Digital Subscriber Line

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The phenomenal growth of the World Wide Web has created an enormous demand for bandwidth. Access to the Internet, and the need for remote LAN access, are pressuring telecommunications companies to expand their bandwidth immediately. Telephone companies do not have the luxury of waiting to upgrade their existing copper wire infrastructure to fiber. The competition, using cable modem and wireless technologies, is breathing down their necks. In the following pages, this paper provided a brief inventory and description of the wide variety of xDSL technologies. In addition, new ADSL services by Ameritech and Bell Atlantic were investigated.

Digital Subscriber Line

The phenomenal growth of the World Wide Web has created an enormous demand for bandwidth. Access to the Internet, and the need for remote LAN access, are pressuring telecommunications companies (telcos) to expand their bandwidth immediately. Telcos do not have the luxury of waiting to upgrade their existing copper wire infrastructure to fiber. The competition, using cable modem and wireless technologies, is breathing down their necks.

Currently deployed technologies such as narrow band ISDN (Integrated Services Digital Network) and 56-Kpbs modems (V.90) offer only minimal relief as both the average customer, and those with advanced applications, demand transfer rates more than 100 times greater than ISDN and V.90 technologies are designed to deliver. Telcos and competitive local exchange carriers (LECs) are looking to digital subscriber line (xDSL) technology as the solution to their current lack of bandwidth.

In the following pages, this paper will provide a brief inventory and description of the wide variety of xDSL technologies. In addition, new ADSL services by Ameritech and Bell Atlantic will be investigated.

xDSL and Its Variations

xDSL was named as one of 1997's ten hottest technologies by Telecommunications magazine (Flanagan, 1997). xDSL is a modem technology that increases the digital speed of ordinary copper telephone lines by a significant amount over common V.90 (56Kbps) modems. 3Com's Robin Aber defines xDSL services as, "dedicated, point-to-point, public network access technologies that allow multiple forms of data, voice, and video to be carried over twisted-pair copper wire on the local loop ("last mile") between a network service provider's (NSP's) central office and the customer site (Aber, 1998)." Telephone companies originally developed xDSL as a simultaneous television and voice transmission technology in response to cable company competition (Patton, 1998).

This competition was spurred by the Telecommunications Reform Act of 1996, which allows local phone companies, long-distance carriers, cable companies, radio/television broadcasters, Internet service providers, and telecommunications equipment manufacturers in the U.S. to compete in one another's markets. The major advantage of xDSL services are that they are supported by the ordinary copper telephone lines already installed in most commercial and residential buildings.

Although xDSL technologies have only recently become viable, numerous variations have surfaced (many of which have yet to be implemented on a large scale). In spite of this, Dataquest predicted that xDSL will become a major high bandwidth solution <http://gartner3.gartnerweb.com/dq/static/dq.html > (Strauch, 1997). Sales are estimated to grow to $2.5 billion by 2000. xDSL has 163 million potential users in the public switched telephone network (PSTN).

This phenomenal growth estimate is based upon xDSL's use of advanced digital signal processing (DSL) to increase both the throughput and signal quality possible using ordinary copper telephone wire. Depending upon the application, xDSL may be deployed in a variety of topologies. Possible xDSL variations are listed below.

Asymmetric Digital Subscriber Line (ADSL)

ADSL variation is the most flexible DSL variation and has numerous upstream and downstream transfer rates. ADSL operates in a different frequency range than analog voice so the line is able to handle both voice and data (voice - 4kHz, upstream data - 75kHz, downstream data - 900kHz). ADSL interfaces are standardized by ANSI T1.413 (1995) <http://www.nssn.org/search.html>. Data rates vary upstream from 64 - 640 Kbps and downstream from .5 - 8 Mbps. The maximum distance is 12 - 18,000 feet.

ADSL has two competing modulation schemes: carrierless amplitude phase (CAT) and discrete multitone (DMT). CAT and DMT use the same modulation technique (quadrature amplitude modulation (QAM)). They differ in how it is applied. CAP is a single carrier system and is available today at 1.544 Mbps (T1) speeds. CAP's lower cost is due to its simplicity.

