NETWORKING

Networks are an extremely important part of computing. Take the internet for instance - the internet is the largest network, spanning the entire globe. Since you are a part of this network, you are able to access this web site.

Sometimes people like to connect all of the computers in their office together in order to share a modem or printer. Other setups may get as small as two PC's networked in the same room for the sole purpose of enjoying two-player games.

WHAT IS A NETWORK?

First things first. You need to know what this thing is. Quite simply, a network is simply a group of two or more personal computers linked together. When configured in this way, the PC's can share files, use a common printer or modem, etc.

WHAT TYPES OF NETWORKS EXIST?

There are many different network types. Let's run through them here in order to define these terms for you.

- Local Area Network (LAN) : This is a network of computers that spans a relatively small space. Common LANs would be in an office or home. Some LANs span a series of buildings, usually in close proximity. Most LANs connect a series of workstations (a very powerful computer used usually in engineering applications) or PCs together. Each computer on the network, called a node, has its own hardware and runs its own programs like any normal PC, but they can also access any other data or devices connected to the LAN. This is useful so that many users can share expensive pieces of equipment, such as laser printers. Users can also use the LAN to communicate via e-mail or chat.
- Wide Area Network (WAN) : This is a network that spans a larger area. It consists of two or more LANs connected to each other via telephone lines or some other means of connection.
- Ethernet : a type of LAN. It is more or less a LAN protocol developed by Xerox Corporation back in 1976. We will get into more specifics later. The original supported transfer rates of 10 Mbps. A newer version of Ethernet, called *100Base-T* (or *Fast Ethernet)*, supports data transfer rates of 100 Mbps. And the newest version, *Gigabit Ethernet* supports data rates of 1 gigabit (1,000 megabits) per second.
- Metropolitan Area Network (MAN) : This is a term not used as often. Nonetheless, this is a network that spans a town or city, usually connected by fiber optic cable, so it boasts high speeds.
- VLAN : Short for *virtual LAN,* a network of computers that behave as if they are connected to the same wire even though they may actually be physically located on different segments of a LAN. VLANs are

configured through software rather than hardware, which makes them extremely flexible. One of the biggest advantages of VLANs is that when a computer is physically moved to another location, it can stay on the same VLAN without any hardware reconfiguration.

- The Internet is a system of linked networks that are worldwide in scope and facilitate data communication services such as remote login, file transfer, electronic mail, the World Wide Web and newsgroups. With the meteoric rise in demand for connectivity, the Internet has become a communications highway for millions of users. The Internet was initially restricted to military and academic institutions, but now it is a full-fledged conduit for any and all forms of information and commerce. Internet websites now provide personal, educational, political and economic resources to every corner of the planet.

- With the advancements made in browser-based software for the Internet, many private organizations are implementing intranets. An intranet is a private network utilizing Internet-type tools, but available only within that organization. For large organizations, an intranet provides easy access to corporate information for employees.

- Token Ring is another form of network configuration which differs from Ethernet in that all messages are transferred in a unidirectional manner along the ring at all times. Data is transmitted in tokens, which are passed along the ring and viewed by each device. When a device sees a message addressed to it, that device copies the message and then marks that message as being read. As the message makes its way along the ring, it eventually gets back to the sender who now notes that the message was received by the intended device. The sender can then remove the message and free that token for use by others.

ELEMENTS OF A NETWORK

Network interface cards, commonly referred to as NICs, are used to connect a PC to a network. The NIC provides a physical connection between the networking cable and the computer's internal bus. NICs come in three basic varieties: 8-bit, 16-bit, and 32-bit. The larger the number of bits that can be transferred to the NIC, the faster the NIC can transfer data to the network cable.

Cards are available to support almost all networking standards, including the latest Fast Ethernet environment. Fast Ethernet NICs are often 10/100 capable, and will automatically set to the appropriate speed. Full duplex networking is another option, where a dedicated connection to a switch allows a NIC to operate at twice the speed.

