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Home Networking Using "New Wires" — IEEE 1394, USB, and Fast Ethernet Technologies

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Summary

With the proliferation of digital television more and more people around the world are beginning to distribute audio and video signals around their homes. A number of interconnection technologies are available to meet the requirements of in-home video and multimedia distribution, namely IEEE 1394, USB, and Ethernet.

While the IEEE 1394 and USB seem similar, they are intended to fulfill different bandwidth and cost needs. The 1394 standard can move more data in a given amount of time, but is more expensive than USB due to its more complex protocol and signalling rate. Applications that are best suited for 1394 are disk drives, high-quality video streams, and other high-bandwidth applications; all higher end consumer devices. USB is appropriate for middle and low bandwidth applications such as audio, scanners, printers, keyboards, and mice. USB and 1394 are complimentary technologies. 1394 is for devices where high performance is a priority and price is not, while USB is for devices where price is a priority and high performance is not.

For the home networking purists, Ethernet equipment offers inexpensive and proven products that can be bought at retail in both kit form or a la carte. Ethernet technology can reliably and efficiently network all the Internet appliances (PCs, printers, game consoles, digital televisions, security cameras, and much more) at home. Xilinx solutions enable these evolving technologies in consumer devices today.

Introduction

The computer industry has been promising users the ability to easily connect electronics devices such as digital TVs, cameras, cable set-top boxes, and stereo equipment to each other and to PCs for many years. USB and IEEE 1394 interconnection technologies are the two solutions that have been developed specifically to meet commitments to their customer base.

USB and 1394 are complementary technologies, differing in their application focus. USB is the preferred connection for most PCs and PC peripherals such as keyboards, digital cameras, and scanners. 1394's primary target is consumer electronic devices such as digital camcorders, digital PVRs, DVD players, and digital televisions. Even though Ethernet was not originally designed to operate in a home entertainment environment, some of its variants are beginning to provide consumers with the ability to distribute high-speed data and video around the house.

IEEE 1394, USB, and Fast Ethernet (100 Mbps) technologies are ideal for advanced entertainment networks, however they all require additional special wiring. This white paper explores the benefits and technologies associated with deploying such solutions.

High-Speed In-Home Interconnection Technologies

Consumer electronic appliances have different applications in a networked home. Each device has its own content and usage pattern, individual, or family usage (see Table 1).

Table 1: **Different Usage Patterns for Home Networking Applications**

	Home Automation	Entertainment	Information	Personal Communications	Communication
Devices	- Home appliances - Security/safety systems - Utility meters	- TV sets - Set-top boxes - DVD Players - Game consoles - VCRs - MP3 Players	- PCs - Screen phones - Printers - Modems - Routers - Hubs - Scanners	- Mobile phones - Smart phones - Handheld - Laptop - Pagers	- Corded/Cordless telephones - Fax machines
Content	Information on home processes, house environment, remote diagnostics and technical support	Rich multimedia content, electronic programming guides, impulse purchases	Discrete information on external world, shopping for household goods	Information used on the move or requiring instant action: travel, weather, local services, stock market	Information on how to reach people in time and space
Usage Pattern	Communal	Communal	Individual Shared	Individual Personal	Communal or Individual Shared
Connection to Outside World	- Power line - POTS	- Cable - DBS	- Cable modem - ADSL - POTS, ISDN	- GSM - Infrared	- POTS
Practical Networking Technology	- CEBus - X-10 - LONWorks	- IEEE 1394 (Fire Wire)	- HomeRF - HomePNA - Ethernet	- Infrared - Bluetooth	- POTS - DECT - 900MHz, 2.4GHz

This pattern of usage has been instrumental in the development of a variety of different technologies used to connect these devices together. For instance, powerlines are the best medium for interconnection of appliances that control or manage lighting, temperature, and home security. Interconnecting PCs, printers, scanners, security cameras, and Web phones can be done through the existing phonelines.

Wireless home networking technology can be used for handheld devices, such as pocket PCs and PDAs. The best mediums for interconnecting multimedia entertainment devices such as digital set-top boxes, camcorders, and PCs are new wire technologies based on IEEE 1394, USB, or Fast Ethernet standards.

IEEE 1394

What is IEEE 1394?

With expansion of digital technology, more and more people are sharing video, still images, and audio. Consumers are constantly searching for faster and easier ways of transferring and sharing such information. This phenomenon is driving the convergence of computers, consumer equipment, and communications. Communication is the force that draws these separate market segments together.

