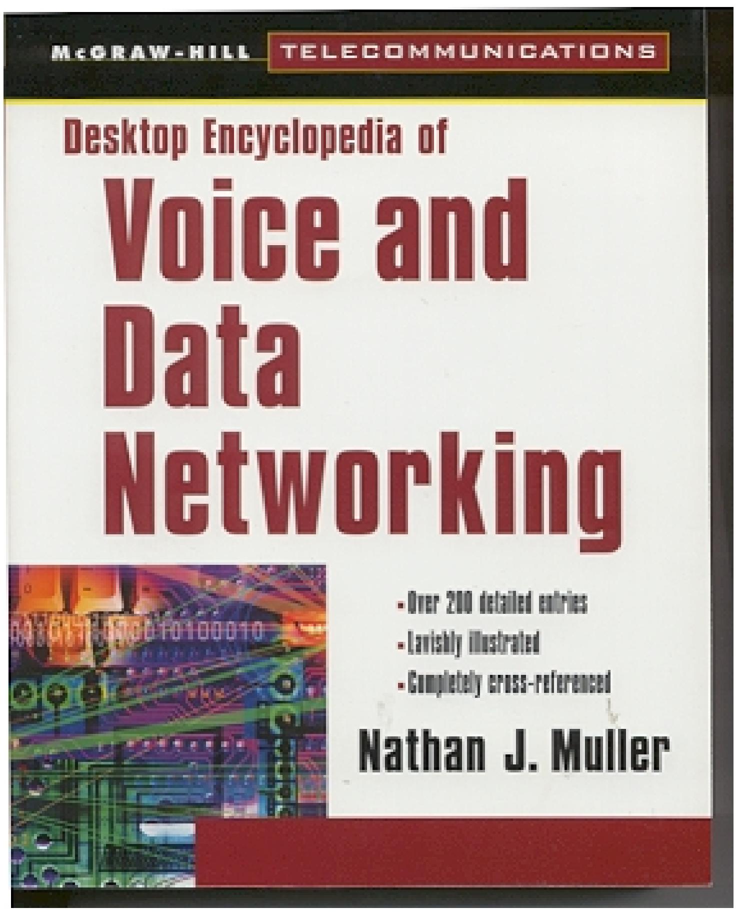
FURTHER READING:

As a preview for further reading, the following reference has been provided from the pages of the book below:

Title: Desktop Encyclopedia of Voice and Data Networking
Author: Nathan J. Muller
Publisher: McGraw-Hill

ISBN: 0071347119

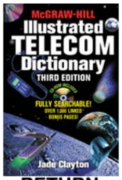


SUMMARY

Both the level of traffic and the need for reliable Internet services is increasing. Flow management is the next logical step in increasing the performance and management of Web sites and corporate intranets. Optimizing performance at the WAN level results in enterprise-wide increases in availability and speed.

See Also **Load Balancing, Network Caching**

Frame Relay



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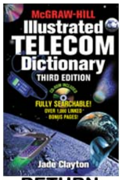
Frame relay is a fast-packet technology for transmitting data in high-speed bursts across a digital network. Frame relay can be used for integrated data, voice, and fax applications, as well as legacy Systems Network Architecture (SNA) and mission-critical intranet applications. Available since 1992, frame relay also supports multiple protocols, offers compatibility with other networking technologies, and costs less than other wide-area networking solutions.

The need for frame relay arose partly out of the emergence of digital networks, which are faster and less prone to transmission errors than older analog lines. Although the X.25 protocol overcomes the limitations of analog lines, it does so with a significant performance penalty, due mainly to its error-checking capability, which relies on the store-and-forward method of transmission. In being able to do without this and other functions, and be able to support different types of virtual circuits, frame relay offers more efficient usage of available bandwidth and, as a result, more configuration flexibility.