Hubs The hub is probably the most important part of the networking puzzle. It is the core of almost any Ethernet setup, except for 10Base-2 networks which only require a 50 ohm terminator wherever a PC does not exist on the cable. The hub is used to bring all the PCs together and provide a single connector to a network server or another hub. The hub has varying numbers of ports, each port being where you plug in each PC. Hubs are quite simple. They do no error checking or data filtering. They just diligently pass data along. They preserve the electrical signal that passes through them, allowing you to span your network further than what is typically allowed in your Ethernet standard.

There are both Manageable Hubs, which allow advanced configuration of Hub properties via a software package, and Standard Hubs, which are cheaper, and usually used for home or small office networks. We recommend purchasing a standard hub, since the extra features included in Manageable Hubs are not useful for a home or small office network.

There are three types of hubs:

- Standalone hubs: a single hub. These hubs are the least expensive. They are expandable in that you can connect them to other standalone hubs. They boast a number ports, depending on the hub. They are best for smaller networks.
- Stackable Hubs: These are like standalone hubs, except that they can be stacked on top of one another. When stacked, they are connected via a short piece of cable and they act like one single modular hub, able to be controlled as one. These are ideal for those who want to start a network with minimal investment but with room for expansion.
- Modular Hubs: These are more ideal for the larger networks. These are bought as a chassis. In the chassis, you install module cards, each card having as many as 12 twisted-pair ports. You can install as many cards as the chassis will take. You can get modules that take different types of cabling, depending on your needs.

Bridges, Routers, and Switches

Bridges and routers are devices used for linking different LANs or LAN segments together. There are many companies that have LANs at various offices across the world. Routers were originally developed to allow connection of remote LANs across a wide area network (WAN). Bridges can

also be used for this purpose. By setting up routers or bridges on two different LANs and connecting them together, a user on one LAN can access resources on the other LAN as if they were on the local LAN.

There are maximums on distances between workstations and hubs, hubs and hubs, and stations connected to a single LAN. You can exceed these maximums by linking two LAN segments (groups of users/devices) together using a Bridge or Router.

Bridges

Bridges are simpler and less expensive then routers. Bridges make a simple do/don't decision on which packets to send across to segments they connect. Filtering is done based on the destination address of the packet. If a packet's destination is a station on the same segment where it originated, it is not forwarded. If it is destined for a station on another LAN, it is connected to a different bridge port and forwarded to that port.

Routers

Routers are more complex and more expensive than bridges. They use information within each packet to route it from one LAN to another, and communicate with each other and share information that allows them to determine the best route through a complex network of many LANs.

Routers are often used to connect networked users to the internet. Since they let users share things such as modems, ISDN adapters, or ISP accounts they are useful for this function.

Routers can be fairly pricey. A less expensive option to shared internet access is a proxy server. Products such as WinProxy let you easily set up internet access for several networked PCs, using a single modem or ISDN line.

Switches

Switches are another type of device used to link several LANs and route packets between them. A switch has multiple ports, each of which can support either a single station or an entire Ethernet. With a different LAN connected to each of the ports, it can switch packets between LANs as needed.

NETWORK STRUCTURE

Networks are usually classified using three properties: Topology, Protocol, and Architecture.

