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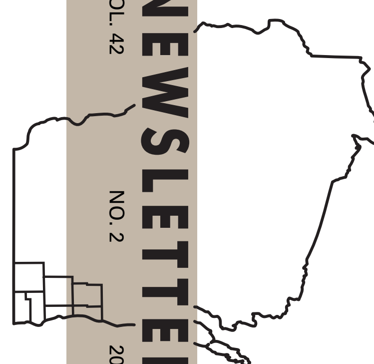

REGIONAL TELECOMMUNICATIONS STUDY UNDERWAY

In Fall 2004, the Commission initiated the conduct of a regional telecommunications planning program. The program is following a work scope identified in a Commission Prospectus published in December 2003. The new planning program is being guided by a Regional Telecommunications Planning Advisory Committee comprised of representatives from local and state governments, wireline and wireless service providers, and other interested parties. The Committee membership is listed on page 2.

The Commission recognized that following the breakup of the Bell System and the American Telephone and Telegraph Company, and with the subsequent rapid advances in communications technology, telecommunications, while becoming increasingly important in the local, national, and global economies, also was becoming increasingly difficult to understand by those outside the telecommunications industry. The Federal Telecommunications Act of 1996, intended to further encourage local competition, has led to the development of a "network of networks" largely beyond the regulatory purview of any level of government.

These networks also have become national in scope, organized and operated by corporations outside of Wisconsin and with priorities not necessarily coincident with the social and economic aspirations of the Region. The nonregional character of these networks is reflected in the traffic patterns that primarily are routed outside Wisconsin even for local calls within the Region. This network structure, developed for the new packet-switched networks, is in sharp contrast to the older circuit-switched voice and data telephone networks that were highly integrated through switching centers located within the Region. The regional telecommunications program will explore the potential development of integrated telecommunication networks within the Region. Such networks can have a significant impact on both the economic development and the security of the Region.

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A major objective of the program relates to the provision of high speed, broadband telecommunication services throughout the Region. Currently, the first generation of broadband services in the form of telephone company DSL (digital subscriber line) and cable company hybrid fiber-coaxial cable (cable modem) are available in most urban and suburban areas of the Region. These services typically have capabilities to rapidly download web pages and other large files, particularly those with high video content for residential users and to expedite large data file transfers of all kinds for businesses and other enterprise organizations. Neither of these asymmetrical technologies has strong upload capabilities for applications such as video conferencing. Fixed wireless broadband is also available in some areas of the Region. The goal of the regional telecommunications planning program, however, is to range out beyond the current networks to help plan for the next generation of broadband service capabilities (10 to 100 megabits per second for homes, and 1 to 10 gigabits per second for businesses and industries) that will be required to compete in the global economy. Such planning must also identify the broadband infrastructure required for public needs in such areas as healthcare, education, public safety, and the environment.

Accordingly, the end products of the regional telecommunications planning process in Southeastern Wisconsin are envisioned to be three network plans:

- Regional Antenna Site and Related Infrastructure Plan
- A Regional Public Networks Plan
- A Comprehensive Regional Wireline-Wireless Telecommunications Network or Universal Broadband Access Plan

ANTENNA SITE PLAN

The regional antenna site and related infrastructure plan is intended to provide guidance to county and local units of government and to service providers operating within the Region on the location of antenna sites for mobile and fixed wireless networks. This plan will also be used in the preparation of the wireless component of the regional network plan. The antenna base station site is the basic element of any wireless network. The antenna and supporting electronic equipment at a particular site provide the means for communication with remote mobile and fixed location users. Wireless service providers seek to locate antenna sites so as to maximize their return on investment. They seek locations that will lead to new subscribers and increased revenues. The antenna site location process can be lengthy and costly for both the provider and the county and local units of government concerned. Site installation delays of several years are not uncommon.

The primary objective of the antenna site location plan is to provide a rational basis for antenna site location in the form of a set of site locations that provide adequate coverage and network capacity while minimizing the number of sites required to provide the needed service. The antenna site planning process will make extensive use of mathematical modeling software for both delineating antenna site coverage and for determining the best combination of sites necessary to provide the needed wireless services within the Region. The antenna site plan will be prepared in cooperation with the wireless service providers.