Convergence will happen when seamless, high-speed communication becomes readily available. There are some interconnection technologies that enable us to connect these devices across home. The IEEE 1394 protocol appears to be a strong contender for the communications channel that will make this happen

IEEE 1394, also known as FireWire™ or iLink™, is a versatile, high-speed, and inexpensive method of interconnecting a variety of consumer electronic devices (e.g., home theatre equipment) and personal computer peripherals (e.g., color printers). It requires new optical fiber or high-grade copper wiring throughout the home.

Origins of IEEE 1394

The FireWire bus standard, originally created by Apple Computer was born out of the need for a low-cost, consumer-oriented connection between digital-video recorders and personal computers. It grew into a standard called the IEEE 1394 for low-cost, high data rate connections.

In 1994, an organization called 1394 trade organization was formed to support and promote the adoption of the 1394 standard. In 1995, they formally released the 1394 specification. Since 1994 a couple of new versions have been developed. 1394a was introduced in 1998 and 1394b was introduced the following year. 1394b is fully backwards compatible with the current 1394 and 1394a specifications. Each revision of 1394 has some added features, performance, and capabilities.

IEEE 1394 Architecture

To understand how 1394 operates, we need to now briefly examine the elements of a 1394-based home network. The components that form an IEEE 1394 based home network may be classified as the actual protocol itself, the cabling system, and the architectural design of the network itself.

Demystifying the IEEE 1394 Protocol

Similar to other high-speed networking systems, IEEE 1394 adopts a layered approach to transmitting data across a physical medium.

Note: A layer is best defined as a group of functions.

The four layers used by the IEEE 1394 are graphically depicted in Figure 1.

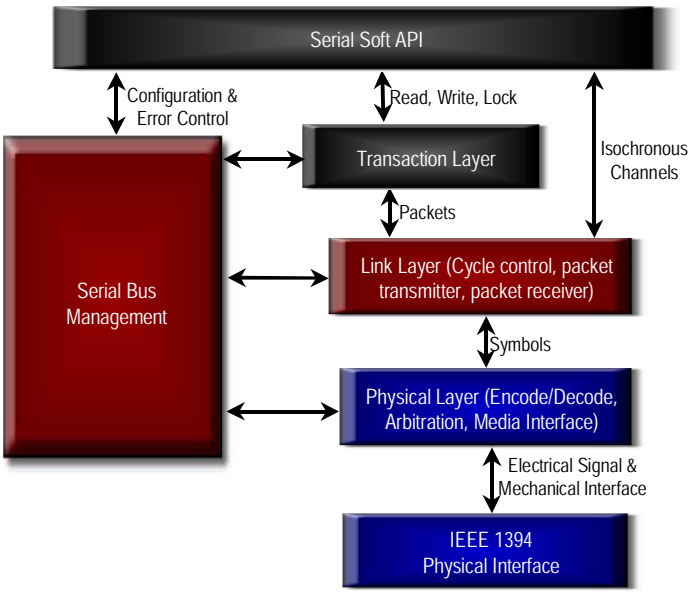

Figure 1: **IEEE 1394 Protocol Stack**

The physical layer provides the electrical and mechanical connection between the 1394 appliance and the cable itself. Besides the actual data transmission and reception tasks, the physical layer also provides arbitration to insure all devices have fair access to the bus. The link layer takes the raw data from the physical layer and formats it into two types of recognizable 1394 packets—Isochronous and Asynchronous.

1. Isochronous data transfer puts the emphasis on the guaranteed timing of the data, and less emphasis on delivery. Isochronous transfers are always broadcast in a one-to-one or one-to-many fashion. No error correction nor retransmission is available for Isochronous transfers.
2. Asynchronous data transfer puts the emphasis on guaranteed delivery of data, with less emphasis on guaranteed timing.

The third layer used by the IEEE 1394 protocol is called the transaction layer and is responsible for managing the commands that are executed across the home network. The fourth and final logical grouping of functions is responsible for the overall configuration control of the serial bus.

Cabling and Connectors

The cabling required to interconnect devices on an IEEE 1394 based home network is quite similar to that of Ethernet. So unlike other home networking technologies, IEEE 1394 requires the installation of new wires. The IEEE 1394 cable medium allows up to 16 physical connections (cable hops), each up to 4.5 meters in length. This gives a home network using IEEE 1394 a total cable distance of 72 meters.

1394 is physically small. The thin serial cable can replace larger and more expensive interfaces. The 6-pin connectors have two data wires and two power wires for devices, which derive their power from the 1394 bus.

Home Network Topology

The topology of a 1394 system can either be daisy chain, tree, star, or a combination of these. The 1394 protocol is a peer-to-peer network with a point-to-point signaling environment (see Figure 2).

