Broadband Access: High-Speed Alternatives

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Executive Summary

My summer work term at IBM Canada Ltd. gave me the opportunity to see what networking was all about. While there a trial was taking place using broadband technology in conjunction with some of the services IBM offered normally to dial-up clients. Through many discussions about broadband access, I realized that I wanted to learn more about this topic. Therefore, I have taken the opportunity to use this report as a research tool so that I can learn more about the different broadband alternatives available to users.

Currently there are two alternatives on the market that are directly competing with one another. These technologies are cable and digital subscriber line (DSL).

Cable uses the existing cable TV infrastructure and a special modem to let users have access to the Internet at theoretical speeds up to 30 megabits per second (Mbps). Unfortunately, since cable is a broadcast medium this means your connection is shared with others in your neighbourhood and can be well below the theoretical value if everyone happens to be connected at the same time. Cable is reasonably priced but still is not available in all areas. Despite this, cable will be the early choice of many home users.

DSL is a family of technologies; all very similar except each is dependent on the distance an end-point is from the telephone company's central office. The most pervasive type of DSL is asymmetrical DSL (ADSL). It uses the current copper wires that make up your telephone line to provide high-bandwidth Internet access. This is done by splitting the line into voice and data bands at both the subscriber's side and at the central office's side. Doing so allows theoretical speeds of up to 8 Mbps. One of the drawbacks is that distance plays a factor of who can have ADSL and who cannot. Therefore service is currently limited to major urban areas. Also with the different variations of DSL, no set standard has been created although steps are being made to do so. This technology though has a lot to offer and will be expanded in the near future where it will become one of the market leaders.

The future of broadband looks bright. In addition to these technologies satellite, wireless and fiber-optic services are being developed. All bring exciting different ways to connect to the Internet at high-speeds and will be important players in the market within the next 5 years. Which one will come out on top is difficult to tell at this stage, but there is much to look forward to.

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Overview of the Placement

For my second work term during the period of May and August, 1999, I was fortunate enough to be hired by IBM Canada Ltd. in Markham. At IBM, I held the position of Technology Development Assistant. I was working in Network Services, which is part of IBM Global Services. Within this department I worked with the Planning and Development team as well as the Technical Support team. My supervisor was David Denault, who is the manager of Connectivity Services.

Since IBM's beginning in 1924, IBM has become synonymous with computers. IBM has been at the forefront of computer technology for many years and today their role in the computer industry is targeted towards developing and manufacturing computer systems, software, networking systems, storage devices and microelectronics. These are in addition to providing consulting services, systems integration, and technical support. As the computer industry has changed over the years, so has IBM. Today IBM is known to the computer world as:

1. Creating the industry's most advanced information technologies;
2. Helping customers apply those technologies to improve what they do and how they do it.

IBM Global Services is instrumental in helping and furthering this image by providing customers with the information technology services needed in today's fast paced world of business. As one of the most successful divisions within IBM, Global Services provides e-business solutions, business and IT consulting, business transformation, total systems management and strategic outsourcing.

Network Services is a part of IBM's Global Services, in that it provides customers with business solutions relating to network orientated problems. Network Services revolves around IBM's formerly owned Global Network, which is a high-speed network infrastructure that spans the globe, allowing IBM to offer its customers the broadest range of industry-leading managed networking solutions, advanced IP solutions and custom network outsourcing solutions available worldwide. Some of these solutions include content hosting, electronic data interchange/web, workgroup services, remote access services and global VPNs.

I mention IBM's "*formerly*" owned Global Network because late last year, IBM and AT&T announced a series of strategic agreements under which AT&T acquired IBM's Global Network for $5 billion ($US) cash. The two companies also entered into outsourcing contracts. In Canada, this transition took place September 1, 1999 and therefore, the department I formerly worked for is now known as AT&T Global Network Services. The name may have changed, but the department still conducts the same business as it did under the IBM banner.

My main role in the department was to help in the testing and developing of new connectivity services. I worked closely with the Planning and Development team, in particular with IBM's remote access services and IBM's content hosting services.

One of my main duties throughout my work term was to assist in the Y2K testing of IBM's IP dial services. This allowed me to learn how the Global Network infrastructure is set up for remote access. I became familiar with many different protocols and networking devices used throughout this infrastructure. A Y2K test lab was set up for the many different groups that had testing to do. My role was to build a Windows NT Token-Ring local area network (LAN) that had a domain name system (DNS) server, a web server, a file transfer protocol (FTP) server and a Lotus Notes mail server. I then used this LAN to test the many different IP dial services to make sure they were Y2K compliant. From this, I became involved in conducting a functionality test of a service (VCOM Protocol Encapsulation Feature "VPEF") related to Lotus Notes which was not in use yet by any customer in Canada. It required me to learn some of the advanced features of Lotus Notes as well as some of the technology used to make a communication between two Lotus Notes servers using the Global Network. This communication required me to learn more about the TCP/IP protocol and the technology behind virtual communication ports.

From my work with IBM's remote services, I also became more involved with the maintenance of some of the equipment used in providing these services. This equipment included hardware, such as routers and local and global interface gateways (LIG/GIG) and software, such as the IBM Global Dialer that allows customers to log onto the Global Network. From my knowledge of Windows NT, I was asked to help solve some customer problems with the Global Dialer on the NT platform. In Canada, IBM is offering a trial related to broadband connections that mirrors the remote access services already provided. This trial required some data to be generated about the users that logged onto the Global Network through a GIG. My task was to produce some reports that had information needed to make future decisions such as whether the trial was successful and to generate possible considerations for future capacity planning. I was given the specifications of what data had to be gathered and from that I decided to generate these reports by writing a Perl and shell script. I decided on this approach because the platform I was working on was AIX and I knew that these specific programming languages suited the job at hand. Since this trial was to continue beyond my work term, I had to make sure my program had the proper documentation so that someone else could take over from where I left off.

