The Local Loop Adapts for New Roles

Bart Stuck

First it carried only voice, then data and increasingly video. New applications demand new solutions.

The local loop touches virtually every home and business in the U.S. While local loop originally referred to the copper wire pairs owned and operated by the LECs, during the past 15 years, other service providers have used different media to reach out and touch everyone. TV arrives via coaxial cable or satellite, optical fiber ups the speed of business connections, while cordless and cellular phone calls and paging messages ride the radio waves.

Complex and separate regulations control the use of local and long distance telephone service, cable TV and wireless spectrum. Restrained from participation in market categories other than their own, big players in each category merge and acquire their way around the rules and periodically mount campaigns to change them. As of early September, hot and heavy and lobbying was under way as Congress—and plenty of interested parties—tried to hammer out differences between the House and Senate versions of the telecom reform bill. One of the principal issues—the rules under which the local loop will be opened to competition and the LECs are allowed into long distance.

Whatever the outcome, new laws won't change the participants' common objective: to take customers from their competitors without losing the customers they have. And it won't change their common view of the access market: customers want bigger, faster pipes—and they don't want to pay too much for them.

What could change is the service providers' expectations: Will customers want one or more of these pipes, and if so, for what purpose? And what about all that legacy equipment—phones, TVs and PCs? No one really knows how big this high-speed access market pie can get, let alone how to label the slices. The scope of the current market is illustrated in Tables 1 and 2 (p. 56).

Two LEC Choices for Higher Speed on Copper

The LECs must upgrade their copper network access facilities to carry higher-bit-rate traffic (see "Copper Wire and Optical Fiber," p. 57). They will also have to drop prices to compete with other providers, but they can't do so too quickly, because they need to finance their copper enhancements. Strong cash flows from cellular subsidiaries will help some LECs—until cellular prices also have to be cut to compete with the interexchange carrier (IXC) wireless services.

The LECs have two basic choices for copper upgrades: Asymmetric Digital Subscriber Loop (ADSL) and High-bit-rate Digital Subscriber Loop (HDSL). HDSL products, which are currently available, are the current choice of most LECs, and the technique is relatively insensitive to both bridge taps (which need not be removed) and transmission distortions caused by wire gauge changes.

HDSL delivers T1/E1 over a single pair of copper wires, and reaches up to 9,000 feet without signal regeneration. HDSL upgrades typically support LAN interconnection on corporate and university campuses, and interconnect copper with digital wireline or microwave backbone networks for government agencies. The LECs have already installed over 100,000 HDSL circuits and are adding 40 to 45 percent more annually. BellSouth, for example, can turn around an HDSL installation in less than a week.

Bart Stuck is president of Business Strategies LLC (Westport, CT), a consultancy that specializes in business strategic planning for network computing and telecommunications.

TABLE 1 1994 U.S. Telecommunications Network Access Ports

Category	Ports	Source of Information
Total Telco Access Lines	147,850,397	FCC Common Carrier Stats
Television Households	95,100,000	Paul Kagan Associates, Inc.
Basic Cable TV Households	59,020,000	Paul Kagan Associates, Inc.
Pay-per-View CATV STBs	43,510,000	
Cellular Telephone Subs	24,134,000	Cellular Tel. Industry Assoc.
Digital Cellular Telephones	600,000*	Cellular Tel. Industry Assoc.
Paging Subs	24,500,000	Personal Comm. Industry Assoc.
Point-to-Multipoint Microwave Circuits	378,547	Volpe Welty
Analog TV Satellite Dish	4,200,000	U.S. Satellite Antenna Assoc.
Digital TV Satellite Dish	1,003,420	DirecTV
Optical Fiber Business Lines	8,694	Compet Acc Provider Assoc.
Optical Fiber Res. Lines	7,895	Goldman Sachs/Merrill Lynch

* The 600k is part of the Cellular Telephone Subs.