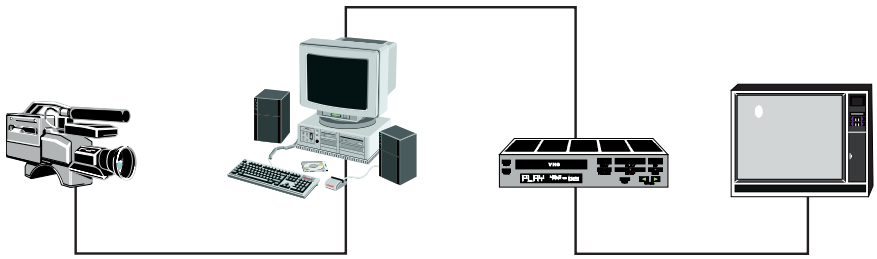

Figure 2: **Peer-to-Peer 1394 Based Home Network**

This type of topology means that there is no need for a dedicated PC to administer the home network. This feature is particularly useful for streaming data from digital cameras to both the digital PVR and the DVD drives without any assistance from other devices on the home network.

Benefits of IEEE 1394

- **Broad support:** The home networking industry has a very positive attitude towards the 1394 technology. Additionally, 1394 has the advantage of being adopted by consumer electronics manufacturers such as Sony, Panasonic, Philips, and Grundig.
- **Low cost:** 1394 is a low-cost digital interface available for audio/video applications.
- **Endorsed by international standards bodies:** The European Digital Video Broadcasters (DVB) have endorsed IEEE 1394 as their digital television interface.

  Note: Founded in September 1993, the DVB Project is a market-led consortium of public and private sector organizations in the television industry. Its aim is to establish the framework for the introduction of MPEG-2 based digital television services. Now comprising over 200 organizations from more than 25 countries around the world, DVB fosters market-led systems that meet the real needs and economic circumstances of the consumer electronics and the broadcast industry.
- **Speed:** Multimedia entertainment is the most frequently used application in today’s homes. A high-quality distribution of video for entertainment applications requires larger bandwidth than audio and data. IEEE 1394 is capable of transporting data at 100, 200, 400, or 800 Mbps. The next version of the standard will be capable of transporting data at 3.2 Gbps.
- **Plug and play:** Consumers can add or remove 1394 devices and there is no need to reset the home network.
- **Non-proprietary:** Like all IEEE standards, IEEE 1394 is an open, royalty-free standard.
- **Different applications**: There are so many different applications for IEEE 1394. Almost all of the consumer electronic, office automation, industrial, biomedical, and networking devices can benefit from 1394 features and capabilities.

Types of IEEE 1394 Products Currently Available

IEEE 1394 is an enabling technology for connecting multimedia devices, such as:

- Digital camcorders and VCRs
- Direct-to-Home (DTH) satellite
- Cable TV set-top boxes
- DVD players
- Video games
- Home theater
- Musical synthesizers/samplers with digital audio capabilities
- Digital audio tape (DAT) recorders, mixers, hard-disk recorders, and video editors

Market Forecasts

IDC forecasts that by the year 2003, over 50 million different types of informational and entertainment appliances will come with a digital IEEE 1394 interface as standard. This will have a profound affect on the design of home networks based on this advanced home networking technology.

Xilinx IEEE 1394 Solutions

The IEEE 1394 technology consists of a physical layer for encoding-decoding, arbitration, a medium interface, and provides an electrical signal and mechanical interface (Figure 3). The link layer provides cycle control, packet transmit, packet receive, CRC and provides the host and application interface. The Spartan™-II FPGA can provide complete link layer functionality with the ability to connect to multiple interfaces such as PCI, audio-video, etc. True FPGA capabilities are realized when there is a proprietary application interface. However, in an IEEE 1394 system, the Spartan-II FPGA provides system interface and other ASSP functionalities.