My other main task involved working on a pilot project with the content hosting team. They were offering a content hosting trial aimed at mid-sized businesses in which they needed a monitoring program built to monitor the environment on a daily basis. The project was to start in August and the team had a new student ready to come and work on the trial in September, so they needed me to fill in the gap until the new student started. The monitoring program needed to be completed in early August so they assigned me to this task. Again I chose Perl as the programming language and I was given almost complete control in the design and structure of the program. I was given a few specifications that I had to achieve, but how I was to do this was left for me to decide. I enjoyed this freedom and was able to build a program that checked the connectivity of the servers and routers involved in the pilot using the least amount of network traffic. Since someone else was going to take over the maintenance of my program, I had to also produce sufficient documentation to help with the transition. In addition to my programming, I was also involved in the documentation and presentation of the support process for this pilot to the team. I found that this project taught me many things about the programming cycle, from the design phase through to the maintenance and documentation phase.

Overall, I found this work term to be very beneficial. I was able to learn a lot about networking, in terms of the technology and planning issues involved. I also found that networking is a field I find challenging and enjoyable and is definitely a field I would like to find full-time employment in upon graduation.

Introduction

Over the past year, the Internet has seen increased attention due to its ability in acting as a global medium for information. As Lou Gerstner, Chairman and Chief Executive Officer of IBM Corp. says, "Every day it becomes more clear that the Net is taking its place alongside the other great transformational technologies that first challenged, and then fundamentally changed, the way things are done in the world." With the cost of Internet access ever decreasing, more and more people are finding themselves "surfing the Net". Businesses are realizing this and are spending a vast amount of money on e-business activities, hoping to make huge profits with the growth of the Internet.

With this increased focus, technology companies are revolutionizing the way we connect to the Internet. We can all think back to the days when we had 9.6 kilobits per second (Kbps) and 14.4 Kbps modems, some of which are still around today. Now, however, these types of connections are seen as a hindrance, if one is to keep up with the fast paced growth of the Internet. Streaming audio and visual presentations line the Internet and cannot be seen properly with slow connection speeds. Therefore, connection speeds have increased over the years, as the technology has improved.

In terms of dial-up modems, 56 Kbps is the standard; but even this is considered to be passé. Instead, connections using the same cable lines that bring us our television programs are allowing us to connect to the web and watch television at the same time. The same has been done with our normal telephone lines; connect to the web and still use the telephone for voice communication simultaneously. Other technologies are also entering the field, such as wireless and satellite connections. These technologies are grouped together into what is known as *broadband access* and are the way of the future.

My position at IBM allowed me to learn some of the technology that helps run the Internet. Working with the Dial team allowed me to see what limitations are present when it comes to networking involving a dial-up modem. IBM Canada started a trial that involved clients being able to use their home broadband connections to connect to the Internet and their company's Intranet. I had heard about this trial, but I did not work in great detail on it. As well, hearing family and friends say that they had a cable modem at home and were able to connect to the Internet at great speeds intrigued me to find out more about these high-speed connections. In addition, I found myself in a position where I could use this report to further develop my knowledge of broadband access and at the same time possibly enlighten the readers of this report to the details behind these fast changing technologies.

I hope to meet my objective for this report by first providing a brief introduction to the environment these technologies work in. This will provide the foundation to explain the current and future connection options for broadband access and then look further at the next five years and see where these technologies will stand. I hope to be able to conclude my report with a concise analysis of which broadband connection types will succeed.

Broadband Access: High-Speed Alternatives

An Introduction to Broadband and its Effects on the Internet

With the increasing number of people accessing the Internet daily, there is a large market needing a way to connect to this global network. In the past, for many people a 9.6 Kbps modem was more than sufficient to connect to the Internet, seeing that much of the web was text based or had few graphical features. However, as more and more people realized the possibilities the Internet possessed in terms of a communication tool, the Internet found itself growing at an alarming rate. With this, the Internet became more graphically orientated. Companies started opening on-line stores that required database systems to be created which saw a need for web based programming languages like Java to be developed and utilized extensively. For all these enhancements to the Internet to be successful, access to the Internet needed to become faster. If a web page takes too long to load, people will just go elsewhere, and for businesses this means lost revenues. So as the market demanded faster Internet access, technology companies, and later telecommunication companies, realized the business possibilities of rolling-out new equipment that could capture this growing market.

The market quickly saw modems increase in speeds from 14.4 Kbps to 56 Kbps within three years. Technology companies such as 3COM/US Robotics created these modems and Internet Service Providers (ISP) such as AOL were providing the connections to the Internet. Many of these companies saw revenues increase substantially. On the outside at this time, were the telecommunication companies who saw their telephone lines being used to make these connections but yet were not making any profit off of this new explosion. This brought about increased research and development into newer technologies that could make use of these fixed telephone lines and also increase access speeds; directly competing with modem makers and ISPs. Within the last three years, technology has moved from our old analog modems to Integrated Services Digital Network (ISDN) which allows up to 128 Kbps service to what is now the latest technology, broadband access.

Integrated Services Digital Network in concept is the integration of both analog or voice data together with digital data over the same network. ISDN requires adapters at both ends of the transmission, so your access provider, usually your telephone company, also needs an ISDN adapter. The initial problems with ISDN were that it was not available in all areas, was often difficult to set up and, initial pricing was expensive. This caused many users to stay with their regular analog modems since it was not worth the extra cost to upgrade to ISDN.

