Digital Subscriber Line Access Multiplexer (DSLAM)

Definition

A digital subscriber line access multiplexer (DSLAM) delivers exceptionally highspeed data transmission over existing copper telephone lines. A DSLAM separates the voice-frequency signals from the high-speed data traffic and controls and routes digital subscriber line (xDSL) traffic between the subscriber's end-user equipment (router, modem, or network interface card [NIC]) and the network service provider's network.

Overview

This tutorial will examine strategies for improving upon and maximizing the benefits of DSL technology deployment and identifying those products and services that best increase carrier revenue yield.

Topics

1. DSL Background

DSL technology is a new platform for delivering broadband services to homes and small businesses. DSL can support a wide variety of high-bandwidth applications,

such as high-speed Internet access, telecommuting, virtual private networking, and streaming multimedia content. In the past, these services were either not possible to support or were ineffectively supported by conventional, dial-up, data-delivery technologies. DSL can transmit more than 8 Mbps to a subscriber—enough to provide Internet access, video on demand (VOD), and local-area network (LAN) access. This increases the existing access capacity by more than fiftyfold, enabling the transformation of the existing public network. No longer is this network limited to voice, text, and low-resolution graphics. It promises to be nothing less than a ubiquitous system that can provide multimedia (including full-motion video) around the globe.

To enable this technology, service providers must have a DSLAM located in their networks to interact with the customer premises equipment (CPE) at the end-user location.

2. DSL Services, Their Applications, and Market Segments

The three main DSL service types—asymmetric DSL (ADSL), symmetrical DSL (SDSL), and integrated services digital network (ISDN) DSL (IDSL)—each enable different applications and serve differentiated markets.

ADSL fulfills the needs of the mass market of residential users, as its asymmetry is ideal for using the World Wide Web (WWW). Full-rate ADSL provides roughly 8 Mbps downstream and 0.64 Mbps upstream, while lite versions will provide roughly 1.5 Mbps and 0.5 Mbps. As a result of its mass-market appeal and its ability to counter the cable-modem threat, ADSL is expected to take the largest share of the three DSL varieties. End-user pricing for ADSL service generally runs from $40 to $100 per month, depending on the speed.

While ADSL is likely to be the most attractive option for casual Internet users, SDSL is the most popular with businesses and teleworkers. SDSL meets the requirements of these segments, because symmetric bandwidth up to 1.5 Mbps mimics LAN connectivity. This enables workers to send and receive large files from corporate servers with high speed in both directions. As the business and teleworker segments are predicted to be early adopters of DSL services, SDSL is an important offering. SDSL is also generating significant interest in the telco industry because symmetry provides an advantage over cable modems. Because SDSL serves the less price-sensitive and more service-conscious business segment, it is priced higher than ADSL—usually around $150 per month.

IDSL serves a unique market segment as a result of its greater reach. Typical IDSL speeds are 128 or 144 kbps, symmetric, and the technology is ideal for any customers too far from the central office (CO) for ADSL or SDSL, as well as any customers wanting to preserve their existing ISDN CPE.

The Multiple Benefits of Multiservice DSLAMs

To offer a menu of DSL services cost effectively, carriers must deploy these services from a single integrated DSLAM platform. Unfortunately, most of the DSL systems available today cannot accommodate the full suite of DSL technologies. This leaves a service provider with the following three choices:

- deploy a limited DSLAM and ignore some market segments
- serve the whole DSL market by deploying multiple DSLAMs from different vendors
- deploy a multiservice DSLAM with the ability to serve the entire broadband-access marketplace

A multiservice DSLAM is a broadband-access network element (NE) that combines support for multiple DSL transmission types. When coupled with high-capacity asynchronous transfer mode (ATM) switching, multiservice DSLAMs deliver scalability, port density, and a redundant architecture for reliability. Multiservice DSLAMs, together with various CPE elements, can enable the relatively efficient deployment of broadband networks for high-speed Internet access as well as voice and video applications. Such DSLAMs often allow for full ATM switching, traffic management, and quality of service (QoS), in addition to the delivery of a full range of services. These services include analog, ISDN, IDSL, SDSL, rate-adaptive DSL–competive access provider (RADSL–CAP), and RADSL–discrete multitone (DMT) on a single platform.

