The Last Mile: Where Telecommunications Traffic Slows to a Crawl

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Abstract

The paper addresses the problem of congestion on the access ramps of the information superhighway and examines both near and longer-term solutions. The focus is on the customer's ability to gain access to multiple transit networks and service providers by building bridges into and out of the customer premises and by managing information within the home. The authors recommend a new type of service / connectivity provider, a *Local Services Integrator* (LSI) operating in the customer loop, and a *Customer Premises Integrator* (CPI) operating within the residential environment. An LSI may be either the operator of a multiple services network such as an LMDS licensee; a digital-ready CATV operator running over a hybrid fiber / coax infrastructure; a phone company or CLEC using multimegabit DSL technologies; or a heretofore unknown entity with the capital, technology and regulatory authority to negotiate services from any and all providers and to integrate them into an affordable, easy-to-use residential package. The mission of the CPI is to bring to market innovations for the managing of telecommunications traffic within the home. Since the mix of services will be both symmetric and asymmetric—arriving from more than one service provider using multiple signal formats deployed over a growing number of wireline and wireless media—home applications must be dynamically configurable and controlled by both CPI and customer.

The Problem

Telecommunication highways of terabit-per-second speeds now link most American cities but few home owners have access to even a megabit of that. Fiber stops before it gets to the home. Coaxial cable TV (CATV) provides broadband service but with few exceptions is still a one-way pipe. Telephone lines are slow and inefficient.

In the wireless world, local stations soon will begin digital TV (DTV) broadcasting in competition with direct-to-home broadcast satellites (DBS), broadband wireless such as LMDS and MVDS and other providers aimed at luring residential consumers as subscribers. Yet, in this complex offering of digital multicast programming, only very modest prospects for interactivity are now possible and integration of the various wireless and wireline services is still some distance away.

From the consumer's perspective, the problem does not seem to be a lack of future options. On the contrary, what is promised Jo Customer and her family is more choice, more bandwidth, more speed than ever dreamed of. But which one—which ones—to choose? Will the ISDN-anywhere lines planned to connect Mom to her corporate network also get Dad and Kids onto the Internet? Will the cable TV, satellite TV and over-the-air broadcast channels that feed the home entertainment center offer more than passive viewing? Will any of these technologies be integrated with each other? In brief, will the enabling technologies be in place and will the services be packaged in a way that the family can both afford them and get maximum use out of them?

The number of suitors are certainly growing, as are the number of telecommunications paths into the home and the variety of services planned. Awaiting the go-ahead from those who make the business decisions are a surprising number of technological solutions capable of addressing the traffic jams that currently exist between the end of the nearest high capacity trunk line and the home premises. Breakthrough developments in hardware and software in both the wireline and wireless domains have given telecommunications managers new tools with which to work.

What seems to be focusing attention on the home consumer is the prospect of selling increased-speed access to the Internet, switched video services such as video-on-demand and, to an extent that is still undefined, easy exchange of multimedia products among end users. Whether these are niche markets—therefore limited—or a global mass market ready to take off remains to be seen. Technological developments will represent a big part of whatever solutions there are, but the answers will also be largely economic and part regulatory, social and cultural. As long as the Last Mile infrastructure is absent or unresponsive to the felt needs of those consumers, however, no serious market will develop.

Proliferation of Paths and Players

Mom, Dad and the Kids each have their own reasons for reaching into that vast store of information and interactivity that has come to exist in the digital world and bringing it into the environment of their home. These could be reasons related to communicating with others, connecting to work, engaging in learning activities or just enjoying life. In brief, this family and millions like them are open to a sales pitch from service providers.

Soon there will be multiple broadband corridors heading in the direction of the home, a fact which these families will not realize by talking to a single vendor. Providers of information services are already engaged in research on the best ways to use one or more of these paths to help families realize their dreams. But what the vendors will not tell the folks at home is that for the foreseeable future both they and their service providers will be wringing their hands over the inadequacies of a telecommunications infrastructure which promises much but delivers little. These channels, which will be wireless as well as wireline, will all be incompatible. Not only will they require specialized interfaces to the terminal equipment within the home, they will require different access technologies beyond the home.

Why? One reason is the way we got here. Wireless and wireline access providers have traditionally operated in different worlds. Historic territorialities and regulatory oversight have dampened efforts at collaboration. Each has represented protected industries with its own consumer base which was huge and profitable. Now their subscriber/audiences have fragmented, their missions are less well-defined. Competitors have emerged.

Another reason for this complexity is that delivery of interactive broadband services to the home is a relatively recent phenomenon largely occasioned by the Internet. Until now, research and marketing departments have worked in vain to come up with a clear picture of what the next generation of videotext, videophone, movie-on-demand interactive data services would look like, or what consumers would be willing to pay for. Because profitable services are already in place, there is massive anxiety over leaving the safe havens of voice (telcos) and one-way video (broadcasters) and fear of encountering some unforeseen disaster in the cutover from analog to digital.

One way to think about today's customers, providers and delivery/access networks is to use the model developed by the International Telecommunications Union (Figure 1).

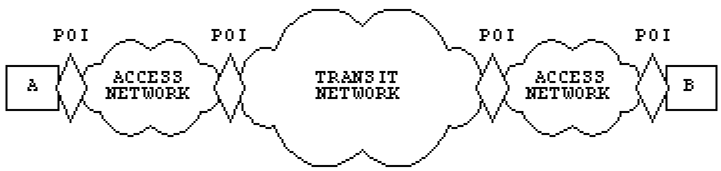

Figure 1. ITU reference model. *POI,* point of interface.

The model helps to analyze and simplify the complexity of services, players and paths into the home. This model can be applied to any end-to-end communication regardless of the underlying medium: wireless or wireline, narrowband or broadband. For example, in a plain old telephone service (POTS) call:

- A and B are two customers talking on the phone.
- The customer-access points-of-interface (POI) are the standard network interface (SNI) boxes attached to the homes.
- The access networks are the copper loops connecting the SNIs to the central offices.
- The access/transit POIs are the central offices. In certain analyses, the POI could be equipment in the CO such as the main distributing frame or switch.
- The transit network is the public switched telephone network (PSTN) of long-distance, interexchange carriers.

Wireline Access

The following wireline technologies provide the home and small business with digital access to the Internet and other interactive services:

- SW56/ISDN, Switched 56 and Integrated Services Digital Network.
- HDSL/SDSL, high-bit-rate and symmetric/single-line DSL.
- ADSL/VDSL, asymmetric and very-high-bit-rate DSL.
- FITL, fiber in the loop.
- HFC, hybrid fiber/coax.

SW56 and ISDN

The first access networks were those of the telephone companies, consisting of analog signals carried entirely on twisted pairs, or loops, of copper. Later refinements of the customer loop used analog and digital pair-gain technologies to multiplex lines coming out of the central office, but the final drop into the home remained the analog copper pair. Analog telephony was later augmented by digital signals into the home, ushering in the digital subscriber line (Table 1). Early versions of DSL technology were *Switched 56* (SW56) and *Integrated Services Digital Network* (ISDN).

Table 1. DSL abbreviations

Abbreviation	Full Name
DSL	digital subscriber line
xDSL	x=whatever DSL
SW56	Switched 56
ISDN	Integrated Services Digital Network
IDSL	ISDN DSL
HDSL	high-bit-rate DSL
HDSL2	HDSL version 2
SDSL	symmetric single-line DSL
ADSL	asymmetric DSL
RADSL	rate-adaptive DSL
VDSL	very-high-bit-rate DSL

Residential ISDN is not available everywhere and it is expensive to install and subscribe to, but such lines can provide twice the speed of telephone lines using the fastest (56 kbps) analog modems available today. With the discovery of faster DSL technologies in the late 1980's by a research team led by Joseph Lechleider at Bell Communications Research, phone companies had the ability to convert their copper outside plant into multimegabit access networks.

HDSL and SDSL

After SW56 and ISDN, the next DSL technology to be deployed by the phone companies was *high-bit-rate DSL*, which runs over two twisted pairs of copper. The main application of HDSL has been to replace T1 lines, the high-capacity (1.544 Mbps) workhorse of local trunking. Because the T1 carrier requires repeaters at intervals of 3000-6000 feet, and because tuning of these repeaters is labor intensive and therefore expensive, repeaterless HDSL was embraced as soon as it was ready for deployment in the early 1990s. Since 1996 a one-pair version of HDSL, called *HDSL2* or *symmetric single-line DSL* (SDLS), also has been available.

