



November, 2000

Exploring Home Networking

Executive Summary

Just as television has revolutionized entertainment and news during the last fifty years, today the Internet is revolutionizing how individuals and companies conduct commerce and communications. According to recent statistics, more than 50% of the homes in the U.S. have PCs. With a market this pervasive, the potential for home networking products, typically called home personal networking products, is projected by research companies like International Data Corporation to expand significantly throughout the next three years.

Linksys believes that the explosive growth of multiple-PC households will continue, creating a substantial demand for home personal networking products throughout the coming years. Because of this belief, Linksys has developed a vigorous commitment to technology leadership, with a strong focus on the needs of present and potential home customers in the personal networking product marketplace.

The intent of this white paper is to define the perspectives Linksys has on the emerging home personal networking marketplace, including a summarization of the important technology trends influencing this marketplace. This white paper also highlights the congruence Linksys is accomplishing with products in this arena.

Market Drivers Impacting Home Networking Growth

Clearly, of all networking marketplaces, the personal home networking arena is marked by the greatest opportunities for growth and the most volatile of market dynamics, all based on the steadily increasing adoption rates of PCs and the Internet into the home. The widespread use of bundling PCs with online access services, as well as the decline in price of both of these products has triggered an increase in the adoption of multiple PCs in the home. International Data Corporation reports that in 1998, 1 million U.S. households had an active home network installed, growing to 4.1 million by 2000.

The most dominant market factors that continue to drive the growth of the home networking marketplace include:

- **Rapid growth in multiple-PC household penetration.** By the end of 1999, 52% of U.S. households had at least one PC according to International Data Corporation. By 2004, IDC expects this figure to reach 62.4%. A large part of this growth will be the increase in multiple PC households. One in every four of U.S. households (25.3%) at the close of 1999 has multiple PCs. By 2004, it is predicted that this figure will be 43.3% of all U.S. households. Growth in this market is driven by a dominant need for sharing peripherals and files between home PCs, providing a means of handling gaming applications in the home and with other gamers across the Internet, and also the continued convergence of video and computing in the home.
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- Increasingly available broadband access.** The single largest technological shift that is driving the adoption of home networking technology is broadband access. No longer constrained by the limitations of dial-up speeds, the Internet offers entertainment, education and commercial benefits, especially when networked throughout a home. Linksys strongly believes that in conjunction with broadband access, wireless home networks will be commonplace by 2005. Serving to further illustrate the pervasiveness of this marketplace, IDC predicts that today there are 2.1 million households with broadband access, rising to 21.2 million in 2003.
- Increasing growth of home-based offices.** The emergence of small home-based businesses and teleworking has also had an impact on this market. More and more people are creating home offices for their own businesses and for completing tasks for their fulltime jobs. This subsegment of the home networking marketplace is less price sensitive and much more focused on the productivity returns of a given networking peripheral. Table 1 provides a comparison of the various access technologies and their relative number of users in the U.S. Home Office segment. The figures in this table are from International Data Corporation.

**Table 1: U.S. Home Office Broadband Forecast, 2000 - 2004
(Subscribers in thousands)**

Technology	2000	2001	2002	2003	2004	CAGR
ISDN	65	113	191	471	617	56%
DSL	195	499	1,178	5,561	8,804	114%
Cable Modem	735	1,242	1,998	4,250	5,569	50%
T1/Wireless	86	181	347	1,146	1,877	85%
TOTALS	1,081	2,035	3,714	11,428	16,866	

Source: IDC

- Increasingly Knowledgeable Consumers driving new applications.** Consumers are more educated now than ever about the potential that PCs represent. No longer satisfied with just word-processing and e-mail, many consumers now demand Internet sharing, file sharing, gaming both within the same household and across the Internet, peripheral sharing including networked printers and even DVD video applications. Granted that consumers using the fullest extent of the Internet are early adopters, their needs and focus on a wide variety of applications is already having an impact on how standards are defined and devices are designed and manufactured.

Technology Comparison driving the Home Networking Marketplace

Continually monitoring the technical trends in the marketplace and looking for opportunities to add greater value is essential. Linksys continually monitors the evolving home networking technologies today for applicability to the needs of its customers, and strives to add greater value through the inclusion of differentiated features. Linksys is committed to continually watching the competitive dynamics between HomeRF and 802.11b specifically as each of these technologies has strong implications for the development of the overall home networking marketplace.

