Copper Loop Management in a Digital Environment: Migration from an Analog to a Digital Local-Loop Network

Definition

The copper local loop is evolving from an analog network optimized for telephony to a broadband digital network capable of delivering voice, high-speed data, and other value-added communication services. Supporting this network will require a new approach to local-loop management.

Overview

This tutorial explores the evolution of the local loop, with emphasis on new service opportunities enabled by digital subscriber line (DSL) and the need for an alternative approach to local-loop management.

Topics

1. Introduction

The copper local loop is going digital. The local loop, the twisted-pair network that delivers telephony services to homes and small to medium-sized businesses, is evolving to become a broadband network capable of delivering high-speed data and other value-added communication services (see *Figure 1*). To date, the local loop has bottlenecked service provider's high-speed backbone networks. Existing analog technology in the local loop limits the bandwidth between the subscriber and the central office (CO) to 56 kbps. But by integrating new technologies into today's twisted-pair, local-loop network, service providers are discovering that the same lines that deliver standard telephony services or 56–kbps, dial-up data access can now economically deliver high-speed data plus multiple voice connections. DSL technology is enabling this new generation of service. Historically, high-speed data service has primarily been delivered via T1 lines to businesses. A 1.5–Mbps high-speed data service delivered via a traditional T1 line is typically priced at $350 to $650 per month. With DSL over the copper local loop, service providers are now offering 1.5–Mbps data service for $140 per month (see *Figure 2*).

Figure 1. The Local Loop

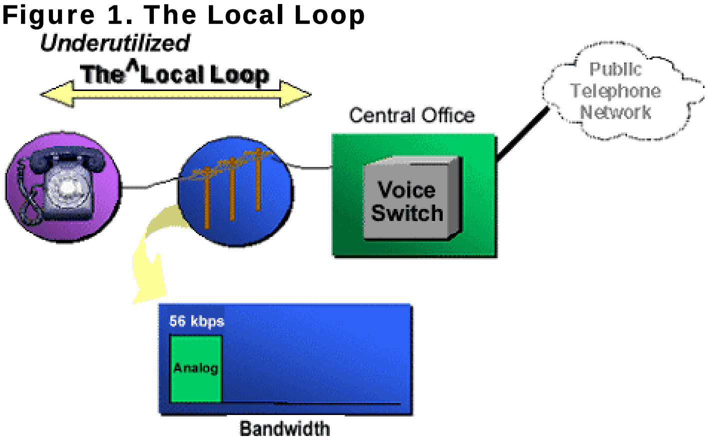
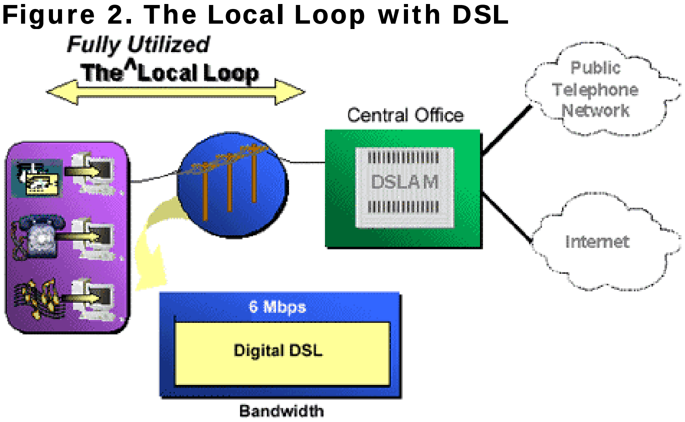


Figure 2. The Local Loop with DSL



Offering high-speed data service over the copper local loop is achieved by integrating DSL equipment at the subscriber premises and at the edge of the service-provider backbone network, typically at the CO. With DSL technology integrated into the local loop, information is transmitted as digital signals at much higher frequencies than for traditional analog telephony transmission. This enables more communications traffic to be transmitted over an existing twisted pair. But installing and managing this network requires new local-loop management tools and strategies optimized for broadband digital transmission and rapid network deployment.

2. Local-Loop Service Opportunities

Competition in the communications services market is strong. Competitive service providers have successfully penetrated some segments of the communications services market. For example, large businesses have multiple choices for voice and data service providers. But for residential and small to medium-sized business customers, representing 88 percent of communication service access lines, service choice and service-provider choice is only recently emerging.