An instructive application of HDSL and SDSL is in the cellular telephone network (Figure 2). In this example, an HDSL line connects the cell site to the mobile telephone switching office (MTSO), which in turn is connected to the nearest telco central office by another HDSL/SDSL line or by fiber if PSTN traffic between the MTSO and CO warrants the investment.

ADSL and VDSL

In outside plants where copper extends from the central office to the customer premises, the *asymmetric digital subscriber line* (ADSL) is an obvious choice for the telephone company or competitive local exchange carrier (CLEC) wishing to enter the broadband access market. A likely scenario that will reach a significant number of residences is shown in Figure 3.

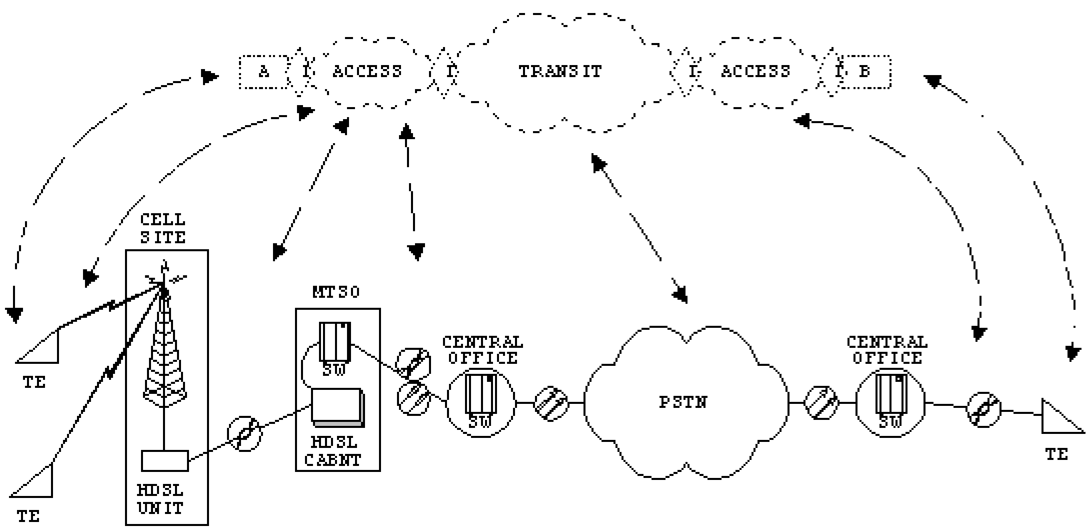

Figure 2. HDSL / SDSL application in cellular infrastructure. *HDSL,* high-bit-rate DSL; *MTSO,* mobile telephone switching office; *SDSL,* symmetric single-line DSL; *SW,* switch; *TE,* terminal equipment.

In this example, a network access provider (NAP) installs a wire center, consisting of ADSL modems or ADSL transmission units-central office type (ATU-C) and a DSL access multiplexer (DSLAM). The NAP connects the wire center to various transit points-of-presence in or near the central office; POPS are the interface between the residential customer's access and transit networks. Network service providers such as ISPs and switched video service providers connect to transit through access networks on their side, thus completing connectivity between customer A and customer B in the ITU reference model.

The wire center may be co-located in the central office or in a facility nearby. A customer premise terminal within the service area of 18,000 feet from the wire center communicates with the ATU-C over the copper loop by means of a residential ADSL modem or ADSL transmission unit-residential type (ATU-R). Downstream transmission rates are in the 2-8 Mbps range, upstream 64-1000 kbps.

Very-high-bit-rate DSL (VDSL) is a high-speed, short-range version of ADSL. For the moment, the choice between ADSL and VDSL is a trade-off between distance and transmission rate. The longer the distance, the slower the transmission, for which a good choice would be an ADSL technology that can be upgraded easily and inexpensively to VDSL. In a hybrid ADSL / VDSL system—a broadband extension of *rate-adaptive DSL* (RADSL)—currently under development, projected rates are 52 Mbps in the VDSL range over shorter distances and 2-8 Mbps in the ADSL range over longer distances.

Comparison of SW56/ISDN and ADSL/VDSL

Switched 56 and ISDN pale in comparison to ADSL and VDSL transmission rates. But the former have proven track records and effectively serve the needs of many residential applications. As researchers and engineers amass experience with the newer, faster DSL technologies, and as competitive LECs enter the market as NAPs and set up wire centers near each CO, it is reasonable to expect ADSL or VDSL to be deployed virtually everywhere in the customer loop.

A valuable feature of ADSL is its compatibility with POTS. Splitters shunt the lower-frequency POTS signal to the PSTN on the network side of the loop and to plain old telephones on the residential side (Figure 4). Since POTS power is fed from the CO, the ADSL customer always has dialtone for 911 / lifeline service if she maintains a legacy phone. Such is not the case with off-the-

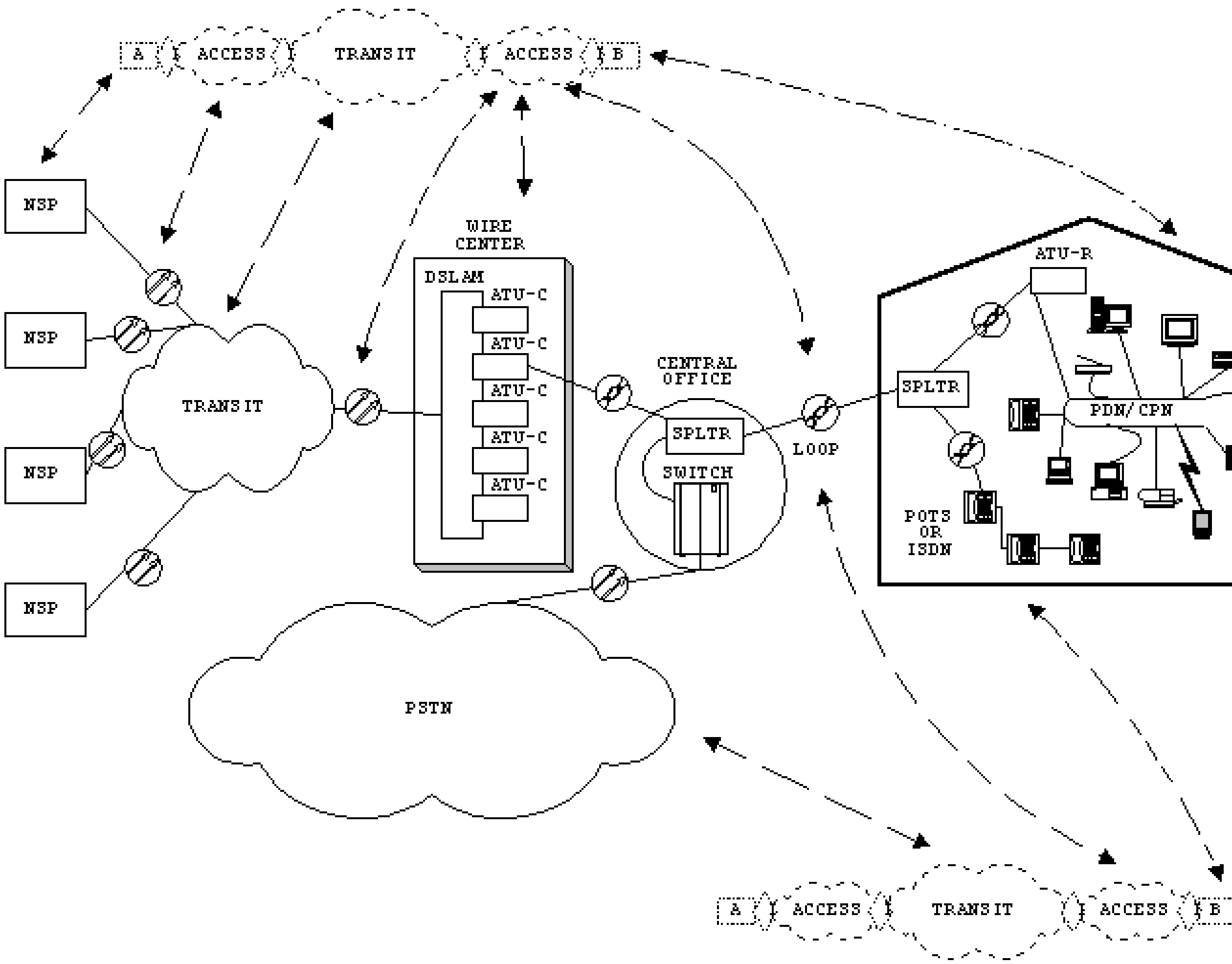

Figure 3. ADSL reference model. *ADSL*, asymmetric digital subscriber line; *ATU-C*, ADSL transmission unit-central office type; *ATU-R*, ADSL transmission unit-residential type; *CPN*, customer premises network; *DSLAM*, DSL access multipexer; *HAN*, home area network; *NSP*, network services provider; *PDN*, premises distribution network; *SPLTR*, splitter.