Given the problems of ISDN and the market still wanting something better, newer technologies were developed from somewhat obvious means. This spawned into what is known as broadband access. **Broadband** *refers to telecommunication that provides multiple channels of data over a single communications medium using frequency dividing multiplexing*. **Multiplexing** in this sense is defined as:

> *Sending multiple signals or streams of information on a carrier at the same time in the form of a single, complex signal and then recovering the separate signals at the receiving end. Analog signals are commonly multiplexed using frequency-division multiplexing, in which the carrier bandwidth is divided into subchannels of different frequency widths, each carrying a signal at the same time in parallel. Digital signals are commonly multiplexed using time-division multiplexing, in which the multiple signals are carried over the same channel in alternating time slots. In some optical fiber networks, multiple signals are carried together as separate wavelengths of light in a multiplexed signal using dense wavelength-division multiplexing.*

At this moment, this definition may be confusing, but later as each of the different types of broadband connections are explained in further detail, this should become a little clearer. Broadband connections now allow service at 400 Kbps and greater. A substantial increase from a normal analog modem.

Current U.S. studies, show that the difference between broadband users and dial users is indeed drastic. In virtually every category surveyed, broadband users do more and get more done as seen in Figure 1.

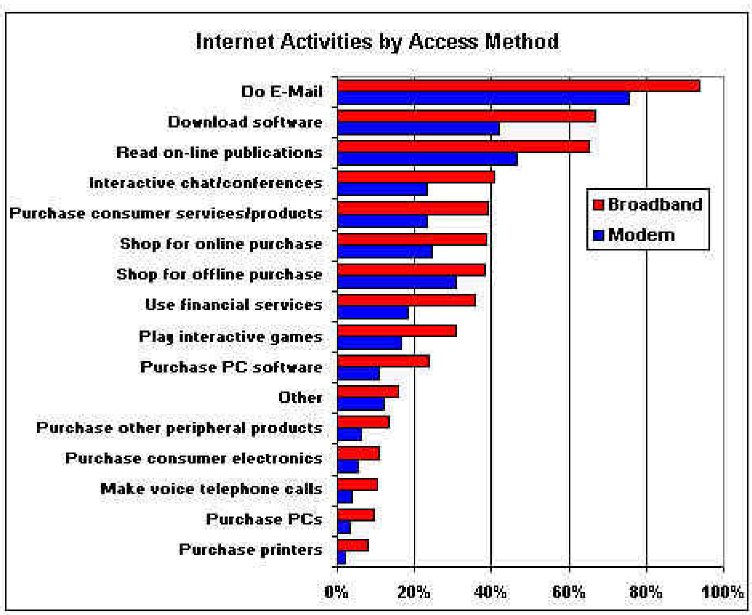


Figure 1. Internet Activities by Access Method

If one looks closely at Figure 1, the greatest area of difference is in the e-commerce activities which is key to Internet business and can substantiate why more companies are focusing on the Internet as a sales platform. Another important aspect brought about by broadband is that faster connections also lead to longer connections, which is illustrated in Figure 2.

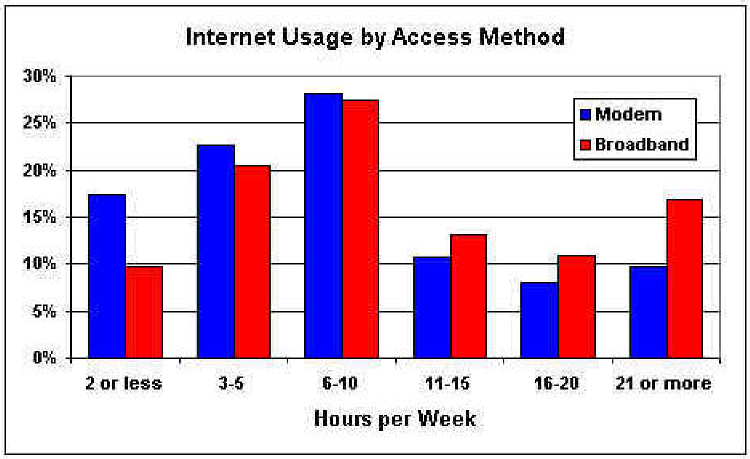


Figure 2. *Internet Usage by Access Method*

So as one can see, broadband allows for the Internet to reach new levels, in terms of marketing and other communicational functions. In the next few sections, I will discuss the different broadband alternatives that will illustrate why the number of people connecting to the Internet is increasing in such large numbers.

Current Broadband Alternatives

Cable

It has been estimated that 75 million homes in North America are cable TV subscribers. With such a presence, coaxial cable connections provide a potentially powerful platform for providing residences and small business with high-speed data access. However, one-way cable television systems must be upgraded to more modern two-way networks to support such communication services, a technically complex and expensive process.

The industry leader @Home saw its user base grow nearly four-fold in 1998 and recent estimates suggest that the number of users of cable is now at half a million in the United States alone. The growth is not surprising. Cable currently offers the fastest download speeds available to home users, theoretically up to 30 megabits per second (Mbps), more than 500 times faster than a 56 Kbps modem. There is no choice either of what provider to choose. Either your cable company offers the service or it does not. Since upgrading the cable infrastructure is such an expensive process, it is currently only available in most large urban areas. It is estimated to take another 5 years until cable service can be brought to all areas.

Currently, if one were to ask for cable service, a technician would be sent out to set up the service for you, which involves setting up a cable modem and an Ethernet card into your PC. User fees are reasonable and there is always a constant connection. An added bonus is that you can watch cable television concurrently while you are also connected to the Net, a constant connection. What makes cable such a strong option is that it has a strong financial backing from companies such as Rogers Cablesystems Ltd., TimeWarner, Microsoft and Compaq, making it a service that will be around for awhile.

