Networking Basics

Thomas Electronics

Sales Support Material

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Overview

This document is intended to provide the reader with the information they require to understand the basics of networking. In today's electronic communication age, this is vital knowledge, especially when dealing with customers in the digital imaging market.

Many of the sections below are split into three levels of details for your convenience:

"Basics": a general explanation of the subject.

"Sales Essentials": what you need to know as a sales person to adequately communicate with and understand your customer.

"Geeky Details": for those of you that like to baffle your subjects with techno babble, or for unknown reasons want to understand the details of how things work.

While not all of information here is strictly to do with networking, it is all commonly used in conjunction with the computers, hardware, and software systems that make up the network.

Basic Networking Terms

Network	A network is a system that interconnects two or more computers together so that they can communicate and share data.
Physical Network	The hardware that makes up a network. This includes wiring, NICs, routers, hubs, switches, etc.
Peer-to-Peer Network	This is a network that has no "server" computers. Workstations are all connected together so that they can share resources (disk space, printers, modems, etc.). This type of network is only used when the number of computers is very small (less than 10, usually), and network performance is not critical.
Client-Server Network	This is a network that is comprised of both "server" computers and "workstations" (or clients). Servers provide the central services of the network such as file, print, and application serving, and clients use those services. This type of network is used in most medium to large setups, and is much more efficient than peer-to-peer networking.
Network Interface Card	Also known as a "NIC", this is the computer board that plugs into your computer's motherboard and provides a connection to the physical network.
Hub	A hub is used to attach many computers into the same network. A hub has many "Ports" (usually between 4 and

	24), and a network cable is plugged into each port. Basically, a hub acts as a "splitter" that attaches each network cable plugged into a port on the hub to the same "network segment". Because it is only a "splitter", signals sent to any port get broadcast to all ports.
Switch	A switch is similar to a hub, and in many cases looks identical to a hub. The main difference is that a switch does not "broadcast" all incoming signals to all ports. The switch reads the data coming in, and determines where it is going, and only sends it out on the proper port so that the data can reach its destination. This is a much more efficient system for high capacity systems, but switches are significantly more expensive than hubs.
Router	A router is used to connect two networks together. A router is similar to a switch in that it looks at the data coming in to determine where it needs to go, and sends it only to that portion of the network. Routers are often used between internal networks and the internet, or between different offices for a single company.
Firewall	A firewall is (usually) a software program that acts as a security screening system between an internal network and an external network (usually the internet). When properly set up, a firewall allows authorized users access to data on the other side of the firewall (both directions), while keeping unauthorized users out.
Client	A client is a computer that does not provide central networking services to other computers on the network, but rather uses the services of other computers.
Server	A server is a computer on the network whose primary task is to provide services of some kind to other computers on the network. This could be networking administration services, file storage services, routing services, email, newsgroups, and other services. In small networks, one server can provide multiple services. In larger networks, many servers are used, each being optimized to provide a single service.
Host	See "Server".
Network Protocol	A protocol can be thought of as the "language" that is used to communicate over a network. While many protocols can be used over the same network, only those speaking the same "language" can communicate with each other. Common protocols are "TCP/IP", "AppleTalk", and "NetBUI".
TCP/IP	"Transmission Control Protocol / Internet Protocol". This is the most common protocol used today for large scale networks and the internet. With TCP/IP, each "client" on a network is assigned a unique "IP" number. An IP number is a series of 4 numbers between 0-255, each separated by a