PUBLIC NETWORKS PLAN

The term public networks in the context of the regional telecommunications planning program refers to communications networks that perform public functions in areas such as public safety, transportation, environmental monitoring, and public health. They all represent public sector applications of communication networks. They may or may not require new network infrastructure. Some public networks could operate as applications on existing physical networks. Others may require augmentations of existing physical networks and still others new network infrastructure.

The public networks plan will take the form of initial findings and recommendations relating to a series of potential public networks such as:

- Public Safety, Emergency Response, and Homeland Security
- Environmental Monitoring
- Home Health Care
- Emergency Medical Services
- Transportation System Control
- Public Administration Network

The findings and recommendations will reflect the attitudes and viewpoints of the various interests that would be involved in the implementation and operation of these public networks. The prospects and procedures for moving to the next stage of development along with possible sources of funding will be documented. Following conceptual plan approval, efforts would be made to convene stakeholder-based committees to stimulate initiation of public network projects aimed at the further identification and possible deployment and operation of these networks.

REGIONAL TELECOMMUNICATIONS NETWORK PLAN

The comprehensive regional wireline-wireless telecommunications, or universal broadband access plan, is intended to provide a set of technologies and a network structure believed to best serve the Region for the target year 2015. This plan will be selected from a set of alternative regional network plans prepared for objective evaluation by the Advisory Committee. Each alternative plan will be evaluated on the basis of agreed upon service objectives and standards and presented to the Advisory Committee for final plan selection and recommendation to the Commission for adoption. A series of public hearings will facilitate citizen input to the plan selection and adoption process.

REGIONAL TELECOMMUNICATION NETWORK ALTERNATIVES

Looking ahead, what are the alternative regional communication technologies and networks offering high speed broadband capabilities, existing or potential within the Southeastern Wisconsin Region?

Digital Subscriber Lines (DSLs)

Digital subscriber lines represent a technology designed to extend the capabilities of the traditional twisted pair of copper wires connecting telephone subscribers to a central office for high speed data transmission. Twisted pair wires are inherently narrow in bandwidth, but innovations in advanced digital signal processing have made it possible to extend the data rates significantly from the typical 56 kilobits per second of an ordinary telephone line into a channel with rates in one direction as high as 6 megabits/second. Actual data rate performance due to line attenuation and other factors is more like 1.5 megabits/second in the download direction and 300 kilobits per second in the upload direction. DSL subscribers must be located within 12,000 feet of a central office or central office extension called a remote terminal to qualify for service. Currently, 85 percent of residences in Southeastern Wisconsin are in DSL service areas. The most common form of DSL is known as asymmetric digital subscriber line (ADSL) and is serviced by a central office as shown in Figure 1. In Figure 1 and the following figures the central office installation provides switching and routing services.

A more advanced form of DSL, very high speed digital subscriber line (VHSL), is serviced by a remote terminal as shown in Figure 2. VDSL is capable of transmission speeds up to 26 megabits per second in the download direction.

VDSL based remote terminals must be located within 3,000 feet of potential subscribers. The name digital subscriber line is actually misleading in that the twisted pair line is

Figure 1

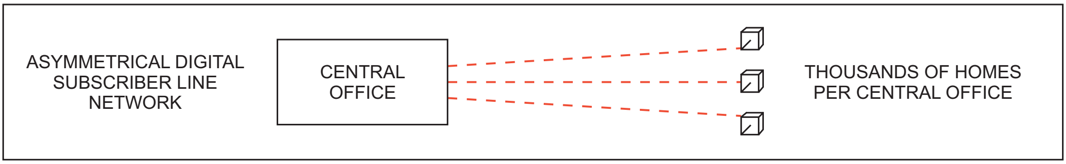
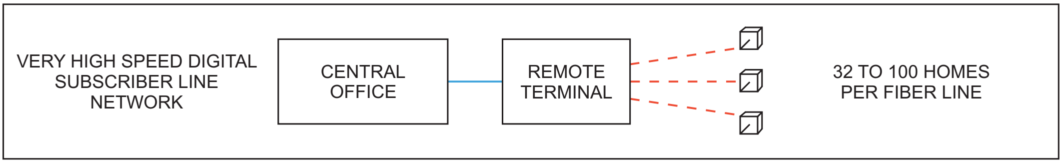


