Payoff

LAN managers will find that routers supporting dial backup, bandwidth-on-demand, and dial-on-demand enable more flexible and efficient internetworking.

Introduction

With more circuit-switched digital services coming online, including Integrated Services Digital Network, network planners now have an array of choices available for meeting diverse data communications and LAN interconnectivity needs. This portends new challenges for router vendors, who have traditionally specialized in providing users with leased-line and packet-switched connectivity solutions.

Routers are typically used to send multiprotocol traffic over private or public backbone networks accessed with dedicated lines. Depending on traffic requirements, these lines may operate at 56K b/s or the T1 rate of 1.544M b/s. But dedicated lines and connection-oriented packet services such as frame relay can be expensive, especially when used intermittently by small branch locations. This situation has network planners looking for alternative solutions in more economical circuit-switched services that can be dialed up when needed.

Analog dialup services are the least expensive way to go, but unless compression is used, they are generally limited to 19.2K b/s. Furthermore, line quality is often poor, unless extra-cost line conditioning is used. For many companies, more reliable digital services like switched 56K b/s and integrated services digital network (ISDN) are the answer, especially when mission-critical applications are concerned.

Among the benefits offered by these services is that they balance cost with demand. Circuit-switched services are very economical when the bandwidth is needed for a relatively short period of time. Flexible dialing and ease of use are other advantages of using circuit-switched services for internetworking. If an office has to communicate with several different locations, it makes sense to use a switched service rather than multiple dedicated lines. Dialing up extra bandwidth is also much easier than trying to reconfigure a dedicated line to reach another location.

Vendor Support

Although circuit-switched services offer more connection flexibility for internetworking and can be more economical than leased lines for locations with low traffic, router vendors are just getting around to supporting them. Often, a hodgepodge of equipment is used for dialup internetworking, including Digital Service Unit and Integrated Services Digital Network Terminal Adapter that have dialing capabilities. These devices set up the connections that the routers need when more bandwidth is required and tear them down when the extra bandwidth is no longer required.

Depending on the size of the file to be transferred, inverse multiplexers can also be used to dial up the appropriate amount of bandwidth. The advantage of using an inverse multiplexer is that it can dynamically expand the network to suit the changing bandwidth requirements of the applications. The inverse multiplexer also sits on the front-end of the router and sets up the amount of bandwidth the router needs in real-time. Or, the inverse
multiplexer can be programmed to automatically set up bandwidth requirements that differ by time of day to accommodate peak-hour traffic, for example.

New technologies are becoming available that let the routers monitor impeding congestion and decide when to dial up extra bandwidth based on user-defined buffer thresholds. With a capability called load balancing, the router distributes traffic across the primary link and the dialup connection. When buffers return to normal fills for a sufficient amount of time, the router automatically terminates the dialup connection.

**Role of ISDN**

Some internetwork equipment vendors have embedded support for Integrated Services Digital Network in their routers, eliminating the need for Terminal Adapter. With an integral integrated services digital network (ISDN) Basic Rate Interface (ISDN basic rate interface), the router has the ability to place two simultaneous calls to different network locations. With an integral integrated services digital network (ISDN) Primary Rate Interface (ISDN primary rate interface), the router has the ability to place multiple simultaneous calls—up to 23 in North America and Japan and up to 30 elsewhere—to different locations. From a hardware perspective, both types of Integrated Services Digital Network services require only one network interface port on the router, rather than multiple serial interfaces, which would be more expensive.

Many industry analysts expect integrated services digital network (ISDN) to become a high-profile service in 1995, either for backup or for dialing up bandwidth only when it is needed. Once integrated services digital network (ISDN) interfaces start to become more available, the router vendors—in their natural drive to differentiate themselves from competitors—will improve support for integrated services digital network (ISDN) and for switched digital services in general, which will fuel the increased use of these services for WAN internets.

Where integrated services digital network (ISDN) is universally available—Europe and Japan—it is very economical for full-time router connections. In Japan, the breakeven point of an integrated services digital network (ISDN) line to a leased line of the same bandwidth, say 64K b/s, is only six to 16 hours of usage per month, with 12 hours being the average. But until pricing for such switched services as Integrated Services Digital Network and switched 56K b/s becomes more attractive in the US, users will have to configure their internets as if they consisted of leased lines that only come up when dialed. This means that the use of circuit-switched services in router networks will be confined to a few specialized applications such as dial backup, bandwidth-on-demand, and dial-on-demand. Still, the cost savings over leased lines can be substantial.