DMT is a multicarrier system that adapts to line conditions by either using or not using a carrier based upon the condition of the line. DMT's main advantage over CAP is that it is the ANSI, ETSI, and ITU standard. However, DMT is initially more costly and is very complex. (Aber, 1998).

ADSL Lite (G.lite)

ADSL Lite or G.lite is a slower version of ADSL with upstream rates of 64 - 384 Kbps and downstream rates of 1 - 1.5 Mbps. Maximum distance is 22 - 24,000 feet. ADSL Lite (a form of Universal ADSL) eliminates the need for the telco to install and maintain an onsite POTS (plain old telephone service) splitter. Eliminating the POTS splitter simplifies installation and reduces cost. In addition, G.Lite will work over a longer distance than full-rate ADSL.

The standard for G.lite has yet to be finalized. Voting by the Universal ADSL Working Group (UAWG) <http://www.uawg.org> will take place on October 23. Once ratified the ITU is expected to ratify a standard for G.lite by the end of the year (Levitt, 1998).

ADSL - Universal (UADSL)

UADSL is a slower version of full-rate ADSL. It focuses on providing a mass market version of ADSL by eliminating the need for a "splitter" box installed at the business or residence. UADSL is less complex and has lower power requirements than ADSL. The UAWG intends UADSL modems to become that defacto standard - replacing the current V.90 analog modem shipping in most PCs.

Consumer DSL (CDSL)

CDSL is a combination of G.lite and regular 56 Kbps V.90 modem access (when the ADSL service is not available). CDSL is a proprietary version of G.lite developed by Rockwell.

High Bit Rate DSL (HDSL)

This is the oldest variation of DSL and is used for wideband digital transmission. HDSL is a proven technology with more than 200,000 T1/E1 installations since 1992 (Strauch, 1997). HDSL provides symmetric transmission, but requires two pairs of wires. Data rata is 1.544 - 2.048 Mbps. The maximum distance is 12,000 feet.

ISDN DSL (IDSL)

IDSL uses ISDN's 2B1Q line encoding over ISDN wiring that has been rerouted at the central office. Maximum distance is 18,000 feet unless extended by line repeaters. IDSL transfer rates are only 128Kbps symmetric. Also, IDSL service uses existing infrastructure and can be activated on any ISDN line.

Rate Adaptive DSL (RADSL)

RADSL dynamically adjusts the transfer rate on a give phone line. RADSL modems test the line at start up and adapt their operating speed to the fastest the line can handle. RADSL use an emerging variation of CAP that divides the spectrum into sub-channels. These sub-channels are adjusted during each transmission to compensate for line quality.

Single-line DSL (SDLS)

Similar to HDSL, but uses only one pair of wires. Data rate is 1.544 - 2.048 Mbps. Maximum distance is 10,000 feet.

Symmetric Digital Subscriber Line (SDSL)

HDSL plus POTS over a single telephone line. This name has not been adopted by a standards group, but is being discussed by ETSI. It is important to distinguish, however, as SDSL operates over POTS and would be suitable for symmetric services to premises of individual customers.

Unidirectional DSL (UDSL)

Unidirectional HDSL as proposed by one company in Europe without much sign of interest from anyone else.

Very-high Data Rate DSL (VDSL)

VDSL is very high data rate Digital Subscriber Line operating at data rates from 12.9 to 52.8 Mbps with corresponding maximum reach ranging from 4500 feet to 1000 feet using 24 gauge twisted pair wiring.

The numerous xDSL variations listed above have one characteristic in common with their cable modem competitors. Both establish a permanent "always on" connection between the central office and the customer's location. xDSL is not a switched network. In fact, the equipment bypasses the telco's voice switch. As a result, data and video transmission traffic do not burden the central office voice switch.