TABLE 2 Traffic/Port, Revenues/Port and Bit Rate

Category	Monthly Traffic	Monthly Revenues	Port Bit Rate
LEC Residential Access	1,000 minutes	$20–$30	64 kbps
LEC Business Access	4,000 minutes*	$50–$60	64 kbps
Basic CATV Service	180 hours	$20–$30	200+ Mbps
Cellular Telephone	140 minutes	$50–$60	19.2 kbps
Paging	50–100 messages	$40–$50	9.6 kbps
Digital TV Satellite Dish	180 hours	$40–$50	200+ Mbps
Optical Fiber Link**	200,000 minutes	$3,000+	155 Mbps

* Voice, modem, fax only; ** Customer access, not carrier network links.

An HDSL chip set is available from Level One Communications (Sacramento, CA), while PairGain Technologies (Cerritos, CA) is the leading HDSL equipment vendor. PairGain equipment costs about $2,000 for each end of the copper wire pair, and the price is likely to fall, since other vendors are expected to enter the market over the next several years.

In contrast, ADSL has been in development and trials since the late 1980s, when it was introduced by Bellcore (Livingston, NJ), but it is not yet available as a service. ADSL allows 7 Mbps (6 Mbps downstream to the customer, and 1 Mbps of two-way capability between the headend and the customer) over a single pair of copper wires at distances approaching 6,000 feet. Bit rates from 50 Mbps to 200 Mbps over shorter distances have been demonstrated in a lab environment. Among the pioneers in ADSL technology are Amati Corporation (Mountain View, CA), AT&T Paradyne (Largo, FL), and Orckit (Tel Aviv, Israel).

MSOs Chase Compressed Digital Video

The cable television Multiple Systems Operators' (CATV MSOs') coaxial network facilities currently provide a broadband channel between 40 and 500 MHz, with each analog TV channel consuming 6 MHz. To deliver more TV channels and to support additional interactive services (data and eventually voice), the MSOs are extending the channel to 750 MHz. The additional 250 MHz could break down into an additional 41 analog or digital channels.

Under the threat of direct broadcast satellite TV, which sold 1 million dishes in only a year, the MSOs have made more entertainment their top priority. In the next three years, both the direct broadcast satellite providers and the MSOs will deploy compressed digital video (CDV) technology. CDV uses MPEG encoding to pack four TV signals into a single 6-MHz channel, resulting in a 200-Mbps digital channel.

The MSOs' first offering is likely to be "Near-video-on-demand" (NVOD)—i.e., starting the same movie on different channels at half-hour intervals. The MSOs have ordered over 10 million set top boxes (STBs) to support this offering, at prices ranging from $250 to $300. STB vendors include General Instruments (Hatboro, PA), Intel (Santa Clara, CA), Scientific Atlanta (Norcross, GA) and Silicon Graphics (Mountain View, CA).

High-speed data services for telecommuters, interactive gaming, shopping and other services will follow. Cable Television Laboratories (CableLabs—Boulder, CO), has already issued a request for proposal for a digital modem that could use a 6-MHz frequency band to deliver 10 to 30 Mbps downstream from a headend to a subscriber, and an upstream rate of 20 to 128 kbps.

This month Cablevision Systems (Fairfield County, CT) will become the first CATV MSO to launch a modem service, using Hybrid Networks' (Cupertino, CA) modems to serve over 1,000 homes. Other vendors offering or developing high-speed modems include Digital (Littleton, MA), General Instruments, Hewlett-Packard (Palo Alto, CA), Intel, LANCity (Andover, MA) and Scientific Atlanta. Modem prices to the MSOs are initially expected to range from $300 to $400.

Although many applications could be supported by such asymmetrical services, if there are too many subscribers using the upstream channel, transmission bottlenecks could occur. Transmission rates can also be reduced by poor-quality coax, although the CATV MSOs are deploying more optical fiber in their backbone networks.

The MSOs have committed vast sums to these network upgrades, and they are highly leveraged. For example, as part of their Wireless Co. (Kansas City, MO) venture with Sprint, TeleCommunications Inc. (TCI—Englewood, CO), Cox (Atlanta), and Comcast (Philadelphia) have spent $2 billion on PCS licenses (and plan to spend another $8 billion) to be in the vanguard of residential and business wireless services. TCI alone has over $13 billion in debt and pays over $1 billion in interest annually. Yet, with $5 billion in annual cash flow, TCI is willing to risk $100 million in CATV PC modems, plus up to $125 million in equity investment in Microsoft's new network to see if there is an interactive pony in this pile.