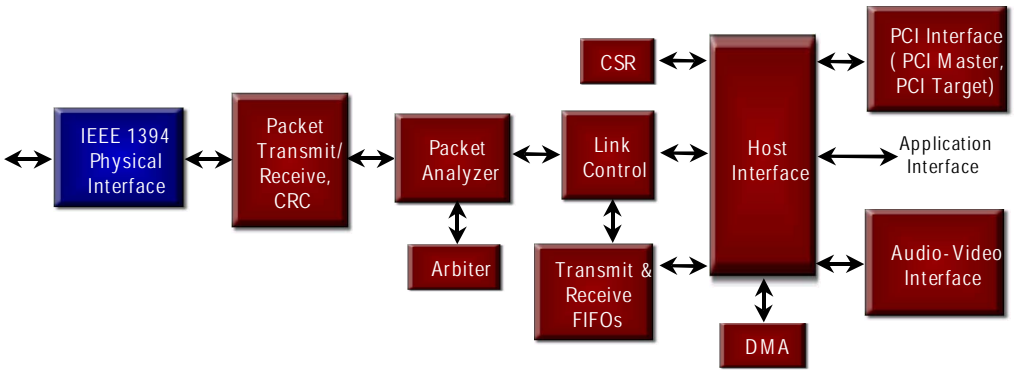

Figure 3: **IEEE 1394 Link Controller and Physical Layer Interface**

Universal Serial Bus (USB)

What is USB?

Dramatic improvements in content quality are pushing the demand for computers and informational appliances with digital interfaces. The most common interface for high-speed data is the USB serial bus. USB stands for Universal Serial Bus. It is an interface standard that was originally specified in 1995. The major goal of USB was to define an external expansion bus, which makes adding peripherals to a PC as easy as hooking up a telephone to a wall-jack.

Virtually all-new PCs come with one or more USB ports. In fact, USB has become a key enabler of the Easy PC initiative, an industry initiative led by Intel and Microsoft to make PCs easier to use. This effort evolved from the recognition that users need simpler, easier to use PCs that don’t sacrifice connectivity or expandability. USB is one of the key technologies used to provide this.

Today, version 1.1 of the USB standard is enjoying tremendous success in the marketplace, with most peripheral vendors around the globe developing products to this specification. Let’s take a closer look at the features and benefits that USB can offer to people who are considering the implementation of a USB- based in-home network.

USB 1.1

USB supports two high-speed data transfer protocols: isochronous and asynchronous. Isochronous connections from the PC USB port to the peripherals such as scanners, video devices, digital cameras, and printers, supports data transfers at a guaranteed, fixed rate of delivery of 12 Mbps. The slower asynchronous protocol is used to communicate with peripherals such as keyboards and mice at 1.5 Mbps.

These data rates of up to 12 Mbps are sufficient for low-speed to medium-speed peripherals. It replaces many different serial and parallel connectors at the back of the PC with one standardized plug-and-play combination, and home networking devices with a USB port can connect up to 127 different USB peripherals. USBs data rate also accommodates a new generation of peripherals, including MPEG-2 video-based products, data gloves, and digitizers. Computer-telephony integration is expected to be a big growth area for PCs, and USB can provide an interface for ISDN and digital PBXs.

Demystifying USB 2.0

USB 2.0 is the next generation standard. From a home networking user’s perspective, USB 2.0 is just like USB 1.1, but with much higher bandwidth (480 Mbps).

Note: USB 2.0 is 40 times faster than USB 1.1

It will look the same and behave the same, but with a larger choice of more interesting, higher performance devices available. In addition, all of the USB peripherals the user has already purchased will work in a USB 2.0-capable system. USB 2.0 is mainly used by consumers who own high-bandwidth electronic products such as high-resolution video conferencing cameras, next generation scanners, and printers.

Cabling and Connectors

Most USB enabled devices will use standard A-to-B cables of various lengths. There are, however, some USB devices that require cables that use non-standard connectors and come with their own cable.

Network Topology

When planning the physical layout of the network you need to make sure that the distances between devices are less than five meters from each other. If you need to connect two or three computers and printers together then you need to purchase a device called a USB bridge.

Note: A bridge is a device that connects two networks together.

Benefits of USB

- **Plug and play:** USB fully supports plug-and-play technology. With plug-and-play, hardware devices such as digital speakers, joysticks, and video cameras can be automatically configured as soon as they are physically attached to a home network.
- **Hot swapping capabilities:** USB also supports hot swapping of devices on a home network. So there is no need to shut down and restart devices.
- **Single port connection:** Gone are the days of opening up your computer and installing a new card and setting the onboard switches. USB replaces all the different kinds of serial and parallel connectors that you have on the back of the PC with one standardized plug and port combination.
- **Multiple connections:** Home networking devices that have a USB port let you connect 127 different peripheral devices at one time.
- **Support for high-speed protocols:** USB supports two high-speed data transfer

protocols: isochronous and asynchronous. An isochronous connection supports data transfers at a guaranteed, fixed rate at 12 Mbps. The asynchronous protocol is slower at 1.5 Mbps.