	period. (ex. 206.12.186.254). These numbers can either be assigned automatically by a "DHCP Server" on the network (Dynamic Host Configuration Protocol), or set up manually on each machine. Because there are a finite number of IP addresses, they must be licensed from an official internet IP registry (reporting to the "Internet Assigned Numbers Authority") when used on a network that is connected to the internet. Internal networks can either use specific IP numbers that are reserved for private networks (the 10.X.X.X series, the 172.16.X.X series, and the 192.168.X.X series), or use a "gateway" between internal networks and the internet that translates IP addresses automatically.
Gateway	A gateway is a computer that acts as a connector between two separate networks, such as a company network and the internet. A gateway usually receives requests for information from one network, and makes that request on behalf of the other computer on the other side of the network. This allows an entire private network to be connected to the internet with only a single licensed IP address (belonging to the gateway). Normally, a firewall is used in conjunction with the gateway to provide security services.
DNS	"Domain Name Service" is used to "translate" between user-friendly names for locations on the network and numerical IP addresses. For example, when you type www.thomaselectronics.com into your Internet Browser program, it automatically contacts a DNS server to obtain the correct IP address for that site. DNS servers usually communicate with a master server to obtain up-to-date tables on a regular basis.

Sales Essentials Networking Terms

File Server	A file server is a computer on the network whose sole purpose is to store and 'serve' data files for other computers. Usually a file server is running a "Network Operating System", and is a powerful computer with lots of processing power and disk space.
Network Operating System	An operating system (or "OS")is the "environment" program that controls most aspects of the computer's operation. Windows 95 is an example of an OS. A "Network Operating System" is an OS that is designed to run best on "server" computers on the network, and is therefore optimized for sharing information over a network. Windows NT Server, UNIX, Linux, and NetWare are all examples of Network Operating Systems.
Network Administrator	A network administrator is the person responsible for maintaining the operation of the network on a daily basis.

	These tasks include assigning IP addresses (if not done automatically by a DHCP server), maintaining the various server computers, maintaining firewalls and routers, and ensuring that the network performs as expected. **Any network that has servers or firewalls should have at least one qualified Network Administrator.**
Ethernet	Ethernet is a type of network architecture. This defines the basics of how signals travel across the physical network. This can be though of as the "rules of the road" for the network, which everyone on the network must obey (such as "drive on the right hand side", and "red means stop, green means go"). Ethernet is the most common network architecture in use today. Other architectures include "Token-Ring", and "FDDI".
10baseT	This is a type of Ethernet. The "10" stands for 10 Megabits per second, which is the theoretical maximum speed of the network. This translates to about 1.25 MB/sec (MB is for Megabyte), which is slightly less than the amount of information on a normal 3.5" floppy disk. In reality, a normal 10baseT network can only carry about 50% of that data volume before "collisions" start to seriously hamper it. 10baseT was the most common type of Ethernet until the last several years when faster systems started to appear.
100baseT	This is the current 'standard' type of Ethernet. The "100" means 100 Megabits per second, or about 12.5MB/sec. This is 10x the speed of 10baseT. Similar to the collision problems that happen with 10baseT at high volumes, 100baseT can realistically carry only 6-8MB/sec. There are several types of 100baseT, with 100baseTX being the most common. The variations have to do with the type of wiring used in the network, with almost all current installations using standard "Cat 5" twisted pair copper wiring and RJ-45 connectors.
1000baseT	This is the current standard for high-speed Ethernet systems, and is only used in data-intensive situations such as connecting servers together, and sites that require large "bandwidth". The "1000" stands for 1000 Megabits per second, or about 125MB/sec of data throughput. Realistically, these systems can carry about 60-80MB/sec of data before "collisions" start causing networking problems. Similar to 100baseT, there are variations of 1000baseT such as 1000baseTX and 1000baseSX. "TX" systems use standard "Cat 5" twisted pair copper wiring, whereas "SX" systems use fiber-optic cable.
GigaBit Ethernet	See 1000baseT
RAID	"Redundant Array of Inexpensive Disks". RAIDs are used for data storage on high-performance server computers. They

