

## **Building an Ethernet Network**

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### **Abstract**

This white paper will cover a brief history of computer networking as well as the basics of how to set up an Ethernet Network. Other items covered include both wired and wireless network implementations as well as premise wiring components.

## **Computer Networking - A brief history**

### **ARPANET/Internet**

The Advanced Research Projects Agency (ARPA) was created by the US government right after the then Soviet Union launched their Sputnik satellite in 1957. ARPA's focus was to research how to best utilize existing computer systems to aid in national defense. Part of this agencies' research was to develop what was to be known as the ARPANET. The ARPANET is the first example of a Wide Area Network similar to today's Internet. The ARPANET was brought online in 1969 and initially connected four major computers at universities in the southwestern US (UCLA, Stanford Research Institute, UCSB, and the University of Utah). The contract was carried out by BBN of Cambridge, MA under Bob Kahn and went online in December 1969. By June 1970, MIT, Harvard, BBN, and Systems Development Corp (SDC) in Santa Monica, Cal. were added. By January 1971, Stanford, MIT's Lincoln Labs, Carnegie-Mellon, and Case-Western Reserve U were added. In months to come, NASA/Ames, Mitre, Burroughs, RAND, and the U of Illinois plugged in. After that, there were far too many to keep listing here.<sup>1</sup>

### **Ethernet**

Ethernet is a data communications architecture that is used to connect multiple computers together either on a Local Area Network or a Wide Area Network.

May 22, 1973, at the Xerox Palo Alto Research Center (PARC), the world's first Ethernet LAN transmitted its first packet (chunk of data). The proud inventors were Bob Metcalf and David Boggs. For years they labored in the laboratory to improve their invention. By 1976 their experimental network was connecting 100 devices.<sup>2</sup>

### **ARCnet**

In September 1977, the world's first commercially available local area network was first put into service at Chase Manhattan Bank, New York, as a beta-site. Short for Attached Resource Computer network, ARCnet was developed by Datapoint Corporation in San Antonio, Texas. It was defined as a group of nodes that communicates to one another over a geographically limited area usually within one building or a campus of buildings. It was the simplest, and least expensive type of local-area network. A special advantage of ARCnet is that it permitted various types of transmission media to be mixed on the same network: twisted-pair wire (Max. extension 150 meters), coaxial cable (650 m.) and fiber optic cable (2.000 m.) Today, ARCnet is still alive in numerous companies all over the world and has more than seven million installed nodes.<sup>3</sup>

## Networking Today

The Majority of today's computer networks utilize the Ethernet architecture and communicate via the IP (Internet Protocol) protocol. Decades of research and development have given us affordable, high speed and relatively secure access to millions of worldwide resource in real time.

## The OSI Model

In the late 1970s, two projects began independently, with the same goal: to define a unifying standard for the architecture of networking systems. One was administered by the International Organization for Standardization (ISO), while the other was undertaken by the International Telegraph and Telephone Consultative Committee, or CCITT (the abbreviation is from the French version of the name). These two international standards bodies each developed a document that defined similar networking models.

In 1983, these two documents were merged together to form a standard called The Basic Reference Model for Open Systems Interconnection. That's a mouthful, so the standard is usually referred to as the Open Systems Interconnection Reference Model, the OSI Reference Model, or even just the OSI Model. It was published in 1984 by both the ISO, as standard ISO 7498, and the renamed CCITT (now called the Telecommunications Standardization Sector of the International Telecommunication Union or ITU-T) as standard X.200.

One interesting aspect of the history of the OSI Reference Model is that the original objective was not to create a model primarily for educational purposes—even though many people today think that this was the case. The OSI Reference Model was intended to serve as the foundation for the establishment of a widely adopted suite of protocols that would be used by international internetworks—basically, what the Internet became. This was called, unsurprisingly, the OSI Protocol Suite.<sup>4</sup>

## There are 7 layers of the OSI model

**Layer 1** of the 7 layer Model is the Physical Layer and defines the physical and electrical characteristics of the network. The NIC cards in your PC and interfaces on your routers all run at this level.

**Layer 2** is known as the Data Link Layer . It defines the access strategy for sharing the physical medium, including data link and media access issues. Protocols such as PPP, SLIP and HDLC live here.