The multiservice DSLAM can also be configured to add value in the form of routing and security functionality. The device is intended to enable service providers to optimize the bandwidth of existing infrastructure as well as deliver high-speed, integrated services over a single physical-access medium.

DSLAM Scalability: Avoiding the Hidden Costs of DSL Deployment

One of the costs of scalability is in network management. The costs associated with network management will be roughly proportional to the number of NEs. A carrier with an evolving DSL network may have to do four software upgrades each year: two scheduled upgrades and two bug fixes. Suppose that each upgrade takes two hours to download and verify correct operation at each NE. At a fully loaded cost of $100 per hour for the network manager's time, this represents an annual cost of $800 per element. Software upgrades are only one category of management cost; others would include installation of added work stations, alarm monitoring, and periodic maintenance. The total annualized network-management costs could easily approach $2,000 per element.

Trunking—the Largest Hidden Cost

Even more significant than network management will be trunking costs. In the year 2002, when there are an average of 2,000 xDSL lines deployed at each CO, Carrier A's DSLAMs would require an optical carrier (OC)–3 trunk for each group of 500 lines, while Carrier B's DSLAMs would need only one trunk for each group of 2,000 lines. In addition to needing fewer trunks, Carrier B can also aggregate more traffic onto each and therefore utilize higher-speed trunks as well. The prices of trunking are not linearly proportional to bandwidth, so the higher-speed trunks will save significant costs for Carrier B. Suppose that digital signal (DS)–3 trunks cost $3,000 per month, and OC–3 trunks have a value of $6,000 per month. These values represent cash costs to a competitive local exchange carrier (CLEC) and opportunity costs to an incumbent local exchange carrier (ILEC). In either case, they are real and affect the bottom line. In our example, Carrier A will experience annual trunking costs of $144 million, while Carrier B will only have costs of $36 million. Even if Carrier A only uses DS–3 trunks for each 500-line group, its annual trunking expense would still be $72 million—twice what Carrier B must pay.

3. Remoteability

Remoteability is the ability to deploy the minimum amount of technology required to support the demand of a given market segment, multidwelling unit (MDU), or neighborhood and then scale that equipment up to meet demand. This allows a lower breakeven point for entry into new markets and more economical growth and demand warrants.

A DSLAM's remote solutions bring DSL capability into areas that require only a handful of DSL lines (e.g., a message display unit [MDU]), as well as into areas requiring a substantial number of DSL lines (e.g., large remote terminal sites). Scalable uplink solutions are also provided so that uplink capacity can be appropriately matched with traffic, thus putting uplink tariff costs in line with revenue generated from the line services.

DSLAM remote options may include a remote line-card shelf (RLCS) and a remote access module. A remote access module should be environmentally hardened for installation in outside digital-loop carrier (DLC) cabinets and be rack- or wall-mountable for remote indoor applications.

4. The Importance of QoS in the Local Loop

The need for QoS functionality in the access portion of data networks is stronger than ever. The rising volume of data traffic, which some analysts estimate doubles every six months, guarantees that access networks will face congestion, regardless of their speed. New applications, such as packetized voice and video, are increasing the amount of delay-sensitive traffic on these networks. QoS prioritization is needed to assure that this delay-sensitive traffic traverses congested networks in a timely fashion.

Even without new real-time media applications, QoS still contributes to the DSL service provider's product portfolio by allowing a better differentiation between data services. This differentiation allows for a suite of differently priced services that can better serve the needs of individual customers and maximize the provider's revenue yield. Such differentiation is only possible with network technologies that incorporate QoS mechanisms, such as ATM.

ATM technology was architected from the ground up to provide standards-based QoS mechanisms. Today, ATM remains far ahead of other protocols in enabling multimedia applications and differentiated service levels. The connectionless nature of Internet protocol (IP) has hampered the development of QoS in IP networks. However, new Internet Engineering Task Force (IETF) work currently in progress may lead to standards-based IP QoS in the future. The addition of QoS features to IP–based networks through new IETF standards such as multiprotocol label switching (MPLS) will complement ATM–based local access QoS and bring end-to-end Internet and virtual private network (VPN) QoS closer to reality. These new standards make it clear that the data-networking industry is moving toward next-generation networks with QoS functionality.