The 802.11b standard allows for a high data transfer rates up to 11 Mbps in the 2.4 GHz frequency band using the Direct Spread Spectrum (DSSS) technology as originally defined by the IEEE work group. There are many advantages to the 802.11b standard. It is capable of compensating for weak signals through its DSSS technology, and it is capable of the highest speed possible on a home networking technology. In contrast, HomeRF only transfers data at 1.6Mbps while using the older radio technology, Frequency Hopping Spread Spectrum (FHSS) in the 2.45 GHz frequency band. This older technology, however, makes it possible to have support for both data and voice on the same network. Because of this advantage, consumers continue looking to HomeRF as a unifying technology in their homes where data and voice line sharing is an issue. In contrast, the focus from consumers on HomeRF and its ability to be a unifying technology, many smaller businesses and corporations are favoring the 802.11b standard due to the legacy implications with existing corporate standards. Table 2 compares these home networking technologies.

Table 2: Comparing Home Networking Technologies

Technology	Ethernet	Phoneline	Powerline	HomeRF	802.11b	Bluetooth
Current data rate (Mbps)	10/100	10	350Kbps	2- legacy 10 (as of 8/1/00)	11	0.72
Future data rate (Mbps)	NA	100	10	10	NA	10 or 20
Availability	Now	Now	Now	Now	Now	2H00
Proponent		HomePNA	HomePlug Powerline Alliance			
Pros	Secure, reliable, and fast	Many backers	Easy to use, flexible access	Mobile, easy to use	Fast data transmissions	Will be used in multiple devices
	One industry standard	Endorsed by top OEMs	Available; powerlines ubiquitous	Voice applications	Mobile, easy to use	Lower cost
		Easy integration into other silicon	Lower cost	Lower cost		
Cons	Requires new wiring	Phone jacks not ubiquitous	Multiple standards, competing technologies	Limited range	More expensive	Currently not robust enough to be a full home network
			HomePlug must choose standard quickly	Slower data throughput		Product not yet available
			Slow speeds, subject to interference			

Evolving Technology Standards

The true test of any standard is its ability to align itself with needs in the marketplace, consistently adding value to consumers through innovation. Presented here is an overview of the essential standards in home networking. Included are significant events that are transforming them to align with the technological pace of this marketplace and the needs of consumers.

802.11b

Currently this market standard has been gaining momentum in the marketplace, as the Wireless Ethernet Compatibility Alliance (WECA) was formed to certify products based on this standard as compatible with one another. Members of this standard now include many PC manufacturers and chip set producers, all focused on having a cohesive set of products that consumers can use in conjunction with each other, regardless of the manufacturer they were purchased from. This alliance also has a website located at www.wirelessethernet.com.

Home RF

The FCC in August 2000 announced it would allow HomeRF to increase data transmission speeds of its Share Wireless Access Protocol (SWAP) to 10Mbps, making it competitive with Ethernet. With this increase in speed, many manufacturers have had to consider the implications for the distances supported by HomeRF products. More power is necessary in order for these devices to transmit faster. Faster transmissions in effect mean shorter actual ranges for many of these devices unless the overall power of the device is increased, reducing their range from a maximum of 1,000 feet to as short as 200 feet. A unified communications strategy throughout the home will require consumers to balance the issues of length of connection and variation in communication standard implementation in their home devices.

Comparing Home Networking Solutions

There are four specific approaches companies have been taking in the development of home networks. These including building networks using the options of wiring a home with Ethernet cabling, using phone lines, power lines, or using wireless devices for connecting to the Internet. The first approach, wiring a home with Ethernet, is what the majority of businesses today use to create their networks, because it is a proven technology. Two additional approaches to home networking focus on using either telephone or power lines. Clearly the most convenient technology to use and the one which promises the highest level of mobility is wireless. Many of the industry analysts see wireless as the single most effective

technology for integrating a network into a home. In this section, each of these approaches to creating a home network is examined.

Traditional Ethernet Home Networks

Think of how a stereo system is put together when it is first brought into your home, and you have a basic idea of how an Ethernet home network would be set up. In order for all parts of the stereo system to work, cables or wiring must connect each part to the other. Long seen as cumbersome and difficult to create and manage, home-based networks based on Ethernet cabling have actually created a significant opportunity for many vendors such as Linksys to supply home networking kits. These kits capitalize on the need to have an optimized set of networking devices for the best possible performance.