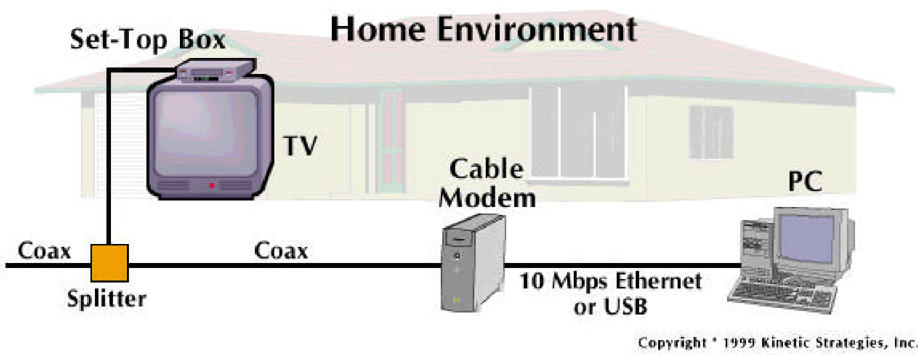


Figure 3. A Typical Cable Connection for a Home Environment

To deliver data services over a cable network, one television channel (in the 50-750 MHz range) is typically allocated for downstream traffic to homes and another channel (in the 5 - 42 MHz band) is used to carry upstream signals. A headend cable modem termination system (CMTS) communicates through these channels with a cable modem at the user's home to create a virtual LAN connection. Cable modems are usually external devices that connect to a PC through a standard 10Base-T Ethernet card and twisted-pair wiring. Universal Serial Bus (USB) modems and internal PCI modem cards are currently under development. With the network technology behind cable modems, IP traffic can be seamlessly delivered over the cable modem platform to end users.

Since cable is a broadcast medium, the same signal is sent to every subscriber. The receiving cable modem recognizes the parts of the signal that are meant for that particular household and extracts them. This means that households share the same cable connection through a neighbourhood distribution hub, which can drastically slowdown connections if everyone in the neighbourhood is connected at the same time. Also security issues have been raised given this method.

With a shared connection, downstream traffic falls far short of the possible 30 Mbps, instead, on average, a connection of 1.5 Mbps - 3.0 Mbps is more reasonable. Upstream information puts even a greater strain on the infrastructure and therefore upstream traffic has been limited to 128 Kbps in some areas. Extra variables such as normal Internet traffic can also bring down connection speeds. This shared connection concept is the one major drawback of cable that has caused people to look for a more stable alternative. For a graphical summary of what has just been discussed please refer to Appendix A.

Digital Subscriber Line (DSL)

Another capable alternative to cable is digital subscriber line (DSL). DSL is a technology that brings high-bandwidth information to homes and small businesses over ordinary copper lines. DSL is not one technology but the name of a family of transmission technologies that use similar concepts and methods of delivery. The difference between the different technologies is the distance of which an end-point (a subscriber) is from its provider, a telephone company's central office.

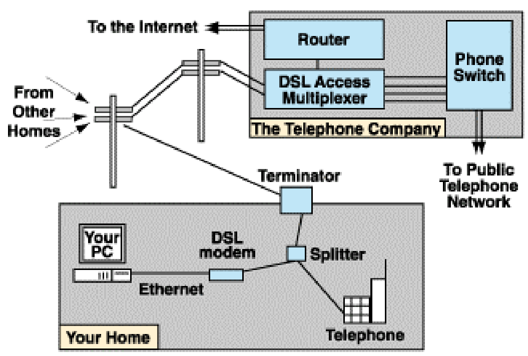
There are two types of DSL: symmetric and asymmetric. A symmetric transmission system provides data to be transmitted at the same speed in both directions (from the user to the provider and vice versa). Asymmetric communications allow faster data transmission downstream and a slower lane upstream. This causes a large difference in top speeds but follows user behaviours more closely. Appendix B, shows the downstream and upstream speeds for the different types of DSL. Upon further review, one can tell that DSL has much greater upstream speeds than any other broadband alternatives currently mentioned in this report. This is a great advantage of DSL.

As mentioned earlier DSL works by using the currently in-place, ordinary telephone lines, also sometimes referred to as "Plain Old Telephone Service" or POTS. POTS connects your home or small business to a telephone company office over copper wires that are wound around each other and called twisted pair. POTS was created to let you exchange voice information with other phone users using an analog transmission signal. A telephone takes a natural analog signal and converts it into an electrical equivalent in terms of volume (signal amplitude) and pitch (frequency of wave change). Since the telephone company's signaling is already set up for this analog wave transmission, it is a lot easier for them to use these wave transmissions as the means of communication between your telephone and the telephone company. This is why a computer needs to have a modem, so that it can translate the analog signal into the string of 0 and 1 values that is called digital information.

Since analog transmission only uses a small portion of the available amount of information that can be transmitted over copper wires, the maximum amount of data that can be received using an ordinary modem is about 56 Kbps. The ability of a computer to receive information is controlled by the fact that the telephone company filters information that arrives as digital data, puts it into analog form for the telephone line and requires the modem to change it back into digital.

DSL assumes digital data does not require change into analog form and back. Digital data is transmitted to the computer directly as digital data and this allows the phone company to use a much wider bandwidth for transmitting it to a subscriber. Therefore, the signal can be separated so that some of the bandwidth is used to transmit an analog signal and hence voice and data can be transmitted on the same line and at the same time. For further detail on *DSL electronics*, which is beyond the scope of this report, a good source is *DSL -- in depth*, which can be found at www.sunworld.com.

Figure 4. *An ADSL Connection*



Given the basis behind the DSL technology, the standard form of DSL since 1997 is ADSL. ADSL requires a specific modem to be installed into the subscriber's PC that uses a POTS splitter to divide the voice and data bands transmitted on the copper wire. The data band is split once again into channels for upstream data and downstream data, where the upstream channel is smaller than the downstream channel. At the telephone company's central office (at most 18,000 feet away), there is another POTS splitter that again divides the data and voice transmissions into their proper networks. Appendix C, can summarize this process.

The drawbacks of ADSL is that because of its distance limitations, it is not available in all areas and unlike cable companies, the telephone industry must go through several regulatory bodies, which has been slowing down the progress of this technology and has left potential customers confused on its status.