**Layer 3** Layer 3 is the Network Layer , providing a means for communicating open systems to establish, maintain and terminate network connections. The IP protocol lives at this layer, and so do some routing protocols. All the routers in your network are operating at this layer.

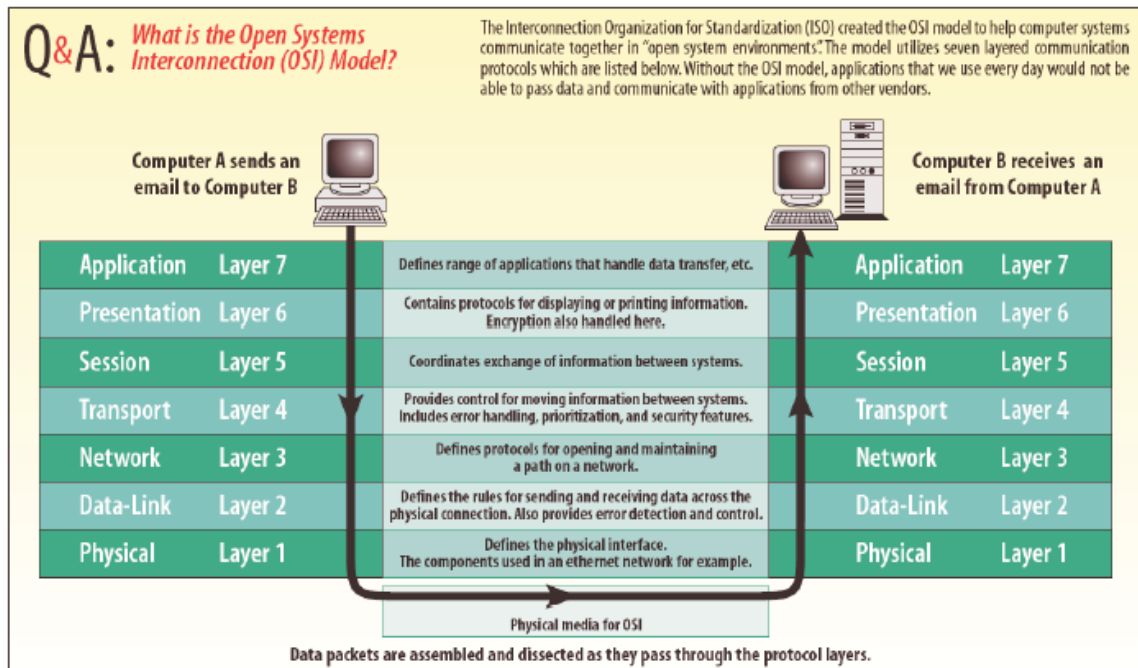
**Layer 4** Layer 4 is the Transport Layer , and is where TCP lives. The standard says that "The Transport Layer relieves the Session Layer [see Layer 5] of the burden of ensuring data reliability and integrity".

**Layer 5** Layer 5 is the Session Layer . It provides for two communicating presentation entities to exchange data with each other.

**Layer 6** Layer 6 is the Presentation Layer . This is where application data is either packed or unpacked, ready for use by the running application. Protocol conversions, encryption/ decryption and graphics expansion all takes place here

**Layer 7** Finally; Layer 7 is the Application Layer . This is where you find your end-user and end-application protocols, such as telnet, ftp, and mail (pop3 and SMTP). 5

Information being transferred from a software application in one computer system to a software application in another must pass through the OSI layers. For example, if a software application in System A has information to transmit to a software application in System B, the application program in System A will pass its information to the application layer (Layer 7) of System A. The application layer then passes the information to the presentation layer (Layer 6), which relays the data to the session layer (Layer 5), and so on down to the physical layer (Layer 1). At the physical layer, the information is placed on the physical network medium and is sent across the medium to System B. The physical layer of System B removes the information from the physical medium, and then its physical layer passes the information up to the data link layer (Layer 2), which passes it to the network layer (Layer 3), and so on, until it reaches the application layer (Layer 7) of System B. Finally, the application layer of System B passes the information to the recipient application program to complete the communication process.6



The basic idea behind computer networking is to share resources such as printers and Internet connections as well as sharing files between computers/users. This saves time and money. Today there are two networking options, wired and wireless. This paper will explain how to set up both types of networks.