Figure 2



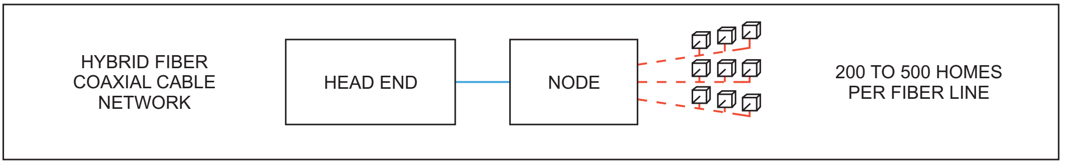
unchanged. The new element in DSL is a modem that converts data signals into a digital format for high speed transmission to the central office or remote terminal.

DSL in its various forms will be a factor in broadband access within the Region for some years to come. Its principal limitation is its asymmetry in which download data rates are much faster than upload data rates. For many applications, this imbalance is not that important, but for others such as video conferencing, balanced symmetric data rates are critical. Other limitations of DSL relate to its reduced performance in older neighborhood installations where line quality may be poor. It also has an upper limit on data rate capability which is inferior to other technologies such as fiber to the home.

Hybrid Fiber–Coaxial Cable (Cable Modems)

A major current provider of broadband telecommunications services in the Region is Time Warner Cable with its Road Runner offering. Charter Communications provides similar services in some counties of the Region. Nationwide, cable service providers control approximately 60 percent of the broadband Internet access market. Cable broadband services are based on a hybrid fiber, coaxial cable (HFC) configuration in which a fiber cable carries network traffic to a remote node and then on to a coaxial cable bus that connects to individual subscribers as shown in Figure 3. Download transmission operates in a broadcast mode at rates as high as 3 megabits per second. Slower upload transmission, as the illustration implies, is shared between users in a manner similar to DSL.

Figure 3



This joint sharing limits upload speeds to about 400 kilobits per second. As the number of users on each node rises, upload transmission rates are reduced. This asymmetric feature of broadband cable services, together with its inherent upper limit on transmission, makes hybrid fiber-coax a transition broadband communications technology.

Fixed Wireless Communications Services

A third alternative exists for broadband communications services in some areas of the Region in the form of fixed wireless Internet access services. Such services are in contrast to the more familiar cellular wireless services used extensively for voice traffic in the United States and throughout the world.

Fixed wireless communications systems typically operate in the unlicensed frequency bands of 2.4 gigahertz or 5.7 gigahertz. Such bands are free to any authorized providers, while licensed bands as in cellular wireless systems are auctioned off to competing bidders for sums measured in the hundreds of millions of dollars. Fixed wireless providers typically employ proprietary wireless equipment, such as the Motorola Canopy System, which operates in the 5.7 gigahertz band. Each antenna site will typically service an area with a radius of about 2.5 miles at data rates as high as 2.5 megabits per second. In addition to data traffic, fixed wireless also has the capability to offer voice over Internet protocol (VoIP) service to its subscribers. Fixed wireless offers a current third alternative for broadband services in the Region and is particularly competitive in areas not served by DSL or cable. Fixed wireless systems are usually operated by Internet Service providers (ISPs). There are at least six such providers currently operating in the Region.

REGIONAL BROADBAND NEEDS—PRESENT AND FUTURE

With all of this broadband communications capability already in place in the Region, why is there a need for investing in more advanced technologies to provide still more bandwidth in Southeastern Wisconsin? The answer to this question lies in both the short-comings of the present networks and the anticipated demands of future applications.

- Spatial Distribution
  Broadband access is not uniformly available throughout the Region. Rural areas of the Region, constituting approximately 70 percent of the land area, may not have either DSL or cable modem service offered. Fixed broadband wireless networks currently cover only a small part of this rural area.

- Advanced Applications
  More advanced applications useful in business, industry, education, and other subscriber activities, such as video conferencing, have bandwidth needs far above current offerings. Such applications often require symmetric transmission not available with either DSL or cable modem services. Moreover, if broadband networks are to compete with cable and satellite in high definition television service delivery, then bandwidths as high as 20 megabits per second will be needed. Further, widespread usage of Voice over Internet Protocol (VoIP) will further stress multimedia networks carrying data and video. Many business and industrial firms, even small ones, have needs for large and frequent file transfers as part of their normal daily operations. Some public sector applications in public safety and telemedicine also require bandwidths beyond current broadband offerings.