With all its recent publicity, DSL is getting a big financial push from large telecommunication companies and vendors such as Microsoft, AOL, Compaq and Dell. ADSL's main advantage is that, unlike cable, your telephone line is dedicated to only one connection, meaning no sharing of bandwidth with other users, hence your connection will always be consistent, but yet still dependent on Internet traffic.

Satellite

Although this is still currently a new technology, about 100,000 homes in the United States are "surfing" the web using satellite dishes. The first broadband satellite dish, DirecPC, was brought to market in 1997 and boasted download speeds of 400 Kbps, which is slower than the other two alternatives already mentioned. But DirecPC states that their connection is constant no matter how many people use the service. If someone is in dire need of a broadband connection, then the good news is that satellite is available to anyone with an unobstructed view of the southern sky.

There are two basic types of satellite systems, Geosynchronous Earth Orbit (GEO) satellites, which DirecPC uses, and Low Earth Orbit (LEO) satellites. GEOs orbit approximately 35,000 km above the equator. Each GEO serves one geographic area, and can theoretically cover about 41% of the earth’s surface. Companies proposing GEO systems are planning on using between three and fifteen satellites to deliver worldwide service. LEOs orbit closer to the earth, between 700 km and 1350 km above the earth’s surface. Each LEO is moving constantly, covering a particular area for only a few seconds. Therefore, a network of many satellites is required to cover the entire world.

There are problems with this technology that still need to be solved. DirecPC is not seamless. A telephone line is still needed with an analog modem for uploads, so again you are facing dial-up speeds with the need of an ISP which increase costs of the service. Also latency plays a factor, in terms of the time needed for commands and data to travel from one satellite to another, slowing down speeds. So given the other alternatives currently available, satellite usually becomes the choice of users where cable and DSL are not available and the only choice for rural areas.

The Future of Broadband

With broadband still in its infancy, it can be seen why it is taking some time to be excepted as a reliable means to connect to the Internet. What makes the future so optimistic and exciting for broadband is that technology issues are slowly being ironed out and more vendors are becoming aware of broadband's possibilities. Therefore, more services are being offered, as there is a fight to capture market share. This is increasing development while at the same time bringing down costs of equipment and services, leaving the consumer with many options to choose from. As we move into the next millenium, here is a review of what potential broadband users will have to look forward to in the next five years.

Cable

As mentioned previously, the progress of cable lies in how fast cable companies can upgrade current cable infrastructures. Once cable becomes available in all areas, it will attract many home users. Currently, the market suggests that cable is the service of choice by a 2-1 margin over ADSL. This figure will be tested with newer services such as satellite and wireless communications entering the market, but cable will still be the method of choice in the near future due to its somewhat low cost and current market stability.

One area of recent focus for cable lies in its sharing of bandwidth. It has been theorized that if congestion does begin to occur due to high usage, cable operators will have the flexibility to allocate more bandwidth for data services. This can be done by simply allocating an additional 6 MHz video channel for high-speed data, doubling the downstream bandwidth available to users. Another possibility is to subdivide the physical cable network by running fiber-optic lines deeper into neighbourhoods thus reducing the number of homes served by each network segment and increasing bandwidth to the end users.

Digital Subscriber Line (DSL)

DSL is in the same position as cable. For it to grab market share it needs to make its technology available to everyone. Unfortunately, with restrictions in distance, this may take some time. Strangely enough, the consensus is that the future of consumer data services lies in DSL. It can offer maximum speed, security and convenience, which cable and soon wireless and satellite cannot yet match. But as the technology gets further developed, more telephone companies will offer the service making it possible for nearly 85% of North America to potentially use it.

Currently, the next step for DSL to develop is ADSL Lite or G.Lite, a lower data rate version of ADSL. As discussed in the previous section, ADSL requires splitters at both end-points to split the telephone line into data and voice transmissions. With G.Lite, the technology may save costs to the end-users and in particular, to the telephone companies in that the POTS splitter can be removed from the subscribers' side of the connection. This leaves cheaper devices, fewer components, reduced power usage and reduced heat than other DSL systems. Also it can eliminate the use of a technician going out to a site for installation. The signal is now carried over the entire house wiring, which results in lower available bandwidth (see Appendix B) due to greater noise impairments on the line. Although lower bandwidth is a "side-effect", the lower costs will make G.Lite more appealing to users. Also, G.Lite is in the tail end of being approved as a standard extension to ADSL by the ITU standards committee after push from Microsoft, Intel and Compaq. This will mean a common standard of DSL that can be offered and marketed to potential customers. Another type of DSL that is gaining some attention is VDSL which is meant for areas within 5,000 feet of a telephone company and can offer download speeds of up to 70 Mbps; challenging corporate T1 connections.

With the possibilities of this technology ever changing, it will have the ability to provide consumers and small business with a secure and high-speed option for future Internet access.

Satellite

With satellite being such a new technology there is still a lot of possibilities and fine-tuning to be done. But many analysts are excited at seeing the possibilities of this new technology. These analysts are so excited, that in a recent survey, they say by 2007, broadband satellite will be the main broadband service used (see figure 5).

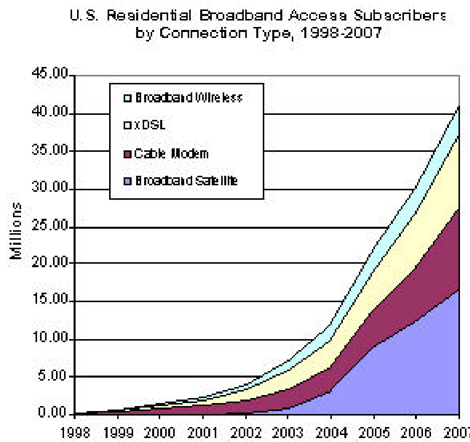


Figure 5.