shelf ISDN for two reasons. First, POTS and ISDN cannot use the same twisted pair. Second, ISDN customer premises equipment must have its own power feed. If the customer loses power, her BRI line goes dead—unless of course she has battery or generator backup.

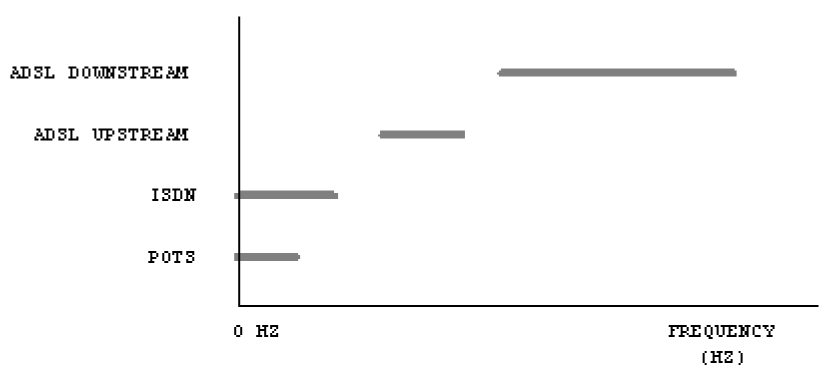

Figure 4. POTS, ISDN and ADSL signal spectra

Fiber in the Loop

Fiber in the loop (FITL) comes in several different flavors:

- Fiber to the home (FTTH).
- Fiber to the curb (FTTC).
- Fiber to the neighborhood (FTTN).

Because of its bandwidth and robust signal, *fiber to the home* (FTTH) is an ideal medium (Figure 5). But FTTH carries such a big price tag that no one gives it serious consideration in the near term. Less expensive, more practical access networks can be built by extending fiber from the central office to an intermediate point, where an optical network unit (ONU) converts the signal from optical to electrical which is relayed on existing copper lines into the home. The section of the network that connects the ONU and central office is the digital loop carrier (DLC). When the ONU serves a large number of homes, the access topology is *fiber to the neighborhood* (FTTN); when the ONU serves a smaller number of homes, it is *fiber to the curb* (FTTC).

When the distance from the ONU to the customer premises is relatively short, as is the case with FTTC, VDSL is a feasible option. Longer distances in a FTTN topology can be served by ADSL but the result is slower transmission. Long and short are relative terms, however, in the fast moving technological environment we live in, as are channel capacities and rates of transmission. Hence, a distance that supports ADSL transmissions under current technological constraints may soon be suitable for VDSL.

CATV and HFC

Just as *hybrid fiber/coax* (HFC) will help telephony providers upgrade their residential services to include broadband communications such as data and video, HFC will help CATV operators add bandwidth and interactive services to their portfolio (Figure 6). This new cable architecture, in which information arriving in the neighborhood on fiber is carried into the home on coaxial cables, will support multimegabit Internet, video-on-demand (VoD), games, shopping and other interactive services as well as telephony. In addition, the infrastructure can be upgraded to support broadband telephony services such as videophone and videoconferencing as well as digital HDTV.

Key to conversion of cable television into an advanced digital network is the installation of new high-speed modems in the subscriber premises and modifications in the cable plant that permit digital signal compression, encryption coding / decoding and real-time two-way data communications based on Internet protocols. Although cable modems promise to deliver downstream speeds 100 times faster than ISDN modems, rollouts of these systems have been slowed by arguments over set-top box standards and architecture and unacceptably high installation costs.

Comparison of DSL and HFC

A communication system is no faster than its slowest link. Although the capacity of the fiber trunk of an HFC system is for all practical purposes unlimited, the last leg or feeder and the drop that enters each home is metallic (coax), thus limited. The coax feeder shares its bandwidth among all customers connected to it. A hundred customers web surfing and pulling in separate VoD streams can degrade quality of service parameters to an unacceptable level even if feeder speeds of 10-20 Mbps or higher are attained.

Such is not the case with ADSL and VDSL. Each customer has her own dedicated line that is fed from an ONU or directly from the CO. The network-side fiber feeds to the ONU and CO can be configured to support any customer demands, provided that the access operator can afford the switching and multiplexing electronics and the service provider's transit network is adequate to the task.

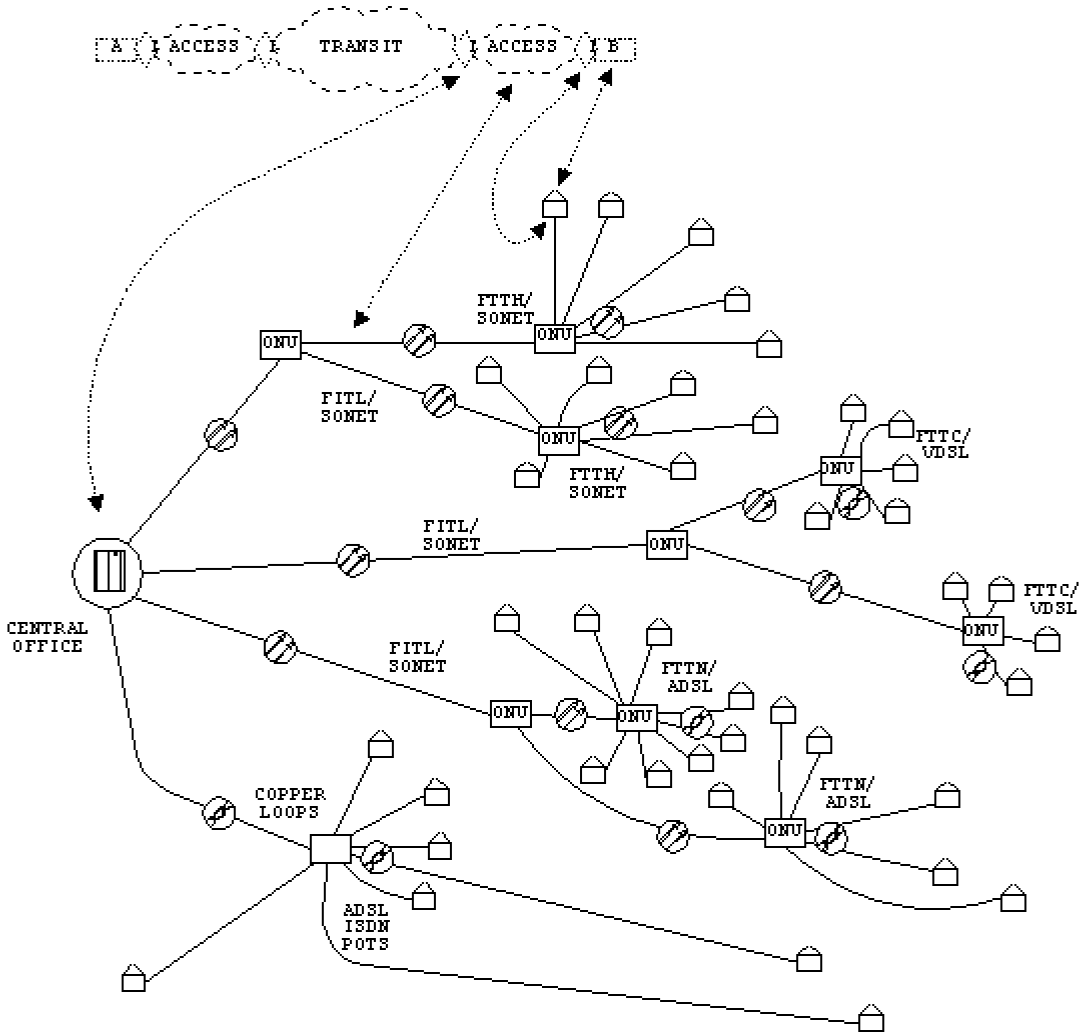

Figure 5. Fiber in the loop. *FITL*, fiber in the loop; *FTTC*, fiber to the curb; *FTTH*, fiber to the home; *FTTN*, fiber to the neighborhood; *ONU*, optical network unit; *SONET*, Synchronous Optical Network.