**Circuit Switched Connections**

Traditional routers are not designed to operate over paths that appear during call setup and disappear with call teardown, which is how Central Office switches handle ordinary phone calls over the public network. Given the state of current routing protocols, circuit-switched connections pose problems for full-time use by routers. The routers exchange “hello” messages that in effect revalidate the path and support the exchange of network topology information so routers can select the best routes. The problem with using switched digital services across wide-area links is that a call has to be set up every time a “hello” message is generated, which nearly eradicates the economy of using switched services. If these messages are eliminated and the right information is not exchanged, the router thinks the route has disappeared and makes it unavailable.
This problem can grow exponentially when the routers are configured to allow any node to call any other node. Potentially, the network can become so busy performing routing updates that not enough bandwidth is left to actually move users’ data. Alleviating such problems requires clever ways to handle these messages (specifically the end-to-end acknowledgments and search broadcasts) so that overhead does not burden the network.

One promising technique, “name caching,” requires the local router to maintain an address table of nodes across the WAN. When a local node broadcasts a search for a remote node, the local router responds instead of forwarding search traffic across the network. Router vendors are working on this and other techniques that will allow full-time use of circuit-switched connections for router-based internetworking. However, the cost of using circuit-switched services for full-time router connections is still prohibitive until carriers shift their emphasis from leasing lines to encouraging the use of switched services, which are billed on a usage basis.

Dialup Applications

The leading router vendors see three major applications influencing the trend toward dialup internetworking over circuit-switched connections: dial backup, bandwidth-on-demand, and dial-on-demand.

Dial Backup

Dial backup establishes temporary circuit-switched connections when dedicated links—leased lines or connection-oriented packet-switched—services fail. These temporary connections maintain network availability until dedicated links can be restored to service.

There are several ways router vendors support dial backup. One way entails the use of a router connected to an external Digital Service Unit that supports dial backup or an Integrated Services Digital Network terminal adapter that does the same thing (see Exhibit 1). Either of these external dial units can control the initiation and termination of the dial connection as well as specific application requirements, such as the types of primary and backup links supported. In this implementation, the signaling required to initiate, monitor, and terminate dialup connections resides in the external dial unit, with the connection remaining transparent to the router.

A Router Connected to an External Digital Service Unit

Raise Data Terminal Ready and V.25bis Standards. Another way routers implement dial backup is through the use of integrated raise DTR and V.25bis dial signaling. This allows the router to initiate, monitor and terminate dial backup connections through any digital service units or integrated services digital network (ISDN) Terminal Adapter that supports either of these standards. Exhibit 2 illustrates how these signaling standards are used to backup dedicated links. In addition to providing centralized dialup internetworking control, raise DTR and V.25bis greatly enhance router flexibility, as they allow interoperability with any external dial unit supporting either of these standards. Supported on V.35 and RS-232 interfaces, raise DTR enables the router to initiate, monitor, and terminate dial connections using a preprogrammed number in the attached external dial unit. V.25bis signaling, supported on V.35 interfaces, permits the router to pass telephone numbers to the dial unit in addition to providing control of the dial connection.
How Signaling Standards Are Used to Back Up Dedicated Links

Some router vendors integrate support for integrated services digital network (ISDN) Basic Rate Interface and integrated services digital network (ISDN) Primary Rate Interface in their products, which eliminates the need for external integrated services digital network (ISDN) terminal adapters in dial backup applications (see Exhibit 3), in turn reducing equipment costs and simplifying dial backup implementation requirements.

Integrated ISDN BRI and PRI Support

Bandwidth-on-Demand

With bandwidth-on-demand, supplemental dialup connections can be used to maintain performance levels when organizations exceed the available bandwidth during peak traffic periods and leased line or packet-switched links become congested. The routers sense when a point-to-point link is about to become overloaded and automatically dialup a circuit-switched line to handle the overflow.

Bandwidth-on-demand is implemented in a variety of ways. One scenario involves the use of an inverse multiplexer, which is positioned at the front-end of the router (see Exhibit 4). The inverse multiplexer monitors congestion on the interface connected to the router. If congestion is detected, the inverse multiplexer initiates dialup connections to provide supplemental bandwidth. It then multiplexes data over the bandwidth-on-demand connections, maintaining acceptable network performance during peak traffic periods.

An Inverse Multiplexer Positioned at the Front-End of the Router

Some interconnect vendors have integrated on-demand capabilities into their equipment (see Exhibit 5), enabling the router to initiate, monitor, and terminate bandwidth-on-demand connections with any digital service units or integrated services digital network (ISDN) terminal adapters that support raiseDTR or V.25bis standards. Based on user-defined intervals, the router monitors its own buffer level to determine whether the primary leased line or packet-switched link is congested. If the user-defined buffer level is exceeded, the router initiates a bandwidth-on-demand connection. To maintain user-required network performance levels, the router provides traffic load balancing across the primary and dialup connection. When the router detects that the volume of traffic has decreased below the user-defined buffer level for a sufficient period, the dialup connection is automatically terminated.

