans for growth and Zippy's Chips is no exception. The choice of Frame Relay for WAN connectivity makes network expansion relatively simple. For example if Zippy's opens a new manufacturing plant in Cleveland, Ohio there are only a few simple steps to get the new site on the network.

1. Order a point-to-point link from the new site to FDP's local frame switch in Cleveland.
2. Configure a PVC from Cleveland to the Schaumburg headquarters.
3. Configure redundant PVC's to the supply offices in Iowa and Idaho as well as to Vend-O-Land's headquarters in St. Louis.

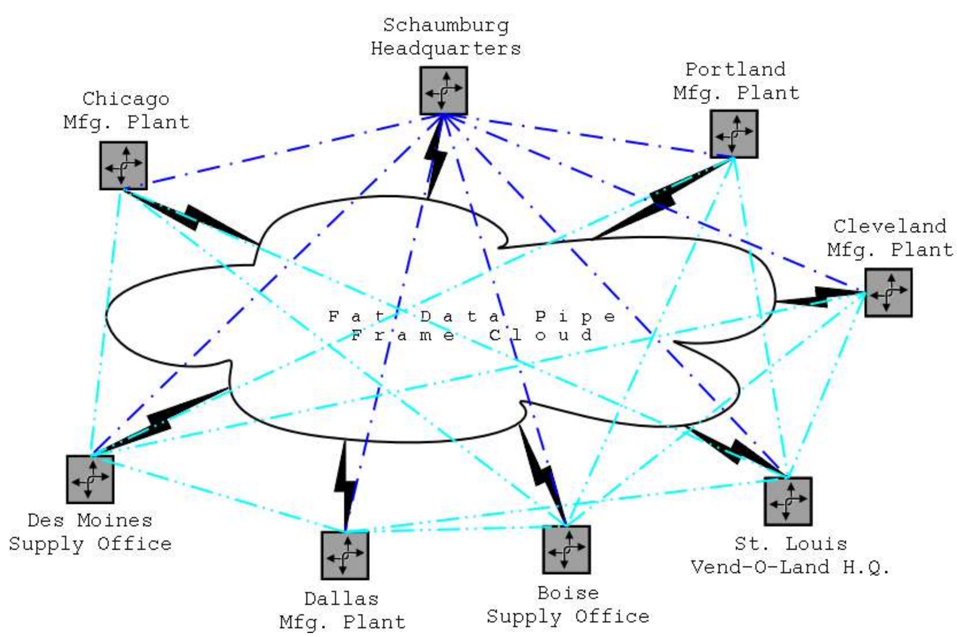

Figure 4 – Scaling the Network to Accommodate Cleveland Plant

Alternative Topology

With the opening of the Cleveland manufacturing plant the network diagram is beginning to look much more complex. The addition of just one site has resulted in four new PVC connections. If Zippy's continues to expand in this manner the network administrator's job of maintaining and troubleshooting the network will be come considerably more difficult due to the shear number of PVC connections. It may be a good idea to consider alternate ways of connecting the network before rapid expansion causes the network administrator to become overwhelmed with PVC's.

Dual-hub Design

The original network design was a simple hub and spoke topology with the hub located at Zippy's Schamburg, IL headquarters. The reason for multiple PVC connections to each site was to provide business continuity in the event of a disaster in the Schaumburg data center. Now that the network is expanding Zippy's needs to reduce the number of PVC connections but still maintain redundant connections for fault tolerance. These requirements stated above can be met by using a dual-hub design. With a dual-hub design Zippy's chooses one of its sites to serve as a second hub and makes PVC connections to each of the other sites from there. [6] For example, Zippy's management may choose the Dallas manufacturing plant as a second hub for the network.