Wireless Access

High speed access to Internet and other broadband interactive services may be provided to the home via, or in conjunction with, wireless telecommunications channels in some of the following formats:

- MMDS, multipoint multichannel distribution system.
- LMDS / MVDS, local multipoint and microwave video distribution system.
- WLL / RITL, wireless local loop / radio in the loop.
- IVDS / DTV, applications of interactive video and data services in broadcast digital TV.

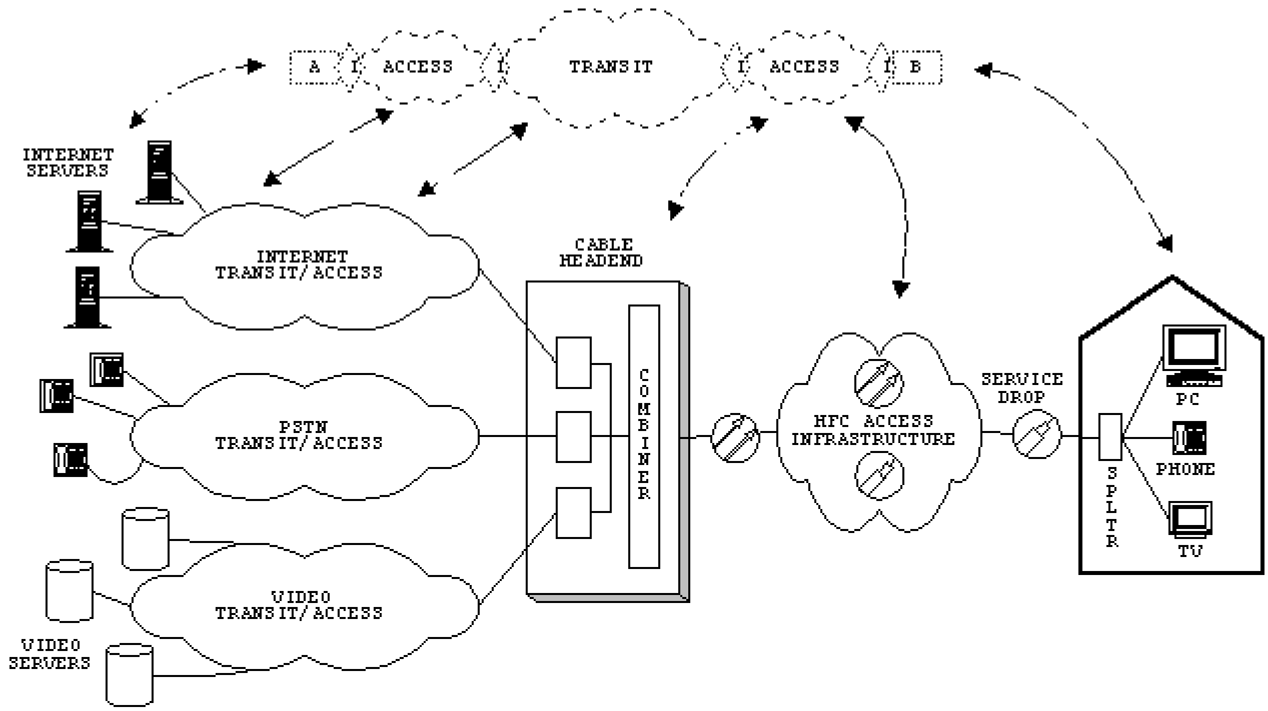

Figure 6. Hybrid fiber/coax architecture

- VSAT (GEO/LEO), very small aperture terminals communicating with GEO/LEO satellites.

MMDS

Providers of wireless cable, the omni-directional multipoint *multi-channel distribution system* (MMDS) using microwave (2.5-2.7 GHz) technologies with a compressed digital signal, are moving rapidly to install return channel capability to their formerly one-way broadcasts.

The principal advantage of the wireless cable approach as an element of the access loop is the availability of big chunks of under-utilized spectrum that will be much more valuable and flexible once digital kicks in. MMDS services have been around for 20 years, so there is a wealth of experience with this previously one-way distribution technology. System implementation, which is little more than an installed transmitter on a high tower and a small receiving antenna on the customer's balcony or roof, is quick and inexpensive. Although MMDS has been slow to find its place in U.S. markets crowded by broadcast TV, DBS and cable, the broadband technology is getting good play in cities such as Beijing, Mexico City, Nairobi, Riga and Moscow.

With the deregulation of U.S. telcos, Bell Atlantic, NYNEX, Pacific Telesis and others invested heavily in MMDS franchises as a way to get quickly up and running as full service providers. By 1997, a major telco programming venture (Tele-TV) had failed and several of its underwriters slowed the buildout of MMDS until a more suitable strategy for approaching the broadband home market could be found. These actions caused a loss of investor confidence, MMDS stocks were hard hit and some momentum in developing this technology has been lost.

LMDS and MVDS

Colloquially called *cellular TV,* the 1997-approved *local multipoint distribution system* (LMDS), operating in the upper microwave (28-31 GHz) frequencies, is designed to be an interactive broadband service using interconnected cells in the local loop (Figure 7). Each transmitter serves an area of 2-3 km in diameter. Cell architecture is similar to that of cellular radio and personal communications services, but LMDS cell size is significantly smaller.