X.25, the only popular, nonproprietary method for wide-area, multiprotocol data communications, included error-correction and flow-control capabilities because at that time the public network was not dependable in terms of noise-free transmission between switches. X.25 became a popular protocol, but extensive switch-processing times and packet queuing at the switch locations caused packet transmission delays.

As noise-free fiber-optic lines came into widespread use, an improved protocol started being used for switch communication. With networks being faster and more reliable, the devices associated with those networks also became faster and more reliable, allowing them to handle end-to-end error correction and flow control. A new fast-packet technology called frame relay produced a higher level of reliability by eliminating switch-to-switch error-correcting procedures that were no longer necessary.

Frame relay is currently in use in various industries for different applications. Airline reservation systemsuse frame relay technology in their networks to improve performance, especially during busy traffic periods, and to lower online transmission costs. Manufacturing companies use frame relay to alleviate the periods of hectic activity when large amounts of data transmission occur between remote LANs. Banks are one of the biggest users of the frame relay technology, using it to connect LAN data traffic, teller machine transactions, and branch office terminals to SNA-based computer mainframes at bank data centers.



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Technology

Frame relay is a fast-packet technology. A *fast packet* is transmitted without any error-checking points along the route. The receiver is responsible for ensuring that the packet arrives without error and for initiating a request for retransmission if needed. Fiber-optic media enables fast-packet transmission to work with a high degree of reliability, making internodal error correction of the kind used in X.25 packet-data networks unnecessary. Without this error-correction process, the queuing and processing of packets within the network is greatly reduced, allowing for faster transmission of data.

Bandwidth is used very efficiently with frame relay technology through the use of statistical multiplexing. In time-division multiplexing (TDM), which is typically used on private leased lines, each device is assigned a fixed-bandwidth channel. If a device has no data to send and none is received, the available bandwidth goes unused. Technologies using packets are able to perform statistical multiplexing, allowing the available bandwidth to be shared by many devices. This is more efficient because any unused bandwidth can be immediately used by another device to transmit data, resulting in faster response times and significant cost savings.

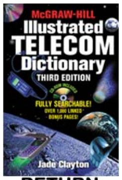
Lower operating costs result from several factors. The cost per transmitted byte is less because frame relay transmits data faster over the same bandwidth than other WAN protocols. Frame relay's ability to combine data packets from various sources via one access point minimizes the number of required access points in a network. The faster frame relay network and more responsive applications allow users to be more productive.

Advantages

The most compelling advantages of a carrier-provided frame relay service include:

NODE-TO-NODE CONNECTIVITY Any node connected to the frame relay service can communicate with any other node via a preprogrammed PVC or dynamically via an SVC. The need for multiple private lines is eliminated for substantial cost savings.

HIGHER SPEEDS Frame relay service supports transmission speeds up to 44.736 Mbps.



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IMPROVED THROUGHPUT/LOW DELAY Frame relay service uses high-quality digital circuits end to end, making it possible to eliminate the multiple levels of error checking and error control in an X.25 network. The result is higher throughput and less delay compared to conventional packet-switching.

COST SAVINGS Multiple permanent virtual circuits can share one access link, eliminating the cost of multiple private-line circuits and their associated customer premises equipment (CPE), for substantial cost savings.

FLAT-RATE CHARGES Once a customer location is connected to the frame relay service "cloud," charges are insensitive to distance.

SIMPLIFIED NETWORK MANAGEMENT Customers have fewer circuits and less equipment to monitor. In addition, the carrier provides proactive monitoring and network maintenance 24 hours a day.

PROTOCOL TRANSPARENCY Frame relay service supports any higher-layer protocol that uses LAPF as the underlying data-link layer protocol.

INTERCARRIER COMPATIBILITY Carrier-provided frame relay service is compliant with the Frame Relay Forum standards associated with frame relay network implementation, namely FRF.2.

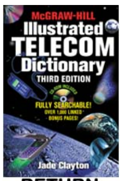
CUSTOMER-CONTROLLED NETWORK MANAGEMENT This allows customers to obtain network management information via in-band SNMP queries launched from their own network management stations. Information available includes performance monitoring, fault direction, and configuration information about frame relay service.