Topology specifies the geometric arrangement of the network. Common topologies are a bus, ring, and star. A bus topology means that each computer on the network is attached to a common central cable, called a bus or backbone. This is a rather simple network to set up. Ethernets use this topology. A ring topology means that each computer is connected to two others, and they arranged in a ring shape. These are difficult to set up, but offer high bandwidth. A star topology means all computers on the network are connected to a central hub. These are easy to set up, but bottlenecks can occur because all data must pass through the hub. You can consult the diagram below to see these three topologies:
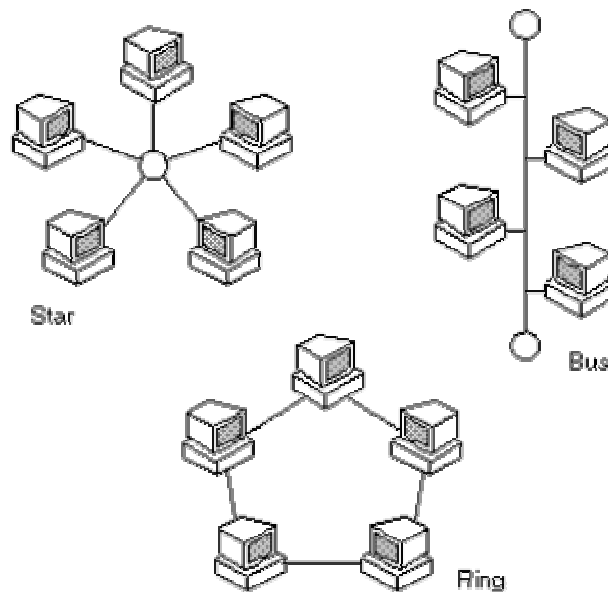
Protocol specifies a common set of rules and signals the computers on the network use to communicate. There are many protocols, each having advantages over others. Let's run through the common ones:

- TCP/IP : Transmission Control Protocol / Internet Protocol. This was originally developed by the Defense Department of the US to allow dissimilar computers to talk. Today, as many of us know, this protocol is used as the basis for the internet. Because it must span such large distances and cross multiple, smaller networks, TCP/IP is a routable protocol, meaning it can send data through a router on its way to its destination. In the long run, this slows things down a little, but this ability makes it very flexible for large networks.
- IPX/SPX: Developed by Novell for use with its NetWare NOS, but Microsoft built compatibility into both NT and Windows 9x. IPX is like an optimized TCP/IP. It, too, is a routable protocol, making it handy for large networks, but it allows quicker access over the network than TCP/IP. The downfall is that it doesn't work well over analog phone lines. IPX continually checks the status of transmission to be sure all

the data arrives. This requires extra bandwidth, where analog phone lines don't have much to begin with. This results in slow access. Of course, the data is more reliable with IPX.

- NetBEUI : Designed for small LANs, this protocol developed by Microsoft is quite fast. It lacks the addressing overhead of TCP/IP and IPX, which means it can only be used on LANs. You cannot access networks via a router.

Architecture refers to one of the two major types of network architecture: Peer-to-peer or client/server. In a Peer-to-Peer networking configuration, there is no server, and computers simply connect with each other in a workgroup to share files, printers, and Internet access. This is most commonly found in home configurations, and is only practical for workgroups of a dozen or less computers. In a client/server network, there is usually an NT Domain Controller, which all of the computers log on to. This server can provide various services, including centrally routed Internet Access, mail (including e-mail), file sharing, and printer access, as well as ensuring security across the network. This is most commonly found in corporate configurations, where network security is essential.

Now that you have a basic understanding of networks, we'll learn about the type of network most people will want to setup, a Local-Area Network.

SETTING UP A BASIC LAN

Materials

The materials needed to create your network are readily available. For a simple LAN, you can get all of it bundled together in a kit. Many large computer stores have such kits.

Let's run through what you need:

First, you must have two or more PCs to network. Make sure you have Windows installed on each machine. You can network DOS machines, but it is much easier to network a Windows based machine.

If you are creating a 10Base2 network, based on coax cable, then you will need the following:

- A Network Interface Card (NIC) for each computer
- BNC T-Connector for each computer
- 10Base2 coax cabling
- 2 50-ohm terminators
- Networking software that should have come with your NIC

To create a 10BaseT network, you will need:

- A 10BaseT NIC for each computer
- 10BaseT UTP cabling
- 1 10 Mbit hub with enough ports for each computer
- Networking software that should have come with your NIC

Network Cabling

There are numerous types of cable:

- 10base-5, Thick coax, thickwire ethernet.
- 10base-2, Thin coax, thinwire ethernet.
- 10base-F, Glass fiber.
- 10base-T, Twisted Pair cable (cat3).
- 100base-TX, Twisted Pair cable (cat5)

Most people use the following two types of cabling for simple networks:

1. Coax, Thin Ethernet, 10base2
Cabling is quite cheap and can usually be installed as set without using any special equipment. Thin Ethernet looks like the copper coaxial cabling that's used for connecting your VCR to your TV. This type of cable requires BNC T-connectors and 50 ohm terminators.