- **No need for dedicated power supplies:** USB distributes the power to all connected devices eliminating the need for clunky power supply boxes in a typical home network.
- **New home control mechanisms:** Because USB connections allow the transfer of data to flow in both directions between PC and consumer electronics devices, it is possible to use a desktop PC to control home appliances in new and creative environments.
- **Operating system support:** Microsoft Windows 98 and Windows 2000 provide complete support for USB technologies.

Xilinx USB 2.0 Solutions

Figures 4 and 5 detail the USB 1.1 and USB 2.0 cores block diagrams, respectively. While the Spartan-II FPGA can implement the USB 2.0 function controller core and a microcontroller/microprocessor, in a USB 2.0 system the FPGA can also provide a programmable application (system) interface, DMA controller, memory controller, and glue logic functionality. The real value of a programmable logic solution is the ability to connect disparate technologies such as USB 2.0 with SCSI, IEEE 1394, HomePNA (phonelines), Ethernet, and others in a single device.

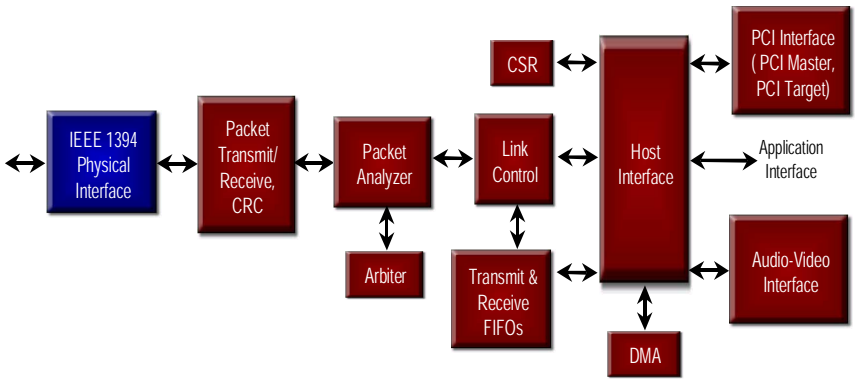

Figure 4: **USB 1.1 Core**

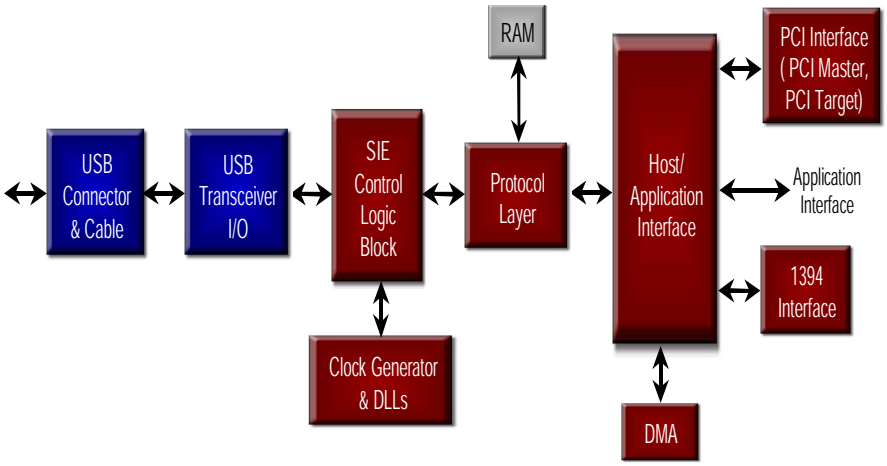

Figure 5: **USB 2.0 Core**

USB vs. IEEE 1394

Many people confuse IEEE 1394 and USB. It’s understandable. Both are emerging technologies that offer a new method of connecting multiple peripherals to a computer. Both permit peripherals to be added to or disconnected from a computer without the need to reboot. Both use thin, flexible cables, that employ simple, durable connectors. But that is where the

similarities end. Although 1394 and USB cables may look similar, the amount of data transfer is quite different.

Today, 1394 offers a data transfer rate that is over 16 times faster than USB. In addition, 1394 has a well-defined bandwidth roadmap, with speed increasing to 1 Gbps+ (125 Mbps) and beyond in the next couple of years. Such dramatic improvements in data transfer capacity will be required to keep pace with bandwidth hogging devices that plan to incorporate 1394 interfaces, such as HDTV, digital set-top boxes, and home automation systems.

1394 has a more complex protocol and signaling rate allowing movement of more data in a given amount of time. But 1394 is considerably more expensive than USB. So does this mean that IEEE 1394 will become the new wires technology of choice for most home networking users? No, in fact most industry analysts expect 1394 and USB to coexist peacefully. Small 1394 and USB connectors will replace the myriad of connectors found on the back of today’s PCs and information appliances. USB will be reserved for low-bandwidth peripherals (mice, keyboards, and modems), while 1394 will be used to connect to the new generation of high-bandwidth computer and consumer electronics products.

