Breaking the Off-Campus Bottleneck

by **STAN HANKS,** Technology Transfer Associates

Building a LAN is basically pretty easy. You can use some combination of concentrators, repeaters, bridges and routers to hook your collection of LAN segments together in a manner that is aesthetically pleasing. Religious wars have sprouted over exactly what the best way to do all this might be. Suffice to say, things get complicated when you have to go off-campus. And for most of us, such connectivity is a daily reality.

In a romp through acronym land, our intrepid author demystifies the 'science' of choosing among the available MAN and WAN technologies.

Off-campus–in the domain of metropolitan-area networks (MANs) and wide-area networks (WANs)–the rules change. No longer can you just run some cable out to where you need the new connection. Constrained by what seems at first to be an alternate reality, you have basically three choices. You can build a private network, either by actual physical construction or by leasing lines from someone else. You can use standard dial-up telephone lines and high-speed modems. Or you can use an advanced switching service such as frame relay, Switched Multimegabit Data Service (SMDS) or others.

Any time your network leaves your property, you must use either a private network or a common carrier, such as the phone company. If you take the private network approach, you open up a very, very large can of worms. In effect, you wind up having to justify that it's less expensive for you to own and maintain your own electronics and cable plant than to buy service from someone who also owns electronics and cable plant, but who buys at significantly lower prices than you and who has a huge economy of scale to make things like round-the-clock service possible. This rapidly becomes difficult for all but the largest companies.

If you use a common carrier, you have another set of problems. While dial-up voice-grade service is ubiquitous and fully interconnected, if you choose to lease lines from the phone company, and you need service across local access and transport area (LATA) boundaries, you may have to deal with two local service phone companies and a long-distance company. Admittedly, you can get the long-distance carrier to handle the local access part for you, but still, the moving-parts count starts to go up.

And there is another issue: If you buy service from the phone company, you basically get to buy what they're selling. And what they sell is mainly voice-grade service, so all of their leased-line facilities come in sizes that are whole multiples of voice-grade lines, and not in LAN-sized pieces.

Specifically, for data you typically consider regular voice-grade dial-tone lines; digital voice-grade lines at either 56 or 64 Kb/s (called DS-0 lines); the next level up, which at 1.544 Mb/s is 24 DS-0 lines (called a DS-1 or T-1); or the next level up, which at nearly 45 Mb/s is 28 DS-1s or 672 DS-0s (called a DS-3 or T-3). Beyond that, you start talking about whole digital fiber-optic transmission systems. Note that you jump from 1.5 to 45 Mb/s without the more common LAN speeds of 4, 10 or 16 Mb/s being available. And the prices jump up correspondingly.

Bringing the Fiber to Mohammed

Metropolitan Fiber Systems was started a few years ago when Peter Kiewit and Sons, the construction company that was building the fiber-optic networks for a number of alternative access providers, decided that the business of bypassing the local phone company for leased-line business looked pretty attractive and decided to buy its customers and consolidate them into a single national company. A rather unconventional approach, but one that seems to have worked well.

The core business for MFS is to provide high-quality stopless leased-line service between buildings roughly in the central business district of a metropolitan area. The first buildings to be targeted are always long-distance carrier points of presence, so they can provide access to the wide area, but MFS is not in the wide-area business itself.

In some cases, where there are really multiple business districts, this means big networks and lots of fiber-optic cable. In other cases, the networks are smaller. In no case can they be considered ubiquitous, and MFS makes a clear distinction between customers in buildings to which it has fiber (called "on-net" buildings) and everyone else ("off-net").

At the present, MFS has operations in Baltimore, Boston, Chicago, Dallas, Houston, Los Angeles, Minneapolis, New York, Philadelphia, Pittsburgh, San Francisco, Washington and its newest city, Atlanta.

Having all this fiber in the ground, connected to where customers are instead of to central offices or the like, made it possible for MFS to recognize the possibility for a new business–that of providing native and reduced-speed LAN interconnectivity. The project, which led to the MDS services, was started in early 1991, and the service was announced in August 1991–with customers already attached.

To insure that MFS would be able to continue to do business without affecting its existing telephony business, it formed a new company, MFS Datanet, earlier this year. So far, MFS Datanet has been relatively quiet about its long-range plans.