The current debate is over which system is better? GEO or LEO. The same company that brought out DirecPC is purposing to offer a new system using GEO, which will guarantee two-way high-speed connections without a modem, or ISP. Also new buffering techniques are being developed to help overcome the latency problem. By 2001, a new LEO system by Teledesic is expected to come to market with true global Net access while cutting down latency. LEOs are well regarded due to their ability to efficiently reuse spectrum frequencies, which is important in satellite technology, but beyond the scope of this report. Also with satellites being closer to the earth, the reliability of such satellites increases over GEOs which are located much further away. The problem with LEOs is that they are very capital intensive. Teledesic plans to launch 840 satellites into orbit in one year, costing over $9 billion in startup costs. This is more than what the entire world has launched in the past 30 years.

During development, it still has not been settled what bandwidth satellite will provide. Initial estimates are at 2 - 3 Mbps. Therefore, if this is the case, and costs do decline, satellite may actually follow analysts' predictions.

Wireless

This latest technology has been initially aimed at business, instead of residential users, which makes it somewhat different from the rest of the alternatives. Although widescale deployment is still somewhere in the future, long-term possibilities look promising. Wireless is based on Local

Multipoint Distribution Service (LMDS) which is a stationary wireless technology which utilizes frequencies in the 28 GHz frequency band. LMDS employs frequency re-use within a distributed architecture to provide simultaneous delivery of two-way voice, data, and video services. The LMDS system can be designed to achieve very high levels of network performance while delivering large amounts of data throughput to customers.

Its initial design is to have two-way wireless transmission links connecting small transceiver units located on a customer's rooftop to supplier node sites. Coverage can be increased by overlapping hubs and by increasing a hub's antenna height. Depending on antenna height, terrain, weather and desired reliability, coverage between one to five kilometers in radius can be achieved.

Rollout of such designs are planned for this year, but as of yet not much has been seen. As with satellite, the technology still needs to be fine-tuned and the current delay may be beneficial since it gives companies more time to fix current problems and also work at lowering cost. It is estimated that wireless broadband will come into its own in about 5-7 years.

Other

There are still a few other alternatives in the works for broadband access. One major alternative is fiber optics. Fiber-optic lines can carry far more data than traditional copper wire and they already play a major part in the Internet. Cable operators already upgrade their systems with these thin glass wires to enhance cable performance. Broadband IDSN (BISDN) is already in development to integrate digital transmission services in a broadband network of fiber-optic and radio media. BISDN will use frame relay for high-speed data that can be sent in large groups with suggested speeds of 2 Mbps and higher. In the U.S., a trial is being started where some homes have direct fiber-optic connections and will be given a wide variety of digital services to choose from. But again this technology is still in development.

Conclusions

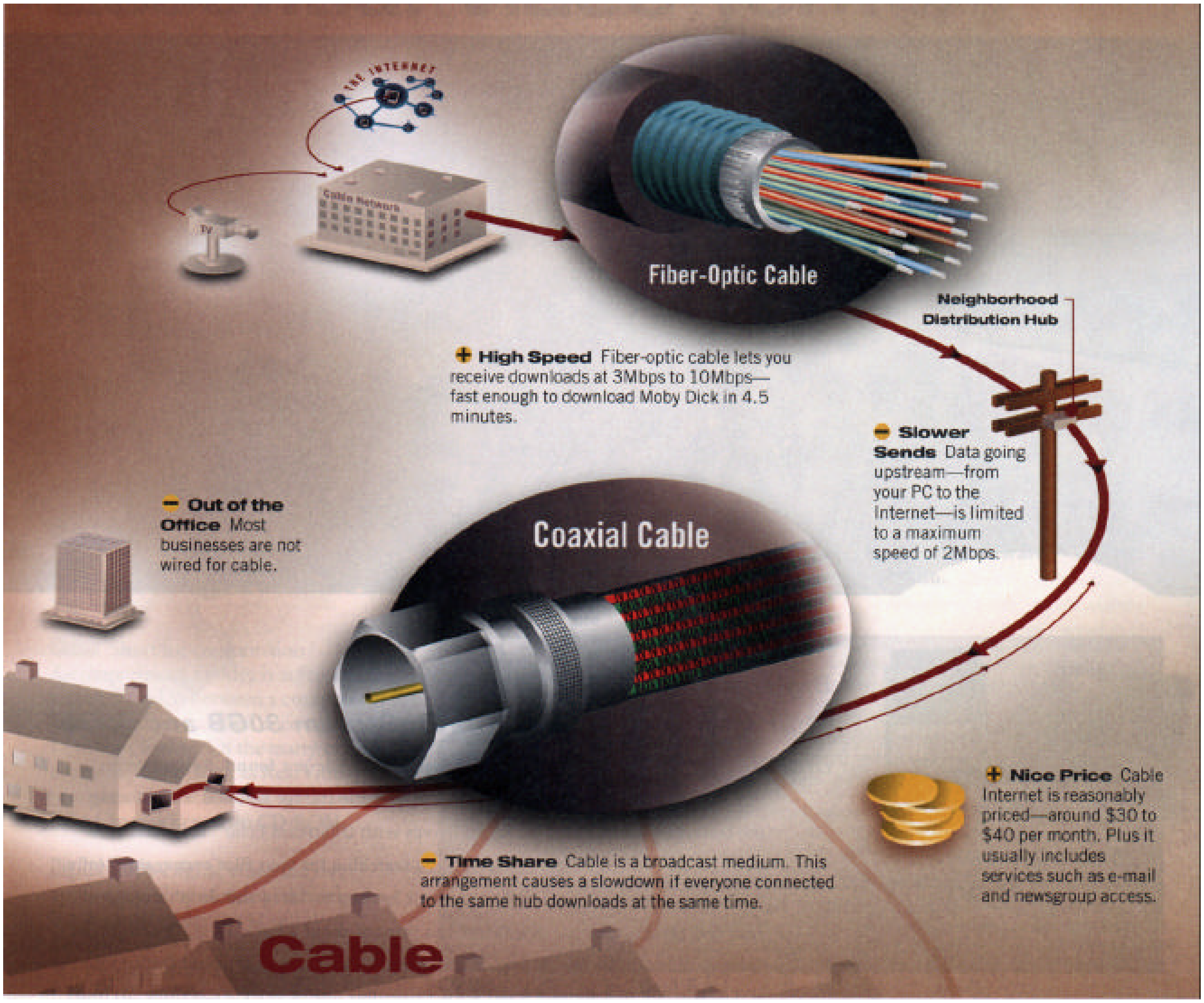
After discussing the several different technologies in broadband access, it is difficult to decide which one will be the best. Many of these technologies are still in their infancy and have on going improvements to look forward to. For some, the future is 5-10 years away, where in the meantime a lot of things can change. A quote from Bill Gates best describes how to play the future:

> *Most people overestimate what is going to happen in the next two or three years and underestimate what is going to happen in the next decade. Take high-speed communications. Once you get the infrastructure in place, then people will expect everything to work that way. Once I tell my lawyer he's got to work that way, then he converts and he starts working that way, and it just sort of pulls everybody in because everybody interrelates to everyone else. With that kind of phenomena, things can be very dramatic. But not in two or three years. The work of conditioning twisted pairs to run ADSL, the cost of upgrading the cable infrastructure to carry two-way data, the time waiting for regulatory things to clear – this doesn't happen in two or three years.*

In the next year, competition will be between cable and ADSL with cable winning the battle in the home market. Its infrastructure is well in place and it is available to more users. Also its lower cost should attract many home users. While ADSL is becoming more competitive in price, it still does not reach the same amount of people as cable currently does. This, however, is quickly changing and my prediction is that within a year or two both cable and some form of DSL will be sharing market share. DSL's (either ADSL or G.Lite) features are very attractive and to the more computer educated user, it would be the more natural choice for consistent Internet access. Businesses on the other hand will find DSL their best option, given it is offered in their area. If DSL takes flight with business, then the future may be bright as prices should drop and standards will settle, allowing the home DSL market to expand.

A prediction for the market five years from now is difficult to make given the progress that still has to be made for the other technologies, such as satellite and wireless. The winner will be the service that can reach the most number of people with a product that is reasonably priced, and offers a reliable connection given the speed it offers. At this moment it is hard to tell. One thing is guaranteed, and that is the future will lead to many interesting broadband developments as the Internet continues to grow.

Appendix A: Graphical Summary of Cable



Picture from PC Computing, August 1999, page 190

Appendix B: Table of Different DSL Downstream/Upstream Speeds

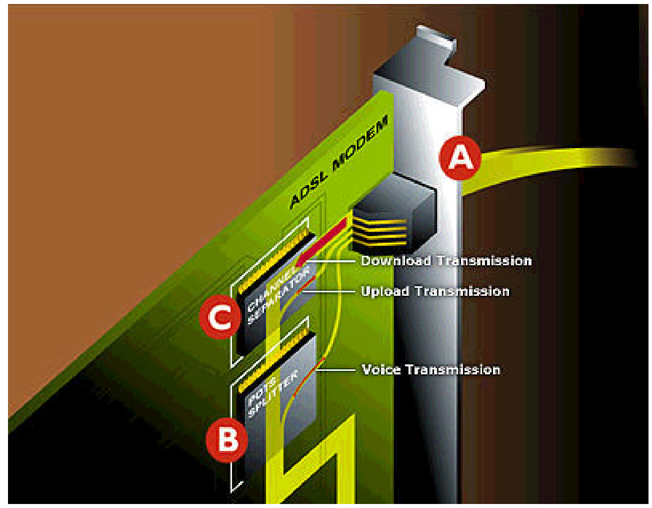
List of Abbreviations:
SDSL - Symmetric DSL
HDSL - High bit-rate DSL
HDSL2 - High bit-rate DSL type 2
UDSL - Unidirectional high bit-rate DSL
IDSL - ISDN DSL
ADSL - Asymmetric DSL
RADSL - Rate adaptive DSL
DSL Lite/G. Lite - DSL Lite/Consumer Lite
VDSL - Very high bit-rate DSL

DSL Type	Distance Limitation	Downstream Bandwidth	Upstream Bandwidth
SDSL	18,000 ft.	384 Kbps	384 Kbps
HDSL	18,000 ft.	1.54 Mbps	1.54 Mbps
HDSL2	18,000 ft.	768 Kbps	768 Kbps
UDSL	18,000 ft.	384 Kbps	384 Kbps
IDSL	18,000 ft.	128 Kbps	128 Kbps
ADSL	18,000 ft.	1.5 - 8 Mbps	16 - 640 Kbps
DSL/G Lite	18,000 ft.	1.5 Mbps	128 Kbps
RADSL	10,000 - 15,000 ft.	768 Kbps - 2 Mbps	384 Kbps - 640 Kbps
VDSL	1,000 - 5,000 ft.	13 - 70 Mbps	1.5 - 16 Mbps