	provide enhanced data integrity (redundancy), better speed, and better reliability than a normal single disk can. RAIDs are made up of many individual hard disk drives that are controlled as a single large drive. Depending on what type of RAID configuration is used, information written to the drives can either be split up and saved in small pieces on each drive (for better read/write speed), or duplicated on more than one drive (for data integrity and safety in case one drive fails). RAIDs are more expensive than an equivalent amount of "normal" storage space, because they typically use fast SCSI drives, and require a RAID controller card.
RJ-45 plug	This is the standard connector type for "TX" type Ethernet systems. It looks like a North American phone connector (RJ-11), but is slightly wider. RJ-45 plugs are used on all recent Ethernet cables using twisted pair copper wire.
Collision	A collision on an Ethernet network is where more than one computer tries to send data at the same time. Normally, computers wait for the network to be 'quiet' before sending a message, but occasionally two computers send data at the same moment. When this happens, both computers stop sending their messages, wait a random amount of time and try again. When collisions occur, "bandwidth" on the network is wasted because the messages are not understandable and must be re-broadcasted. This can cause problems when a network becomes busier because collisions become more frequent, wasting even more bandwidth. In these situations, it is necessary to reduce the amount of traffic on each section of the network by using switches instead of hubs to connect computers.
Windows NT	Windows "NT" is a version of Microsoft Windows that is intended for workstations and servers that require better reliability, more processing power, and support for heavy-duty hardware. "NT" stands for "New Technology". NT Server is used commonly as a Network Operating System, and NT Workstation is used commonly for high-end workstations. Windows NT has been replaced with the more recent Windows 2000.
Linux	Linux (pronounced "Lin-ucks") is an operating system based on the UNIX architecture. Linux has gained popularity in the last few years because it is very powerful, becoming much easier to use, and is "Open Source", meaning that the program code for it is available for free. This allows users to modify the operating system if they wish, and write custom extensions to the OS as they require for their applications. Linux is well suited to being a Network Operating System, as well as being very efficient for processor-intensive tasks,

	however it is not yet as user-friendly as OS's such as Windows or the Mac OS.
Bandwidth	Bandwidth is a measurement of the amount of data that a network can carry at any one time. Although this can be used subjectively, it can also be represented in terms of MB/sec of data.
UNIX	UNIX is a powerful Network Operating System that was originally designed to run powerful MainFrame computers. It is well suited to networking functions, and can host many "Dumb Terminal" computers if necessary. Although UNIX requires typing many commands by hand, graphic interfaces such as "X-Windows" are now commonly used to simplify user interaction with these systems.
SCSI	"Small Computer Systems Interface". This is a method of connecting high speed peripheral devices (hard drives, scanners, etc.) to a computer. Although it costs more than other methods, it is the fastest and most flexible system available today. The most recent SCSI systems can transfer up to 160MB/sec of data between devices, and are well suited to use in server systems and data-intensive workstations.
FireWire ™	Although not related to networking specifically, FireWire ™ (generically known as IEEE-1394 because "FireWire" is trademarked by Apple) is a new method of connecting high-speed peripheral devices to a computer. This includes scanners, printers, hard-drives, monitors, video cameras and more. This system provides user-friendly functions such as hot-plugging (attaching a device while the computer is turned on), and chaining (plugging multiple devices into a port in serial fashion). The speed of FireWire ™ is almost as fast as SCSI (400Megabits/sec, 50MB/sec), and it is much simpler to use. Unfortunately, only a small number of computers and devices currently support FireWire ™, but that list is expanding rapidly.

Geeky Network Terms

DHCP	"Dynamic Host Configuration Protocol" is a method of automatically obtaining all necessary network configuration information for a client computer when the computer is first connected to a network (at boot-up). This includes IP addresses, proxy settings, DNS servers, and more. DHCP services are usually provided by a single "DHCP Server" on the network.
RAID Level 0	This is a RAID system that is set up in