## Wired Network

First, each desktop or laptop computer that you want to add to the network will require an Ethernet Adapter or NIC (Network Interface Card). A lot of computers sold over the last few years have a NIC built right in. You will need to check your computers user manual to see if you already have one in your computer. If you do not have a NIC they are readily available through many retail stores and web e-tailers. You will need to know the exact style of NIC that will fit in your computer, again this will be defined in the user manual. Once you have NIC's in all our computers that will be networked, you will need an Ethernet Switch. An Ethernet switch is a main aggregation point that connects all the PC's, printers and other network peripherals together. In today's wired networks, Category 5E or Cat 5E copper cabling is the standard cable type used to connect the PC's to the Ethernet switch. The standard connector on the CAT5E cable is called an RJ45 connector. Please see diagram 1 for reference.

Diag. 1



RJ45 Male Plug on the end of a CAT 5E cable

PCs, Routers, managed Ethernet switches and some printers must all have an IP address to communicate on a network. The IP (Internet Protocol) address is made up of four numbers separated by periods (each number can range from 0 to 255). Along with an IP address there is a subnet mask, which specifies which bits of the IP address correspond to an individual IP network or host within a sub network. The details and mechanics of IP addresses and Subnet masks are beyond the scope of this paper so we will boil it down to the basics. It is imperative that each IP address and Subnet mask on the PC's in the network be configured properly in order to share resources. Each PC needs to have a unique IP address in order to communicate on the network. For this networking example, you will need to make sure all the numbers are the same on each PC's IP address and subnet mask except for the right most digit on the IP address. This digit must be different on all the PC's and peripherals such as printers in the network. See diagram 2 for reference.

Diag.2



IP address 192.168.10.1  
Subnet Mask 255.255.255.0



IP address 192.168.10.2  
Subnet Mask 255.255.255.0



IP address 192.168.10.3  
Subnet Mask 255.255.255.0



IP address 192.168.10.4  
Subnet Mask 255.255.255.0

Many newer operating systems such as Windows XP have an automatic IP assignment function that will automatically set up IP addresses for you. If your operating system does not support this feature then there are several ways to configure the IP address and subnet mask. One way is to set up a static IP and the other way is to use a DHCP server, which most Cable/DSL routers have built into them. The DHCP (Dynamic Host Configuration Protocol) function automatically assigns an IP address and subnet mask to the PC's on the network. For this automatic IP address assignment to work your PC must be configured to "obtain an IP address automatically".

Info on how to set up a Static or manual IP address in Windows XP

[http://www.microsoft.com/resources/documentation/Windows/XP/all/reskit/en-us/Default.asp?url=/resources/documentation/Windows/XP/all/reskit/en-us/prjj\\_ipa\\_djjs.asp](http://www.microsoft.com/resources/documentation/Windows/XP/all/reskit/en-us/Default.asp?url=/resources/documentation/Windows/XP/all/reskit/en-us/prjj_ipa_djjs.asp)

Info on how to use DHCP to automatically assign IP addresses

[http://www.microsoft.com/windowsxp/home/using/productdoc/en/default.asp?url=/windowsxp/home/using/productdoc/en/howto\\_enable\\_dhcp.asp](http://www.microsoft.com/windowsxp/home/using/productdoc/en/default.asp?url=/windowsxp/home/using/productdoc/en/howto_enable_dhcp.asp)

What you have now created is called a LAN (Local Area Network). This local network has no access to the outside world or the Internet. In order to connect to the WAN (Wide Area Network) or Internet, you will need a router. A router is more "intelligent" than an Ethernet switch and provides security against hackers trying to steal information, disable or take over your network. A lot of routers on the market today come with an Ethernet switch built right into them. This is good since it saves on space and money. Diagram 3 shows a typical router/switch combo device that is very popular today.