FUTURE BROADBAND AUGMENTATION ALTERNATIVES

New broadband technologies for expanding transmission rates above the current 3 megabits per second ceiling fall into three categories: fiber optic cable, wireless, and power line.

Fiber optical transmission has the greatest potential for bandwidth expansion. One fiber strand has the potential for a data rate of 40 gigabits per second, or a thousand times that of most other alternatives which are usually quoted in megabits per second. Using a technique called wavelength division multiplexing in which 100 different colors of light can transmit simultaneously on the same fiber strand, transmission rates as high as 4 terabits per second can be achieved. To place such rates in perspective, the Library of Congress, the largest library in the world, is 3 terabits in size. Such an entire library could be transmitted on a single fiber strand once each second. Even for more prosaic applications in the megabit per second range, fiber optic communication systems are not suitable for all areas of the Region nor for all applications. They do not provide mobile communications, and likely would not be cost effective in rural and low density urban areas. They also may be marginal in older, high density urban areas. These areas offer opportunities for wireless and or power line communication which could be more cost effective in these environments.

Figure 4

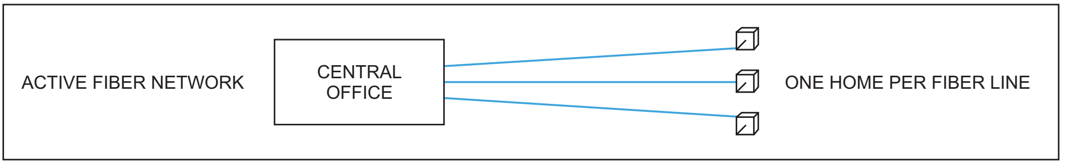
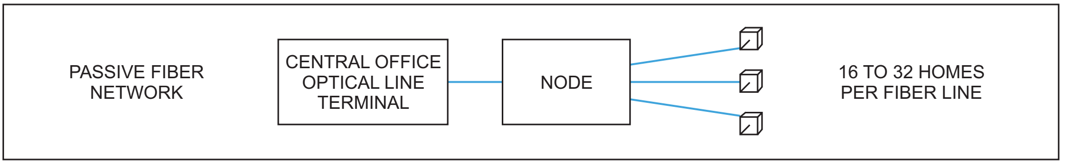


Figure 5



Fiber Optic Cable Broadband Communications

Fiber optic cabling, as previously described, has already played a major role in current broadband communications offerings, both DSL and cable modem services. Both employ fiber cable transmission to extend broadband channels to remote nodes closer to prospective subscribers, but the "last mile" to the end user in these technologies still employs a copper wire connection: twisted pair for DSL and coaxial cable for the hybrid fiber-coax cable networks. Advanced optical fiber systems, however, extend the fiber strand to the subscriber premises thereby allowing for higher transmission rates not limited by the small bandwidth of copper wire.

There are currently two primary types of fiber to the home (premises) configurations:

1. Active fiber optic networks - point to point (P2P)
2. Passive optical fiber networks – passive optical network (PON)

In the active type, shown in Figure 4, each home or business is assigned its own fiber strand for direct isolated communication with the central office. In the passive network version, shown in Figure 5, download messages are broadcast to all subscribers at maximum data rates with only the recipient in reception. Upload messages are in contention, however, so as the network becomes fully subscribed, upload data rates are reduced. PON fiber networks, therefore, despite their fully fiber structure, have some of the same asymmetric limitations as DSL and Hybrid Fiber-Coaxial Cable networks. The original advantage of PON fiber networks were their lower deployment costs resulting from the passive nature of the access infrastructure. That advantage now is in question with recent advances in active fiber network technology. Most early fiber to the home deployments have utilized PON technology, but more recent analysis points to active fiber access as the best long-term solution.

Wireless Broadband Communications

Wireless broadband networks offer an alternative to fiber optic networks in two different arenas: mobile networks and fixed networks. Mobile networks currently exist in two primary forms:

- Cellular –Personal Communication System (PCS) Networks
  - serving primarily voice traffic using the familiar cell phone

- Wireless Local Area Networks (WLANs)
  - serving primarily data traffic in the vicinity of WiFi (IEEE 802.11) hot spots.