Compounding the growth of this type of network is the fact that many homes are being built with cabling included as part of the construction process. It is common, for example, to find in technologically advanced parts of the world, server closets or even server rooms and full category 5 cabling throughout the walls of the home.

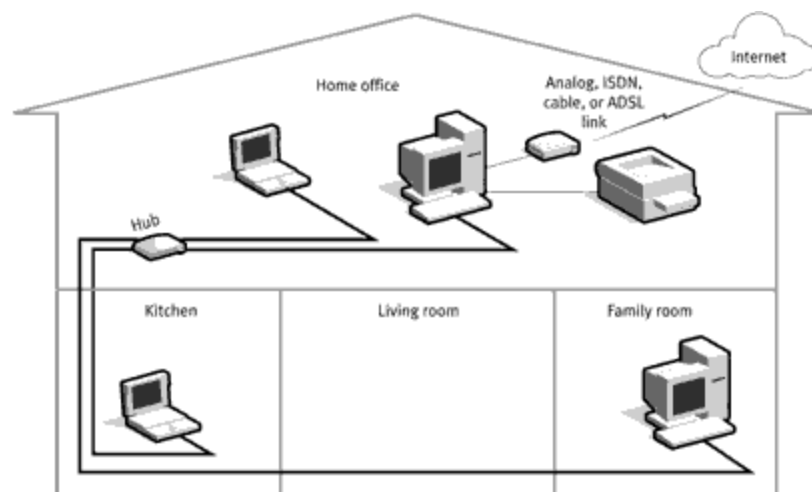


Figure 2: How a Home Network constructed with Ethernet cabling

PhoneLine Networks

Creating a home network by using the existing wiring in a home is also possible. The approaches of using telephone lines and power lines have been developed to overcome the limitations of having to re-wire an entire home with Ethernet cabling. Telephone line networks take advantage of unused transmission capacity on existing telephone lines. Phone line networks, even though using the same lines as telephones, send data at frequencies well above those used for transmitting voice over the plain old telephone services (POTS) or digital

services like ISDN or DSL, so the data does not interfere with voice or other traffic on the line. The typical phoneLine network is constructed as is shown in Figure 2.

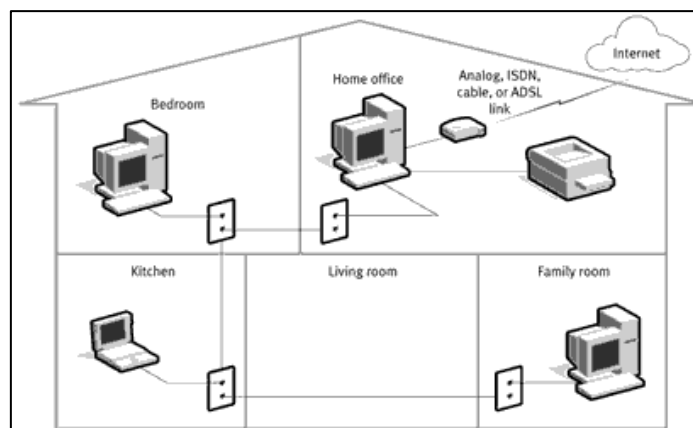


Figure 2: How a Home Network constructed with PhoneLine Networks is constructed

What makes it possible for telephone line networks to handle the variation in frequencies is a technology called frequency division multiplexing (FDM). This technology slices up the total available bandwidth into different frequency bands that are called channels. These channels are then allocated to different types of traffic including power, analog voice and digital information.

PowerLine Networks

Just like phonline networks, powerline networks also use excess capacity for handling communications between devices. This model also requires that there be adapters in each of the PCs connected to the network. Instead of each adapter being plugged into a network, it is instead plugged into a power outline. Just as with other networking approaches, a modem is used for connecting the entire network to the Internet.

This approach also uses a similar approach to handling the frequencies of data sent over powerlines. Called Frequency Shift Keying (FSK) technology, this approach to sending signals over the powerline uses multiple frequencies to get data over a network as reliably and quickly as possible. In a sense the FSK technology which translates data into a binary state is actually somewhat anachronistic; it is somewhat dated compared to the current state of Ethernet technology.

