BROADBAND TELECOMMUNICATIONS TECHNOLOGIES FOR CONNECTING TO THE INTERNET — IGNORE THEM AT YOUR PERIL !

By:

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I. INTRODUCTION

The President's Information Technology Advisory Committee stated almost five years ago that: "Information Technology will be one of the key factors driving progress in the 21st Century – it will transform the way we live, learn, work and play. Advances in computing and communications technology will create a new infrastructure for business, scientific research and social interaction. This expanding infrastructure will provide us with new tools for communicating throughout the world and for acquiring knowledge and insight from information." Since this statement was made, the telecommunication industry has experienced a crash from which it is still picking itself up. The goods news is that much of the expensive optical transmission equipment including optical fiber is in place to provide services as they become economically feasible.

As you may know, the Computer Law Section has recently revised its bylaws to make it clear that "The purposes of the Section are to review, comment upon and apprise members of the State Bar of Michigan and others of developments in the law relating to information technology."

While many might initially think that "Information Technology" broadly means "technology relating to information," a better answer to the question "What is Information Technology?" might be "the combination of telecommunications and computing to obtain, process, store, transmit and output information in the form of voice, pictures, words and numbers."

The continuing convergence of computing and communications has come about in large part by the fact that most, if not all, information such as voice and data can be encoded into digital signals so these signals can be handled, not only by computers, but also by modern telecommunication networks.

Except for the Internet, telecommunications services such as existing telephone networks are still subject to heavy Federal and State control and regulation despite the fact that the Telecommunications Act of 1996 (Pub.L. 104-104) was designed to "reduce regulation and encourage the rapid development of new telecommunications technologies."

In a survey of e-commerce contained within the May 15, 2004 issue of THE ECONOMIST, the rise in e-commerce was largely attributable to the corresponding rise in high-speed Internet connections. It was found that such high-speed connections encourage users to do more things on-line, such as on-line shopping, because the connections are faster and provide more convenience.

A clear, accurate and detailed understanding of broadband telecommunication technologies is essential to proper legal analysis in this important area. In fact, some have taken the position that lawyers who do not understand such technology will almost certainly struggle and may ultimately fail in their legal practice.[1]

This report primarily provides an overview of some basic technical considerations for telecommunications technology as they relate to the Internet. A number of business and legal considerations are also provided for each discussed telecommunication model. In Section II of this report, a simplified, one-way telecommunications model is provided as a basis for the models discussed in subsequent sections. Then, a number of high-speed telecommunications models for Internet access are discussed in Sections III-VI. Finally, a number of telecommunication/information technology trends are identified in Section VII.

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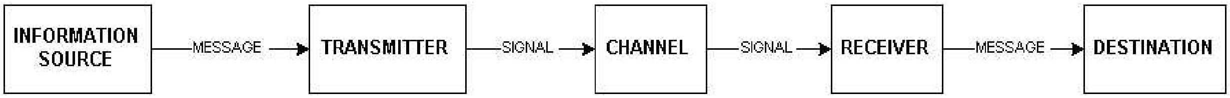
[1] Trend No. 10 in the "Top Ten Technology Trends" prepared by Jeff Kirkey and Gary Kendra for the November 13, 2003 meeting of the Technology Law and Training Advisory Board of ICLE reads as follows: "10. Lawyers who do not understand technology and its implications on their practices will fail. You may think that technology plays a major role in a typical lawyer's life today – just wait. Failing to prepare for and respond to technology trends may be the biggest mistake a lawyer can make. Those who are ambivalent toward technology will certainly not thrive in the future and may not survive."

II. SIMPLIFIED, ONE-WAY, TELECOMMUNICATION MODEL



Technical Considerations

An information source or provider generates a message. The message or content may include computer programs, audio (including voice), video, graphics, data and text. The message may be digitized so it can be stored, transmitted, etc. by computers. The message is transmitted by a transmitter as a signal over a channel after coding or modulation within the transmitter. The received signal includes noise introduced during travel of the signal over the channel.

As discussed later in this report, the main competing high-speed or broadband (high-speed does not necessarily mean broadband) Internet access technologies for end users currently include cable, telephone (*i.e.*, DSL) and wireless. A channel may be either a one-way or two-way path providing communication in either one direction only or in two directions over the channel. Here, "channel" refers to the physical medium, such as cable, telephone and power lines, or non-physical medium (*e.g.*, the atmosphere or space) through which signals propagate. Typically, a medium can be divided into multiple channels or paths, either by frequency or time division or coding to enable multiple types of signals to be transmitted over the same medium. An example is television signals and data signals which can travel over the same coaxial cable.