PERFORMANCE REPORTS Customers can manage their frame relay service to maximum advantage. Available online network reports include those for usage, errors, health, trending, and exceptions.

Types of Circuits

The two primary types of virtual circuits supported by frame relay are Permanent Virtual Circuits (PVCs) and Switched Virtual Circuits (SVCs).

PVCs are like dedicated private lines: once set, the predefined logical connections between sites stay in place. This allows logical channels to be dedicated to specific terminals. SVCs are analogous to dial-up connections, which require path setup and teardown. A key advantage of SVCs is that they permit “any-to-any connectivity.” The SVC requires fewer logical channels at the host because the terminals (endpoints) contend for a lesser number of logical channels. Of course, it is assumed that not everyone will require access to the host at the same time.



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SVCs can lower the expense of frame relay backbone networks by more efficiently supporting endpoints that infrequently communicate with each other. By requiring less backhaul and increased bandwidth usage through dynamic connectivity, SVCs become a very cost-effective solution.

Another type of virtual circuit, not widely implemented, is the Multicast Virtual Circuit (MVC), which can be used to broadcast the same data to a group of up to 64 users over a reserved data link connection. This type of virtual circuit might be useful for expediting communications among members of a single workgroup dispersed over multiple locations, or to facilitate interdepartmental collaboration on a major project.

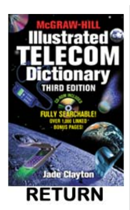
The same frame relay interface can be used to set up SVCs, PVCs, and MVCs. All three may share the same digital facility. It is even possible to bundle SVCs within PVCs to help avoid delays that can time-out SNA sessions and disrupt voice traffic. In supporting multiple types of virtual circuits, frame relay networks provide a high degree of configuration flexibility, as well as more efficient usage of available bandwidth.

Standards

The Frame Relay Forum (FRF) is a nonprofit organization composed of corporate members dedicated to the implementation of frame relay in accordance with national and international standards. The forum was started in 1991 and is made up of carriers, consultants, users, and vendors. The FRF currently has 300 members worldwide. All of the major network equipment vendors are members of the Forum, including 3Com, Alcatel, Ascend Communications, Bay Networks, Cabletron, Cisco Systems, Ericcson, Hewlett-Packard, IBM, Lucent Technologies, Motorola, Nortel, and Siemens.

The Forum develops the growth of frame relay by promoting an understanding of the applications, benefits, and user experiences of frame relay technology. The Forum also concentrates on the development and approval of implementation agreements (IAs) that designate how standards will be applied for support of the frame relay protocol.

The Forum is continually evaluating the development of new applications related to the frame relay market, always seeking interoperability among the various equipment manufacturers and service providers. The FRF's evaluation of these developments will lead to future IAs for designating how the standards will be applied for the support of this protocol. Frame relay IAs to date consist of the following:



FRF.1.1 User-to-Network Implementation Agreement

FRF.2.1 Network-to-Network Implementation Agreement

FRF.3.1 Multiprotocol Encapsulation Implementation Agreement

FRF.4 Switched Virtual Circuit Implementation Agreement

FRF.5 Frame Relay/ATM Network Internetworking Implementation Agreement

FRF.6 Frame Relay Customer Network Management Implementation Agreement

FRF.7 Frame Relay PVC Multicast Service and Protocol Description Implementation Agreement

FRF.8 Frame Relay ATM/PVC Service Interworking Implementation Agreement

FRF.9 Data Compression over Frame Relay Implementation Agreement

FRF.10 Frame Relay Network-to-Network Interface Switched Virtual Connections Implementation Agreement

FRF.11 Voice over Frame Relay Implementation Agreement

FRF.12 Frame Relay Fragmentation Implementation Agreement

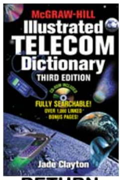
FRF.13 Service Level Definitions Implementation Agreement

The American National Standards Institute (ANSI) T1S1 committee issues standards describing frame relay (T1.606, T1.618, and T1.617) and the ITU publishes similar standards (I.233, Q933, and Q922 Annex A). The Frame Relay Forum expands the capabilities of the technology and works with these standards organizations.