QoS Enables New DSL Services

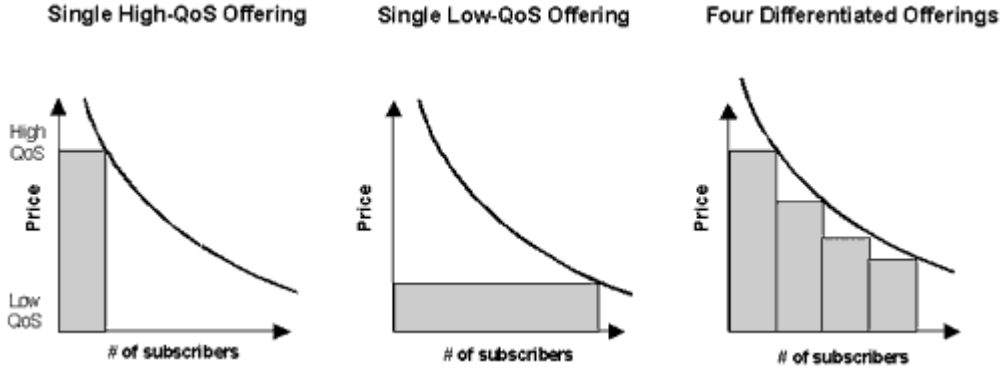
QoS functionality allows for the prioritization of some types of traffic over others when a network becomes congested. In addition, QoS also provides mechanisms for the network to control the delay characteristics (both latency and jitter) of high-priority traffic. Together, prioritization and delay control enable the transmission of real-time voice and video streams. In the past, high-quality voice could only be sent over time-division multiplex (TDM)–based networks (i.e., the public switched telephone network [PSTN]). Today, QoS in DSL–powered local loops has enabled a new service: mixed voice telephony and data service over a single copper pair.

QoS Maximizes DSL Service Providers' Revenue Yield

In addition to enabling new services, QoS allows for differentiation and, hence, increased revenue yield from basic data services. Without QoS, carriers can offer data service at different speeds, but these nominal speeds are often not meaningful because they represent the maximum possible transmission rate, not a guaranteed minimum throughput. With QoS, carriers can guarantee specific data rates to their clients, thus more finely differentiating between services.

Consider the examples in the figure below. Each graph shows the basic price versus quantity demand curve. At higher prices, fewer subscribers choose to purchase the service, while at lower prices the number of customers increases. The area under the curve represents a 100-percent revenue yield from the market: customers are paying the maximum they are willing to pay. For DSL data service, higher prices translate into higher guaranteed data rates (high QoS), and lower prices represent lower guaranteed rates (see *Figure 1*).

Figure 1. Differentiated Services Yield Highest



Revenues

Without QoS mechanisms in a network, a carrier has two basic choices: over-engineer capacity on the network so that all customers get a high level of service, or under-engineer so that all customers receive poor service on a congested network. Providing a high level of service at a high price is depicted in *Figure 1* on the left. Only a few subscribers will choose to pay the high price of this premium service, leaving a large amount of potential revenue unrealized. Providing a low level of service at a low price is shown in the center. This mass-market approach produces a large customer base but not a good revenue yield.

With QoS, a carrier can offer different levels of service to customers at different prices, all on the same network. By setting each client's QoS parameters based on his or her monthly fee, the carrier can provide as much guaranteed bandwidth to

each customer as is desired. Likewise, the carrier is receiving from each customer the maximum service fee the customer is willing to pay, thus maximizing the overall revenue yield from the market. The right section of *Figure 1* illustrates the increased revenue yield obtainable with four distinct service offerings; note that the yield is significantly higher than with either single-offering approach. This case is analogous to having a car dealership that sells everything from a moped to a Mercedes. For whatever amount the customer wishes to pay, the carrier has a service to offer. The carrier can cater to the customer's specific needs, and no customers will be forced to go to a competing carrier to find that for which they are searching.