Advantages

- Cheap
- Installation is simple

Disadvantages

- Not the fastest alternative

2. Standard/Fast Ethernet (10BaseT, RJ45, Modular Twisted Pair)
There are different types of cable of which only 2 are usable for setting up your network, namely cat3 and cat5. Then there are 2 more possibilities, namely Unshielded Twisted Pair (UTP) and Shielded Twisted Pair (STP). UTP is mostly transparent and has no shielded layer. Do not use this cable in areas where there is strong electromagnetic interference (this won't be the case for most of us). STP has a shielded layer (mostly gray) so you can use this in places with strong electromagnetic interference. STP is a bit more expensive. Installation is the same though and from now on I will assume you will use UTP.

Advantages

- Speed UTP/STP (100baseTX) is 10 times faster than coax.
- Duplex

Disadvantages

- Cabling (cat5) is more expensive
- The 100Mbps HUB is quite expensive

How do you choose which type of cabling to use?

When to use 10Base2 cabling

- If you are going to use very few PCs on the network
- If you don't plan on adding any laptops to the network, as these usually require RJ45 connectors
- Expansion in the future isn't much of an issue
- You feel like protecting your pocketbook

When to use 10BaseT/100baseTX cabling

- You plan to use 16 or fewer PC's within a 300 foot radius of each other
- You plan to use portable computers
- You're planning to expand your network

Building the Network

Let's run through the steps:

1. If your NIC is plug-n-play, which most are these days, then you can skip this step. Otherwise, you need to record all of your IRQ settings and set up the NIC to use one that is available. Consult the manual for the NIC.
2. Make sure the PC is turned off and unplugged.
3. Remove the case cover.
4. Find a spare slot on your motherboard for the NIC.
5. Ground yourself by touching something metal with both hands, then install the NIC into the chosen slot.
6. Put the case cover back on.
7. Repeat steps 1-6 for each computer you plan to include on the network.
8. For a coax network, connect each of the T-connectors to the backs of the NICs. For a 10BaseT network, run cabling from the back of each NIC to a port on the hub.
9. For a coax network, attach the cable to one end of the T-connector, usually the end facing the computers you are networking to. You can

come up with your own arrangement. Wherever a cable is not attached to a T-connector, plug in one of your 50-ohm terminators.

10. Double-check all of your connections.
11. Turn on the PC.
12. If your NIC is plug-n-play, then skip this step. Otherwise, you will need to hit Start / Settings / Control Panel / Add New Hardware. Choose not to detect new hardware. Choose your NIC from the list. If your NIC's installation disk has a xxxxxx.INF file, possibly in a Win95 directory, then click Have Disk and follow the prompts. When installed, click Finished and the system will probably reboot. If the NIC doesn't work properly when done, then you may need to go into Device Manager and resolve some IRQ conflicts.
13. Go to Start / Settings / Control Panel / Network.
14. Click ADD, choose Adapter, then choose your adapter from the list.
15. Click ADD, choose protocol, then choose IPX/SPX and NetBEUI.
16. Click ADD, choose Service, then choose Client for Microsoft Networks under Microsoft. If this is not set up as your primary logon, then use the drop down list to choose it as your primary logon.
17. Be sure that each computer on the network is using the same protocols and is set for Client for Microsoft Networks.
18. Click on the Identification tab. All computers on the network must have the same Workgroup name. Each must have a different login and computer name.
19. Click on File and Printer Sharing. Enable both.
20. To make any directory shared for the network, go to Windows Explorer and right-click on the directory name. Choose Shared. If you don't want others to be able to manipulate the files, choose Read Only too.