Mobile cellular networks in the first generation (1G) and second generation (2G, 2.5G) have modest data transmission capabilities—typically less than 100 kilobits/second. Third generation cellular networks, just now coming on line in the United States after earlier introductions in Europe and Asia, have data rates as high as 2 megabits/second. Such transmission rates qualify as broadband communications. WLAN WiFi networks, in contrast, have more robust broadband capabilities transmitting as fast as 11 megabits per second with the original WiFi (802.11b), and moving up to 55 megabits per second for the newer units (802.11g). Such communication, however, is limited to an area within 300 feet of an Internet access point using either a WiFi equipped laptop computer for data or one of the newer Net Phones for voice communications. This range limitation, however, may soon be overcome with the forthcoming WiMAX (IEEE 802.16) technology which is scheduled to transmit as far as 45 miles from an antenna base station.

In the future fourth generation (4G) of wireless communication, the distinction between cellular networks and WiFi-WiMAX networks likely will blur and may even disappear altogether. Most current cellular network traffic moves through the traditional circuit-switched network which has handled voice communications since the days of Alexander Graham Bell. Although these networks are continually modernized with advanced switching equipment and fiber optic transmission lines, the trend is away from circuit-switched networks to packet-switched networks in which data packets are routed through multiple lines and networks to their addressed destinations. WiFi networks utilize the packet-based Internet for all data, voice, and video traffic. The 4G generation of wireless networks has four primary objectives:

- Faster transmission rates—up to 100 megabits per second
- Internet-based, packet-switched infrastructure
- Open architecture
- Multimedia traffic

Faster transmission rates imply higher frequency bands, shorter antenna site ranges, and more but less obtrusive antenna sites. While current 2G and 3G mobile wireless networks generally have an upper frequency limit around 1900 megahertz, 4G networks will range as high as 8 gigahertz for mobile cellular networks and as high as 60 gigahertz in fixed wireless networks.

Aside from faster transmission rates, 4G networks will migrate from current circuit-switched networks to the Internet. Such a migration will also facilitate attainment of two other objectives—open architecture and multimedia traffic. An open architecture means that 4G networks will accept a variety of different 2G, 2.5G, 3G, and other hybrid technologies on the same network. Such a capability will greatly facilitate communication between older legacy systems and newer technologies as communications technology continues its rapid advance.

While predominant interest in wireless communications has focused on mobile usage based on cellular networks, a related but different broadband technology has slowly emerged in fixed wireless networks. These networks feature higher frequency transmission in the 2.4 gigahertz and 5.2-5.9 gigahertz ranges with antenna sites serving fixed location subscribers with broadband transmission rates up to 2.5 megabits per second over a 2.5 mile radius. Such a site is potentially capable of serving up to 200 users—both residential and small enterprise. Most of the systems deployed to date are based on proprietary technologies such as Motorola's Canopy and Alvarion's BreezeAccess. A number of fixed broadband wireless service providers currently operate in the

Region including Wisconsin Internet (Racine County), Netwurx and NConnect (Washington County), and Athenet (Milwaukee County). Most of these carriers originally began operation as Internet Service Providers (IPSs) for dial-up telephone customers, so that high speed Internet access represented an evolution of their service offerings.

All of the above fixed wireless service providers have employed proprietary systems like the Motorola Canopy in their network deployments. It is also possible to construct fixed wireless networks from standard equipment of the WiFi or WiMAX variety. So far such networks have been limited to the small coverage areas of WiFi equipment, but as WiMAX equipment becomes available, such networks may be expected to increasingly be deployed. In fact, with the fourth generation of wireless emerging, the distinction between mobile wireless and fixed wireless may disappear as both converge on the Internet with open network architecture available to a variety of proprietary and standards based technologies.