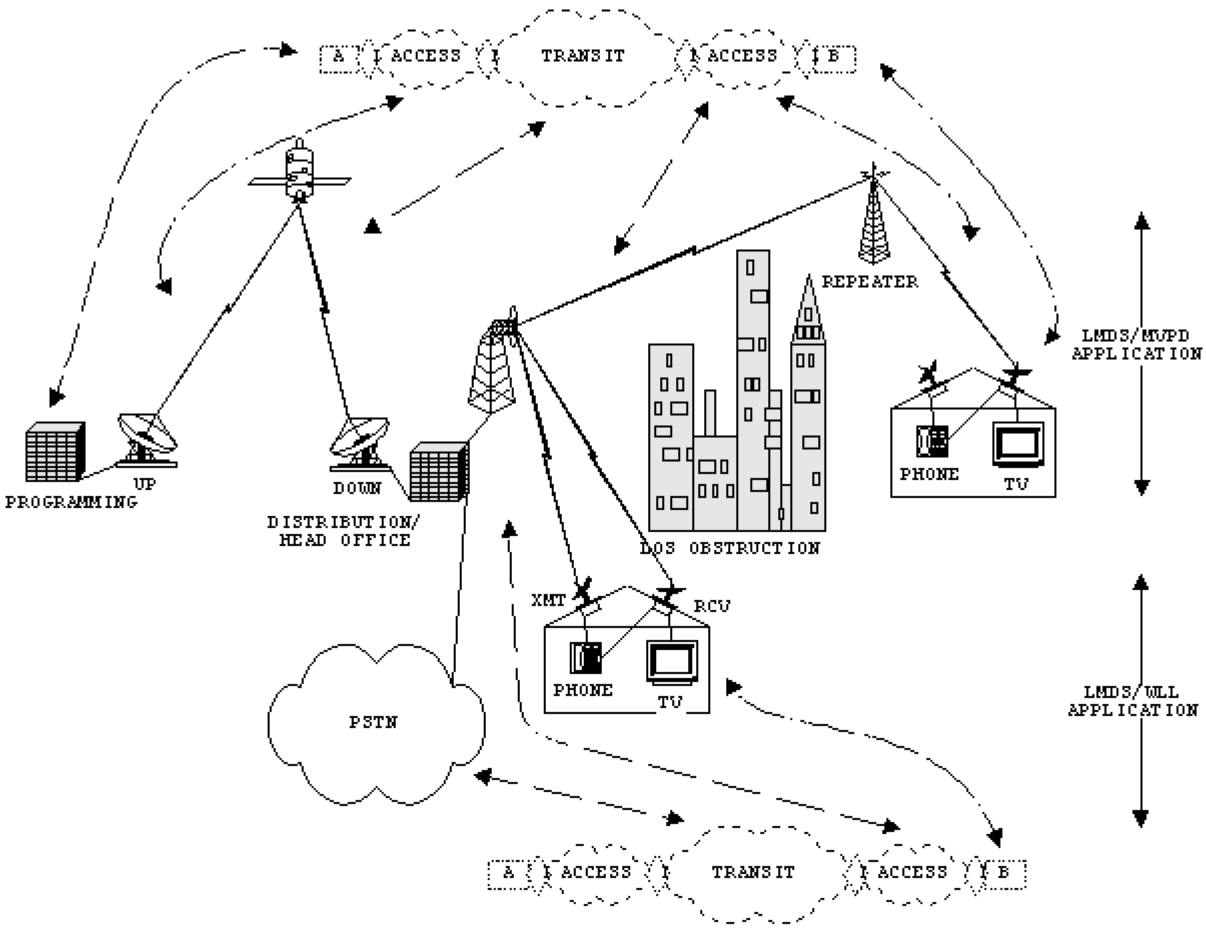

Figure 7. Local multipoint distribution system. *LMDS*, local multipoint distribution system; *LOS*, line of sight; *MVPD*, multichannel video production distribution; *WLL*, wireless local loop; *XMT/RCV*, transmit/receive.

In auctioning the LMDS spectrum, the FCC has designated two licenses in each of the 492 Basic Trading Areas (BTA) in the U.S. The commission allocated a huge block of spectrum—1150 MHz for Block A licenses, 150 MHz for Block B—sufficient to provide telephone, video and data services. With its two-way transceiver capabilities, LMDS is a promising medium for Internet access, videophone, videoconferencing and pay-per-view (PPV) cable television.

LMDS is sometimes referred to as *wireless fiber* to emphasize its greater bandwidth in comparison to wireless cable (MMDS). Engineers estimate that LMDS technologies can produce 1 bit per second for each Hz. Hence a Block A spectrum of 1150 MHz is capable of transmission rates in the 1 GHz range, more than enough bandwidth for simultaneous support of the broadband services discussed in this paper.

A limitation of LMDS is the modest experience base for the technology. Early indications are encouraging. A Pioneer Preference license was granted by the FCC to CellularVision of New York. According to reviews, the digital service performs admirably. However, LMDS has not been tried yet in multiple locations in the U.S., so whether the long-term performance of the technology rivals that of MMDS and PCS remains to be seen.

It is conceivable for a Block A operator to offer narrowband voice, video and Internet access as well as broadband videophone, videoconferencing, multimegabit Internet and interactive multi-channel digital HDTV—and do it on *one unified infrastructure* of hubs and subs. Realization of this scenario is less likely to hinge on the technology than on economic, marketing and regulatory factors.

The commission left the door open to spectrum disaggregation and geographic partitioning. With few limitations, a licensee can sell smaller bands of its spectrum and partition the BTA into geographical units to be sold individually. Will each BTA witness a well funded, unified LMDS slugging it out toe to toe with incumbent telcos and cable, or will the spectrum and geography be balkanized into bits of minuscule but profitable services? Will major metropolitan areas be more supportive environments for unified service than their small town and rural counterparts? Answers are forthcoming in the marketplace.

The European version of LMDS, *microwave video distribution system* (MVDS), transmits at frequencies above 40 GHz and has a signal range similar to that of LMDS. Although the higher frequencies at which MVDS operates are less crowded and therefore capable of supporting more services, not only are the engineering challenges more difficult to meet but the manufacturing and maintenance of such systems pushes investors and network operators to the extreme. However, today's problem at 40 GHz is tomorrow's piece of cake. Technology marches on.

WLL/RITL

The wireless local loop (WLL), also called *radio in the loop* (RITL), adds its own unique set of contributions to the improvement of telecommunication capabilities both outside and inside the customer premises (Figure 8).

WLL applications are most commonly found in developing countries where wireless approaches provide a rapid and cost-effective way of delivering telephone services to not-yet-connected homes and businesses. Communications services are often made available in remote communities by connecting them to the nearest central telephone office via microwave carrier, satellite or other means. At the local point of presence, radio ports are installed which are interfaced to users' home or business equipment.

WLL is currently being tested as a bypass solution and alternative to existing wireline networks in more advanced societies, including tests of broadband transmissions capable of supporting multimedia exchange. Among the applications are switched telecommunications services for small and medium-sized business customers providing a single source for local and long distance telephone and Internet and other high-speed data access as part of the nationwide deployment of competitive local exchange (CLEC) services in the United States. These wireless carriers are giving home and business customers a single point of contact for multiple services. One such company uses previously unavailable 38 GHz frequencies to provide its local communications services.

Applications of IVDS in broadcast DTV

The *interactive video and data service* (IVDS), a new return path for making broadcast TV interactive, was approved for FCC spectrum auction in 1994. IVDS receiver/transmitters are installed in subscriber homes in the form of set-top boxes (Figure 9). Each box hosts a wireless radio frequency modem with remote control through which customers can interact with the programming source. Strategically located cell-tower transceivers gather signals from interactive video users and relay them via satellite or terrestrial links to the transmitting station or affiliated office.

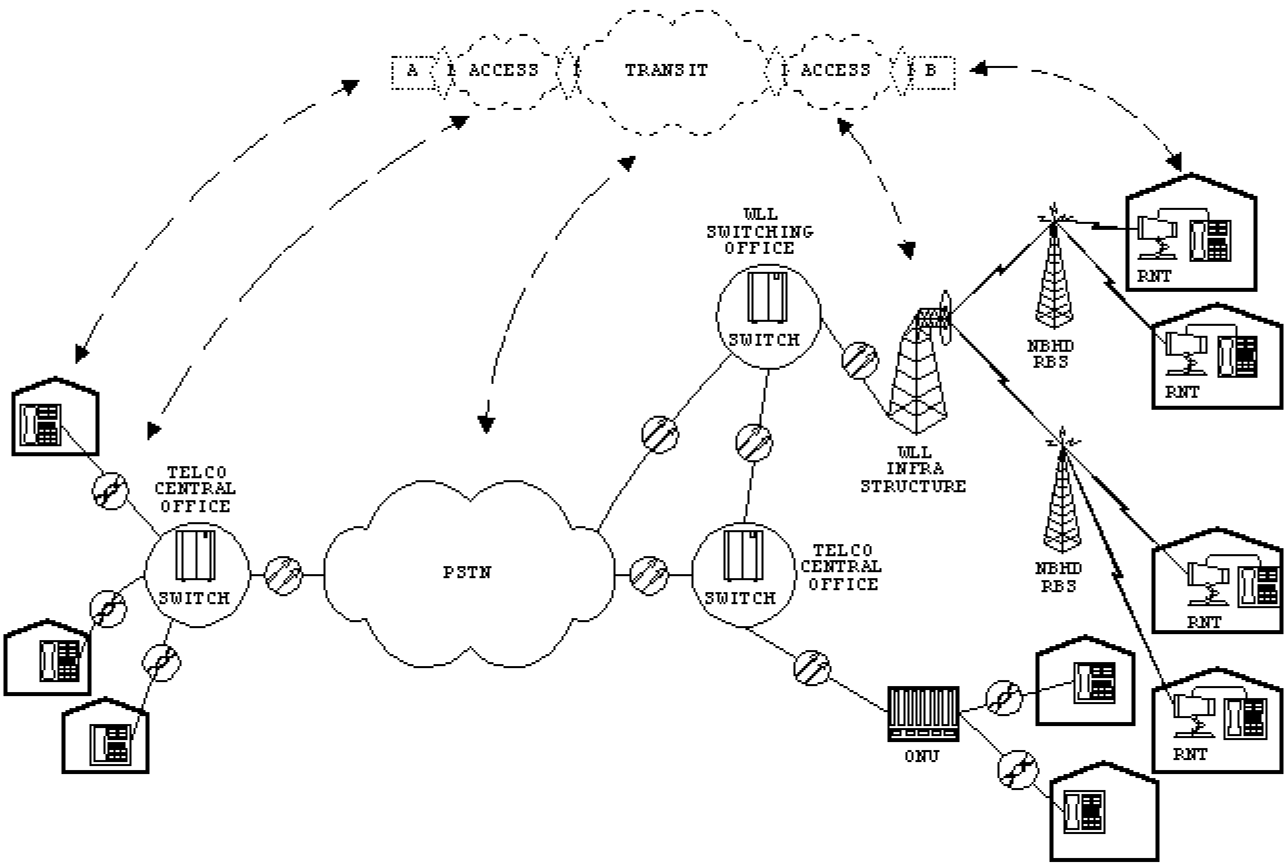

Figure 8. Wireless local loop / radio in the loop. *ONU*, optical network unit; *RBS*, radio base station; *RNT*, radio network termination; *WLL*, wireless local loop.