Ethernet/ Fast Ethernet

What is Fast Ethernet?

Ethernet is a popular and international standardized networking technology (comprising both hardware and software) that enables computers to communicate with each other. Ethernet was developed by DEC, Intel, and Xerox. The Institute of Electrical and Electronics Engineers (IEEE) later standardized it as IEEE 802.3. Therefore, people tend to use the terms Ethernet and IEEE 802.3 interchangeably. It supports data transfer rates of 10 Mbps. A newer version of Ethernet called Fast Ethernet supports data transfer rates of 100 Mbps.

Note: Officially, the Fast Ethernet standard is IEEE 802.3u.

The newest version is called Gigabit Ethernet and supports rates of 1,000 Mbps (1 Gbps). This variation of Ethernet is mostly used for enterprise networking and is rarely deployed within the home.

Fast Ethernet Architecture

To understand how Fast Ethernet (100 Mbps) operates on a home network we need to understand the elements of an Ethernet-based home network. The components that form an Ethernet-based home network may be classified as the actual protocol itself, the cabling system, and the interconnecting devices.

Demystifying the Ethernet Protocol

Similar to 1394 and USB, Ethernet adopts a layered approach to transmitting data across a home network. Ethernet defines the lower two layers of the OSI Reference Model, namely the physical and data link layers. The physical (PHY) layer transmits the unstructured raw bitstream over a physical medium and describes the electrical, mechanical, and functional interface to the network. The physical layer can support a wide range of media specifications. Each of these specifications provides different data rates, media, and topology configurations. Table 2 shows a summary of these specification standards.

Table 2: **Ethernet Physical Layer Media Specifications**

Standard	IEEE	Data Rate	Medium	Topology	Max. Cable Length	
					Half Duplex	Full Duplex
1Base5	802.3e	1Mb/s	Two pairs of twisted telephone cable	Star	250M	N/A
10Base5	802.3	10Mb/s	Single 50-ohm coaxial cable (thick Ethernet)	Bus	500 M	N/A
10Base2	802.3a	10Mb/s	Single 50-ohm RG 58 coaxial cable (thin Ethernet)	Bus	185M	N/A
10Broad36	802.3b	10Mb/s	Single 75-ohm CATV broadband cable	Bus	1800M	N/A
FOIRL	802.3d	10Mb/s	Two Optical Fibers	Star	1000M	>1000
10Base-T	802.3i	10Mb/s	Two pairs of 100-ohm Category 3 or better UTP cable	Star	100M	100M
10Base-FL	802.3j	10Mb/s	Two Optical Fibers	Star	2000M	>2000M
10Base-FB	802.3j	10Mb/s	Two Optical Fibers	Star	2000M	N/A
10Base-FP	802.3j	10Mb/s	Two Optical Fibers	Star	1000M	N/A
100Base-TX	802.3u	100Mb/s	Two pairs of 100-ohm Category 5 UTP cable	Star	100M	100M
100Base-FX	802.3u	100Mb/s	Two Optical Fibers	Star	412M	2000M
100Base-T4	802.3u	100Mb/s	Four pairs of 100-ohm Category 3 or better UTP cable	Star	100M	N/A
100Base-T2	802.3y	100Mb/s	Two pairs of 100-ohm Category 3 or better UTP cable	Star	100M	100M
1000Base-LX	802.3z	1Gb/s	Long wavelength laser (1300nm) over 62.5um multi-mode fiber	Star	316M	550M
1000Base-LX	802.3z	1Gb/s	Long wavelength laser (1300nm) over 50um multi-mode fiber	Star	316M	550M
1000Base-LX	802.3z	1Gb/s	Long wavelength laser (1300nm) over 10um Single mode fiber	Star	316M	5000M
1000Base-SX	802.3z	1Gb/s	Short wavelength laser (850nm) over 62.5um multi mode fiber	Star	275M	275M
1000Base-SX	802.3z	1Gb/s	Short wavelength laser (850nm) over 50um multi mode fiber	Star	316M	550M
1000Base-CX	802.3z	1Gb/s	Specialty shielded balanced copper jumper cable assemblies	Star	25M	25M
1000Base-T	802.3ab	1Gb/s	Four pairs of 100-ohm Category 5 or better cable	Star	100M	100M

The data link layer is responsible for getting data packets on and off the home network. The data link layer is subdivided further into the Logical Link Control (LLC) and Medium Access Control (MAC) sub-layers. The LLC on the upper half of the layer does the error checking whilst the MAC on the lower half is solely responsible for getting the data on and off the home network. Like Ethernet, Fast Ethernet also uses the CSMA/CD access method to handle simultaneous demands on a home network.