Copper Wire and Optical Fiber

The traditional medium for telecommunications network access is copper wire, typically 24-gauge unshielded twisted pair (UTP), with 25 pairs per cable. Analog voice quality is acceptable up to a maximum distance of about 18,000 feet, with exceptions proving the rule.

Since copper wire pairs have been installed by carriers for more than 100 years, copper pair that is decades old is still in wide use. The pairs are spliced as customers and lines are added and removed.

These analog lines also have "bridged taps," which are any portion of the loop that is not in the path between the serving central office and the subscriber's terminal equipment. Bridged taps include unused cable pairs connected at intermediate points, as well as pairs that extend beyond the subscriber's location. Because they introduce additional capacitance, bridged taps can filter out high frequencies and thus distort transmissions.

As shown in Table A1, most network access lines are still analog, but during the past five years digital access lines became more common. However, it will take decades to convert the huge installed base of analog access lines into digital transmission facilities. The process began in the mid 1970s with Dataphone Digital Service (DDS), and as of 1994, an estimated 330,000 Subrate Digital Loop ports (SRDL—the current name for DDS) have been installed. In all likelihood, SRDL will essentially cease being installed over the next 10 years, since fractional T1 and T1 services offer more performance and cost effectiveness. For now, however, it remains less expensive to buy one SRDL channel than a fractional or full T1.

All digital transmission technologies have difficulty with transmission distortions due to bridge taps (which must be removed) or changes in wire gauges (due to splicing). These technologies are also distance-limited (typically 3,000 feet is the maximum distance between repeaters), and subject to delays in provisioning and installation (30–45 days).

TABLE A1 U.S. Telecom Network Access Ports

Category	Ports
Analog Main Access Lines	122,378,795
Analog Centrex Extensions	7,713,943
Digital Main Access Lines	155,126
Digital Centrex Extensions	1,437,595
Basic Rate ISDN Control Channels	261,331
Primary Rate ISDN Control Channels	2,992
Analog Business Access Lines	38,887,272
Digital Business Access Lines	1,593,442
Analog Residential Access Line	94,781,124
Digital Residential Access Lines	82
Non-Switched Analog Access Lines	2,132,309
Non-Switched Digital Access Lines	8,901,910

Source: FCC Common Carrier Statistics, 1993/1994 Edition

Illustrative vendors of Channel Service Units/Data Service Units (CSU/DSUs) for interconnecting customer premises equipment to digital network services include ADC (Portland, OR), Ascom Timeplex (Woodcliff Lake, NJ), AT&T Paradyne (Largo, FL), Motorola Codex (Mansfield, MA), Datatel (Cherry Hill, NJ), Digital Link (Sunnyvale, CA), General DataComm (Middlebury, CT), LarseCom (Santa Clara, CA), Network Equipment Technologies (Redwood City, CA), Newbridge Networks (Herndon, VA), Racal Milgo (Sunrise, FL), StrataCom (Campbell, CA), UDS (Huntsville, AL), and Verilink (San Jose, CA). The average price per port of an external CSU/DSU ranges from $500 to $2000.

After DDS/SRDL and T1, the next generation of digital network access technology, Integrated Services Digital Network (ISDN), was launched in the late 1980s. Only now, however, is ISDN coming into its own, and its revival has been fueled by the growing number of people who work at home—at least 20 percent of the U.S. workforce already does some work at home, and this percentage is growing.

Approximately 300,000 two-wire ISDN Basic Rate (BRI) access ports were in service as of September 1995, and the annual growth rate is 25 to 30 percent. Four-wire Primary Rate (PRI) access trails far behind, with fewer than 10,000 ports, but it is growing more rapidly—35 to 40 percent per year. ISDN CPE vendors include most of the CSU/DSU vendors mentioned above, as well as modem vendors: Ascend Communications (Alameda, CA), IBM (Research Triangle Park, NC), Micom (Chatsworth, CA), Premisys (Fremont, CA) and Teleos (Eatontown, NJ). The average selling price of an ISDN terminal adapter ranges from $400 to $1000.