The message collected by the receiver is forwarded to a destination after being decoded or demodulated within the receiver. The destination may be combined with the receiver to form an information appliance, such as a portable or hand-held computer, a "smart" wireless telephone, a television set-top box or a game console. After receipt by the destination, the message can be utilized or re-transmitted as a signal to another receiver.

The above model is modified for the high-speed Internet technologies or models described herein to show two-way communication wherein messages and signals flow in both directions over the channel between the information source and the destination. In such two-way communication, the destination also becomes an information source and the information source also becomes a destination.

In a two-way telecommunication system, both the transmitter and the receiver might be replaced by a transceiver (transmitter/receiver) which is a combination of a transmitter and a receiver in a single package.

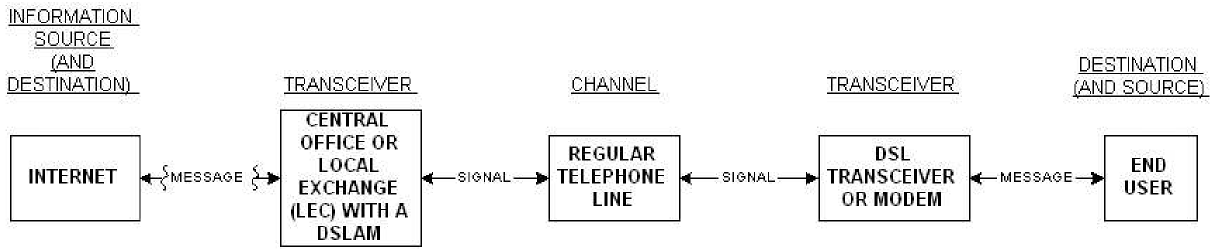
Business Considerations

One of the primary points of this report is to illustrate the battle among telecommunications companies for the “last mile” of infrastructure access to the customer's premises. These companies believe that the one who wins that battle is the company that will be the ultimate provider for all of the customer's telecommunications needs, including both local and long distance telephone service, broadband Internet service, and video/cable service. In other words, the company that controls broadband access is the company most likely to control all telecommunications access.

Legal Considerations

The regulatory picture is complicated by the emergence of multiple competing high-speed Internet access techniques such as fixed wireless, mobile wireless, satellite, cable modem, and DSL. As the number of competing technologies increases, the arguments for government intervention must be reexamined. Meanwhile, the various communications companies and Internet service providers have continued to litigate, trying to improve their position at the expense of their competitors.

III. TELEPHONE (*i.e.* DSL) TWO-WAY MODEL



Technical Considerations

Telephone technology has historically used "circuit switching," wherein, when a telephone call is placed, telephone company equipment sets up an electrical path over a Public Switched Telephone Network (PSTN) from the calling party to the called party. The entire conversation then flows over this path, which is inherently two-way. There is a long history of data transfer over PSTN, which tends to be quite secure.

This report is not concerned with the equipment provided by the Internet Service Provider (ISP) (and perhaps others) located between the Internet and the transmitter. Consequently, the line carrying the message between the information source (*i.e.*, Internet) and the transmitter is broken. Again, this line carries messages in both directions. Rather, the focus of this report is on the "last mile" of infrastructure access to the end user's destination premises. Here, this "last mile" is called a "local loop" which extends from the central office in a particular locality to customers' phones at homes and businesses.

Digital Subscriber Line, or DSL, uses existing telephone lines already in place to virtually every home and business for many years. The telephone line carries information over a series of copper wires. To distinguish the various flavors of DSL, the term "xDSL" is used, with "x" representing the form of DSL. Asymmetric DSL, or ADSL is by far the most common form of DSL in use today. Other forms of DSL will be addressed briefly at the end of this column.

The capacity of a telephone line is measured in terms of Hertz, or Cycles Per Second. For practical purposes, most telephone lines have a capacity (or bandwidth) of 1.5 million Hertz (1.5 Megahertz). Of this capacity, only about four KHz are used for customary voice communications. Voice communications therefore occupy only a tiny portion of the entire capacity available on the average telephone line. At one time, this was probably viewed as wasteful. The extra capacity, however, was eventually recognized as a ready made vehicle for carrying information to and from the Internet at a very high rate of speed.