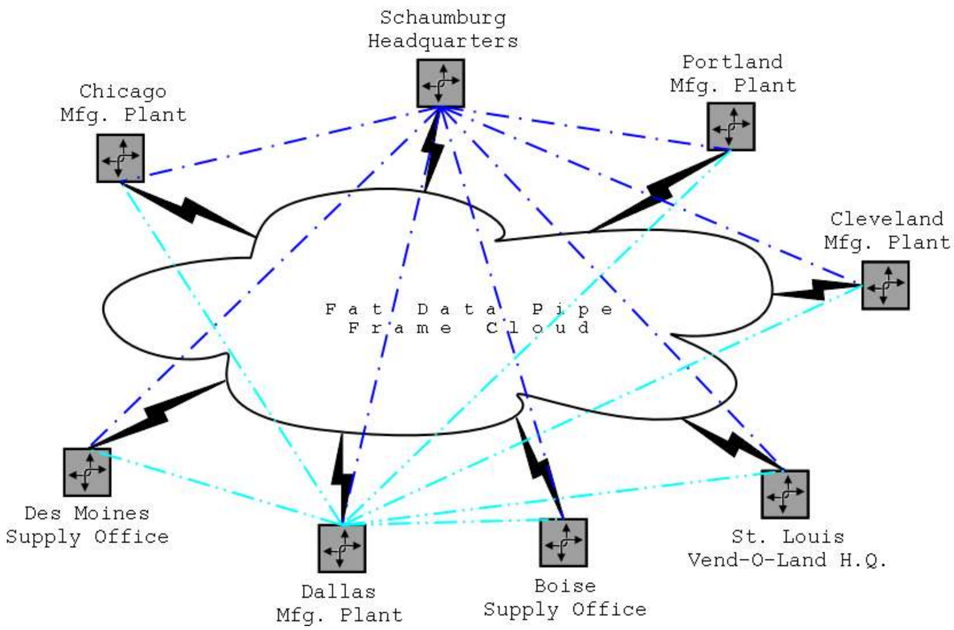

Figure 5 – Dual-hub Design

Management may have chosen the Dallas site for a number of reasons. Perhaps the plant has a larger, more modern data center than the other offices or maybe it has a very capable network administrator on staff. However, it is far more likely that management made the decision based solely on the fact that if the Schaumburg headquarters is in ruins they would like to fly somewhere warm, far away from the board of directors and with easy access to margaritas. Therefore, it is up to the network administrator to make sure that the equipment is suitable for the task of acting as a second hub. It may be necessary to upgrade or replace the Dallas router in order to make this design work.

Co-location With Vend-O-Land

Another way of implementing the dual-hub design is to use Vend-O-Land's facility in a co-location agreement. In this type of situation Vend-O-Land agrees to let their data center be used as a backup site for Zippy's and conversely Zippy agrees to become a backup for Vend-O-Land.

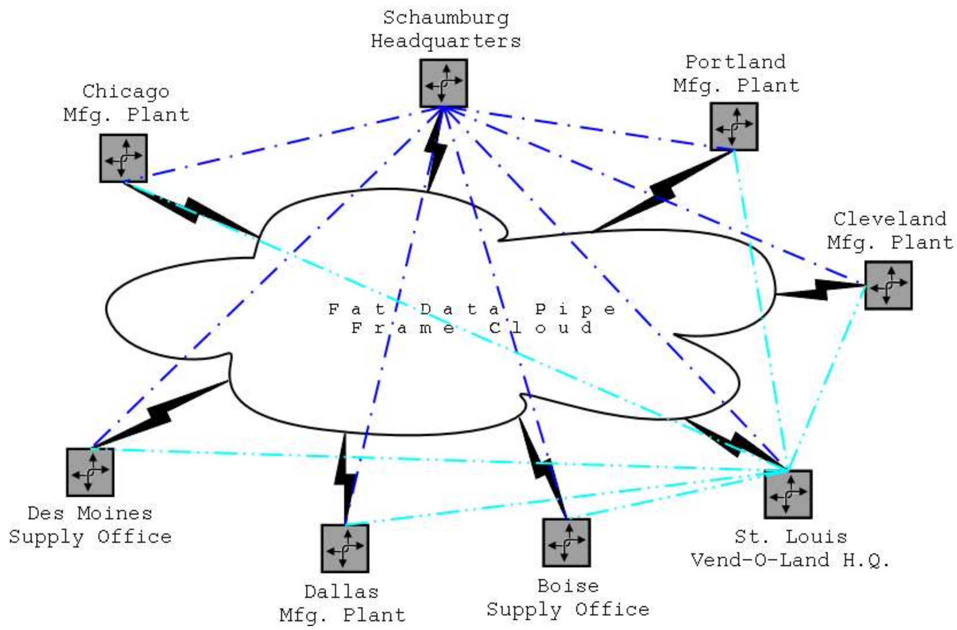

Figure 6 – Co-located Design

From a technical standpoint this design is no more difficult to implement than the Dallas dual-hub design. However, there are many legal details to be worked out between the two companies before this design can become a reality.

Conclusion

When designed correctly Frame Relay can provide a cost-effective WAN solution for businesses with offices dispersed across the country. The example of Zippy's Chips shows how Frame Relay can be used to provide connectivity to multiple sites as well as redundancy to aid in disaster recovery. The choice of Frame Relay also allows for easy expansion of the business and flexibility in the design of the network.

References

1: SBC Communications, SBC PremierSERV (SM) Frame Relay Service, 2004,
http://www05.sbc.com/Products_Services/Business/ProdInfo_1/1,,942--9-1-33,00.html

2: Dennis Baasch, Emerging Technologies Frame Relay FAQ, 1997,
http://www.etinc.com/index.php?page=frfaq.htm

3: Sangoma Technologies, Sangoma - X.25 Tutorial, 2004,
http://www.sangoma.com/x25.htm

4: SBC Communications, SBC PremierSERV (SM) ATM Service, 2004,
http://www05.sbc.com/Products_Services/Business/ProdInfo_1/1,,900--9-1-33,00.html

5: Webopedia Computer Dictionary, What is mesh?, 2004,
http://www.webopedia.com/TERM/m/mesh.html

6: Howard C. Berkowitz, Designing Routing and Switching Architectures for Enterprise Networks, 1999