Available DSL Services

xDSL development and deployment has focused in North America (Aber, 1998). To date, more than 40 telcos have successfully tested ADSL modems. Also, nearly 50,000 lines have been installed in various trials and deployments. Ameritech and Bell Atlantic are members of a select group of service providers that are leading in xDSL deployment.

Ameritech

Ameritech (i.e. Ameritech.net) is currently rolling out ADLS service to customers in Ann Arbor and Royal Oak, Michigan <http://www.ameritech.net/visitors/adsl>. In upcoming months, service will expand to the whole metropolitan Detroit area along with many Chicago suburbs. Ameritech ADSL service is very competitive at $49.95 per month for unlimited access. Since ADSL transfer rates are dependant upon many factors, Ameritech chose to limit the downstream data rate to 1.0 Mbps (regardless of distance from the central office) to insure consistency across many locations.

Ameritech.net uses DMT modulation because of the industry support and ANSI Standard T1.413 that backs it. Alcatel ADSL modems are the company standard <www.alcatel.com>. In addition Ameritech has chosen to use the ATMF-25 (25 Mbps asynchronous transfer mode (ATM) standard) as its topology. ATMF-25 was chosen over Ethernet because Ethernet only offered bridged mode, and multiple users would have been bridged together. On the other hand ATMF-25 employs a routed mode and provides users with their own sessions and security (Ameritech launches…, 1997).

Ameritech has teamed up with Microsoft to ensure the success of its ADSL launch. "We are working collaboratively to make installing ADSL as easy as plug and play," said Cameron Myhrvold, vice president of Microsoft's Internet customer unit. "This technology will make it easy for consumers and businesses to seamlessly enjoy the benefits of high speed Internet access without any problems or needs for additional installation visits. Microsoft supports ADSL and is pleased to be working with Ameritech to make this service available to its customers (Ameritech launches…, 1997)."

ADSL service at Ameritech.net is connected to a state-of-the are ATM backbone. Ameritech was one of four communications companies that formed a buying consortium last year. That group evaluated numerous equipment solutions and chose the Alcatel 1000 for initial deployment <http://www.alcatel.com/telecom/mbd/products/products/opg/products/1000adsl.htm>.

Bell Atlantic

"Infospeed" is Bell Atlantic's brand name for ADSL service. Like Ameritech, Bell Atlantic chose a phased deployment of its Infospeed service. Washington, DC and Pittsburgh will go live this month with Philadelphia, New York, and Boston slated for early 1999.

Unique to Bell Atlantic's rollout is the "ISDN Rewards" program. Realizing the demise of its current IDSN service, consumers that have previously purchased an ISDN modem from Bell Atlantic can receive an ADSL modem at no charge. Another innovative program is "Switch-to-Infospeed." Consumers already subscribing to cable modem or satellite-delivered Internet service will be given a half off discount on the purchase of a new ADSL modem < http://www.bellatlantic.com/invest/news/adsl_program.htm>.

Like Ameritech, Bell Atlantic chose Alcatel to supply its ADSL network technology. Westell ADSL modems are also deployed (Press Release, 1998). Unlike Ameritech, Bell Atlantic offers three levels of service, each priced at a flat monthly rate (i.e. 640 Kbps at $39.95, 1.6 Mbps at $59.95, and 7.1 Mbps at $109.95).

Conclusion

In conclusion, xDSL technology is inherently suited to meet increased user demands for broadband, multimedia communications based upon its ability to support voice, data, and video over the installed base of twisted-pair copper telephone wires. The most promising form of xDSL is ADSL. ADSL service (first introduced in 1997) will become widely available by the year 2000.

Ameritech and Bell Atlantic, along with dozens of other telcos across the country, are rushing to deploy the technology. ADSL is their weapon of choice to beat the increased competition from cable and satellite Internet access services. Fierce market competition, fueled by the Telecommunications Reform Act of 1996, has fostered alliances between telcos, equipment manufacturers, software developers, and PC manufacturers. This cooperation is expediting the adoption of the technical standards necessary to ensure the success of xDSL technology in the future.

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