As with all methods of broadband communication, the power of DLS is measured in terms of speed. Although once considered state-of-the-art, our fast paced lives are frustrated by the comparative slow speeds of conventional dial-up modems. ADSL designers realized that the Internet access required by most users places a much greater emphasis on downloading information into their computers than on uploading information from computers to the Internet. A greater portion of the telephone line is therefore dedicated to downloading than to uploading. At a distance of 6000 feet, ADSL can provide a maximum download speed of 8 Megabits Per Second (Mbps), with an uploading speed of only .64 Mbps. This introduces an additional factor to the DSL equation, distance. One of the main drawbacks of ADSL is that a user's connection functions properly only when it is no more than 18,000 feet from an internet provider's office. Within this distance, the further a household or business is from the central office, the more the access speed is impaired.

One may find ADSL's distance limitations perplexing. We have, after all, been using our standard telephone lines to communicate world-wide for many years. Why are these lines now so limited? Voice signals are boosted by small amplifiers called loading coils. Loading coils are, however, not compatible with ADSL signals. Other factors that make distance a major limitation to ADSL are bridge taps and fiber-optic cables. Bridge taps are extensions between the user and the central office that extend services to other customers. While they are not noticeable in standard voice communications, they reduce the effectiveness of ADSL. Fiber-optic cables limit the effectiveness of ADSL because ADSL signals cannot pass through the conversion from analog to digital and back that is inherent in fiber-optic technology.

There are two forms of ADSL. The older, less sophisticated form is the carrierless amplitude/phase (CAP). The new, higher tech version of ADSL is discrete multitone (DMT). DMT is the officially recognized ANSI standard for ADSL. CAP operates in a relatively straightforward, albeit less efficient manner than DMT. The telephone line's copper wire capacity of approximately 1.5 MHz is simply divided into sections for use in meeting its various requirements. The miniscule 4 KHz required for voice communications occupies the first portion the capacity. The next usable portion, between the 25 and 160 KHz bounds of the telephone line is dedicated to the user's uploading requirements. The remainder of the approximately 1.5 MHz capacity is dedicated to information downloading. The greatest capacity of the available bandwidth is therefore used to download information to ones computer. This is how communication engineers have been able to meet the most highly demanded requirement, fast downloading, as discussed earlier.

DMT divides the available bandwidth into 247 separate channels of four KHz each. The 247 individual channels have the advantage of being accessible in many combinations, as needed. As signal quality is impaired or overused on one channel or set of channels, signals are shifted to alternative channels. In this way quality can be adjusted as necessary. With both CAP and DMT, data transmission is kept from interfering with voice communications by a low-pass filter that is installed between the telephone jack and the telephone.

Two significant pieces of equipment are used to complete the ADSL connection. A DSL Transceiver, sometimes referred to as the DSL Modem is installed at the user's location to ready data for transmission into the system, and for use after receipt from the system. The central office makes data ready for use by the Internet with the use of a DSL Access Multiplexer (DSLAM). The DSLAM provides one of the major advantages of ADLS over the cable modem. Cable modems share a loop of cable that runs through the user's neighborhood. As additional users are added to the loop, quality is impaired. ADSL, however, sends a dedicated signal for each user back to the DSLAM.

As stated earlier, there are other less common, yet efficient forms of xDSL available on a limited basis. Very High Bit-Rate DSL (VDSL) provides an extremely fast connection, but works only over a short distance. The 8 Mbps download speed provided by ADSL is increased to up to 52 Mbsp with VDSL. We have already discussed the significant distance limitations of ADSL. These limitations are greater with VDSL, which is limited to a distance of about 4,000 feet between the user and the central office. However, the limitations of ADSL in its use with fiber optics discussed earlier are overcome by VDSL, which uses various fairly recent innovations, such as Fiber to the Curb (FTTC) and Fiber to the Neighborhood (FTTN). These technologies when combined with a VDSL Transceiver Gateway at the telephone junction box overcome the translation problems.

Several other forms of xDSL are also available, such as HDSL and RDSL. These varieties provide advantages, and are limited by disadvantages when compared with ADSL. Some are less acceptable only because the technologies remain in their infancies. Others are limited because they required extra phone support, thus negating one of the principal advantages of DSL. The main advantage of these technologies is greater speed.