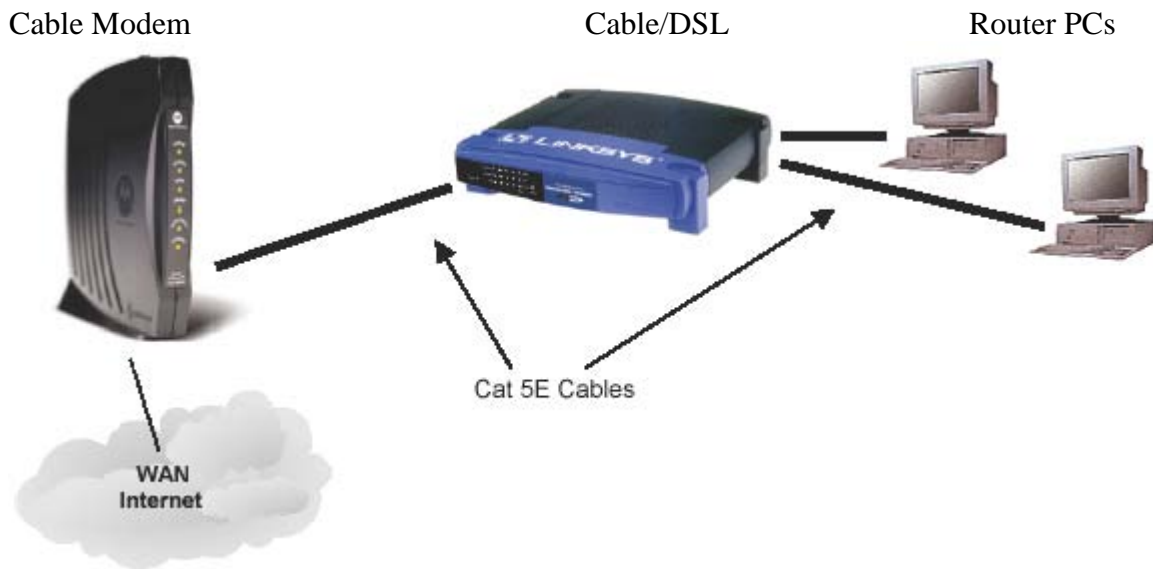
Diag. 3



Router/Switch

The routers we will reference in this paper are Cable or DSL routers. These work in conjunction with your Cable Modem or DSL Modem which is usually supplied by your cable or telephone company. Set up is generally easy when using the supplied set up CD that ships with most Cable/DSL routers. Diagram 4 shows the typical set up for a router.

Diag. 4



#### Wired Network Cat 5E Cable installation

If you are planning a wired network that entails running Cat 5E cabling through the walls and ceilings then this information will be very helpful.

First there are some limitations; Cat 5E cable can only go 100 meters or 328 feet. Once you get to that distance you will need to repeat the signal with an Ethernet switch or repeater. Also if you have machines that produce electronic “noise” where the cabling is going it may be best to use shielded Cat 5E cabling or even fiber optic cabling if required. Most home networks and small to mid sized businesses use Cat 5E copper cabling.

Begin by drawing a map of your network layout including distances between PC’s, routers and switches. Calculate the total length of cabling needed and add 10% to that number. Cat 5E cabling is readily available in 1,000-foot spools and in pre terminated (connectorized) lengths. The connectorized lengths of cable are referred to as patch cables and are used to connect PC’s and networking equipment such as switches and routers to RJ45 wall plates.

Note: Cat 5E cable comes in both stranded copper as well as solid copper conductor versions. Solid is used for long runs inside walls and ceilings and the more flexible, stranded cable is used for shorter patch cables.

#### **Materials needed for Cat 5E cable installations**



1,000 ft spool bulk solid Cat 5E cable    Cat 5E RJ45 Keystone    Jack Punch down tool and cable stripper



After you have run all the cable, stripped and punched down the ends of the cables to the RJ45 keystones you are ready to install the wall plates. We recommend that you use either wall mount termination boxes (if not using a wall plate with RJ45 keystones) or rack mount patch panels. The reason for this is that the solid conductor cable used for long runs inside walls and ceilings is not as flexible as stranded conductor patch cables. If you continually move the solid cable damage may occur sooner than with a stranded patch cable which is more flexible. Also, if damage were to occur to the end of the solid conductor cable you would need to cut it back, strip it and re-terminate. If there were not enough slack left in the cable then you would need to run all new cable in the wall or ceiling. By using a patch panel or wall plate you can ensure the integrity and longevity of your installed solid conductor cable. Also, patch cords are very inexpensive and can be replaced very easily.

