Comprehensive Performance Analysis and Special Issues of Broadband Access Technologies for High Speed Data Communication

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Abstract

Broadband communications consists of the technologies and equipment required to deliver packet-based digital voice, video, and data services to end users. Broadband affords end users high-speed, always-on access to the Internet while affording service providers the ability to offer value-added services to increase revenues. Due to the growth of the Internet, there has been tremendous buildout of high-speed, inter-city communications links that connect population centers and Internet service providers (ISPs) points of presence (PoPs) around the world. This build out of the backbone infrastructure or core network has occurred primarily via optical transport technology. Broadband access technologies are being deployed to address the bandwidth bottleneck for the "last mile," the connection of homes and small businesses to this infrastructure. One important aspect of broadband access to the home is that it allows people to telecommute effectively by providing a similar environment as when they are physically present in their office: simultaneous telephone and computer access, high-speed Internet and intranet access for e-mail, file sharing, and access to corporate servers.

Keywords: *Personal Digital Assistants (PDA), Customer Premises Equipment (CPE), Digital Subscriber Line (DSL), Cable-Modem Termination System (CMTS), Internet Protocol (IP), General Packet Radio Service (GPRS), Direct Sequence Spread Spectrum (DSSS), Orthogonal Frequency Division Multiplexing (OFDM)*

1. INTRODUCTION

Once people obtain broadband access to the home, they find that this access needs to be shared with other members of the family using multiple PCs. This includes workers who use laptop PCs at their workplace and desire to be able to use the same laptop at home. As a result, people are installing local-area networks (LANs) in their home. Once this LAN is in place, people want to use it to share files, printers, and devices such as scanners. Once broadband access and home networking reaches critical mass in terms of market penetration, there will be a new class of end-user devices that will enable many new Internet-enabled applications. Already, people are able to perform functions remotely via the Internet: monitoring and controlling their homes, viewing their children who are in day-care centers, checking on live traffic conditions, and playing stereo-quality music over Internet radios.

The key drivers for broadband growth, along with the resulting impacts, are summarized in Figure 1. The vision of the broadband home is that broadband multimedia-i.e., video, audio, voice, and data-will be delivered *to and within* the home to personal endpoint devices. Services will be affordable, easy to use, and available to the average family and will be delivered quickly, securely and reliably. Moving forward, all things will be connected [1]-[5] [11] [17]-[23].

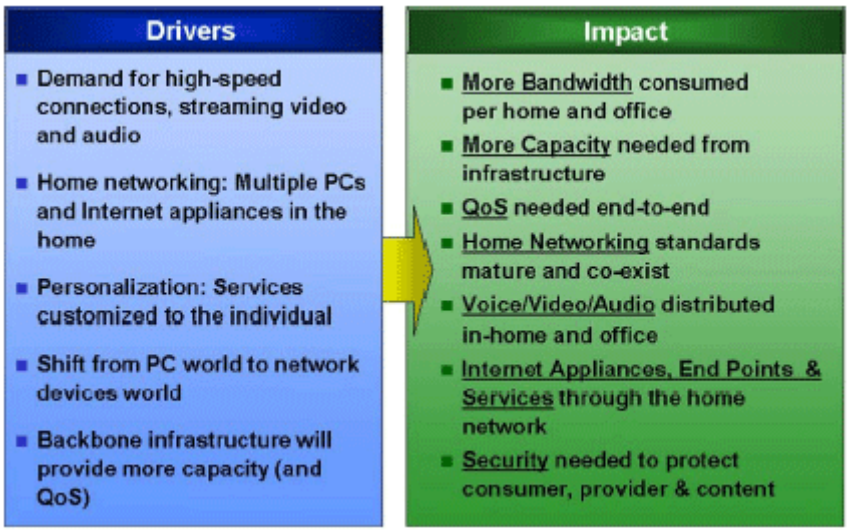

Figure 1

2. CONNECTIVITY

Figure 2 shows how broadband connectivity is extended from the core infrastructure to end users' devices such as PCs, personal digital assistants (PDAs), telephones, television sets, and digital cameras. Infrastructure gateway equipment provides broadband access to the packet-based infrastructure. Customer premises equipment (CPE) access gateways extend broadband access connectivity to end-user devices via one or more home networking technologies.