	"striping" mode, where data is split up into small segments and written simultaneously to multiple disks. This speeds the read/write speed of the RAID tremendously, but is more susceptible to hardware failures (if one disk fails, data on all disks is lost). This setup is used mostly in systems that require fast data throughput, but where the data can be easily replaced if it is lost due to hardware failure.
RAID Level 1	This is a "mirroring" RAID setup, where data is written identically to two drives at the same time. This provides better read performance because data can be read from either disk, and it provides security because the data is automatically backed up. However, write performance is decreased because two writes are performed, and only ½ of the total drive space is usable because of the redundancy.
RAID Level 10 (or "0+1")	This is a combination of RAID 0 and RAID 1 where data is both mirrored and striped. Normally, a minimum of 4 disks are required for this. It is fast, and data-safe, but only ½ of the data storage capacity can be used due to redundancy.
RAID level 3	"Striping with Parity" RAID setup. Data is striped across multiple disks as in RAID 0, but a single dedicated drive is used to store "Parity" information. Parity information aids in the recovery of information from a damaged drive. This is a common compromise between RAID 0 and RAID 1, but does not provide the performance of RAID 0.
RAID level 5	"Striping with Distributed Parity". Similar to RAID 3, but the parity information is distributed across all the disks in the array. This provides good data integrity, adequate performance, and reasonable disk utilization.
IRIX	IRIX is a version of the UNIX operating system for SGI computers (Silicon Graphics Inc.).

Cat 5	Short for "Category 5" type networking cables. Cat 5 cables consist of two pairs of copper wires that are twisted around each other to reduce electromagnetic interference. Cat 5 is the standard grade of cable used today for high-quality networks, and any networks that use 100baseT. Telephone networks in most buildings use lower grade cable and are not suitable for use in high-speed data systems.
Single-mode Fiber-optic	Fiber-optic cable that is comprised of a single, high-quality (usually glass) fiber. This type of cable is much more expensive than multi-mode, and is more sensitive to breakage by bending too tight. This cable can carry much more bandwidth than multi-mode fiber, and carry it for much longer distances (up to hundreds of miles)
Token-Ring Network	This is an older networking architecture than Ethernet. Computers are connected to the network in a serial fashion, forming a giant "ring". A "token" is passed from computer to computer around the circle in one direction. When a computer receives the token, it is allowed to send data across the network. Once that data is sent, it passes the token on to the next computer. This bypasses the collision problems that Ethernet experiences in high-usage situations, but is not as efficient overall and has unique wiring constraints due to the circular nature of the data path.
Thin-net (a.k.a. 10-base2)	This is a very old type of Ethernet that used coaxial cable (similar to cable TV wiring) instead of Cat 5 wiring. You'll see very few of these networks still around, but some older 10baseT NICs also have connectors for Thin-net.
T-1 line	This is a leased-line system that connects computer systems over long distances that is common in businesses today. It is commonly used to connect company networks to the internet, or to connect multiple offices together. Although very fast by comparison to typical "modem"

	connections, it is slower than a 10baseT network. T-3 lines are becoming common for higher speed connections.
X-Windows	X-Windows is a graphic user interface that can be used on many UNIX-based computers. It provides a more user-friendly way to control the computer than traditional command-line input, but is not nearly as efficient.