About CSMA/CD

CSMA/CD stands for carrier sense multiple access with collision detection. On a home network that uses the CSMA/CD access method, a device can send data at any time—so there is multiple access. When an electronics or PC device has data to send, it listens to the line to see if it is busy. The device is sensitive to any carrier on the line—which is why this access method is said to have “carrier sense”. If there is traffic on the line, the device waits—in other words, it enters waiting mode. If the line is free, the station transmits its data immediately. Let’s say that another device in another part of the home decides to send data at the same time. In such a case, a collision may occur. Collision detection allows the two devices to detect this event and perform the required recovery. The devices back off for a period before retransmitting. Of course, it is essential that the two devices do not back off for the same length of time. If, for example, all appliances on the home network were set to back off and retry after half a second, the same two data broadcasts would collide again. To prevent continual collisions, each appliance on the network backs off for a random amount of time.

Cabling and Connectors

Ethernet is very precise about proper cabling. There are three different major types of cables available for Ethernet applications—twisted pair, coaxial, and fiber optic. Each medium has its

own characteristics and these characteristics determine the suitability of the medium for any given set of circumstances.

Twisted Pair

Twisted pair is the oldest medium. It’s also the least expensive, the easiest to install, and the most common cable type. Twisted pair is made up of two copper wires, which are twisted around one another. These wires are known as the signal and return paths. The wires are coated in an insulating material, so they can be handled and moved easily. A twisted pair cable may be either flat or round. In either case, it usually contains four or more conductors that carry data. There are three types of twisted pair:

- Unshielded twisted pair (UTP)
- Shielded twisted pair (STP)
- Foiled twisted pair (FTP)

STP has a shield around the cable to reduce susceptibility to interference. UTP, on the other hand, relies on the tightness of the twists to reduce susceptibility to interference. In fact, the twists continue right up to the connector. FTP is like STP in that it incorporates a shield which, as the name suggests, is made of foil. UTP is the most common form of twisted pair.

> **Note:** With more recent, advanced encoding schemes, UTP cable can now carry 100 Mbps of data and more.

Coaxial

Coaxial cable (coax) is similar to the lead that links a television to its antenna. The cable is constructed using a single inner wire or core called a conductor. This is surrounded by an outer shield or wire mesh that acts as the ground. The core and the ground must be separated by insulation in order to protect the core from interference. There are two insulation methods. Either a solid continuous insulator can be used, or insulating disks can be spaced evenly along the cable.

> **Note:** CATV cabling is the 75 ohm coaxial cabling commonly known for its use in transmission of cable TV signals:

Fiber Optic

Fiber optic cables (also known as optical fibers) are the third type of Ethernet cable. A fiber optic cable consists of a bundle of glass threads, each of which is capable of transmitting messages modulated onto light waves. Light provides a larger bandwidth than that provided by an electrical signal. Optical fiber can be used for either analog or digital transmission. The fiber may be made from either glass or plastic. If the transmission is digital, bursts of light may represent “On” and the gaps between the bursts may represent “Off”. If the transmission is analog, the light will vary as an analog electrical signal does. Fiber optics has several advantages over traditional twisted pair and coaxial communication lines:

- Fiber optic cables have a much greater bandwidth than metal cables
- Fiber optic cables are less susceptible than metal cables to interference
- Fiber optic cables are much thinner and lighter than traditional wiring systems
- Fiber optic cable may also be used to carry 1394 and USB data

The main disadvantage of fiber optics is that the cables are expensive to install in a home. In addition, they are more fragile than metal based cabling. There are two types of fiber optic cables available for home networking applications, “single mode” and “multiple mode”. Fiber optic cabling is a technology where electrical signals are converted into optical signals, transmitted through a thin glass fiber, and reconverted into electrical signals.

Fiber optics is a particularly popular technology for corporate networks. In the future, Xilinx believes that fiber optic technology will act as a backbone-cabling infrastructure for consumers who want to distribute rich multimedia video content throughout their homes.

As regards to connectors, BNC connectors are used in home networks that have installed coaxial cables and RJ-45 connectors are used on networks that are configured with twisted pair cabling.