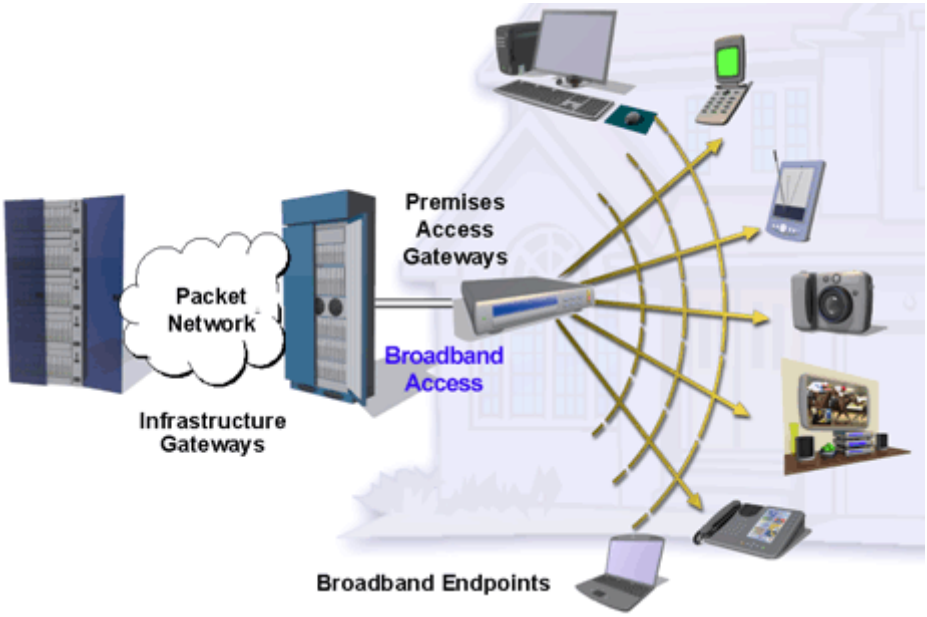

Figure 2: Broadband Connectivity

3. TECHNOLOGIES

There are many competing broadband access technologies being brought to bear to address last-mile connectivity, including the following:

- Cable modem
- Digital subscriber line (DSL)
- Fiber
- 2.5G and 3G cellular wireless
- Wireless Ethernet

Cable. As an alternative to existing copper phone wires, cable companies have been providing broadband access by upgrading their cable plant to carry data and voice services in addition to traditional video services. A cable-modem termination system (CMTS) communicates with cable modems located at the customer premises to provide broadband access services. The cable modem typically provides an Ethernet interface to a PC or to a small router when multiple PCs are connected. Today's cable networks generally deliver data with download speeds roughly between 500 kbps and 2 Mbps and upstream speeds of 128 kbps. Newer-generation cable-modem technologies will significantly increase the available bandwidth to further enable interactive applications such as videoconferencing and high-end on-line video.

Internet protocol (IP) telephony is one of the services that can be delivered over coaxial cable. For the cable operators, IP telephony enables them to offer voice services that, to date, have been the domain of the telephone companies [12]-[23].

DSL. DSL technology is a copper-loop transmission technology for transmitting high-speed data over ordinary telephone wires. A DSL modem is installed at the customer premises and at the central office (CO). Different variants of DSL exist to address different technology trade-offs that can be made regarding different network environments and applications. One of the key trade-offs is distance (referred to as reach) from the CO and data rate. Asymmetrical DSL, or ADSL, is primarily used for residential services. ADSL takes advantage of the fact that there is more crosstalk interference at the CO end of a copper pair than at the subscriber end due to the large bundles of cabling entering the CO. ADSL can provide data rates up to 8 Mbps from the network to the subscriber direction, and up to 1 Mbps from the subscriber to the network direction. The asymmetry of ADSL works well for today's home applications where the majority of bandwidth is consumed in the network to user direction.

Symmetrical DSL, or SDSL, is a cost-effective solution for small and medium enterprises, offering a competitive alternative to T1 and E1 lines. The International Telecommunication Union-Telecommunications Standardization Sector (ITU-T) standard G.991.2, also known as G.shdsl, is a replacement standard for proprietary SDSL. G.shdsl offers data rates from 192 kbps to 2.3 Mbps while providing a 30% longer reach than SDSL.

Very-high-data-rate DSL, or VDSL, can support symmetrical or asymmetrical services. Asymmetrical VDSL is capable of providing data rates to the user of up to 52 Mbps, making it suitable for transporting high-speed applications such as real-time video streaming. The trade-off for this high speed is restricted reach. This requires that the customer be located close to the CO or that the infrastructure access gateway resides outside the CO (and closer to the customers) in a remote terminal (RT).