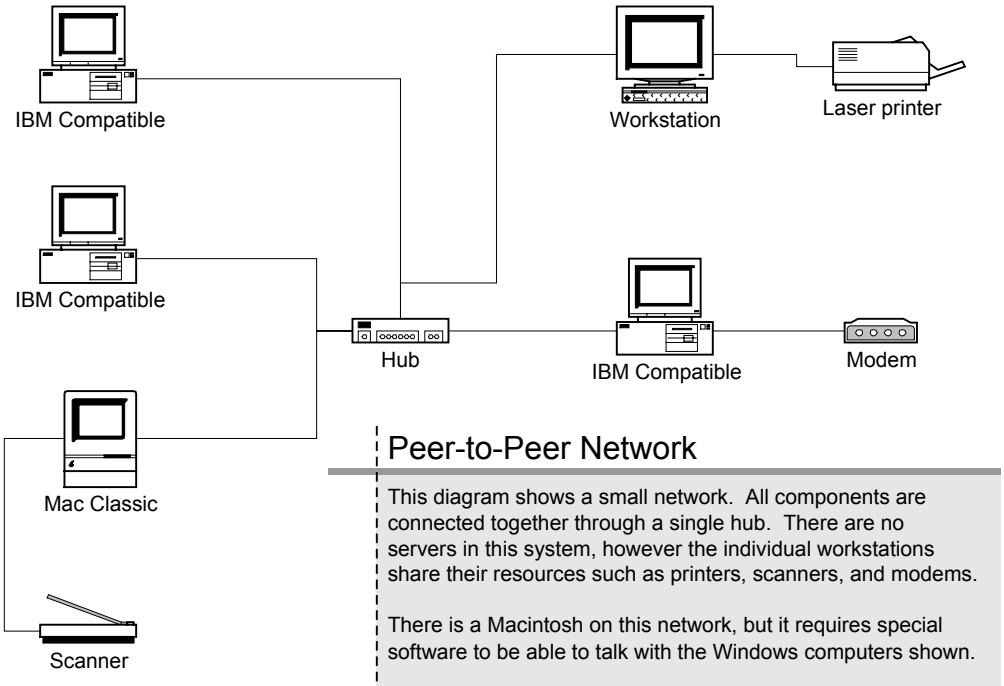
How Networks are Set Up

Basics

Because Ethernet networks are by far the most common systems in use today, we will only deal with them in this section.

Typically, a "Network Interface Card" (NIC) is installed and configured on the computer that you wish to connect to the network. Many new computers have NICs built into the motherboard for 10/100baseT. A network cable is used to connect the NIC to a hub or switch. This connection may go through a wall-socket and/or a patch panel on it's way to the hub/switch.

Many hubs and switches can be connected together on a network, allowing large numbers of computers to communicate with each other. In larger systems, switches are used instead of hubs so that data is not broadcast to segments of the network that do not require that data, improving the overall bandwidth of the network.



Sales Essentials

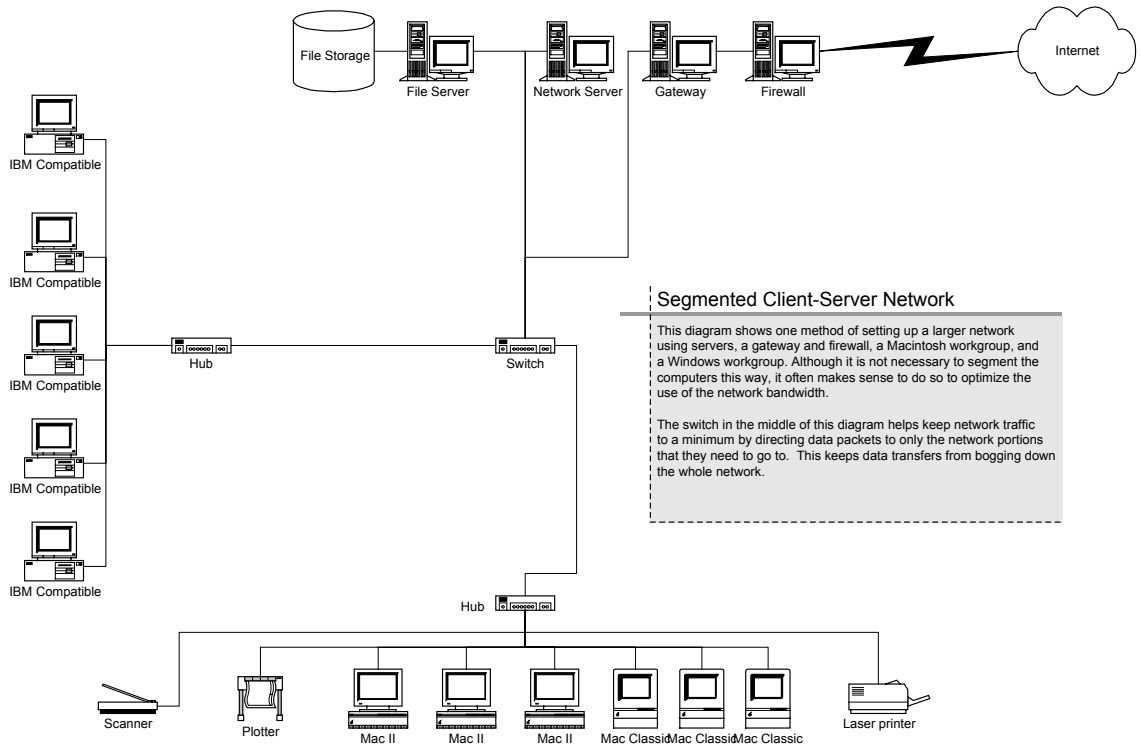
When a network is installed, a lot of planning usually goes into how it will be laid out, and what hardware will be used in the system. For basic systems, a Network Administrator usually decides these matters themselves, but for larger or more complex systems, a Networking Consultant should be brought in. Although it is not hard to connect many computers together on a network, designing an efficient one that can handle your current and future data bandwidth requirements can be much more complex.