Because of the approach that the FSK technology takes for translating data, this approach to networking within a home is slower than any other. Because many electrical devices are connected to the same electricity source in a home, when a network is also included the result is that there is significant “noise” or interference. This limitation slows the network down to a third of the speed of an Ethernet-based network. In addition to the difference in the voltage, there is also the issue of ensuring data stays secure since many homes use the same power lines, especially in older neighborhoods. Due to the security limitations and the speed issues,

this approach to home networking is expected to be quickly eclipsed by both phonline and wireless technologies.

Wireless Networks

Based on long-standing technologies that have been used for both in-building and building-to-building communications, wireless local area networks or WLANs for short, show the most promise for the future of home networking. The benefits of having a wireless-based home network are the mobility it provides and the cost savings in terms of setting up and maintaining the network devices and connections. This ultimately leads to a lower cost of ownership over time. These benefits have lead initially to WLANs being used in vertical market applications throughout the last fifteen years as this technology has matured. Now the focus is on integrating WLANs into homes as easily as possible. The benefits of mobility in the home networking environment have prompted industry analysts, including Frost and Sullivan, to project aggressive growth of this technology. Figure 3 shows the market forecast for Wireless Home Networking through 2005.

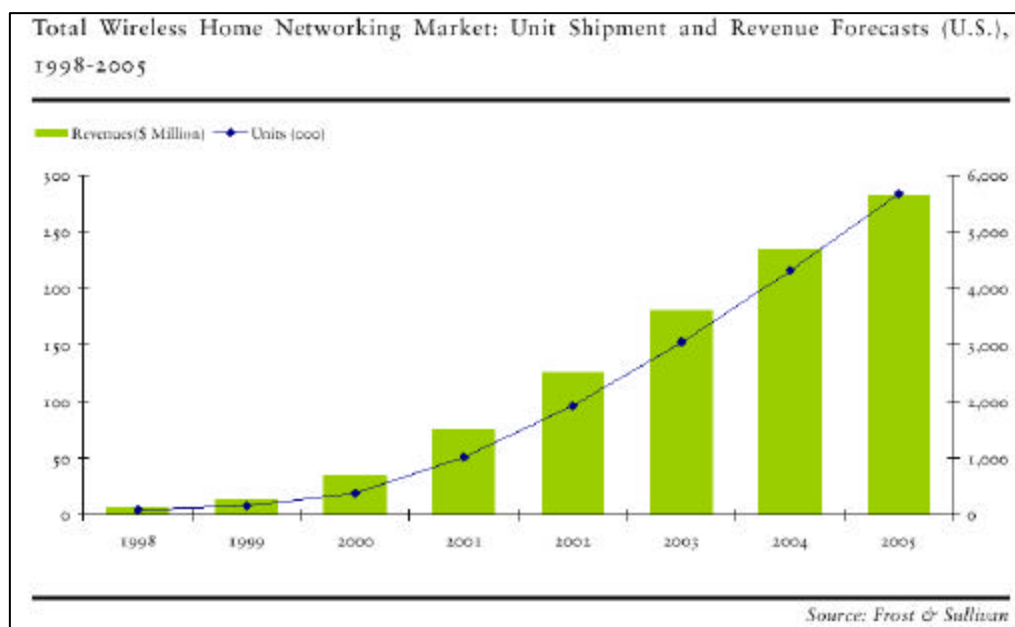


Figure 3: Frost & Sullivan's Forecast of the Wireless Home Networking Marketplace

Major trends that are driving the ongoing adoption of home-based WLANs are the growth of home offices and the need for mobility, ease of configuration and support, and scalability. Home offices will also drive the development of this market, since the mobility inherent in this approach makes this approach popular with portable PCs.

Exploring Linksys' Home Networking Products

Linksys has created a series of products specifically developed for home networking. Each of these products are briefly described here:

HPB200 HomeLink Phoneline 10M Ethernet Bridge



The Linksys HomeLink Phoneline 10M Ethernet Bridge offers a complete Internet connection solution for your phoneline network. The HomeLink 10M Bridge makes sharing your broadband access easier than ever. This unique new device features a 10BaseT/100BaseTX RJ-45 Ethernet port, an Uplink port, and a HomeLink RJ-11 port. Plug in your cable modem or DSL modem's 10BaseT connection, then attach your Bridge to the nearest telephone jack using standard phone cables, and any PC on your phoneline network will be able to access the Internet.