5. Voice over DSL (VoDSL)

To date, the telecom industry has considered DSL a data-oriented service. The explosive growth in Internet traffic to homes and businesses has been the primary driver of DSL's deployment as a replacement for both dial-up modems and fractional T1 data services. However, data CLECs are discovering that adding voice services to their portfolio yields an attractive business model, and ILEC's are discovering that VoDSL allows them to free up valuable PSTN facilities. Although voice and data traffic are of roughly equal magnitude in terms of bits transmitted, voice services command over 90 percent of telecom revenue. CLECs wishing to capture a share of this lucrative market are examining solutions to providing voice service to their small-business DSL customers.

The Business Case for VoDSL Service

Packetized voice, the transmission of telephone calls over a data network with xDSL as the access method, is widely predicted to become a reality over the next five years. International Data Corporation (IDC) research forecasts that telephony on packet networks will grow from $2 billion in service revenue in 1998 to over $25 billion in 2002, capturing a 20-percent share of all telephony worldwide.

There are many compelling reasons why packetized voice makes sense. Using the same network for data and voice allows the most efficient use of available bandwidth and also enables more intelligent value-added services, thus decreasing costs while increasing revenues. These benefits are industry-wide, accruing to both ILECs as well as CLECs.

Packet-based, or data CLECs who offer DSL–based data service, stand to benefit even more from VoDSL than the industry as a whole. These CLECs, such as Covad Communications, NorthPoint Communications, and Rhythms NetConnections, are discovering that adding voice capability to a DSL infrastructure originally justified by data services yields an excellent return on investment. The bandwidth available on a single DSL circuit allows the carrier to

provide data services in the range of hundreds of kbps and also accommodate 4 to 16 plain old telephone service (POTS) lines. The incremental revenues and costs associated with these POTS lines form a compelling business case, as shown in *Table 1*.

Table 1. CLEC's Revenues and Costs Associated with Data and Voice Services

	Data-Only Service[1]	Incremental Revenue and Cost for Adding Voice[2]	Total for Data + Voice DSL Line
Monthly Revenue	**$125.00**	**$160.00**	**$285.00**
Monthly Recurring Costs			
co-location space	$10.00	—	$10.00
local loop rental	$20.00	—	$20.00
traffic backhaul from DSLAM	$5.00	$5.00	$10.00
network management, operation	$15.00	$10.00	$25.00
Monthly Amortized Capital Costs[3]			
truck roll	$10.00	—	$10.00
DSLAM equipment	$10.00	—	$10.00
DSL CPE equipment	$10.00	$30.00 (IAD)	$40.00
voice gateway equipment	—	$6.00	$6.00
class-5 switch ports	—	$9.00	$9.00
Total Monthly Costs	**$80.00**	**$60.00**	**$140.00**
Contribution Margin	**$45.00**	**$100.00**	**$145.00**
Margin	**36%**	**63%**	**51%**

Notes

The figures shown are per–DSL circuit, per month.

[1]assumes carrier has 500 DSL lines per CO; data service is assumed to be at 384–kbps symmetric

[2]assumes each DSL line with voice capability carries 8 POTS circuits, with each POTS circuit generating $20 of net revenue per month; costs of voice gateway and Class-5 switch ports assume a 4-to-1 oversubscription of POTS circuits

[3]amortized over 36 months

This analysis shows that while providing data-only service over DSL is an attractive business, adding voice services for a customer dramatically increases

revenue with minimal costs. The major costs associated with adding voice capability are an integrated access device (IAD) at the customer premises, a voice gateway, and a Class-5 switch at the carrier's point of presence (PoP). Or, these services may be leased from a co-lo hotel, with additional network-management costs. Also, allowance has been made for increased backhaul costs as a result of the higher QoS requirements. *Table 1* clearly shows that voice on DSL lines is a winning proposition, providing the additional contribution margin needed to support the CLEC's overhead, SG&A, and profitability.