SHARING A MODEM OVER A NETWORK

Sharing Files and playing multiplayer games is not the only advantage of a peer-to-peer network. In this section I will give you the information to setup your network and be able to connect your network to the Internet with a single modem. Some people ask- "Doesn't this slow the connection for both PC's ?" And the answer is not that you would notice it is definitely worth the effort. In order to connect your network you will need an application called Proxy Server. There are several available today, 2 of which I have used personally. These applications are available commercially and by immediate download from the internet those being Wingate and Winproxy. Both of these applications perform their function well and have very good documentation on the web at the links I have provided. That documentation includes screen shots of the settings you will need to make for the network interface cards. In my opinion the Winproxy setup was a bit easier and the proof for me is that my 12-year-old son was able to set up a client PC with no problem following the instructions and the ease of the interface.

Sharing a Cable Modem on a Peer-to-Peer Network

If using windows 95 two network cards will be needed in the computer with the cable connection (one for your cable modem and the other connected to your internal network). Configure the internal IP address of the server to 90.0.0.1 and the clients to 90.0.0.2, etc. Then set up Winproxy with an Internal IP address of 90.0.0.1 and it should work. Another part of using a cable modem is, connecting the cable line to a cross over cable going into the Network Interface Card on one of the two Network Interface Cards on the PC running the Proxy. (Such as Winproxy)

LAN Pinouts (10baseT and 100baseT)

Category 5 (UTP) colour coding table

The following table shows the normal color coding for category 3, 5 and 5e cables (4 pair) based on the two standards supported by TIA/EIA (see also or primer on this topic)

TIA/EIA 568A Wiring

Pin	Colour
1	White and Green
2	Green
3	White and Orange
4	Blue
5	White and Blue
6	Orange
7	White and Brown
8	Brown

TIA/EIA 568B Wiring

Pin	Colour
1	White and Orange
2	Orange
3	White and Green
4	Blue
5	White and Blue
6	Green
7	White and Brown
8	Brown

10BASE STRAIGHT CABLE (PC TO HUB/SWITCH)

Straight cables are used to connect PCs or other equipment to a HUB or Switch. If your connection is Pc to PC or HUB to HUB you MUST use a Crossed cable.

The following cable description is for the wiring of both ends (RJ45 Male connectors) with the normal category 5 wiring colors.

Pin No.	strand color	Name
1	white and orange	TX+
2	orange	TX-
3	white and green	RX+
4	NC	
5	NC	
6	green	RX-
7	NC	
8	NC	

NC means not connected.

We use **BLUE CABLE** for 10baseT straight cables. NOTE: Almost all our wiring is now done to the 100baseT spec which you can use with 10baseT networks - but NOT the other way around.

10BASET CROSSED CABLE (PC TO PC OR HUB TO HUB)

Crossed cables are used to connect PCs to one other PC or to connect a HUB to a HUB. If your connection is PC to HUB you MUST use a Straight cable.

The following description shows the wiring at both ends (male RJ45 connectors) of the crossed cable.

One end RJ45 Male	Other end RJ45 Male
1	3
2	6
3	1
6	2

NOTE: Connections not specified are NOT CONNECTED.

We use **RED CABLE** for crossed cables. NOTE: All our crossed wiring is now done to the 100baseT spec which you can use with 10baseT networks - but NOT the other way around.

100baseT Straight Cable (PC to HUB/SWITCH)

Straight cables are used to connect PCs or other equipment to a HUB or Switch. If your connection is Pc to PC or HUB to HUB you MUST use a Crossed cable.

The following cable description is for the wiring of BOTH ends (RJ45 Male connectors) with your category 5 wiring colors (TIA/EIA 568A or 568B).