In most digital imaging situations, networks are required to handle very large amounts of data on a regular basis. If you consider that a single 8x10" image file can be over 18MB of data, multiplied by the number of images a typical customer processes per day, this can add up very quickly. To make matters worse, images are normally transferred multiple times over the network before they are ready for printing.

Consider this situation: An image is scanned and saved onto a data server. Next, an operator opens the file on another computer for retouching and formatting. Then, they save it back to the server, and a third person copies it to the computer that it will be printed from. This already makes 4 transfers of that file, totaling 72MB of information! Multiply this by 1000 images per day (which is not a lot by any means), and you have 72GB of data going across the network, more than

20 times the entire storage capacity of the average computer! (Obviously, this depends on what you consider 'average"…)

This is a very simple workflow for the customer, and it could easily become 6-8 or more transfers of the image data before printing. Designing a network to handle this data load is an important task in a successful lab; don't think it's not! The way that data moves around the network must be considered when designing an efficient network, so it is important to design the workflow system first.



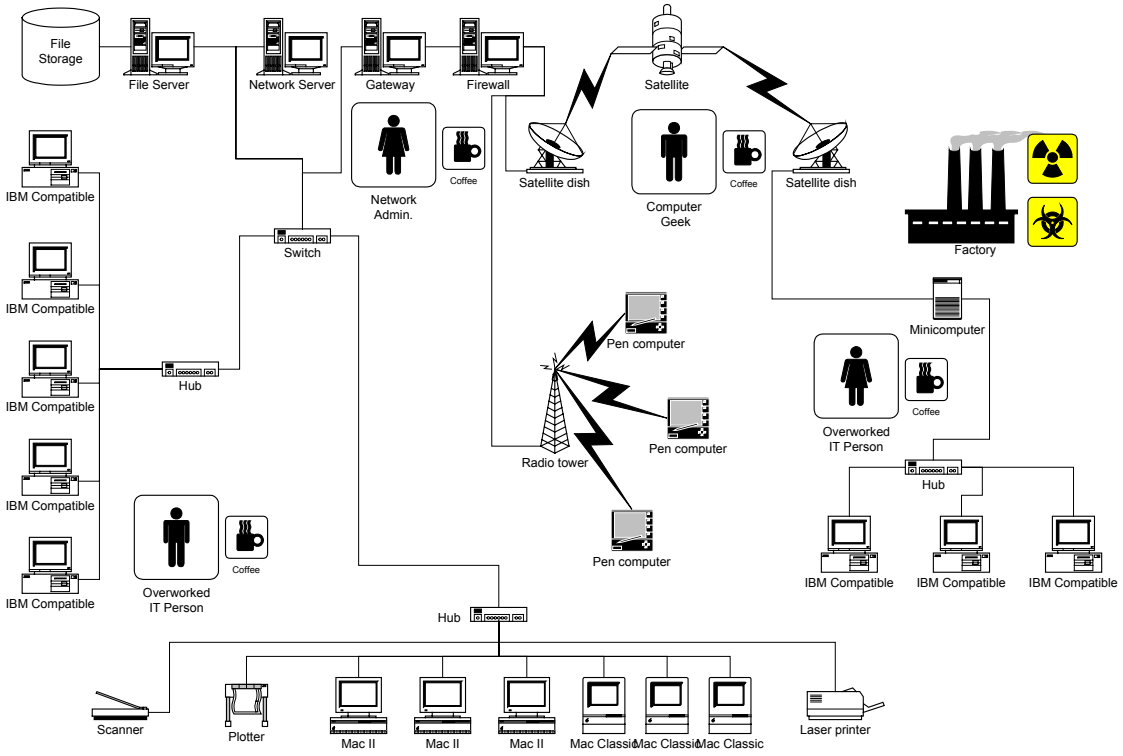
Geeky Details

Without getting too geeky, here's a few interesting networking tidbits.

- Networks can be comprised of multiple segments of different types that are linked together by "bridges". A bridge can be a dedicated interfacing device, or simply a single computer that has more than one type of network interface installed.
- Large-scale high-speed networks often use fiber-optic based networking systems such as FDDI, ATM and Frame Relay. Fiber optics can carry huge amounts of data long distances, and use lasers traveling in glass fibers rather than electrical signals to represent the data.
- There are wireless networking systems that use either radio waves or light to send data. These can be short-range systems for internal use (in a

warehouse, for example), or larger scale for use in vehicles and hand-held units. IR light and Lasers are commonly used in these systems too.

- Besides having fast hard drives (such as RAID systems) to share computer files quickly, data servers usually have very fast processors and lots of memory. This helps them efficiently send data to many computers at the same time because the OS needs to process and direct each request before the data is retrieved and sent.
- High-end server computers often have "hot-swappable" components, or at least redundant components. This allows them to be maintained and repaired without having to shut them down! In critical systems, this ensures that their services are available at all times, even if something goes wrong with the server hardware.
- Some switches and routers have advanced self-diagnostics, and can send email to the Network Administrator notifying them of a problem with them as soon as it occurs!