Implementation Issues

For any network service, cost is the primary issue that usually merits the most consideration, and frame relay is no exception. The cost of implementing frame relay technology varies with each network and organization. Frame relay service providers can invoice users for a wide range of items, including:

- Access rate, which is the cost of the total bandwidth needed at the access point
- Burst characteristics, usually determined by a committed burst size and burst excess size
- Committed Information Rate (CIR), the anticipated, average rate of data flow through the access point
- Customer Premises Equipment, which includes the frame relay or internetworking access equipment leased by the service providers
- Port fee, the cost for connection to a port on the service provider's switch
- Required Private Virtual Circuits (PVCs) and Switched Virtual Circuits (SVCs)
- Usage amount, normally invoiced at a cost per megabyte of data moved over the network



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For companies moving from IBM's host-centric (mainframe) environment to a distributed computing environment (local-area networks), the major carriers offer wide-area network services that address the specific needs of SNA users. Carriers have become quite adept at prioritizing traffic so SNA can be handled reliably end to end.

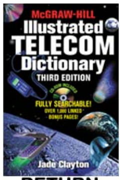
The attraction of frame relay is that it reduces transport costs by eliminating more costly leased lines. A carrier-managed service relieves customers of having to continually monitor and fine-tune network performance to handle delay-sensitive SNA traffic. If implemented from a central office, there are savings in the cost of equipment as well, since the carrier provides it. Carriers also provide service-level agreements that guarantee latency, frame discard rates, network availability, and response to trouble calls..

For a legacy SNA shop that does not have the expertise or resources, a managed SNA service can be an economical interconnectivity option. Although frame relay networks generally are much more difficult to configure, administer and troubleshoot than private lines, the carrier assumes these responsibilities. Subscribers can even obtain periodic reviews of their network's performance and efficiency from the carrier. This helps ensure that mission-critical applications are providing the highest level of performance, reliability and availability.

National carriers like AT&T, MCI WorldCom, Sprint, and Cable & Wireless Communications offer managed frame relay services for SNA traffic. Some regional carriers such as U S WEST and Ameritech also offer managed SNA service. SNA has traditionally been carried over dedicated point-to-point wide-area links. It is estimated that 60 percent of the data traffic over private lines consists of SNA traffic, which explains why carriers want to address this market with managed SNA services over frame relay.

SUMMARY

Networking professionals today must deal with a variety of difficult networking issues, including improving performance and manageability, reducing costs, providing high levels of availability, and ensuring their network's future by providing a path for new technologies. Frame relay is a proven technology with many demonstrable benefits. It integrates multiple protocols and applications, and has proven to be fast, reliable, and cost-effective.



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***See Also* Asynchronous Transfer Mode, Frame Relay Access Devices, Integrated Services Digital Network, Video over Frame Relay, Voice over Frame Relay**

Frame Relay Access Devices

Frame relay offers a more economical alternative to wide-area networking than private leased lines, delivering high availability and predictable response times. Connecting a site to a frame relay network requires the use of a Frame Relay Access Device (FRAD) or router. Both types of devices assemble data into frames suitable for transmission over a frame relay service and return them to their original format at the destination end. Some routers can do this as well, but FRADs are generally more adept at congestion control and prioritization than routers. Some FRADs have a built-in CSU/DSU.

Basic Features

FRADs perform basic routing functions. Like routers, FRADs are primarily used for data transport and provide multiprotocol support to address legacy and LAN networks. Through a modular approach, voice and dial backup can be added as well. Both types of devices can be managed with the Simple Network Management Protocol (SNMP) and both provide additional management features. Generally, FRADs are a more economical