What about Fiber?

LECs, CAPs and CATV operators have indicated their willingness to order cost-effective optical fiber network access products based on Synchronous Optical Network (SONET) transmission standards. SONET add/drop/multiplexers (ADMs) currently cost less than $3,000 per OC-3 (155 Mbps) port. As prices continue to fall, SONET and optical fiber will play a major role in high-speed network access.

At present, however, only very large business customers need or are willing to pay for OC-3 (155 Mbps) network access service. Nevertheless, Broadband Technologies (Research Triangle Park, NC) is betting on the residential video service market, and it has been teaming for the past several years with AT&T Network Systems to provide such a service. Some of the vendors that have spent more than $100 million on product development targeting the optical fiber network access equipment market include Alcatel Network Systems (Research Triangle Park, NC), DSC Communications (Plano, TX), Fujitsu (Richardson, TX) and Northern Telecom (Research Triangle Park, NC) □

IXCs and CAPs Will Use Microwave

To extend their reach beyond their current points of presence (POPs) and deeper into the access market, both the IXCs and the competitive access providers (CAPs) will make microwave their first technology choice. Unlike copper, coax and fiber, microwave boasts modest construction costs, low fixed costs and variable costs proportional to the number of subscribers. This makes microwave ideal for small trials that can scale upward as the number of subscribers grows.

With no cables to cut and fewer points of failure, microwave lowers operating costs as well. Microwave-based cellular and paging services now number more than 50 million access lines, up from less than five million 10 years ago.

These services will migrate to higher speeds in the next three years. For example, carrier Winstar Communications (New York) uses P-Com's (Campbell, CA) 38-GHz digital transmission system to provide customers with digital access—up to four T1s on a single link—to its backbone interexchange network. Another carrier, Metricom (Mountain View, CA) has developed its own spread spectrum technology and, with venture capital backing, has begun to offer a 1+ Mbps service to support multimedia communication in and around Silicon Valley.

The network access plans of the larger IXCs also include microwave: AT&T, via its wireless subsidiary (formerly McCaw), offers AMPS and TDMA; MCI via nationwide cellular resale; and Sprint via CDMA with Wireless Co. CAPs like Metropolitan Fiber Systems (MFS—Oak Brook, IL), Intellicom Communications Group and its ICG Access Services (Denver, CO) and Teleport Communications Group, (TCG—Staten Island, NY) will also use microwave to extend their services, since optical fiber can't be run economically to every customer building.

Of course, the IXCs and CAPs face the same dilemma as the local exchange carriers—lowering prices fast enough to gain market share, but not so fast as to shortchange their new ventures. Microwave equipment providers include: Alcatel Network Systems (Research Triangle Park, NC), AT&T Network Systems (Morristown, NJ), California Microwave (Sunnyvale, CA), Cylink (Sunnyvale, CA), NEC (Herndon, VA), Nortel (Richardson, TX), P-Com (Campbell, CA), and Western Multiplex (Belmont, CA). The average price per T1/E1 microwave link of $5,000 to $10,000 can be expected to drop rapidly over the rest of the decade.

Conclusion

It will take seven to 10 years for this once-in-a-century change in the local loop market to sort itself out. Eventually, legislation will establish more—if not complete—competition in all the current access market categories. In roughly the same period, customer demand for network access will coalesce around some collection of products/services that may only be in their infancy today.

Meanwhile, equipment vendors will have a field day selling gear to the LECs, IXCs, MSOs and CAPs. The service providers will in turn offer a variety of better, cheaper, faster network access options for business and residential customers.

Over the next three years, however, expect more of what we have seen in the past few: loud lobbying for various flavors of deregulation from all quarters, a feverish pace for mergers/acquisitions/alliances, an endless parade of new products/services and falling prices for everything□