6. The Importance of Rapid Deployment

Time has become the most valuable commodity in the DSL industry. With the number of DSL subscribers in the United States doubling each quarter during 1999, it has become clear that any carrier considering a serious DSL rollout must act quickly. A window of opportunity will soon close. Those who have not built a DSL business by the end of 2000 will be left behind. By then, there will be over two million active U.S. customers on DSL lines, and virtually every major U.S. city will have installed DSLAMs in its COs. Early-adopter customers who have not been signed up by this time will go to another DSL carrier or to cable modems. Floor space in the most desirable COs will soon be gone, with multiple DSL CLECs competing in each region. Furthermore, mass media marketing of DSL is already underway; any carrier without a DSL brand presence will soon be hard-pressed to compete for mindshare. The stock market values Bell companies at over $2,000 per subscriber; therefore, there are tens of billions of dollars of value at stake over the next three years, as 10 million DSL subscriptions are sold in the United States.

The clear imperative is to deploy a DSL network footprint rapidly and begin provisioning customers on the service. To succeed at this in a competitive environment, allies are needed. Equipment providers can supply an often-overlooked source of support for the carrier. Too often, vendors are thought of simply as a source of NEs or boxes. The wise carrier, however, knows that vendors can be much more.

Services and Support

Network infrastructure providers can supply much-needed project management; engineering, furnishing, installation (EF&I); and support. For a DSL carrier looking for a turnkey, rapid deployment solution, these services are absolutely critical. The expertise of an experienced equipment vendor can fill gaps that a carrier will have with a new technology such as DSL.

Although every telecom gear supplier provides some level of support, the differences are in the details. Every carrier should ask itself the following questions:

- How much experience does the supplier have in project-managing rapid deployment of DSL networks?
- Will your supplier help you design a network that scales and fits your needs?
- To whom has the supplier provided these services before?
- What is the vendor's EF&I capability?
- How responsive is the carrier support organization?
- Will you dedicate technicians to support your rollout locally?
- Is the support proactive or evident only when you point out problems and issues?
- Will the supplier help with training your employees on the equipment and the technology?
- Is assistance with spare-part management available?
- What is the response time to trouble calls?

Only with this type of information can a carrier entering the DSL arena make an intelligent choice about who to choose as an ally.

Complete Equipment Solutions

Although a DSLAM is the central element in a DSL access network, its usefulness is determined by the other network components that surround it. For example, a subscriber management device, such as a subscriber management system (SMS), can ease the burden of provisioning subscribers on the service. An SMS allows for different users to be easily and flexibly connected to various Internet service providers (ISPs); this is a key functionality for LECs using an ISP resale channel. In addition, an SMS allows for custom portals and content, thus transforming DSL from commodity high-speed access into branded value-enhancing services.

A metallic-layer CO cross-connect device can alleviate many of the costs and delays of DSL deployment and provisioning. Upon attempting to turn up a customer on DSL, a carrier often finds that the service offered will not reach the customer's premises, as a result of loop length or quality issues. Instead, the user must be moved to a different, lower-speed service, such as IDSL or G.lite ADSL. Without the ability to cross-connect loops remotely in front of the DSLAM, this switch to a new service would require extra truck rolls and technicians' time. A CO cross-connect allows new users to be turned-up quickly and efficiently on the

proper DSL service. In addition, a metallic cross-connect in front of the DSLAM also helps with remotely upgrading users to new services, or with automatically switching loops onto different DSLAM ports in the event of a DSL line-card failure.

VPNs are a very important high-speed access application, critical to the business and teleworker market segments. DSL CPE that can implement VPN functionality must be tested and integrated with CO DSLAM equipment, as well as with network-operations-center (NOC) gear, such as the previously mentioned SMS. A single source for VPN and DSL gear will ease the costs and delays associated with deploying this important application on top of DSL access.

Another key application emerging in DSL today is VoDSL. This delivery of packetized voice to small- and medium-sized entities (SMEs) over a single copper pair is seen as one of the most economically compelling applications of DSL in the upcoming years. However, its success hinges on the quality of the packetized voice, which in turn depends on the overall QoS properties of the DSL/ATM network. A successful rollout of VoDSL requires an end-to-end solution of CPE, DSLAMs, and gateways, which have previously been tested and deployed together in the field. Lab trials will not necessarily locate all of the problems with this type of system; the only way to know for sure that interoperability is seamless is to use a proven solution set.