Interconnection Devices

Network interface cards, repeaters, and hubs are the main interconnection devices used in an Ethernet home networking environment. A network interface card is an expansion card used to connect a digital device to a home network. Most network interface cards are designed for a particular type of network, protocol, and media. A common problem in the home networking world is that of weakening electrical signals. Electrical signals traveling through wires weaken due to the wire’s electrical resistance. This effect limits the lengths of the cable that can be used. A repeater is a network device that repeats a signal from one port onto the other ports to which it is connected. Repeaters are low-level devices that amplify or regenerate weak signals. The hub’s major function is to replicate data it receives from one device to all others.

Benefits of Fast Ethernet-Based Home Networks

- **Proven technology:** There are several million 10 Mbps Ethernet users in the world today. By keeping the essential characteristics of the Ethernet technology unchanged in the 100 Mbps world, home networking users can benefit from the body of Ethernet expertise developed over the years.
- **Reliability:** Ethernet technology can reliably and efficiently network most types of information appliances, including PCs, high-definition televisions, set-top boxes, security cameras, and modems (see Figure 6).

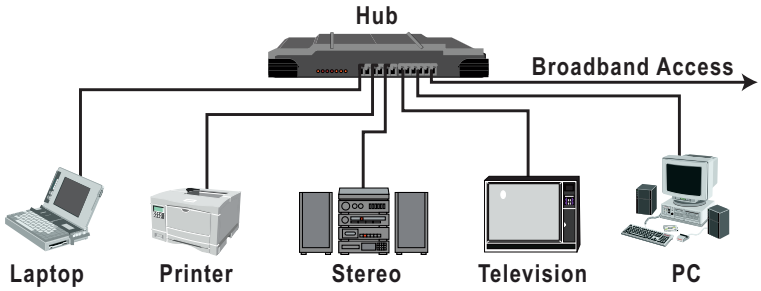

Figure 6: **Fast Ethernet-Based Home Network**

- **Support for high-bandwidth in-home applications:** Multimedia entertainment is the most important application in today’s homes. The bandwidth requirement of high-definition television and streaming video cannot entirely be satisfied by the “no new wires” technologies that are available in today’s homes. Ethernet technology can reliably and efficiently deliver this level of functionality to home networking users.
- **Wide industry support:** Fast Ethernet is widely supported by many different companies.

Market Data

According to the Cahners In-Stat Group, the Gigabit Ethernet segment continues to grow impressively, with nearly $48 million worth of products shipped in the third quarter of 2000, up dramatically from about $14 million in the third quarter of 1999.

Xilinx Fast Ethernet Solutions

Figure 7 shows a 10/1000 Ethernet core which includes the physical layer (PHY), media independent interface (MII), and the medium access control (MAC). The Spartan-II FPGA can provide the Ethernet solution by fitting the MII and MAC. It can additionally provide the benefit

of interfacing to any of the home networking and networking interfaces. It also provides features such as clock management, embedded memory, and I/O translation to different I/O types.

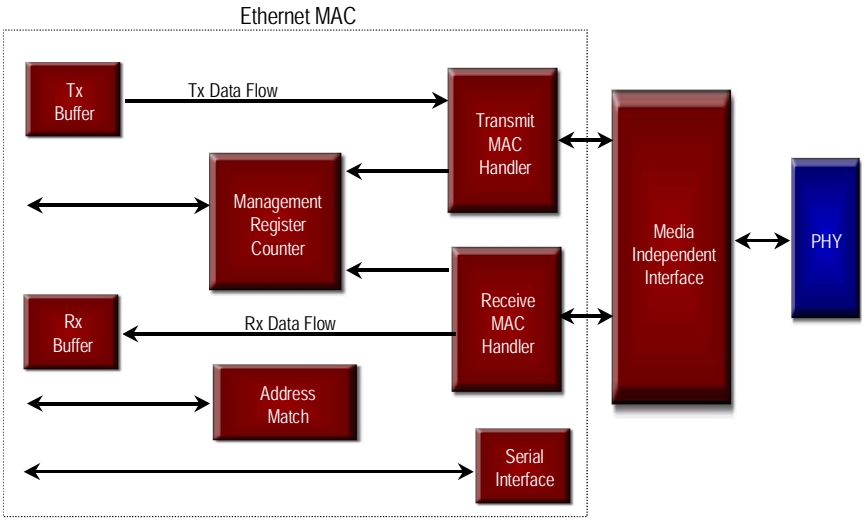

Figure 7: **10/100 Ethernet PHY-MII-MAC**

Revision History

The following table shows the revision history for this document.

Date	Version	Revision
03/21/01	1.0	Initial Xilinx release.