This technology is being positioned as a way to give added value to the TV broadcasts of local stations. With the prospect of a viable home-to-station return path in the local market, IVDS will be an option under consideration as U.S. television stations look for ways to profit from their new DTV channel assignments.

One of the limitations of this option is that the frequencies were auctioned before the technology to use them had been perfected. Set-top boxes were late in arriving and the FCC found itself facing multiple defaults by auction winners. Such defaults do not diminish the long-term value of the technology, but they have made investors cautious. Meanwhile, the dogfight over CATV boxes in the home has left IVDS on the outside looking in.

VSAT in GEO and LEO Satellite Applications

This is an interactive satellite service (Figure 10). It gets its name from the *very small aperture terminal* (VSAT) dishes found atop business premises, now being seen at home premises as well. The VSAT service operates from *geosynchronous orbit* (GEO) relaying digital data, voice and video signals, in real time or downloaded for later use, to on-site computers. The upstream is by return signal to the satellite or, as in the case of the Hughes DirecPC home and small business service, Internet searches and requests are made by way of low-speed terrestrial link (telephone lines) with content delivery direct to user premises via the advanced digital capabilities of satellite.

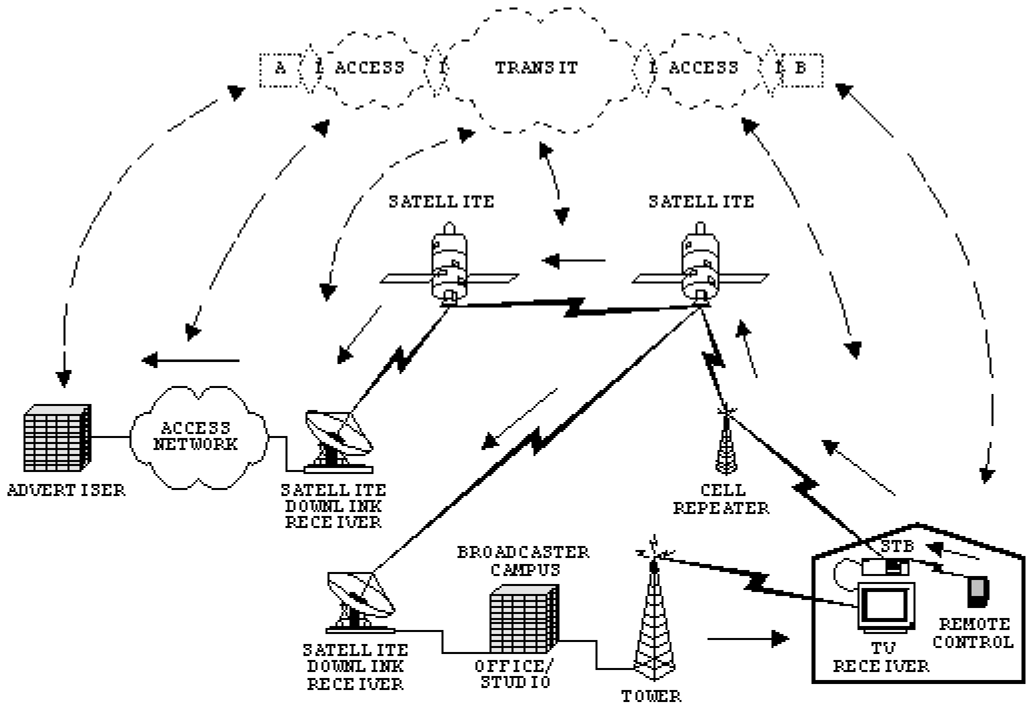

Figure 9. IVDS interactive TV. *STB*, set-top box.

Rapid implementation of service is one of the attractive features of VSAT technologies. Installation of subscriber equipment—the dish, the receiver and computer interface—can be accomplished in a day. With mass marketing and ready availability of digital DBS services, costs are coming within reach of users who have a need to download Internet data at faster speeds, or who subscribe to data broadcast servies such as stock market reports, customized news feeds or company bulletins. The technology offers an advantage over cable modems and digitized phone lines in that it is available everywhere, whether in rural or urban areas.

There are constraints in the hybrid satellite/twisted pair telephone line configuration. The customer can order up material from heavily-loaded Web sites and great quantities of text, graphic, audio and video information can be delivered quickly. But were users to wish to send large files, the outpath is likely to be the same slow telephone lines that forced them to the satellite option in the first place. Direct return to the satellite of home-originated transmissions is possible but for the moment not yet a product for mass consumer use.

More than one *low earth orbiting* (LEO) satellite system are now approaching launch. These constellations of satellites that communicate both with terrestrial stations and among themselves will orbit some 800 kilometers or higher and provide on-demand global Internet access, videophone, videoconferencing and interactive multimedia to fixed and mobile transceivers. LEO services are suited for urban or rural areas not yet connected to a broadband terrestrial infrastructure or which cannot be covered economically using traditional terrestrial infrastructures. These Year 2000 Plus technologies are suited especially to bi-directional asymmetric services as they offer a very short round-trip propagation time, enabling them more easily to share common communication protocols, standards and applications with terrestrial networks.