HPES03 HomeLink Broadband Network Bridge



The Linksys HomeLink Broadband Network Bridge offers a complete Internet connection solution for your Home Phoneline network. The HomeLink Broadband Network Bridge makes sharing your broadband access easier than ever. This unique new device features two 10BaseT Ethernet ports and two HomeLink RJ-11 Ports. Plug in your cable modem or DSL modem's 10BaseT connection, then attach the bridge to the nearest telephone jack using standard phone cables, and any computer on your Home Phoneline network can access the Internet.

HPN100 HomeLink Phonewire Network Card



The HomeLink Phoneline Network Card utilizes Advanced Micro Devices' (AMD®) PCnet™-Home technology which allows phone lines to carry data at a 1Mbps transfer rate without interrupting regular telephone voice service (POTS) or feeds from a Digital Subscriber Line (xDSL). You can talk on the telephone and share resources over a network at the same time. Every standard telephone jack in the home is capable of hosting a PC. You can connect up to 25 devices on any given phone number. With the HomeLink Phoneline Network Card, you will instantly transform the home's telephone wiring into an easily expandable network.

The HPN100 (North American Distribution ONLY) now comes with a free copy of Sygate Technologies Sygate Home Network™ Gateway Software. With this software users can share one Internet connection, one modem, and one phone line simultaneously. It also features access monitoring, retains an Internet activity log across the network and automates Internet dial-up on demand. Sygate Home Network also provides network protection, creating and enforcing Internet access policies, and preventing hackers from entering the network.

HPN100SK HomeLink Phonewire Network in a Box



The HomeLink Phoneline Network in a Box utilizes Advanced Micro Devices' (AMD®) PCnet™-Home technology which allows phone lines to carry data at a 1Mbps transfer rate without interrupting regular telephone voice service (POTS) or feeds from a Digital Subscriber Line (xDSL). You can share resources over a network while talking on the telephone or while downloading files from the Internet with your modem. Every standard telephone jack in the home is capable of hosting a PC. You can connect up to 25 devices on any given phone number. With the HomeLink Phoneline Network in a Box, you will instantly transform the home's telephone wiring into an easily expandable network.

HPN200 HomeLink Phoneline 10M Network Card



The Linksys HomeLink Phoneline Network Card is the second generation Network Card of the Linksys HomeLink series. Now able to transfer data at the same speed as a standard Ethernet network, the HomeLink Phoneline 10M Network Card is the simplest way to build a network in your home or small office. Share your Internet connection over multiple PCs, connect directly to your first-generation HomeLink or home phoneline network, print from any PC to any printer, and play multi-player games at top speeds without installing a switch, a hub, or even network cables.

By allocating certain frequencies for certain types of data transfer, the Linksys HomeLink Network 10M Card allows your phone line to simultaneously carry computer data along with your voice. You can talk on the telephone, download files from the Internet, and share data between PCs—all at the same time (assuming that you are using a cable or DSL modem). Every standard telephone jack in the home is capable of hosting a PC. You can transform your telephone wiring into an easily expandable network.

HPN200SK Homelink Phonenumber 10M Network Starter Kit

The Linksys HomeLink Phonenumber Network Card offers instant connectivity to multiple PC's over a home's existing telephone lines. You can network any computer by connecting it to any telephone jack in your wall. The network runs on standard homegrade telephone wires just like the ones you use everyday so there's no extra hardware to buy. The Linksys HomeLink Phonenumber Network Card utilizes new HomePNA-compliant technology that allows your phone line to carry computer data as well as regular telephone voice service simultaneously. You can talk on the telephone, share files, and share resources such as a cable modem or DSL connection at 10Mbps all at the same time. Every standard telephone jack in the home is capable of hosting a PC -- you can connect up to 30 computers, thus transforming the home's telephone wiring into an easily expandable network.

PCM100H1 HomeLink Phonenumber + 10/100 Network PC Card

The card fits into any standard Type II PCMCIA slot, leaving room for a 56K modem or other PC Card in dual-slot notebooks. You can share Internet access via a dial-up, cable modem or DSL connection, as well as files, printers, and CD-ROM drives at 1Mbps without interrupting regular telephone service.