Routers with Integrated On-Demand Capabilities

An enhanced version of the bandwidth-on-demand capability provides more flexibility in maintaining user-required network performance levels. For example, the router can implement mechanisms that ensure packet sequencing across multiple bandwidth-on-demand circuits. With integrated integrated services digital network (ISDN) support (see Exhibit 6), the need for external Integrated Services Digital Network terminal adapters is eliminated, reducing the cost of equipment while simplifying bandwidth-on-demand implementation.
Integrated ISDN Support

Dial-on-Demand

Dial-on-demand extends internetwork connectivity to small remote offices on an as-needed basis when the limited amount of traffic makes leased lines and packet-switched services cost-prohibitive.

Routers that support dial-on-demand typically do so in combination with digital service units and Integrated Services Digital Network terminal adapters. These external dial units monitor the interface to the router and establish dial connections when data is received from the router. In response to the technical challenge of dealing with broadcast packets that would require a dial-on-demand link to stay continuously active, the dial units configure static routes.

A more sophisticated implementation integrates the dial-on-demand capability into the router (see Exhibit 7). The router provides automatic dial-on-demand with any digital service units or integrated services digital network (ISDN) terminal adapters that supports raise DTR or V.25bis dial signaling. The router initiates, monitors and terminates dial connections based on time-of-day or receipt of data. More specific application requirements can be met through user-defined filters that qualify which packets automatically trigger dial-on-demand and which type of packets are transmitted over an already-established dial connection. Manual dial-on-demand connections can be set up using the router's management system.

Dial-on-Demand Router Capability

Routers with integrated integrated services digital network (ISDN) support eliminate the need for external Integrated Services Digital Network terminal adapters (see Exhibit 8).

Routers with Integrated ISDN Support

Dialup Alternatives

Leased lines are an economical alternative to circuit-switched services when full-time connectivity is required. There are two relatively new types of leased lines that merit attention: channelized T1 and Nx64 service. Both essentially offer the same advantage as circuit-switched service—that is, they lower costs.

Channelized T1

Channelized T1 involves the telephone company gathering individual 56K-b/s channels from multiple remote sites and multiplexing them over a T1 line. Up to 24 56/64K-b/s time slots are available on a T1 line. These are presented to a router as a single bit stream for transport over the backbone network. Cost savings accrue in two ways. First, the router needs only one high-speed serial port instead of multiple lower-speed serial ports. Second, transmission cost are reduced, because each remote location pays for only the bandwidth it needs.
Nx64

Nx64 (or Nx56) is a hybrid service that requires a T1 link from the customer premises to the carrier's point-of-presence (POP). The carrier then supports multiple 56/64K-b/s lines to remote sites, allowing the customer to bring a number of 56/64K-b/s lines to a single hub site, while paying only for a single local T1 line and the multiple remote 56K-b/s lines, for potentially significant cost savings.

Although channelized T1 and Nx64 can save a business money, especially when internetworking locations with low traffic requirements, they are not as easy to use and to reconfigure as dialup circuit-switched services. Reconfiguration requires telephone company involvement, which can take anywhere from a few minutes to a few hours, whereas reconfiguring a circuit-switched service only requires the dialing of another number.

Conclusion

Routers that support comprehensive dialup internetworking capabilities offer companies more flexibility for interconnecting geographically dispersed LANs. Selecting routers that support dial backup, bandwidth-on-demand, and dial-on-demand provides a cost-effective and efficient method of maximizing the WAN Internet's availability, performance, and connectivity. In choosing the right internetwork equipment vendor, users can position themselves to take advantage of the changing economies of circuit-switched services, as well as new technology innovations.

The lack of availability for some circuit-switched services should not stop users from considering hybrid internetwork arrangements, including channelized T1 and Nx64, which make use of both leased lines and switched services. Of course, the appropriate mix has to be evaluated in terms of the connectivity and availability requirements of each location, as well as cost and performance issues.

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Nathan J. Muller is an independent consultant in Huntsville AL, specializing in advanced technology marketing and education. He has more than 22 years of industry experience and has written extensively on many aspects of computers and communications. He is the author of eight books and more than 500 technical articles. He has held numerous technical and marketing positions with such companies as Control Data Corp., Planning Research Corp., Cable & Wireless Communications, ITT Telecom, and General DataComm, Inc., and holds an MA in social and organizational behavior from George Washington University.