Don't Just Stand There–Guess

So what's a LAN gal or guy to do? Well, the first thing you really need to do is decide how much bandwidth you need between sites. If you currently don't have any intersite connectivity, you get to do something really

Speeds of Transmission

Size of File in MB	Transmission Rate	Seconds to Transmit	Minutes to Transmit
0.1	56 Kb/s (DS-0)	14.29	0.24
0.1	1.544 Mb/s (T-1)	0.52	0.01
0.1	Ethernet	0.08	0.00
0.1	token ring	0.05	0.00
0.1	45 Mb/s (DS-3)	0.02	0.00
0.1	FDDI	0.01	0.00
1	56 Kb/s (DS-0)	142.86	2.38
1	1.544 Mb/s (T-1)	5.18	0.09
1	Ethernet	0.80	0.01
1	token ring	0.50	0.01
1	45 Mb/s (DS-3)	0.18	0.00
1	FDDI	0.08	0.00
100	56 Kb/s (DS-0)	14,285.71	238.10
100	1.544 Mb/s (T-1)	518.13	8.64
100	Ethernet	80.00	1.33
100	token ring	50.00	0.83
100	45 Mb/s (DS-3)	17.78	0.30
100	FDDI	8.00	0.13

Source: Technology Transfer Associates

dangerous: guess. And here's why guessing is dangerous: If you don't have facilities, you don't know how they may be used; if you guess too small, performance will be so bad that no one will make more than limited use of the network; if you guess too big, you may be shot by your boss for "wasting money" on the network that no one has figured out how to really use yet.

There are some rules of thumb: If you are only using the link for electronic mail and maybe network management, you can probably get away with a DS-0; if you even think about anything else, you probably really want at least one T-1; if you are doing serious distributed file sharing or cooperative processing, you really want LAN speed. Of course, you can use routers to limit information flow and multiple parallel lines to increase overall throughput. But even doing this doesn't solve one of the other problems, which is latency.

The laws of physics being what they are, if two pieces of data leave Point A heading for Point B at the same time on different speed lines, the first bit of each datum will arrive at about the same time. However, the *last* bit will not, and the faster line will arrive first. From the time the first bit is sent until the last bit arrives is called latency and ultimately determines how useful a transmission line is for LAN purposes. One analogy I happen to like is that a DS-0 is like a garden hose, a T-1 is like a bundle of garden hoses all tied together, but a LAN is more like a water main. And you just can't do the same thing with a bunch of garden hoses that you can with a water main, any more than nine women can have a baby in a month.

To fix this problem in constructing networks, there are a variety of new technologies emerging. And, when you slice away all the buzzwords, there are really three worth looking into: frame relay, SMDS and the Multimegabit Data Services (MDS) from MFS Datanet.

Frame Relay: The LAN-Like Option

Frame relay is a technology that has been somewhat available for about a year. It is very LAN-like, using variable-length packets that are routed from a source to a destination address. It is a packet- (or frame-) forwarding technology that provides a "data cloud"-like structure to which you attach end points. Unlike a point-to-point network of leased lines, you don't have to worry about how the data will be sent, how failures are recovered from or the other things that keep network managers up at night, any more than you worry about such things for dial-up voice traffic. However, there are some problems with it.

For starters, while frame relay is available from a number of vendors–including Sprint, Williams Telecommunications Group (WilTel) and CompuServe Inc., to name a few–as a long-distance service, it is quite rare in the local loop. So while it may be attractive for WANs, it doesn't really play in the MAN scene. Second, frame relay is only available at T-1 speeds and below. It should eventually be available at up to DS-3 speeds, but no one is sure when. So it's not really useful for LAN-speed connectivity. (Note: All the Bell companies have filed tariffs for frame relay to be offered later in the year.)

Finally, there is the issue of congestion control–or the lack thereof. Frame-relay switches have capacity planned on the basis of your

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committed information rate (CIR), which is the minimum data rate you will be guaranteed. Data arriving more frequently than your CIR is tagged as "Eligible for Discard." Since you have to use a common carrier to connect you from your site to the frame-relay service, you will wind up using either a DS-0 or maybe a full T-1 and can in theory use the whole bandwidth of that link if there is no congestion in the network. However, if the switch gets congested, all packets above your CIR get thrown away and must be retransmitted. And since it is hard to know when a frame-relay switch is going to congest, some carriers just routinely throw away data over your CIR.

One last note: Frame-relay networks internally support a 16-bit address field. As a result, carriers have to be careful about how their networks are built and how customers are connected. And, of course, the various carrier frame-relay networks *do not* interconnect or even interoperate, so you get stuck with a single vendor solution, which is always a cheery prospect.