High-Speed Data Services for Residential and Small- to Medium-Sized Business

Although successful with large business customers, competitive service providers have had difficulty establishing profitable business models to offer services to residential and small to medium-sized business customers. Building a network from scratch is too costly and reselling incumbent local exchange carrier (ILEC) services leaves slim margins and little room for differentiation. But the Telecommunications Act of 1996 and the availability of DSL technology are changing this. Competitive local exchange carriers (CLECs) can now lease copper local-loop pairs from the ILECs. By integrating DSL technologies into the local loop, ILECs and CLECs are transforming the local loop into a network capable of delivering high-speed data services. ILECs recognize the opportunity to increase revenues by leveraging the existing copper plant to deliver cost-effective, high-speed data services to their customers. Armed with DSL and leased copper loop pairs, CLECs are rapidly expanding revenues by selling high-speed data services to residential and small- to medium-sized business customers.

Multiline Voice Services

In addition to high-speed data services, DSL is a cost-effective means of delivering multiline voice services. With voice over DSL (VoDSL), multiple voice lines can be multiplexed and delivered over a single local-loop DSL connection.

Basically, the same line that traditionally supported a single voice telephony connection can now support multiple voice lines and high-speed data. Both ILECs and CLECs have discovered that VoDSL allows them to generate significant additional revenues from local-loop pairs. In some geographies, ILECs are running out of copper lines. Running new lines out to subscriber premises is expensive. With VoDSL, ILECs can run multiple phone lines over a single copper loop pair, eliminating the expense of pulling new lines to the subscriber. Voice CLECs also see a strong opportunity in VoDSL. Voice CLECs have invested heavily in voice equipment to offer service to large businesses and institutions. But as a result of the high cost of network buildout and the small margins associated with reselling ILEC services, they lack a strong business case for targeting residential and small- to medium-sized businesses. However, by deploying DSL over the copper local loop, they believe they can leverage their voice services infrastructure investments and deliver an economical voice and data service solution to a large, previously unreachable segment of the market, as well as serve their existing customers more cost effectively.

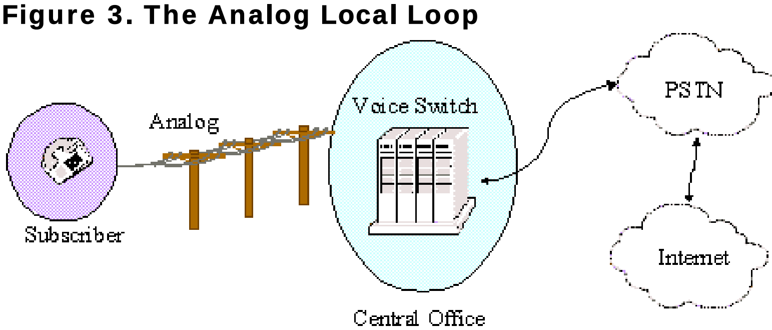
Furthermore, DSL broadband networks are not limited to delivering multiline voice and high-speed data; they provide the network foundation necessary to expand services to include enhanced voice, data, and video.

3. The DSL Local Loop

To deliver these new service capabilities, the local-loop network is evolving from an analog narrowband network optimized for voice traffic to a digital broadband network engineered for voice, data, and video.

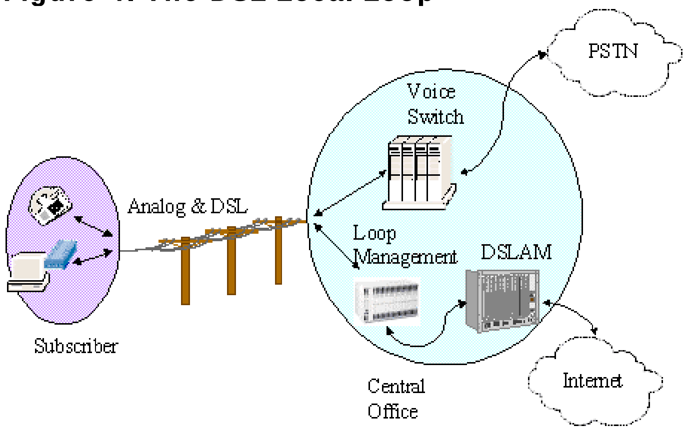
The traditional analog local-loop network transmits narrowband analog signals between subscribers and voice switches in the public switched telephone network (PSTN). This network is optimized for telephony and limited in bandwidth (see *Figure 3*).