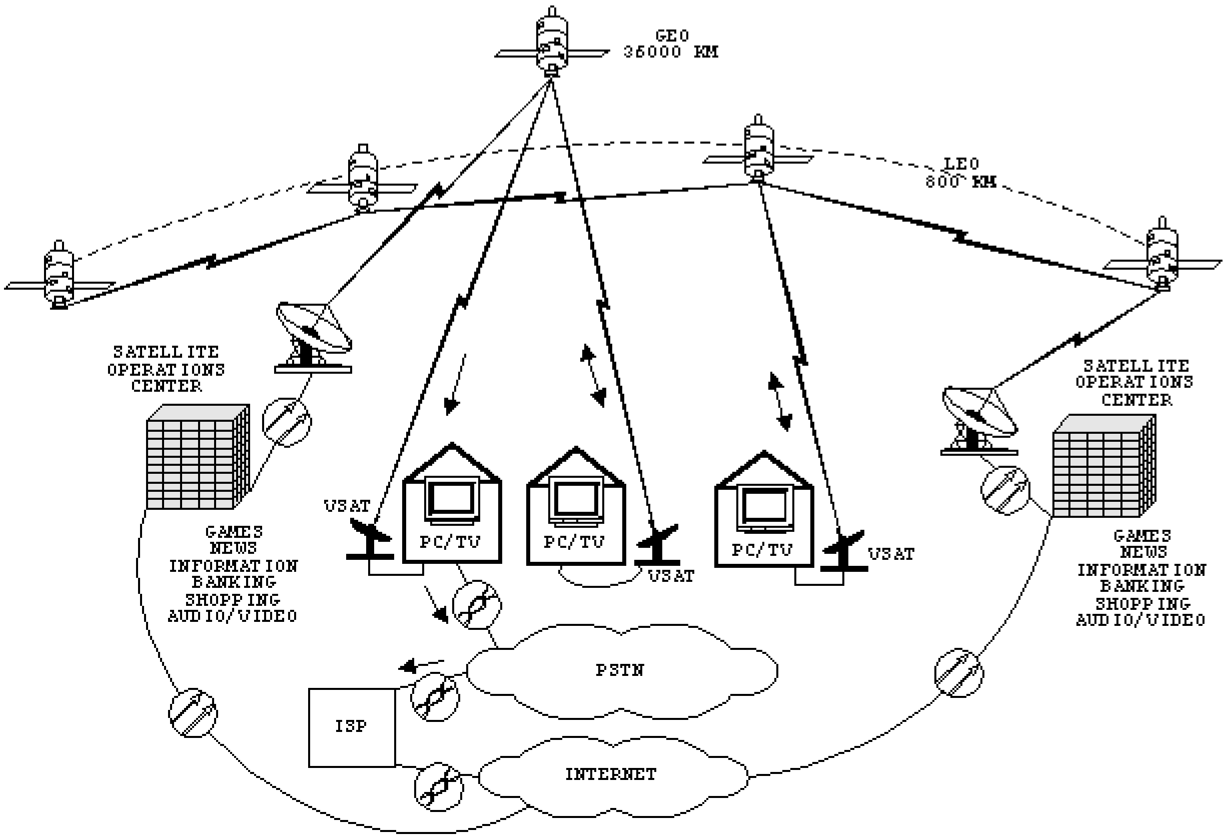

Figure 10. VSAT applications in GEO and LEO satellites. *GEO,* geosynchronous orbit; *ISP,* Internet service provider; *LEO,* low earth orbit; *VSAT,* very small aperture terminal.

Convergence in the Local Loop

A quick R&D literature review and visits to various telecommunications forums will show that the technologically advanced nations of the world truly are on the brink of plunging into broadband residential services running on multiple networks comprised of components from multiple manufacturers and vendors. The reason for the industry initiatives which will make such a future possible is the realization that there are opportunities out there in accommodating to those services defined by third-party integrators who don't operate the networks over which the services run—and that a changed regulatory environment will permit this to happen.

Providers of home services and those working on near-home connectivity have been held back by the fact that service architectures have been dependent on a particular core transport network, either on a particular transport technique or bearer service. Due to the multiplicity of services, technologies and standards, it is difficult to port services (Figure 11).

What is needed is a more open software creation platform so that multiple services from multiple providers have a chance of being offered transparently across the many competing but technologically incompatible networks, so that individual services can be constructed and rapidly deployed using systems and software developed by different vendors. Thus, the retailer of services, the Internet services provider and the games-on-demand operator, is able to integrate his system into a plug-in environment, making more feasible seamless communication of feature-rich information into and out of the customer premises.

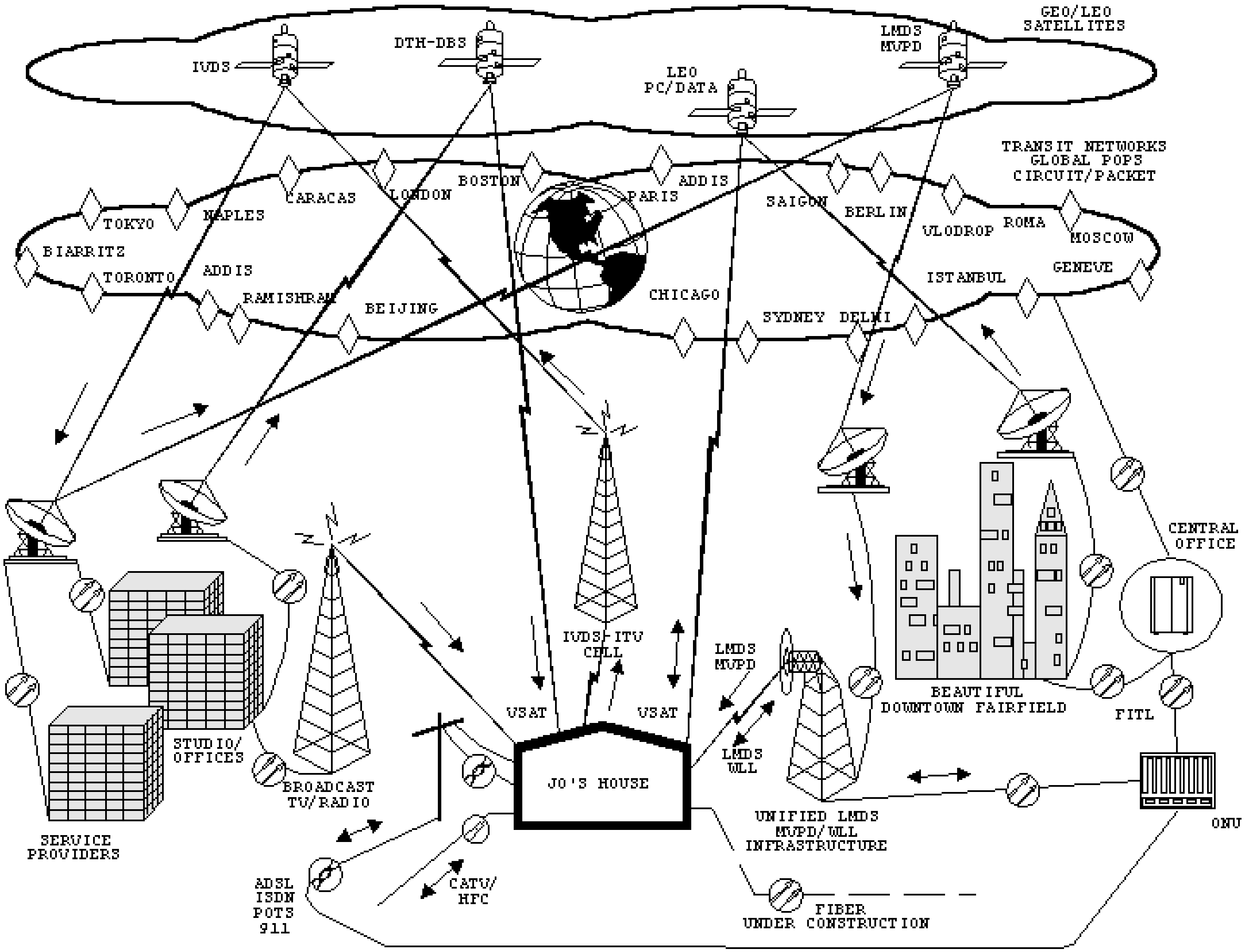

Figure 11. Telecommunications options in the local loop. *ADSL*, asymmetric digital subscriber line; *CATV*, cable TV; *DBS*, direct broadcast satellite; *DTH*, direct to home; *FITL*, fiber in the loop; *GEO*, geosynchronous orbit; *HFC*, hybrid fiber/coax; *ISDN*, Integrated Services Digital Network; *ITV*, interactive TV; *IVDS*, interactive video and data services; *LEO*, low earth orbit; *LMDS*, local multipoint distribution system; *MVPD*, multipoint video programming distribution; *ONU*, optical network unit; *POP*, point of presence; *POTS*, plain old telephone service; *VSAT*, very small aperture terminal; *WLL*, wireless local loop.

Supported both by technical and regulatory changes, we are likely to see the impossible now happen. Bearer services will begin to cooperate, allowing their diverse networks to interface and be configured by independent service/connectivity providers in the Last Mile. This will happen for a simple reason. Nobody wins when Jo Customer is confused and frustrated that what she wants is beyond her ability to pay.

Given the following, consensual standardization is the best way to open the home, wherein resides the largest consumer base in the world:

- Telco, CATV, MMDS, DBS and now LMDS and DTV operators are all chasing the same residential customer.
- Jo and her family would like to have some of all of them, but probably not all of any one of them.
- The family has the purchasing power to invest in only one good home telecom appliance/network and monthly subscriptions to one or two carefully chosen services.

How will such cooperative competition come about? One prospect is that a single powerful operator with enormous capital and investor backing, persuasive technology and a bundle of services will capture and dominate the Last Mile market, and this could happen. We think a different model is both more desirable and more likely. The model is that of the *Local Services Integrator* (LSI), who will provide robust, convenient and affordable connectivity to myriad services found on diverse networks. Which technology or technologies will be used? There are several promising possibilities including ILEC/CLEC using DSL, CATV using HFC and LMDS/WLL using wireless fiber.