Wireless DSL has provided users with access to broadband technology where conventional digital subscriber lines and digital cable are not available, as well as to those users who simply choose to "go wireless." Here, a base station, often located on top of a cellular tower or other high location connects a user to a PSTN by way of a terminal located on the user's premises. To provide access to wireless DSL both now and in the future, many providers are now building the required functionality into the equipment installed on the customer's premises.

Business Considerations

DSL technology is currently one of the dominant means of providing broadband Internet access to end users worldwide. This technology piggybacks on existing PSTN telephone technology and provides links for approximately ten million people in the United States.

ADSL, as with all forms of broadband communication, has advantages and disadvantages. Some of these have already been discussed. Speed is a major advantage over the standard dial-up modem, as is the ready made link to the Internet provided by the standard copper wire telephone line. In addition, voice communications do not need to be discontinued when an ADSL connection is opened. As already addressed however, ADSL has limitations. Distance between the user and the central office limits the technology's effectiveness. Because a far greater portion of ADSL bandwidth is dedicated to downloading data, there is less bandwidth and thus slower speeds available for uploading.

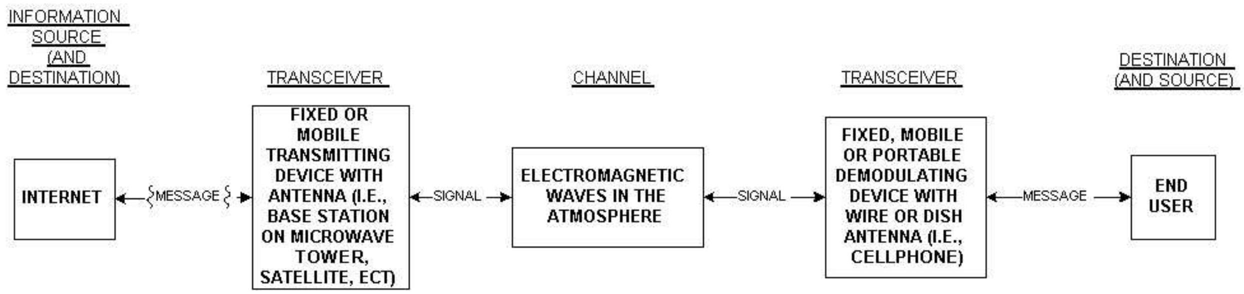
Legal Considerations

Regulatory agencies such as the FCC and/or the courts sometimes force telephone companies to lease or resell their fixed-lines, *i.e.*, local telephone "loops," and their DSL equipment to competitors to provide DSL service while the telephone company provides voiceband service. This is called "line sharing." This has caused a lot of controversy and had caused America to lack a coherent broadband policy since there is little incentive for the telephone companies to expand their existing networks if such expansions must be leased to others at low rates. Ironically, the Telecommunications Act of 1996 was designed to promote competition and reduce regulation in order to encourage "the rapid deployment of new telecommunications technologies."

As reported at 2004 WL 374262, the U.S. Court of Appeals for the District of Columbia on March 2, 2004 rejected Federal Communication Commission (FCC) rules that force the Baby Bells to open their phone networks to rivals at regulated prices. Also, the court struck down as unreasonable the agency's February, 2002 decision to give the 50 states the responsibility for determining which parts of a local phone network should be available to rivals at relatively low prices. The court chastised the agency for failing to develop lawful unbundling rules (how to separate different services over the same channel) since the 1996 Telecommunications Act and for failing to adhere to prior judicial rulings of the courts. *United States Telecom Association v. Federal Communications Commission.*

Also, at the state and local level, right-of-way and zoning issues are important to allow the laying of fiber-optic or new copper lines.

IV. WIRELESS TWO-WAY MODEL



Technical Considerations

Wireless systems may have a fixed, portable or mobile transmitter (transceiver for two-way communication) and a fixed, portable or mobile receiver or transceiver. A handheld cellular phone is an example of a digital or analog portable transceiver (operates as a transmitter or receiver). An automotive cell phone is an example of a mobile transceiver. New third generation (*i.e.*, 3G or IMT-2000) networks and their phones support high-speed Internet access.

One kind of fixed transceiver or base station may provide wireless service over a large area. Such a system may be called a "fixed-fixed" system wherein a central antenna of the transceiver is mounted on a large tower such as a radio tower and rooftop antennas on homes or offices are provided as part of their transceivers. A "fixed-portable" system may use such a fixed transceiver and handheld cell phones.