Figure 3. The Analog Local Loop



With DSL technology, the copper twisted-pair lines remain the same, but new equipment is integrated, enabling a service provider to deliver voice and high-speed data service (see *Figure 4*).

Figure 4. The DSL Local Loop



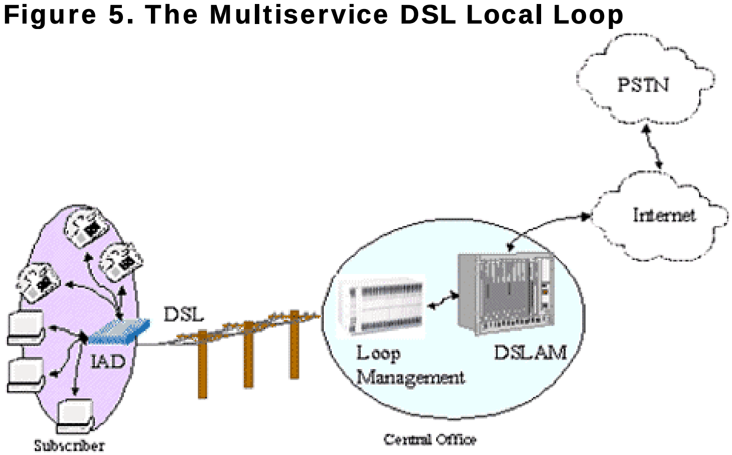
At the subscriber, voice traffic is transmitted as standard analog telephony signals into the copper local loop. Data traffic is transmitted over the same line but via a DSL modem that transmits the data as high-frequency digital broadband signals. These signals are transmitted from the subscriber to the service-provider CO.

At the CO, the signals pass through a splitter and a local-loop management system to a digital subscriber line access multiplexer (DSLAM). The splitter filters the standard telephony signals and passes them to a voice switch. The broadband digital signals are directed to a DSLAM that terminates and consolidates traffic from multiple local loop lines. The loop management system may be in front of or behind the splitter and provides protection switching, metallic access, plain old telephone service (POTS) testing, and broadband digital testing to aid service installation, troubleshooting, and maintenance.

From the DSLAM, the traffic is sent to a router that directs traffic to the Internet.

To deliver high-speed data and multiple voice lines, additional equipment must be integrated into the network (see *Figure 5*).

Figure 5. The Multiservice DSL Local Loop



At the subscriber, voice and data lines are connected to an integrated access device (IAD) where voice is packetized and the packetized voice and data are multiplexed and transmitted as digital high-frequency broadband signals to the CO.

At the CO, the signals pass through a local-loop management system and terminate on a DSLAM. The loop management system provides protection switching, metallic access, POTs and broadband digital testing to aid service installation, troubleshooting, and maintenance. The DSLAM terminates and consolidates traffic from multiple local-loop lines.

From the DSLAM, the packetized traffic is transmitted to the Internet and routed to the appropriate PSTN or Internet destination.

With this new digital local-loop network, the characteristics of the traffic traveling between the subscriber and the switching office are different than for a narrowband analog network. The traffic is sent at higher frequency through a broader spectrum. The information for multiple services, possibly multiple voice lines, high-speed data, and video is transmitted as a digital signal. To manage this network effectively, service providers need new tools and new network management strategies.

4. The Impact of DSL on Local-Loop Management

The migration from an analog to a digital local loop introduces several new loop management considerations.

Speed of Deployment and Maintenance

Strong demand for high-speed data service is driving massive deployment of DSL equipment. Deployment for a metropolitan area requires installing access equipment in hundreds of COs. Once access equipment is installed, subscribers can be provisioned for service. Provisioning a subscriber involves installing customer premises equipment (CPE), correctly connecting a copper local loop from the CPE at the subscriber to a DSLAM port at the CO, and initiating service. Staffing a field organization to meet the demand for this popular service is an enormous undertaking. The time that technicians spend traveling to a CO or to a customer site to install and provision service can delay initiation of service to the subscriber and delay realization of revenue and service profitability to the service provider. The time spent manually patching copper lines to initiate service, modify service, or bypass failed equipment slows deployment. Tools that remotely automate and facilitate installation, provisioning, line switching, and management of the digital local loop can reduce costs and speed deployment.