Customer Premises Integration

There is also need for integrative services within the home (Figure 12). Bellcore and others have done extensive research on home area networks (HAN) and customer premises networks (CPN). The goal has been to work toward common standards for interconnecting, adding to and upgrading the services of multiple providers in the broadband home market, thereby simplifying access and giving users greater control over traffic within the home.

Here too, as with the Local Services Integrators, the challenge is to devise a means by which home users may gain on-demand access to the networks of more than one operator. But what is even more demanding of this model is the need to give enhanced creation, storage, distribution and control capabilities to Jo Customer and her family so they can customize applications to taste. The customer is in the driver's seat. This assumes that each member of the family, according to that person's recreational, educational, professional or other agenda, will be free to roam from one network to another, connecting, sampling, downloading, clipping, pasting, processing, storing, exchanging and consulting at will. Ideally, this approach will account for service requests that originate at any time from any home terminal, fixed or mobile—in other words, on demand.

The *Customer Premises Integrator* (CPI) will have the task of devising gateway interfaces which will set up the call, connect to the appropriate service/access networks and translate the signal into a format that will be recognized by such diverse home equipment as the computer workstation, multimedia creation center, home entertainment center and security/energy management systems. Such a gateway will have to be dynamic and scalable, that is, capable of responding to a range of transmission/compression options and schemes, so that differently formatted services can be reconfigured on the fly. It must be able to manage the intelligent sorting and distribution of those services among diverse users within the home environment.

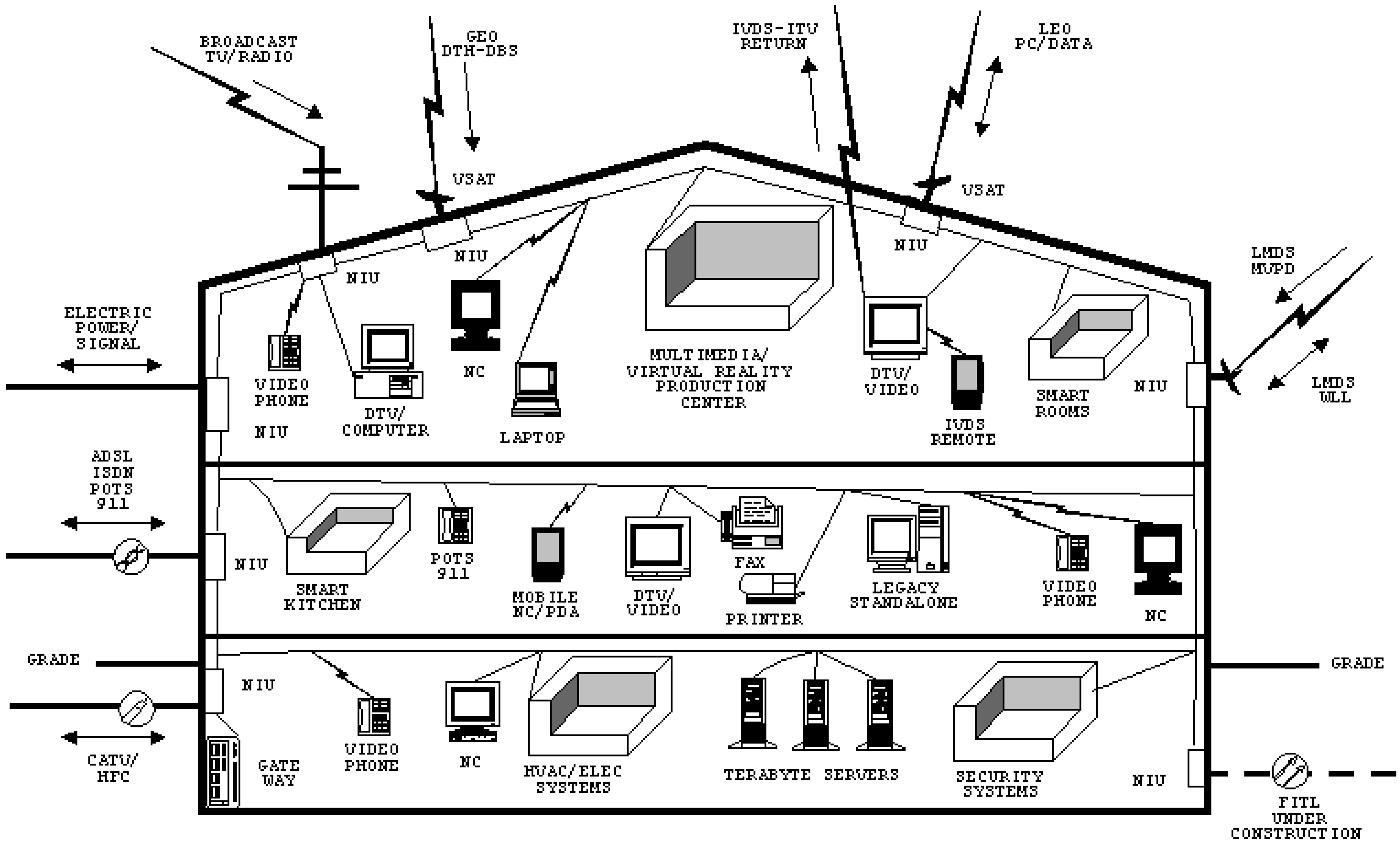

Figure 12. Telecommunications options in the customer premises. *ADSL*, asymmetric digital subscriber line; *CATV*, cable TV; *DBS*, direct broadcast satellite; *DTH*, direct to home; *DTV*, digital TV; *FITL*, fiber in the loop; *GEO*, geosynchronous orbit; *HFC*, hybrid fiber/coax; *HVAC*, heating, ventilation, air conditioning; *ISDN*, Integrated Services Digital Network; *ITV*, interactive TV; *IVDS*, interactive video and data services; *LEO*, low earth orbit; *LMDS*, local multipoint distribution system; *MVPD*, multipoint video programming distribution; *NC*, network computer; *NIU*, network interface unit; *PDA*, personal digital assistant; *POTS*, plain old telephone service; *VSAT*, very small aperture terminal; *WLL*, wireless local loop.

Yet to be figured out is how to account for usage, devise a service bill and protect copyright. This will be no small matter. Some operators rely on metering of use and per-product purchases to determine charges; others rely on subscription contracts based on a package of services delivered or availability of on-demand services over time. An integrated accounting system is needed, one that will be perceived as cost-acceptable by users, prove profitable to content and service providers and understandable to all.

Summary

The home user stares out at a daunting array of competing products and services. These are positioned to reflect the strengths of their providers, many of which Jo Customer and her family would love to sample from time to time. Unfortunately, what is offered comes in the form of all-or-nothing contracts on incompatible platforms. Families would be unable to afford many of these even if they could arrive at informed decisions as to which ones to choose.

The challenge to the telecommunications industry is:

- To integrate services and platforms.
- To work toward affordable, easy-to-use gateways that funnel into the customer premises information products and services under the control of the home and small business user.

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Useful Web Sites

1. AT Home Network: www.home.net

2. The ADSL Forum: www.adsl.com
3. The ATM Forum: www.atmforum.com
4. CellularVision: www.cellularvision.com
5. C-LEC info: www.clec.com
6. Digital Audio-Visual Council: www.davic.org
7. Dudley Lab: www.dudleylab.com
8. Eon Corporation: www.eon.com
9. Federal Communications Commission: www.fcc.gov
10. The Institute for Telecommunications Studies, Ohio University: www.tcomschool.ohiou.edu/itshome.htm
11. International Telecommunication Union: www.itu.ch
12. ISR Global Telecom: www.isrglobal.com
13. MediaOne: www.mediaone.com
14. Network Management Forum: www.nmf.org
15. OptaPhone Systems: www.optaphone.com
16. Paradyne Corporation: www.paradyne.com
17. Road Runner: www.excalibur-group.com
18. Telecommunications Information Networking Architecture: www.tinac.com
19. Telegroup: www.telegroup.com
20. USA Global Link: www.usagloballink.com
21. The Veda Home Company: www.veda-home.com/TelecomTom

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