Hybrid Fiber Coax Networks: A Viable Option for Telemedicine

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WIRELINE NETWORKS most commonly in use today were designed for transmission of analog voice traffic. As such, these networks severely limit the amount of information that can be transmitted across them. In the world of telemedicine, use of these transmission media has been one limiting factor to the progress of better diagnostic tools being available.

There are newer networks available today that have characteristics which should be extremely attractive to the practitioners of telemedicine. This report will introduce the reader to these networks.

ATTRIBUTES OF AN "IDEAL" NETWORK

The attributes one might seek from the ideal network for telemedicine would be the following:

1. *Broadband.* The "ideal" network would have huge capacity to transmit information over it. It would not be limited to narrowband transmission methods deriving slow data rates or inability to transmit or receive live full motion video information.
2. *Ubiquity.* The "ideal" network would have the huge capacity described above across entire metropolitan areas. This would enable medical centers to interconnect with each other, with Physicians offices, and with the homes of medical personnel. Such ubiquity would allow instant high speed interconnection of all the above named facilities.
3. *Flexibility.* The high-capacity, ubiquitous network described above would also have to have the flexibility to simultaneously transmit and receive multiple types of information (eg, data, voice, video) at varying speeds without interference.
4. *Reliability.* The "ideal" must do all the things listed above but most of all do them reliably. Telemedicine is, by definition, a life or death matter.

THESE NETWORKS EXIST TODAY

Hybrid fiber coax (HFC) networks exist today in every city in America. These networks have historically provided video services to the residential community, but are quickly transitioning to full-service networks serving the commercial community as well. These full-service networks have all

the attributes described above as ideal for the needs of telemedicine.

Who operates these networks? Your cable company. Consider the following.

Capacity

Today's HFC networks have significantly more bandwidth than any other, currently deployed, metropolitan-wide networks. As currently configured, they have as much as 700 MHz of bandwidth downstream (meaning from the headend processing center towards the customer) and 35 MHz of bandwidth in the opposite direction. This asymmetrical division of bandwidth reflects the current needs of the users of the network, but is relatively easy to reconfigure in more symmetrical ways.

How does this capacity compare? Consider that twisted-pair copper telephony networks are optimized for only 8 KHz of bandwidth. This means that the capacity of an HFC network, even in its most constrained configuration of 35 MHz in the upstream direction, is 4,000 times greater than the standard telephony twisted pair. For significantly higher prices, the twisted-pair copper provider can combine pairs and add repeaters and provide up to T-1 (1.5 megabits per second) speeds. This still pales when compared with the speeds provided by HFC networks. High-speed data connections over an HFC network are commonly available that provide up to 10 megabits per second at a fraction of the monthly cost of a tariffed T-1 twisted pair.

Ubiquity

Consider the accomplishment of the cable industry in terms of building America. Without the benefit of low-interest government (REA) loans, the cable industry has erected 1.23 million miles of HFC network throughout the nation. This translates into HFC network availability to 97% of all TV

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homes in the nation. While these networks serve every town and city, they generally do not extend into rural areas where the economics do not make sense.

Reliability

Perhaps the most difficult barrier the cable industry has to overcome is the well-deserved, but outdated reputation for poor reliability. The less than desirable performance of the early networks was primarily caused by two factors: long amplifier cascades and connection to the public power grid (Fig 1).

Amplifier cascades. Before deployment of fiber optic technology, the cable industry would place repeating amplifiers to overcome the losses in the cable used. It was common for networks to have 30, 40, or 50 amplifiers in cascade to be able to cover a service area. Like Christmas tree lights of days gone by, if one amplifier failed in the string, all subsequent subscribers were left without service. The large numbers of amplifiers in cascade just increased the probability of outage. This problem has been significantly eliminated through deployment of fiber optic lines . . . eliminating the long cascade of amplifiers. Fiber optics allows for transmission over large distances without the need for amplification.

Commercial power outages. The amplifiers described above required electricity to power them. This power was provided by the local power utility company in the serving area. If the power went off, the amplifiers went off, creating an outage for all subsequent subscribers. Since power outages can be very localized, the customer's power might have been on, but cable off because the power was off at some serving amplifier many miles away. This problem has been eliminated.

Fig 2 details the improvement in network availability (reliability) over the last 10 years at Cox Communications.

Added reliability factors. In addition to the items mentioned above, some cable operators are deploying ring architecture in their fiber optic backbone network. This means that every fiber route has a second diverse path to the same location, thus eliminating the downtime that could be caused by fiber cuts or other physical failures.

These rings are fed with redundant transmit and receive electronics to further eliminate the possibility of downtime.

Figure 3 depicts the primary attributes of the cable network that provides the reliability. From the master telecommunications center (MTC) the signals are transmitted by redundant lasers over diversely routed fiber to the fiber node. The fiber

Fig 1. Reliability.

Fig 2. HFC network in Lubbock today.

node, which is typically located to provide service to neighborhoods up to 1,000 homes, has redundant receivers and transmitters. The fiber node and the attendant amplifiers are powered with a standby power supply that includes both batteries and a natural gas powered generator as back up power sources. This eliminates loss of commercial power as a potential outage source.

Commercial Applications

As the cable industry overlayed its network with fiber optics, many operators expanded into the commercial areas of the community. These were the first forays into the alternate access business, whereby cable companies offered businesses commercial services including telephony. These busi-

Fig 3. Simple schematic of HFC network.

Fig 4. Detailed network schematic.

nesses have flourished, providing competition to the local telephone companies.

The detailed network schematic in Fig 4 is a more complete view of the network including the commercial network (on the left side of the chart) and the integrated residential/commercial network (on the right side of the chart). What is important about this chart is that it shows that the network is totally interconnected. This interconnectivity allows for delivering services across both networks. As depicted in the example, images collected at a cross town medical facility could be viewed by a

physician from his/her home or office. This connectivity is achieved using both networks.

SUMMARY

Cable companies have improved their networks to the degree that they are viable alternatives to currently deployed networks. A detailed look at these cable networks shows them to be superior in bandwidth (capacity), speed, flexibility, and ubiquity. The services that can be provided by these networks are ideal to numerous advanced applications, including telemedicine.