Another often-overlooked piece of the solution set is customer-care and billing software. There are many software packages available, and a carrier could even make its own. The difference between one that helps rapid DSL deployment versus one that hinders it is how well the software integrates and interfaces with the DSLAM. An ideal DSLAM supplier will be able to supply its own customer-care and billing package, or at least assist the carrier in creating one with an effective visual interface to its network of DSLAMs.

With so many necessary hardware and software elements, a DSL carrier can easily become overwhelmed with systems-integration issues. A vendor that can supply a completely tested and verified network solution provides enormous assistance to the carrier in the midst of a rapid DSL deployment. It does not make sense for a carrier to become mired in testing equipment-interoperability issues, when vendors with broad product lines are already performing this task themselves. Shorter time to market is possible by outsourcing system verification to the test labs of a vendor with a broad product portfolio.

DSLAM Scalability and Management

Today, with the fast proliferation of DSL across the United States, leading carriers have DSLAMs in over 1,000 COs. Within those COs, the number of subscribers are growing at exponential rates. Clearly, scalability of DSL equipment is mandatory for keeping such networks under control. A carrier must

be able to manage 1,000 customers out of a CO as easily as a dozen. NE proliferation must be avoided as the customer base grows and more infrastructure equipment is added.

The key issue a carrier must address when selecting a DSL architecture is how the DSLAM scales as the number of active subscribers per CO grows into the thousands. How many subscribers can a DSLAM handle and still be managed as a single NE? It is important not to confuse this metric with the often-quoted figure of number of subscriber ports in a single bay. The number of ports per bay measures the physical density of the system, which is usually made irrelevant by the power restrictions placed by network equipment building standards (NEBS) rules. However, the logical scalability of the system, measured in number of subscribers per managed-NE, is absolutely critical to the manageability of a DSL network as the number of users grows by orders of magnitude.

Field-Proven Equipment

For rapid deployment, there is no time to struggle with bugs and software patches to fix them. For a DSL carrier, a stable and reliable DSL system with at least two years of history supporting revenue deployments is a must. It is important to understand the difference between a customer being the hundredth or the hundred-thousandth customer with service provided by this platform. The difference between deploying and managing a three-month-old platform and a 30-month-old platform is tremendous. In a rapid-deployment phase, there will not be time to iron out the wrinkles. Too many pressing issues will present themselves to a new DSL carrier; fear for the DSLAM and the software that makes it run is an Achilles' heel. One must look to the equipment provider so as to understand exactly how stable the system is, how much testing it has undergone, and how much time will be spent maintaining it.

Equipment Financing

No carrier should overlook the financial partnership options available with an equipment vendor. For an upstart carrier, equipment financing can make the difference between financial success and failure. Equipment financing can best be considered a source of medium-term financing upon which to rely, even when the capital markets turn down. For an incumbent carrier with significant financial resources, equipment financing can still be attractive, as it leaves capital resources to be spent on marketing, customer acquisition, and customer care in the critical early stages of an exploding market.

Carriers should look to their vendor partners for financial assistance in the form of flexible equipment-financing packages. Generally, these packages will take the form of a lease, but, when appropriate, could even extend beyond a typical lease into the arena of risk sharing. A vendor partner with solid financial strength and

experience in DSL rollout financing is an excellent resource for fueling rapid deployment.

Applications, Marketing, and Branding Support

Vendors with experience in high-speed access can also lend a hand with understanding the key applications of bandwidth and how to market them. Furthermore, global vendors know how end-user applications vary around the world. High-speed access enables much more than just faster WWW downloads; other exciting applications exist that can be marketed to drive DSL adoption. A vendor partner will have relevant market research that can help jump-start a carrier's marketing of DSL.

Eventually, residential DSL service will move to a retail CPE distribution model. When this happens, consumer brand identity will become a critical element in DSL marketing. A vendor with a strong brand image will be a valuable partner in the retail channel. Many customers may first visit their retail store to inquire about DSL, rather than first calling a carrier's toll-free number. This is a scenario typical of the cellular-telephony market today. In this model, comarketing with a well-known CPE brand will be an invaluable channel for signing up new users.