Network Costs

Basics

In a simple network, costs are mostly made up of the hardware necessary to connect the computers together. This means NICs, hubs, switches, network cables, and such. Here are some examples of the approximate

costs for basic networking equipment (remember, these are approximate, and not for high-end components!):

- 10/100baseT NIC $60
- 15' network cable $10
- 8 port 100baseT hub $150
- 8 port 100baseT switch $400

From these prices, you can see that it's not very expensive to set up a basic network. However, using only the above components, it's very difficult to design a quality network that can handle a lot of data, or to connect more than 8 computers together.

This type of basic network is only useful for very small offices, home networks, or home offices.

Sales Essentials

To design a network that is suitable for most digital imaging workflows, you're probably best off to use a networking consultant. If a customer already has a network in place, their network administrator may (or may not!) be capable of deciding what improvements need to be done.

Here are a few of the things that will need to be considered in this process:

- How many computers will be attached to the network (now and in the future)?
- Where will the highest data traffic will occur, and how much traffic it will be?
- Are servers required? What types of servers are needed? Can one server provide several services?
- Should the network be broken up into logical segments? Where should these divisions be? What type of network is best for each segment?
- Is there equipment in place that can be well used for parts of the network? Where is the best place to use older / slower networking hardware, and how should it be implemented? How will it connect to the new networking equipment?
- Should the network be attached to the Internet? How should this be done? What firewalls and gateways are required? What type of connection should be used? Who should provide the Internet services?
- What Operating Systems should be used for servers? What OS's are used on client computers? Can all of these OS's talk to each

other? Do you need special software to allow file and service sharing between them?

- How will the network be administered? Is there a person that can take care of the routine maintenance and setup of the systems? Do you need to hire somebody full time? Part-time? On contract?
- If there's a problem with the network, whom do you call? Seeing as there are so many different components connected together, whose problem is it? Did a networking consultant put it together for you, and are they responsible for making it work? Are you on your own?

As you can see, networking issues can get quite involved, and the list above only scratches the surface. Although Thomas Electronics can make suggestions as to how to set up a network, we're best off in most situations to let the customer talk with a networking consultant. Technology is changing so fast that it is difficult for us to be up to date at all times.