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SMDS: Somewhere Over the Rainbow

SMDS is a proposed service specification from Bellcore that is being widely adopted by the regional Bell operating companies (RBOCs). It is currently in trials in a number of areas and has even been tariffed as a regular service by at least one RBOC.

SMDS is quite a bit like frame relay in some respects. It also provides a data cloud to which you attach and uses a packet-forwarding technology. The difference is that it is built on a technology that is supposed to be forward-compatible with Broadband Channel Integrated Services Digital Network (B-ISDN), Synchronous Optical Network (SONET), Asynchronous Transfer Mode (ATM) and all the other cool buzzwords. Also the SMDS service specification says that it will be available in a variety of speeds between T-1 and DS-3, including the popular LAN speeds of 4, 10 and 16 Mb/s.

Unlike frame relay, SMDS is currently pretty much a local service offering. At this time, none of the long-distance carriers offer SMDS service, although some clearly have plans to do so. So you can build MANs out of SMDS in some areas, but it may be a while before you can connect them together. But (as another ray of good news) when you can connect SMDS networks together, everything should work fine. SMDS uses something called E.164 addressing, which is international in scale and has desktop-level resolution. Between that and the fact that all of the switch manufacturers are working from the same service specification, things *should* interoperate fairly well.

Still, there are some problems. Currently, to go faster than T-1 speeds, SMDS requires dedicated fiber-optic paths. And while there is a lot of fiber in the ground, almost all of the RBOC fiber is dedicated to linking their central offices together and to the long-distance carrier points of presence. As a result, it will be a long and very expensive undertaking to get widespread availability of full-band SMDS. Second, the SMDS switches are very expensive. Even a small switch in a minimal configuration is several hundred thousand dollars. By the time you get something that will be usable in a metropolitan service area, you're starting to talk about some *serious* money. This leads to another problem: Federal Communications Commission (FCC) and state regulation of the RBOCs.

Since it's clearly going to be very expensive to build full-band SMDS networks, the RBOCs will likely be required to price service in a way that avoids something called cross-subsidization. That is, the revenue gained from SMDS pricing must pay for the costs of building and operating the network, taken over some time frame. This is to prevent the folks at home using plain old telephone service (POTS) from seeing rate increases to help the phone company pay for its fancy new technology. It's all political, messy and generally unpleasant for all parties involved when such issues arise.

The bottom line is that while SMDS is very attractive and holds promise for the future, it won't make a big difference in your life soon. At least not at speeds greater than T-1.

MDS: Fiber in the City

Which brings us to the Multimegabit Data Service (MDS), available from Metropolitan Fiber Systems and its sister company, MFS Datanet (see "Bringing the Fiber to Mohammed").

The basic MDS services are Ethernet and token ring, with Fiber Distributed Data Interface, Channel Extension and "Special Services" (i.e., custom-engineered stuff) available as well. The Ethernet and token-ring services come in a reduced rate service at less-than-LAN speed, a dedicated service that guarantees that you always have 4, 10 or 16 Mb/s available and a switched service that provides a lower cost service through a switched fabric, much like SMDS or frame relay does.

Unlike leased lines, frame relay or SMDS, the MDS services don't require special interconnection equipment like Channel Service Units (CSUs) or the like. The hand-off from the MDS network to the customer is a LAN connector--an Ethernet

Attachment Unit Interface (AUI), for example– to which you can connect the same type of equipment used internally. This simplicity of service seems to have great appeal because you no longer have to be a telephony expert to design a MAN–you just treat the network like all of the segments are in one building and order MDS segments to link the buildings up like a LAN backbone.

There are some disadvantages, though. If you are not in a city served by MFS, you are out of luck. If you are in an MFS city, but not in a building which is linked via fiber, you may or may not be able to have service (MFS may elect to add your building to its network). And if you need service outside of your metropolitan area, MFS can help you design your network to most effectively use its service and provide very low-cost leased lines to the long-distance carrier of your choice, but it currently doesn't do customer WANs as a service.

There's Always Fedex

So concludes our romp through WAN land. If you need a low-speed network, there are a variety of options available. If you are looking for something small today that has a growth path to higher speed networking, then you'd probably be best off choosing SMDS or MDS if it is available in your area. If you know that you will need high-speed networking sometime in the next year or two, then you can plan on things being very different than they are today. SMDS, frame relay and MDS will probably still be with us, but there may be other better alternatives. Or you could just let Federal Express be your network. Never underestimate the bandwidth of a box of Exabytes!

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