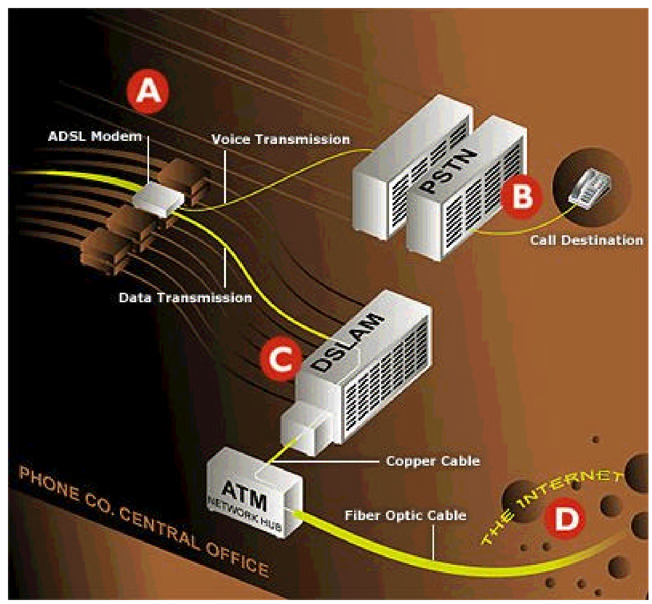
Table from DSL -- in depth

Appendix C: How ADSL Works - In Summary

A. Inside Your PC: Your computer's ADSL modem connects to a standard analog phone line.
B. Voice and Data: A DSL modem has a chip called a POTS splitter, which divides the existing phone line into two bands: one for voice and one for data. Voice travels on the first 4kHz of frequency. The higher frequencies--up to 2MHz depending on line conditions and wire thickness--are used for data.
C. Split Again: Another chip in the modem, called a channel separator, divides the data channel into two parts: a larger one for downstream Internet data and a smaller one for upstream Internet data.

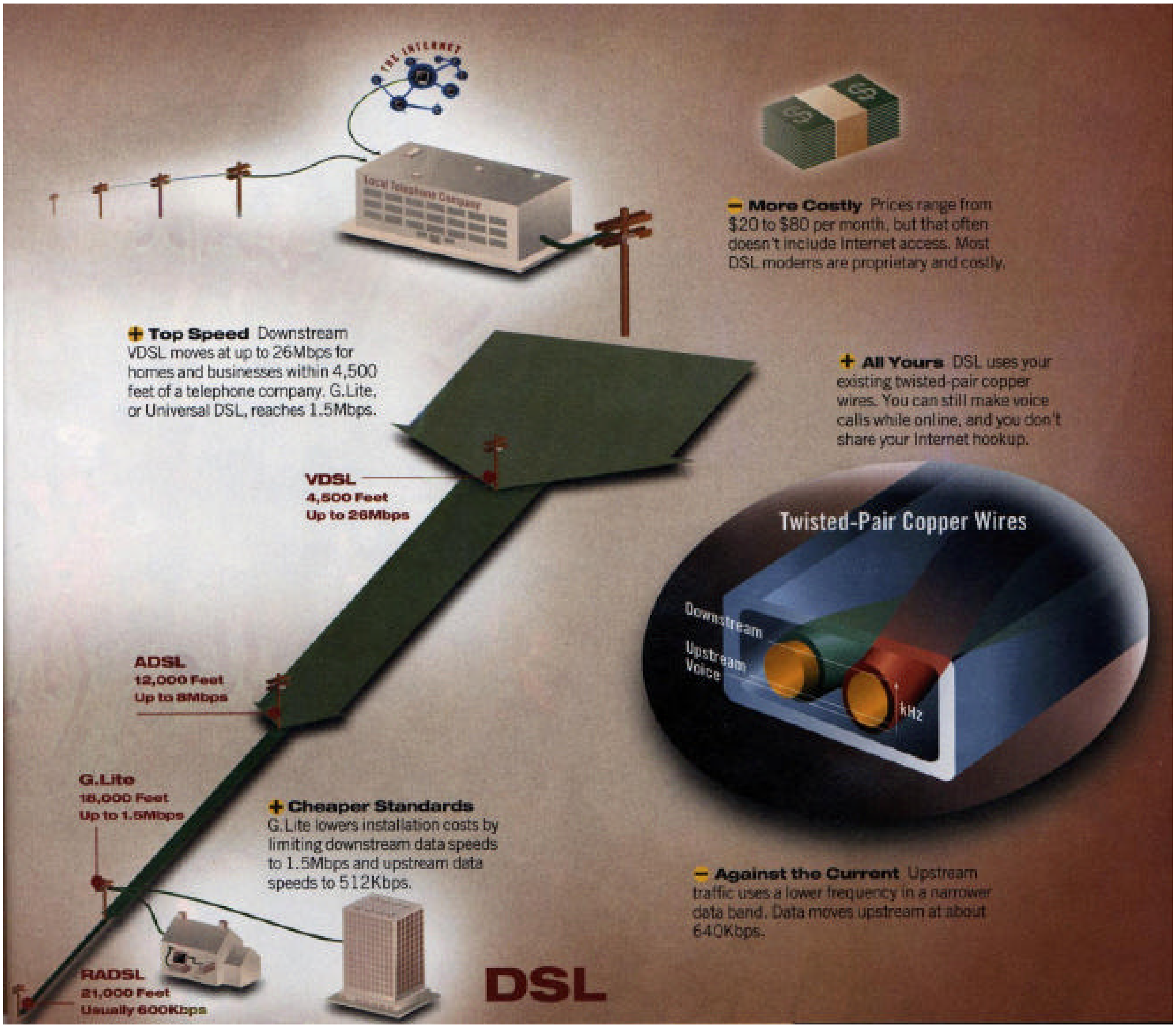


A. Over the Wire: At the other end of the phone line--18,000 feet away at most--is another ADSL modem, located at the phone company's central office. This modem also has a POTS splitter, which separates the voice calls from the data.
B. Telephone Calls: Voice calls are routed to the phone company's public switched telephone network (PSTN) and proceed on their way as usual.
C. Internet Requests: Data coming from your PC passes from the ADSL modem to the digital subscriber line access multiplexer (DSLAM). The DSLAM links many ADSL lines to a single high-speed asynchronous transfer mode (ATM) line, which in turn connects to the Internet at speeds up to 1Gbps.
D. Back at You: The data you request is retrieved from the Internet and routed back through the DSLAM and ADSL modem at the phone company's central office before coming back to your PC.



Picture and explanation from PC Computing, January 1998, page 264-265

Appendix D: Graphical Summary of DSL



Picture from PC Computing, August 1999, page 191

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