One type of a wireless system includes a mobile transmitter within an orbiting satellite which may also operate as a receiver (*i.e.*, to form a transceiver) in a two-way system. In such two-way systems, a user's dish antenna also is used to receive and transmit signals to the satellite. In a one-way satellite system, a different, slower communication system such as a regular telephone line is utilized to send messages from the destination back to the original information source.

The satellite typically includes a transponder, a combination receiver, frequency converter and transmitter package designed to receive a signal from the ground and retransmit at another frequency. Wireless systems which utilize satellites may experience "rain fade" and solar interference at various times.

One wireless Local Area Network (LAN) technology utilized between a receiver and its ultimate destination is a wireless technology entitled "Wi-Fi" (Wireless Fidelity or IEEE 802.11). When Wi-Fi is used, a fixed base station is utilized as the transceiver to set-up a Wi-Fi zone for use by destination devices such as lap-top computers having special hardware and software. The destination devices typically must be located within 300-500 feet of the base station within the Wi-Fi zone.

Business Considerations

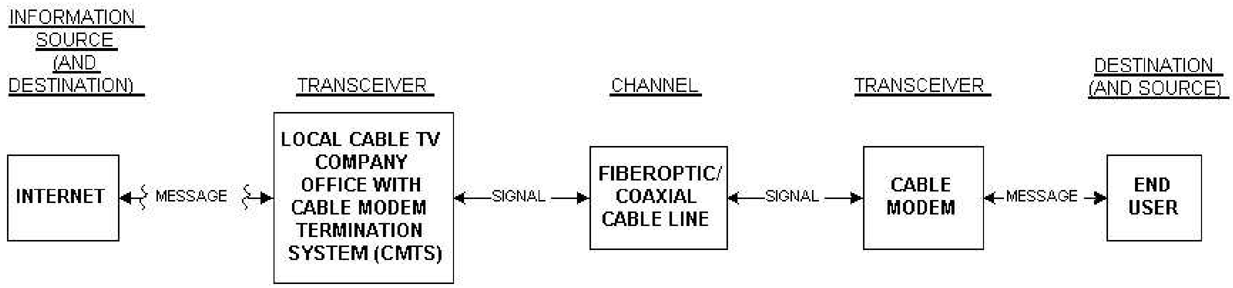
Wireless Internet technology is rapidly "coming of age" and by most accounts will shortly be a viable competitor in the race for the "last mile."

Legal Considerations

Availability of alternative "last mile" technologies such as wireless Internet technology lessens the strength of arguments for compulsory sharing of a particular technology.

The Telecommunications Act of 1996 has hindered the increased use of satellite technology. As directed by Congress in Section 207 of the Telecommunications Act of 1996, the FCC promulgated a rule, cited as 47 C.F.R. § 14, effective October 14, 1996, that prohibits unreasonable restrictions that impair the installation, maintenance or use of antennas, including satellite receivers, used to receive signals. Although this rule seems to give satellite dish users the right to place a dish on their premises without municipal or contractual restriction, the rule carves out an exception that allows local governments, community associations and landlords to enforce certain restrictions. These entities have used this regulatory groundwork to hamper a user's access to satellite signals, which has slowed the widespread adoption of this technology.

V. CABLE MODEM TWO-WAY MODEL



Technical Considerations

When cable television (CATV) systems were originated, only television service was originally provided to end users. Now, high-speed data and television service may be provided over the "last mile" to consumers.

Before a cable modem termination system (CMTS) sends signals over the cable line, it must first modulate the signals. Much like the DSLAM of the DSL model, the CMTS aggregates the connections from many end users into a single, high-speed Internet connection to an Internet Service Provider (ISP). At the transmitter, the television signals are also added.

Some systems use a channel of only coaxial cable while other systems use fiber-optic cable which extends to different neighborhoods. Then, the signals move from the fiber-optic cable into coaxial cable for distribution to individual end users.

The coaxial cable has an available bandwidth and can be viewed as having a bundle of pipes or channels through which signals of different frequencies travel. For example, one particular television channel can be given a slice or pipe of the total bandwidth. High-speed data or signals to and from the Internet are given their own channel or pipe on the coaxial cable.

A relatively new telephone service utilizing Voice Over Internet protocol (VoIP) technology using "packet-switching" may be provided in this model. Packet-switching allows individual messages to be subdivided into smaller "packets" that may be sent along different paths to the destination where they are reassembled by the receiver in their correct sequence. The subdividing and the reassembling are performed by computers at the transmitting and receiving ends, respectively. Packet-switching may eventually replace the circuit switch technology of telephone networks.