Fiber. For new infrastructure buildout, where copper wires are not currently present, the installation of fiber is being employed. Fiber-optic technology, through local access network architectures such as fiber-to-the-home/building (FTTH/B), fiber-to-the-cabinet (FTTCab), and fiber-to-the-curb (FTTC) offers a mechanism to enable sufficient network bandwidth for the delivery of new services and applications. A fiber-optic cable is run from the CO to the neighborhood. Passive optical splitters are used to provide point-to-multipoint connectivity. This is referred to as a passive optical network or PON. In the case of FTTCab or FTTC architectures, the signal is converted to provide connectivity to the subscribers via copper-pair wires. Since these cabinets are collocated in a neighborhood, the copper-pair run is typically less than 3,000 feet; thus enabling high-performance xDSL access to be achieved.

2 and 2.5 Generation (G) Cellular Wireless

Next-generation cellular is providing high-speed data capabilities in addition to traditional voice. Current 2G cellular services only offer data service rates on the order of 9.6 kbps. The emerging 2.5G services will boost available bandwidth to the user and facilitate always-on data services. For 2.5G networks, there are two primary technologies: general packet radio service (GPRS) and enhanced data rates for GSM and TDMA (IS-136) evolution (EDGE). Third-generation (3G) wireless communication technologies support even higher data rates. The packet switching is IP-based, making for efficient routing of data from the Internet through the carrier's gateway. The higher bandwidth should allow for better integration of voice, data, and video signals. Delivery of data services over cellular offers the promise of ubiquitous high-speed data access, including while in moving vehicles [7] [21]-[33].

Wireless Ethernet. In addition to cellular-based wireless data services, wireless Ethernet, traditionally a home and enterprise networking technology, is being used for broadband access in public areas such as airports, hotels, sports arenas, convention centers, and coffee shops. This allows users to take their laptop and PDA devices with them and to use a common access technology to deliver high-speed Internet services in their office, home, and while on the road.

Home and Enterprise Networking Technologies. While most corporations today have some form of wired Ethernet LANs to address their networking needs, most homes do not have any form of networking infrastructure. There are several competing home networking technologies, including the following:

- Ethernet
- HomePNA
- HomePlug
- Bluetooth®
- Wireless Ethernet

Ethernet is the most ubiquitous LAN technology and as such, very low-cost Ethernet adapters exist for PCs and other devices. However, installing Ethernet cabling in existing homes is expensive as it involves labor-intensive work to snake cables through existing walls, install outlets, and repair drywall. As such, installation of Ethernet cabling is typically relegated to new construction. As an alternative, technology has been developed to use existing phone wiring to run LAN traffic simultaneously with voice. The Home Phone Networking Alliance (HomePNA) defines standards for interoperability using this technology. Unfortunately, most homes have a limited number telephone jacks for access to the wires. Thus, the expense of adding new wires must still be tackled. Technology has been developed to use existing home AC wiring to run LAN traffic. As most rooms have multiple AC outlets, there is access to the LAN from practically anywhere. This still requires the device accessing the LAN to be tethered, as it must plug into the AC outlet.

As an alternate to wired networks, wireless standards exist, including Bluetooth and wireless Ethernet (wireless LAN or WLAN). Bluetooth was developed to replace the need for interconnect cabling between devices for short-range and relatively lower data rates. Wireless Ethernet is a standard developed by the Institute of Electrical and Electronics Engineers (IEEE) (802.11) that preserves Ethernet compatibility and data rates. It is gaining wide traction for home, enterprise, and public access networking.

The current standard for wireless Ethernet is 802.11b, and it offers 11 Mbps transmission rates using direct sequence spread spectrum (DSSS) technology. The standard, also known as Wi-Fi™, is widely used in offices, campuses, and homes. Radio transmission is in the 2.4-GHz band. The 802.11a variant of the standard operates in the 5-GHz frequency band and offers transmission rates up to 54 Mbps using orthogonal frequency division multiplexing (OFDM) technology in which the

devices determine a set of noninterfering frequencies, multiplex these frequencies, and use them in parallel to achieve greater bandwidth. A recent addition to the 802.11 standard is 802.11g, which extends DSSS operation to 22 Mbps and also supports OFDM operation in the 2.4-GHz frequency band [27] [30] [32].

Wireless standards must address potential transmission interference with other devices, including microwaves, cordless telephones, and other wireless standards that operate at the same frequency. Also, since it is wireless, solid encryption is required for security purposes.