Fixed broadband wireless systems are particularly viable in rural and other low density population areas where DSL or cable broadband service is not available. They also provide for symmetrical transmission rates with equivalent rates in both the upload and download directions. Both DSL and cable broadband services are very asymmetrical, with much slower data transmission rates in the upload direction. Symmetry can be an important feature in teleconferencing and other interactive video applications. Most current fixed wireless broadband networks employ the point-multipoint architecture in which one antenna base station serves multiple line-of-sight users. A new form of wireless network architecture is now emerging in the United States called mesh networking. In mesh networks, subscribers communicate through neighboring subscribers in a “multi-hop” fashion rather than in a longer single “hop” to the antenna base station. Mesh networks have definite cost, redundancy, and bandwidth advantages over point-multi-point systems as well as disadvantages in initial deployment. The Village of Jackson in Washington County has selected a mesh network design for its own municipal telecommunications utility. Mesh networks will represent a major wireless broadband alternative in regional telecommunications planning.

Power Line Broadband Communications

Power line communications (PLC) technologies have been known since the 1930s, but they have not been traditionally considered as a medium for communications due to their low speed, low functionability, and high cost. New modulation technologies, particularly orthogonal frequency division multiplexing (OFDM), have enabled PLC to become a viable alternative for access networks. Broadband PLC applications can be classified into three types:

- In-home networks
- Low voltage (LV) access networks
- Medium voltage (MV) access networks

In-home networks use internal house wiring to provide communications between outlets. This technology can service local area networks as an alternative to conventional wiring or WiFi wireless interconnections (IEEE 802.11b). The user employs home networking devices such as Ethernet-to-PLC or USB-to-PLC USB (universal serial bus) for interconnecting several computers, sharing printers, or DSL or cable modem connections. In-home PLC networking is a well established technology with devices commercially available from a number of manufacturers. It is not of primary concern in regional telecommunications planning since it does not provide access to wide area networks.

Low voltage PLC networks can provide access to open networks such as the Internet. With this approach, users gain access through a head-end modem installed in an MV-to-LV transformer providing connections to all subscribers in a neighborhood. The high end modem has a medium voltage link to a high speed core network. Cost reduction is achieved if the MV connection is used for communication since this link minimizes the number of remote modems required.

The primary advantage of PLC as an access technology is the presence of power line circuits in virtually every home and building in the nation. PLC access networks would utilize this existing power line network. Problems encountered in PLC networks include time-varying channel attenuation, fading, and background noise. Another class of problems relates to electromagnetic interference with other forms of communications. Although multiple technical and regulatory problems still exist with PLC as an access technology, it will be evaluated as an alternative access technology in regional telecommunications planning. PLC was recently approved by the FCC for operational deployment in the United States.

Access Networks Summary

A schematic summary representation of all of the broadband access technologies, current and future, is illustrated in Figure 6. All of these technologies will be considered in the original telecommunications planning effort.