The cable modem at the end user includes a modulator and a demodulator to provide two-way communication as well as a microprocessor to help separate the television signals from the high-speed data or message.

Business Considerations

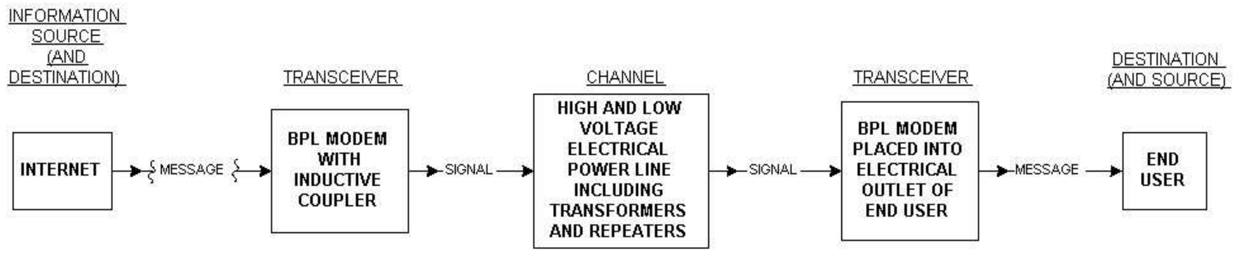
There are about sixty million users of this technology in the United States.

Legal Considerations

Like the telephone system, regulatory agencies sometimes force CATV companies to lease their lines and equipment to competitors who, in turn, provide telephone service to end users. Congress' stated intent in the deregulation of cable was to stimulate competition, and to reduce prices. But the trend has been toward higher prices. There is a question as to whether regulation or competition is an appropriate answer to the problem of higher communications rates.

The FCC is still struggling with the issue of whether or not to apply telephone regulation rules to VoIP.

VI. BROADBAND POWER LINE (BPL) ONE-WAY MODEL



Technical Considerations

This is a largely experimental technology. However, it is attractive because the electric distribution network extends almost everywhere including almost everywhere within the destination.

Inductive couplers are used to connect BPL modems to medium voltage power lines (*i.e.*, the electric lines that one sees at the top of utility poles beside roadways). The inductive coupler wraps around the medium voltage power line to transfer the high-speed data signal onto the power line.

One problem is that transformers which lower (*i.e.*, transform) the medium voltage (*i.e.*, thousands of volts) into a low voltage (*i.e.*, 220/110 volts) for use by the end user breaks apart the data signals. Potential solutions are available, but are currently costly. Another problem on some installations is interference to and from signals, particularly on the low voltage power lines in the "last mile" of the electric distribution network.

Business Considerations

The technology is potentially very costly because repeaters are needed to periodically amplify the data signals appearing on the power lines.

VII. SOME TELECOMMUNICATION/INFORMATION TECHNOLOGY TRENDS

1. The use of mobile phones is increasing at the expense of fixed-line phones.

2. The continued demand and growth of faster Internet access speeds both to and from end users.

3. The overlap between information technology and telecommunications is continuing to increase or converge as relatively new Internet technology appears to be dominating the "old" telecommunication technology. For example, in the corporate telecommunication market, new Internet-based technology to interconnect regional offices via virtual private networks provides advanced data services as well as connectivity. Such networks may provide broadband, Ethernet-based, data transmitters in local area network (*i.e.*, LAN) and wide area network (WAN) environments.

4. Also, voice calls are being conducted over corporate data networks utilizing technologies such as Voice Over Internet Protocol (VoIP). In this technology, voice calls are digitized and placed into packets of Internet data. Such technologies may eventually replace separate voice networks wherein voice and data are provided over a single communications channel.

Presently, a large amount of optical fiber is in place wherein the transmitter includes optical transmission equipment such as lasers and/or light-emitting diodes. However, the "last mile" to the receiver of the end user typically is not optical fiber, but rather, is a copper telephone wire. The future may bring a fiber-optic "local loop" to provide this "last mile" to the receiver which may include a photodetector diode. Alternatively, this last mile of service may be provided by wireless local loops. Various companies are battling for the "last mile" of infrastructure access to the customer's premises since they believe that the owner of this "last mile" will eventually provide all of the customer's future telecommunications needs including local and long distance telephone service, broadband Internet access and video/cable service.