Broadband communications consists of the technologies and equipment required to deliver packet-based digital voice, video, and data services to end users. Broadband offers users high-speed, always-on Internet access, while offering service providers increased revenue from new, value-added services. Broadband solutions residing within today's broadband communications equipment are complex and require semiconductor manufacturers to integrate a wide variety of innovative technologies to offer low-power, cost-effective system solutions that address the needs of OEMs, service providers, and end users[3][9][11]-[19].

4. CONCLUSION

Broadband access is not only about providing the pipes to carry the traffic on the Internet but also about how the traffic will be carried. As was said at the outset, the Internet has changed our sense of time itself. The increasing importance of the Internet has brought about dramatic changes in the way goods and services are produced and distributed to end users. The Internet continues to play a significant role in shaping the new economy by enabling firms to communicate and conduct business on a global basis without regard for location or asset size. Investment in high technology continues to serve as an engine of strong productivity growth for the U.S. economy. Federal Reserve Board Chairman Alan Greenspan expects this trend to continue in the years ahead. The increasing penetration of broadband access among both business and consumer users significantly augments this trend. There are many players in the same space, and the winners will be the technologies and the companies that clearly define their products and services, know and satisfy their customers, are forward-looking and flexible, and set the pace for the industry. Technological innovation and, in particular, the spread of IT has revolutionized the conduct of business during the past 10 years and has resulted in large increases in productivity. The surge over the past few years in business capital spending is a direct result of the higher rates of return brought about by the application of new technologies. The pace of innovation may have temporarily slowed down, but it is expected to resume soon as companies begin to exploit the largely untapped potential for e-commerce, especially in the B2B sector, from which much of the growth is expected to come. The demand for high-speed bandwidth continues to grow at a fast pace, driven mostly by growth in data volumes, as the Internet and related networks become more central to business operations. Today's telecom industry is undergoing a bandwidth shortage driven mostly by the continuing explosion of the Internet and data markets. The rapid growth of distributed business applications; the proliferation of private networks, e-commerce, and bandwidth-intensive applications (such as multimedia, videoconferencing, and VOD); and the continuing deregulation and privatization of the telecommunications networks throughout the world all help fuel the demand for bandwidth. Moreover, an increasing number of teleworkers are fueling the demand for second and third lines for fax and Internet dial-up. To meet this explosive demand for bandwidth and to capitalize on this growing data opportunity, many data CLECs are targeting small business, SOHOs, and teleworkers in the selected areas of the country in which they are operating.

In only a few short years, all Internet appliances or electronic devices will be able to access the Internet and obtain the same content as PCs. The continued evolution of Internet appliances will continue the trend of making regulatory boundaries and lines between customer equipment and

network services and communications and broadcasting very murky. It will become increasingly difficult to classify particular services, industries, and providers in nice little boxes, where it will be easy to tell if a service is subject to regulation or not. With accessibility to technology no longer an issue, how and when content and content providers will change to accommodate this ubiquitous access from any type of Internet-enabled device has yet to be answered.

Networking Standard	Description	Type	Installation Requirements	Maximum Data Rate Mbps
802.3 Ethernet	Highest capacity; commodity hardware	Wired	New wires	10/100
802.11 Ethernet	Wireless Ethernet	Wireless	No wiring required	11/22/54
HPNA	Home networking using existing telephone wires	Wired	Some new wires	1/10/32
Bluetooth	Short range cable replacement	Wireless	No wiring required	1
HomePlug	Home networking using existing AC power	AC Wires	No new wires	10

Table 1

5. REFERENCES

[1] James Gaskin, Broadband Bible (Bible), ISBN13: 9780764569517, ISBN10**:** 0764569511, Powell's Publications, 2003, Pp 43-195.

[2] Yassini Rouzbeh, Planet Broadband, Publisher: Cisco Pres, ISBN: 1587200902, 2004, Pp 110-210.

[3] Jeffrey G. Andrews, Fundamentals of WiMAX: Understanding Broadband Wireless Networking, Published in 2007,Prentice Hall, ISBN 0132225522 , Pp 87-152.

[4] A. Bakre and B.R. Badrinath. I-TCP: Indirect TCP for mobile hosts. Proceedings of the 15th International Conference on Distributed Computing Systems (ICDCS). May 1995, Pp 48-90.

[5] H. Balakrishna, et al. A comparison of mechanisms for improving TCP performance over wireless links. Proceedings of ACM/IEEE Mobicom, Pp. 77–89, September 1997.

[6] H. Balakrishna et al. Improving TCP/IP performance over wireless networks. Proceedings of ACM/IEEE Mobicom. November 1995, Pp 110-134.