USB100H1 HomeLink Phonenumber + 10/100 USB Network Adapter

The HomeLink Phonenumber + 10/100 USB Network Adapter allows you to instantly connect to a network from a USB-enabled PC, notebook PC, or even a USB hub. Connect a standard telephone cable (or a Category 5 network cable if you want to connect to a Fast Ethernet network) into the adapter, install the included drivers, and go. The HomeLink Phonenumber + 10/100 USB Network Adapter is bus-powered -- it draws power from the host PC and requires no external power cords. Compatibility with Windows 98 makes it easy for almost anyone with a USB-ready PC or notebook to connect to a HomeLink or 10/100 network. Easy-to-read LEDs, compact design, a 1-year warranty and free world-class technical support make it a must for any home or office.

USB200HA HomeLink Phoneline 10M USB Network Adapter

The HomeLink Phoneline USB Network Adapter allows you to instantly connect to a network from a USB-enabled PC, notebook PC, or even a USB hub. Connect a standard telephone cable into the adapter, install the included drivers, and go-- you'll be networked in no time. The HomeLink Phoneline 10M USB Network Adapter is bus-powered! It draws power from the host PC and requires no external power cords. Compatibility with Windows 98 and 2000 makes it easy for almost anyone with a USB-ready PC to connect to a HomeLink network. Easy-to-read LEDs, compact design, a 1-year warranty and free world-class technical support make it a must for any home or office.

Summary

As the Internet makes sharing access, peripherals, video possible the demands for home networking solutions will continued to increase significantly in the coming years. Clearly, Ethernet-based and wireless home networking scenarios show the greatest benefits to consumers, and a correspondingly higher rate of growth than any of the other networking technologies. In comparing the home networking approaches possible, the issues of scalability, cost of maintaining the network, security, and performance all are issues that need to be considered when a home network is designed. The rise of wireless networking will continue to be a force in this marketplace, with the future promising greater performance and security in this technology arena.

Glossary

Access Point – Linksys’ wireless-based device for connecting roaming wireless PC cards directly to the Internet. The Access Point is a device that provides the benefits of roaming and mobility from a stationary Internet connection.

Bandwidth – A generic term in the world of the networking that refers to the speed or rate of transmission between devices connected to a network. In the majority of cases, the bandwidth of a given device in connecting with and using the Internet is directly proportional to the amount of data being transferred.

Cable modem – A class of modem that is used for connecting to a cable TV network, which in turns connects directly to the Internet. Cable-modem based connections to the Internet are typically much faster than dial-up modems, yet have the issue of security, as a cable-based network is comparable to a closed network.

Digital Subscriber Line – A digital phone services that provides for voice, video and digital data over existing phone systems at higher speeds than are available in typical dial-up Internet sessions.

DSL modem – A modem that connects a PC to a DSK network, which in turn connects to the Internet.

Ethernet – Based on the IEEE 802.3 networking standard, this term defines the transmission of data at speeds of 10Mbps.

Home Phonenumber Networking Alliance (HomePNA) – An organization that works to ensure that all products sold into the home networking marketplace adopt a single, unified phonenumber networking standard. This is specifically done to bring a unified set of interoperable home networking solutions to the marketplace. Linksys is a member of the HomePNA association.

Hub – A networking device that enables attached devices to receive data streams that are transmitted over a network. This device also makes it possible for devices to share the network bandwidth available on a network.

ISDN – An acronym that stands for Integrated Services Digital Network. This is an all-digital circuit-switched telephone network.

ISP – An acronym that stands for Internet Service Provider. An ISP is typically a company or organization that provides Internet access for individuals and companies.

Local Area Network (LAN) – A series of PCs that have been joined together via cabling so that resources can be shared, including file and print services. LANs are increasingly being found in homes, where sharing of Internet access is one of the most dominant uses of this networking approach.

Megabits per second (Mbps) – Defines the speed at which data is travelling, which are measured in millions of per second. This is a measure of a performance of a device.

Network – Typically a collection of devices that include PCs, printers, and storage devices that are connected together for the purpose of sharing information and resources.

Network Interface Card (NIC) – A device that provides for connecting a PC to a network. NIC cards are also called network adapters, are provide the essential link between a device and the network. NICs are also found in many peripherals including storage subsystems and printers.

Wide Area Network (WAN) – A public or private networks that provides coverage of a broad geographic area, hence the name “wide” in the description. WANs are typically used for connecting several metro areas as part of a larger network. Universities and larger corporations typically use WANs to connect their geographically dispersed locations.