CURRENT ACTIVITY IN REGIONAL TELECOMMUNICATIONS PLANNING

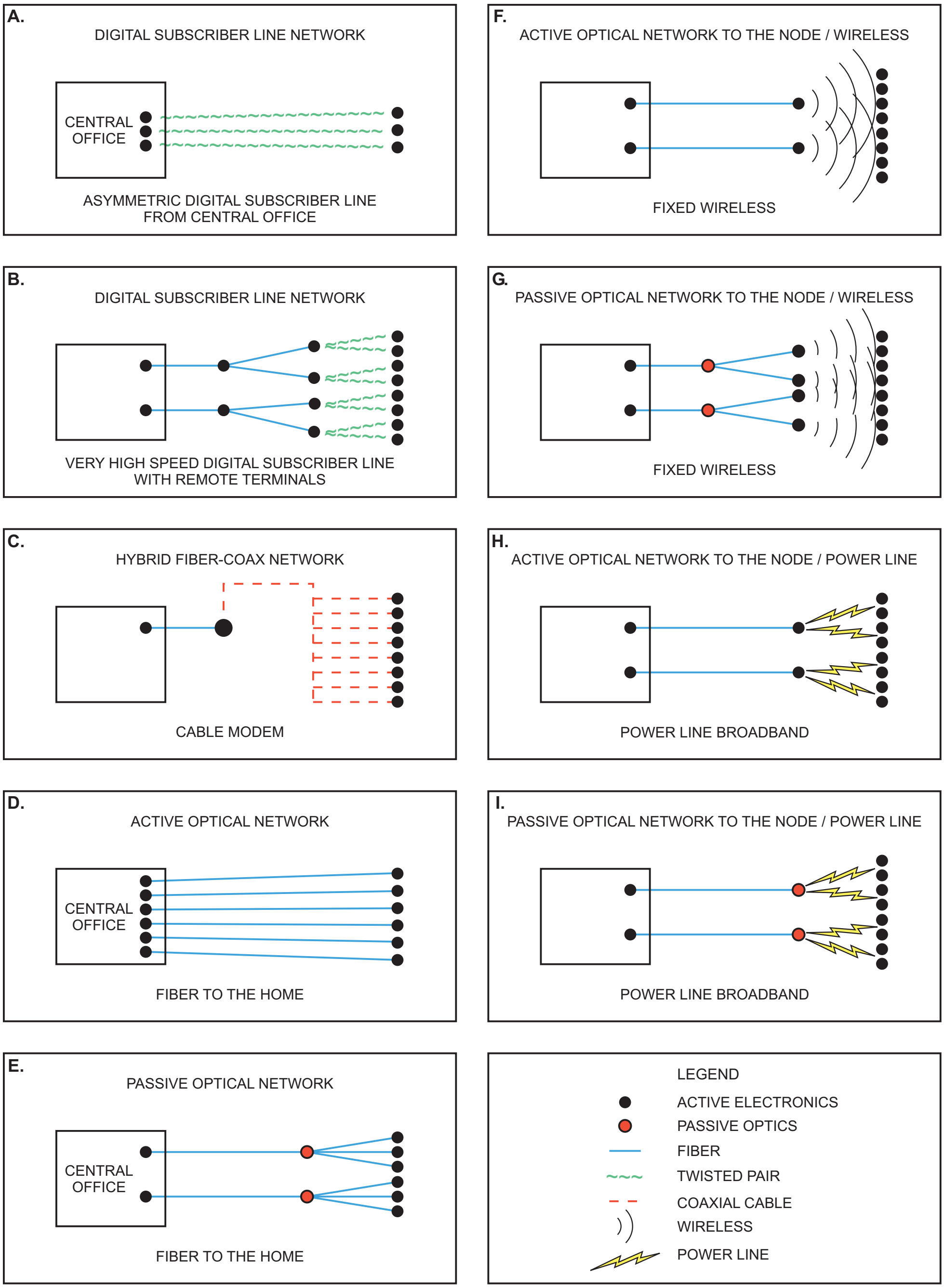
Initial staff and Advisory Committee efforts related to the preparation of six study design memoranda that detailed planning procedures to be applied in the telecommunications planning program. Work efforts are now focused on the development and startup of a regional network monitoring system which will measure network performance in terms of connection speed, response time, transmission rates, and accuracy on a continuing basis. Such monitoring will allow for an assessment of the quality of the regional network and the identification of "bottlenecks" that limit network performance.

The Commission staff is also engaged in developing an inventory of the current telecommunications infrastructure within the Region—both wireline and wireless. Infrastructure data are being compiled partly from public information at the Public Service Commission of Wisconsin, partly from Federal data banks, partly from individual service providers, and additionally from "trace route" programs that scan the Internet and identify transmission routes from all parts of the Region. Such trace routes allow for the identification of the nodes and links making up the Regional packet-switched network.

The other major work activity relates to the Regional antenna site plan. Starting with an inventory of existing antenna sites in the Region related to mobile cellular or fixed wireless communications, a set of preferred antenna site locations for existing and future wireless communications in the Region will be developed. A mathematical model will be employed to determine a best set of antenna site locations that will provide the necessary coverage and capacity while minimizing the number of antenna sites required. A major goal is to expedite the antenna site approval process for the benefit of both service providers and local communities.

Figure 6

ACCESS NETWORK ALTERNATIVES



Source: IEEE Optical Communications and SEWRPC.

IN THIS ISSUE

This entire issue is being devoted to a SEWRPC initiative concerned with regional telecommunications planning.

SOUTHEASTERN WISCONSIN REGIONAL
PLANNING COMMISSION

W239 N1812 Rockwood Drive
P.O. Box 1607
Waukesha, Wisconsin

CHANGE SERVICE REQUESTED

Telephone: (262) 547-6721
Fax: (262) 547-1103
Web: www.sewrpc.org

Philip C. Evenson, AICP
Executive Director

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