[7] L. Blunk and J. Vollbrecht. PPP extensible authentication protocol (EAP). IETF RFC 2284. March 1998.

[8] C. Borman et al. Robust header compression (ROHC): Framework and four profiles: RTP, UDP, ESP, uncompressed. IETF RFC 3095. July 2001.

[9] R. Braden et al. Resource reservation protocol. IETF RFC 2205. September 1997.

[10] L. Brakmo and L. Peterson. TCP Vegas: End to end congestion avoidance on a global internet. IEEE Journal on Selected Areas in Communication, Pp 1465–1480, October 1995.

[11] H. Gossain et al. Multicast: Wired to wireless. IEEE Communications Magazine, 40(6):116–123, June 2002.

[12] M. Gudmundson. Analysis of handover algorithm. Proceedings of the IEEE Vehicular Technology Conference, May 1991.
[13] M. Gudmundson. A correlation model for shadow fading in mobile radio. Electronics Letters, Pp 14–21, November 1991.
[14] J. Hodges and R. Morgan. Lightweight directory access protocol (v3): Technical specifications. IETF RFC 3377, September 2002.
[15] K. Xu et al. TCP—Jersey for wireless IP communications. IEEE Journal on Selected Areas in Communications, Pp 747–756, May 2004.
[16] J. Zander, and SL. Kim. Radio Resource Management for Wireless Networks. Artech House, 2001,Pp 112-197.
[17] K. Leung et al. Mobility management using proxy mobile IPv4. draft-leung-mip4-proxy-mode-01.txt, Internet Draft, June 2006.
[18] Broadband Powerline Communications: Network Design by Halid Hrasnica, John Wiley, ISBN:9780470857410 , 2004,Pp 89-176.
[19] Integrated Communications Management of Broadband Networks by David Griffin,Crete University Press, Heraklion, ISBN 960 524 006 8, Pp 77-145.
[20] G. W. Bernas and D. M. Grieco, "A Comparison of Routing Techniques for Tactical Circuit-Switched Networks," *Proc. ICC '78*, pp. 23.5.1-.5.
[21] B. W. Boehm and R. L. Mobley, "Adaptive Routing Techniques for Distributed Communications Systems," *IEEE Trans. on Communications*, vol. COM-17, pp. 340-349 (June 1969).
[22] B. Widrow, et al., "Adaptive Antenna Systems," *Proc. IEEE*, vol. 55, pp. 2143-2159 .
[23] B. Widrow, et al., "Adaptive Noise Cancelling: Principles and Applications," *Proc. IEEE*, vol. 63, pp. 1692-1716
[24] P. J. Smith, M. Shafi, and H. Gao, "Quick Simulation: A Review of Importance Sampling Techniques in Communications Systems," *IEEE J. on Selected Areas in Comm.*, Vol. 15, pp. 597-613 (May 1997).
[25] E. S. Sousa, J. Silvester, and T. D. Papavassiliou, "Computer-Aided Modeling of Spread Spectrum Packet Radio Networks," *IEEE J. Sel. Areas in Comm.*, Vol. 9, pp. 48-58 (January 1991).
[26] S. Chennakeshu and G. J. Saulnier, "Differential Detection of pi/4 - Shifted-DQPSK for Digital Cellular Radio," *IEEE Trans. on Vehicular Technol.*, Vol. 42, pp. 46-57 (February 1993).
[27] B. Cutler, "Effects of Physical Layer Impairments on OFDM Systems," *RF Design Magazine*, May 2002, pp. 36-44.
[28] M. Da Silva, "Data Above Voice Systems," *Mobile Radio Technology*, October 2003, pp. 16-27.
[29] C. C. Davis et al., "Flexible Optical Wireless Links and Networks," *IEEE Communciations Magazine*, March 2003, pp. 51-57.
[30] A. Wegener, "CRF: Subtract Peaks to Add Value," *Wireless Design and Development*, October 2005.
[31] D. A. Wiegandt, et al., "High-Performance Carrier Interferometry OFDM WLANs: RF Testing," *Proc. 2003 IEEE ICC*.
[32] J. E. Wieselthier, G. D. Nguyen, and A. Ephremides, "Algorithms for Energy-Efficient Multicasting in Static Ad Hoc Wireless Networks," *Journal on Special Topics in Mobile Networking and Applications* (MONET), Vol. 6, pp. 241-263, June 2001.
[33] D. Wong and T. J. Lim, "Soft Handoffs in CDMA Mobile Systems," *IEEE Personal Communications*, December 1997, pp. 9-17.

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