Loop Qualification

DSL requires high-frequency signal transmission over a copper plant optimized for low-frequency signals. Service providers need tools that allow them to analyze line suitability for higher-frequency signals. Not all lines can support DSL. Service providers must qualify lines remotely to determine whether and what type of DSL service may be supported. Ideally, this loop qualification should be integrated into service-provisioning operations support systems (OSSs), so that when a customer request for service is made, the line can be qualified remotely without the cost and delay of sending a technician on site.

Audible Loop Identification

Installing a DSL service to a subscriber requires connecting a DSL modem or IAD at the customer premises to one end of a copper local loop line and connecting the other end of the line to DSLAM equipment at the CO. To verify that the line is properly connected, it must be possible to generate an audible loop identification signal on the line at the CO. The technician installing CPE equipment at the customer premises uses this audible loop identification signal to verify that the line is correctly connected.

Provisioning, Testing, and Troubleshooting the Digital Local Loop

With DSL networks, signals are transmitted through a broader spectrum than for standard telephony networks. Service providers need metallic access to the local loop and test equipment that can remotely analyze digital broadband signals to aid troubleshooting and monitoring in the local loop.

Service Availability and Access Equipment Failover

With standard analog telephony services, subscribers dial into a switch or modem at the local switching office. If there is a failure, such as a line-card failure in the modem bank, then calls are dropped and the subscriber can redial to connect to the network. With DSL, subscribers are always on and connect directly to a DSLAM line-card port. If there is a DSLAM line-card failure, subscribers connected to the failed line card are out of service until the service provider can get a technician to the CO to patch around the failed card or replace the card. When access equipment fails, service providers need quick, cost-effective ways to reroute traffic to other equipment.

5. Loop Management Success in the Digital World

The race to deliver a new generation of services over the local loop is on. Service providers are investing in DSL technologies to increase bandwidth to subscribers and enable high-speed data and other value-added communication services. To successfully deploy and manage the new broadband digital local loop, service providers need tools that can remotely accomplish the following tasks:

- qualify the local loop to verify suitability for delivery of DSL services
- generate audible loop identification signals to aid service installation
- provide metallic access in the network and analyze broadband signals to aid troubleshooting and fault isolation
- provide metallic line switching for access equipment failover
- provide metallic line switching for service changes
- integrate loop management into the OSS environment to manage and deliver service efficiently

Today's reliance on troubleshooting on-site with tools optimized for narrowband analog telephony cannot meet the service provider's need to quickly and efficiently deploy and manage the emerging broadband digital local-loop network.

Self-Test

1. The copper local loop is the section of the public network that interconnects CO voice switches.

   a. true

   b. false

2. The local loop can transmit data at a maximum rate of 56 kbps.

   a. true

   b. false

3. DSL is a narrowband, analog technology.

a. true

b. false

4. DSL technology enables service providers to deliver high-speed data and multiline voice services over a single twisted-pair line.

    a. true

    b. false

5. A digital broadband network can be tested with the same tools used to test an analog narrowband network.

    a. true

    b. false

6. DSL will operate over any copper local-loop pair.

    a. true

    b. false

7. If a DSLAM fails at the CO, disconnecting a subscriber's service, the subscriber can redial to reconnect to the network.

    a. true

    b. false

Correct Answers

1. The copper local loop is the section of the public network that interconnects CO voice switches.

    a. true

    b. false

    See Topic 1.

2. The local loop can transmit data at a maximum rate of 56 kbps.

    a. true

b. false

See Topic 1.

3. DSL is a narrowband, analog technology.

   a. true

   b. false

   See Topic 1.

4. DSL technology enables service providers to deliver high-speed data and multiline voice services over a single twisted-pair line.

   a. true

   b. false

   See Topic 2.

5. A digital broadband network can be tested with the same tools used to test an analog narrowband network.

   a. true

   b. false

   See Topic 3.

6. DSL will operate over any copper local-loop pair.

   a. true

   b. false

   See Topic 4.

7. If a DSLAM fails at the CO, disconnecting a subscriber's service, the subscriber can redial to reconnect to the network.

   a. true

   b. false

   See Topic 4.

Glossary

CLEC
competitive local exchange carrier

CO
central office

CPE
customer premises equipment

DSL
digital subscriber line

DSLAM
digital subscriber line access multiplexer

IAD
integrated access device

ILEC
incumbent local exchange carrier

ISP
Internet service provider

OSS
operations support system

POTS
plain old telephone service

PSTN
public switched telephone network

VoDSL
voice over digital subscriber line