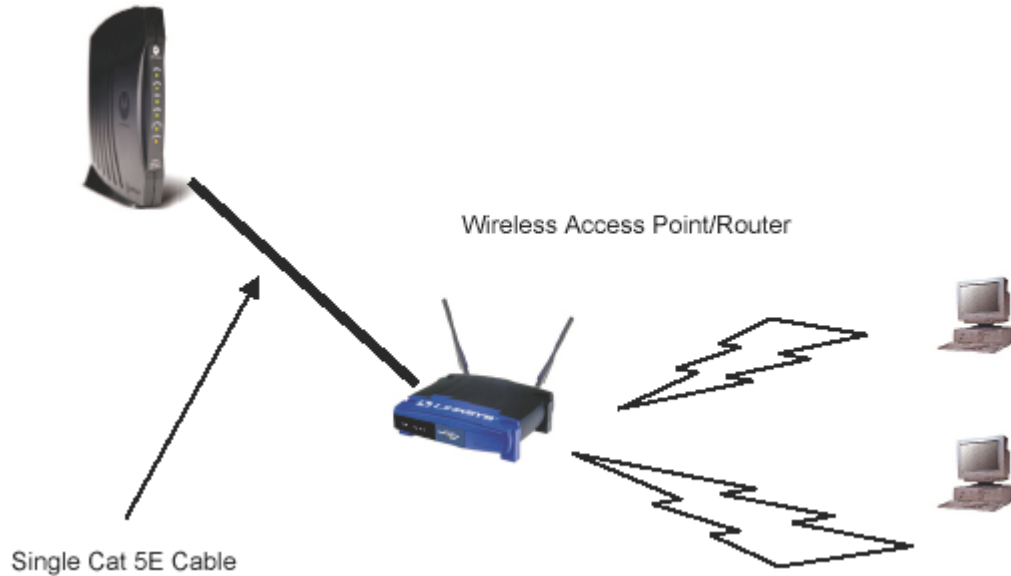
## Wireless Networks

A wireless network is very similar to the wired network in that all the same pieces are still required, a wireless NIC, Access Point (similar to a wired network Ethernet Switch) and a wireless router. The only thing that's missing is the Cat 5E cable.

First you will need to determine if your desktop or Laptop PC already has a wireless NIC built in. Again, check your user's guide to confirm this. Once your wireless NIC is installed you will need to configure the SSID (service set identifier) on each of the PC's to use the same name. Also, you need to make sure all the wireless NICs are configured to be on the same channel and set levels of encryption if desired. Your wireless access point or router should come with detailed explanation of how to configure the SSID and security features such as encryption and access lists. Many of today's wireless routers come with the access point functionality built right in. The diagram below shows a typical wireless network set up.

Diag. 5

Cable or DSL Modem



With wireless networks you can either set up a LAN or a WAN depending on your needs. To set up a LAN you will simply need wireless NIC's in all PC's and peripherals such as printers and a wireless Access Point. The wireless access point acts as a repeater, which sends the wireless communications between PCs. To set up a WAN connection you will need to use a router. See Diagram 5 above.

In addition to setting up SSID's and encryption on the wireless network, you will also need to follow the IP address and subnet rules defined earlier in the wired network section of this paper for the wireless users to communicate.

## **Additional Resources**

### **Network cabling**

[http://www.l-com.com/images/multimedia/tips/tip\\_utp\\_stp.pdf](http://www.l-com.com/images/multimedia/tips/tip_utp_stp.pdf)

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### **General Networking Info**

[http://www.l-com.com/images/multimedia/tutorials/datacom\\_tutorial.pdf](http://www.l-com.com/images/multimedia/tutorials/datacom_tutorial.pdf)

## **References**

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3. <http://www.old-computers.com/history/detail.asp?n=23&t=3>
4. [http://www.tcpipguide.com/free/t\\_HistoryoftheOSIReferenceModel.htm](http://www.tcpipguide.com/free/t_HistoryoftheOSIReferenceModel.htm)
5. [http://www.pcsupportadvisor.com/OSI\\_7\\_layer\\_model\\_page1.htm](http://www.pcsupportadvisor.com/OSI_7_layer_model_page1.htm)
6. [http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito\\_doc/introint.htm#xtocid](http://www.cisco.com/univercd/cc/td/doc/cisintwk/ito_doc/introint.htm#xtocid)



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