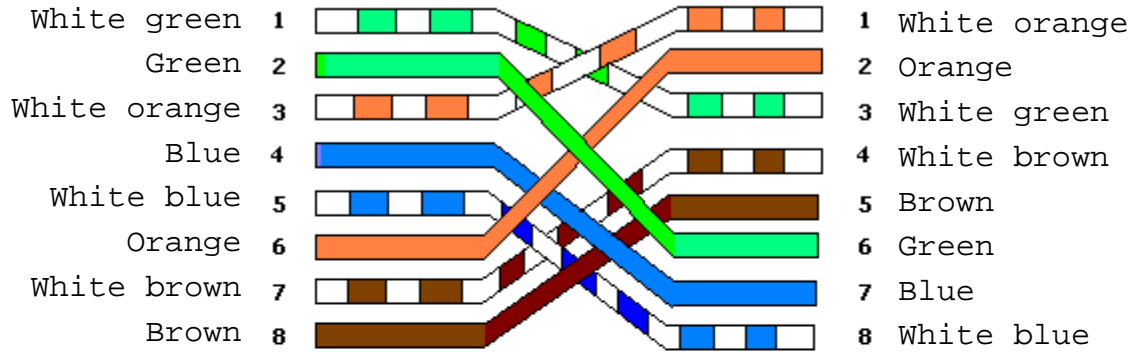| Pin No.	strand color	Name
1	white and orange	TX_D1+
2	orange	TX_D1-
3	white and green	RX_D2+
4	blue	BI_D3+
5	white and blue	BI_D3-
6	green	RX_D2-
7	white and brown	BI_D4+
8	brown	BI_D4-

We use **BLUE CABLE** for 100baseT straight cables. NOTE: Almost all our wiring is now done to the 100baseT spec which you can use with 10baseT networks - but NOT the other way around.

100baseT Crossed cable (PC to PC or HUB to HUB)
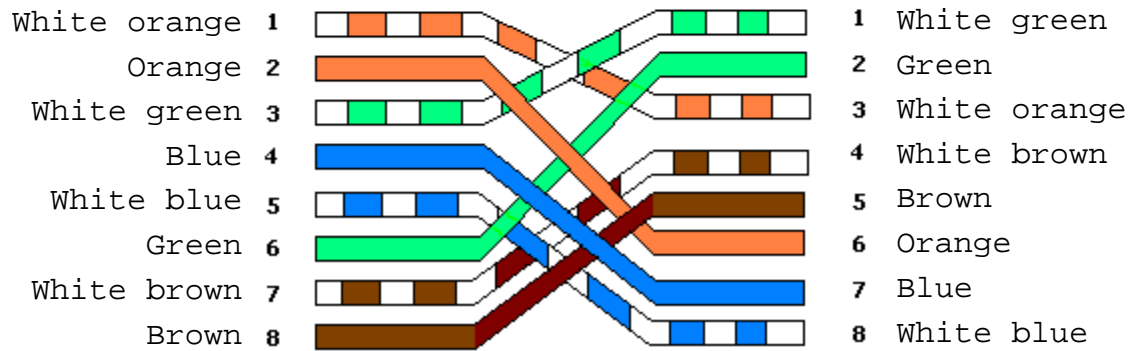
Crossed cables are used to connect PCs to one other PC or to connect a HUB to a HUB. If your connection is PC to HUB you MUST use a Straight cable.

The following description shows the wiring at both ends (male RJ45 connectors) of the crossed cable.

TIA/EIA 568A Crossed Wiring

Left	Pin			Pin	Right
White green	1			1	White orange
Green	2			2	Orange
White orange	3			3	White green
Blue	4			4	White brown
White blue	5			5	Brown
Orange	6			6	Green
White brown	7			7	Blue
Brown	8			8	White blue

TIA/EIA 568B Crossed Wiring

Left	Pin			Pin	Right
White orange	1			1	White green
Orange	2			2	Green
White green	3			3	White orange
Blue	4			4	White brown
White blue	5			5	Brown
Green	6			6	Orange
White brown	7			7	Blue
Brown	8			8	White blue

We use **RED CABLE** for crossed cables. NOTE: All our crossed wiring is now done to the 100baseTX spec which you can use with 10baseT networks - but NOT the other way around.

RJ45 Connector Pin Numbering

RJ45 Male Connector

Top View

Front View