Furthermore, a leading-edge partner can assist with creating value and differentiation through innovative CPE offerings. To the public, a DSL line will soon become a well-understood and common commodity. However, a carrier will be able to create differentiation via CPE, which provides additional value to the user. For example, wireless LAN CPE can prove valuable to a small business operating in an environment that requires mobility or in an office space that is not prewired for voice and data. Another example is home-networking CPE and other consumer applications that create the residence of the 21st century. DSL is only the entry point to the user's site; the unique value that will create customer loyalty is in applications.

Vendors as Partners, Not Just Suppliers

A vendor willing to operate as a partner will work with a company to understand its deployment plans and schedules. Equipment order lead times can be minimized by cooperation in this regard. How well a vendor can respond to orders for equipment and how tightly integrated a carriers forecasting will be with the vendor's manufacturing planning are factors that must be considered. A true partner will work with a carrier to ensure that carrier's success.

Additionally, a vendor will work with a carrier to make sure that it can support the carrier's company's strategic plans. Even for a start-up CLEC focused today on DSL, DSL is likely not the only access technology in its future. To broaden their product portfolio and accessible market, carriers will consider also using T1,

frame relay, wireless, and POTS as access methods. A vendor working as a strategic partner will help not only with understanding which technologies are appropriate, but also how they can be integrated into the same access platform and management system.

From financing, to project management, branding, and marketing guidance, the overall lesson of this analysis is to think of an equipment vendor as a source of much more than hardware and software. Successful and rapid deployment requires a real partnership between carriers and equipment vendors. There is much more to be gained from a large, experienced vendor than infrastructure equipment.

Self-Test

1. Which of the following is expected to take the largest share of the three DSL varieties?

    a. SDSL

    b. ADSL

    c. IDSL

2. Which of the following is expected to be most popular with businesses and teleworkers?

    a. SDSL

    b. ADSL

3. Which of the following is ideal for the price-sensitive portion of the small-office/home-office (SOHO) market?

    a. SDSL

    b. ADSL

    c. IDSL

4. To offer a menu of DSL services cost effectively, carriers must deploy these services from a single integrated DSLAM platform.

    a. true

    b. false

5. At present, high-quality voice can only be sent over TDM–based networks.

    a. true

    b. false

6. Which of the following protocols is better for enabling multimedia applications and differentiated service levels?

    a. ATM

    b. IP

7. Which of the following commands over 90 percent of telecom revenue?

    a. voice

    b. data

8. With packetized voice, only one network connection and one service provider must be managed.

    a. true

    b. false

9. Time is the most valuable commodity in the DSL industry.

    a. true

    b. false

10. Lab trials will be able to determine if interoperability is seamless among CPE, DSLAMs, and gateways when rolling out VoDSL.

    a. true

    b. false

Correct Answers

1. Which of the following is expected to take the largest share of the three DSL varieties?

    a. SDSL

    b. ADSL

c. IDSL

See Topic 2.

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    b. false

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Glossary

ADSL
asymmetrical DSL

ATM
asynchronous transfer mode

CLEC
competitive local exchange carrier

CO
central office

CPE
customer premises equipment

DLC
digital loop carrier

DMT
discrete multitone

DS
digital signal

DSL
digital subscriber line

DSLAM
digital subscriber line access multiplexer

EF&I
engineering, furnishing, installation

IAD
integrated access device

IDC
International Data Corporation

IDSL
integrated services digital network DSL

IETF
International Engineering Task Force

ILEC
incumbent local exchange carrier

IP
Internet protocol

ISDN
integrated services digital network

ISP
Internet service provider

LAN
local-area network

MDU
message display unit

MDU
multidwelling unit

MPLS
multiprotocol labeling system

NE
network element

NEBS
network equipment building standards

NIC
network interface card

NOC
network operations center

OC
optical carrier

PoP
point of presence

POTS
plain old telephone service

PSTN
public switched telephone network

QoS
quality of service

RADSL–CAP
rate-adaptive DSL–competive access provider

RLCS
remote line-card shelf

SDSL
symmetrical DSL

SMEs
small- and medium-sized entities

SMS
subscriber management system

SOHO
small office home office

TDM
time division multiplex

VOD
video on demand

VPN
virtual private network

VoDSL
voice over DSL

WWW
World Wide Web