For many people, the topic of networking is a particularly confusing one. The intent of this article is to present some basic network concepts. A list of references at the end of the document provide areas for further study.

Sharing services

In the simplest sense, networks allow users to share devices like printers or file servers. Network connections are usually made over a cable, and so, to start, let's look at the three most common kinds of guided media[1] that are used in networks (see Figure 1):

- **Twisted pair** – Refers to two intertwined, insulated copper wires. Twisted pair cables may contain anywhere from one to one hundred (or more) of these twisted pairs. Twisted pair is available in both shielded (STP, Shielded Twisted Pair) and unshielded (UTP, Unshielded Twisted Pair) versions. STP is more expensive than UTP. Twisted pair is probably best known in its use for local telephone cabling. One type of twisted pair cable that is used in Ethernet networks is called 10 Base T.[2]
- **Coaxial** – A three-layered cable in which an insulated wire is surrounded by a second wire, which is surrounded by an outer layer of insulation. Coaxial is often used for long distance phone lines and cable television.

  Among coaxial cables, two types are particularly common: Thinnet and Thicknet. Thinnet and Thicknet are used in Ethernet networks. Thinnet is also known as 10 Base 2, thin coax (coaxial), Cheapernet, and RG-58. It is easier to install, more flexible, and less expensive than Thicknet. Thicknet is also known as 10 Base 5, thick coax, and RG-11. Much of the older cable already in place in many installations is Thicknet. Although both Thinnet and Thicknet are coaxial cables, they use different connectors.
- **Fiber optic** – Thin, flexible, insulated, glass fibers used for the transmission of light. While coaxial and twisted pair are prone to interference, fiber optic cables are not because the data is carried via a light beam. And though fiber optic cables are generally more difficult to splice than conventional cables, new splicing techniques have simplified the procedure.

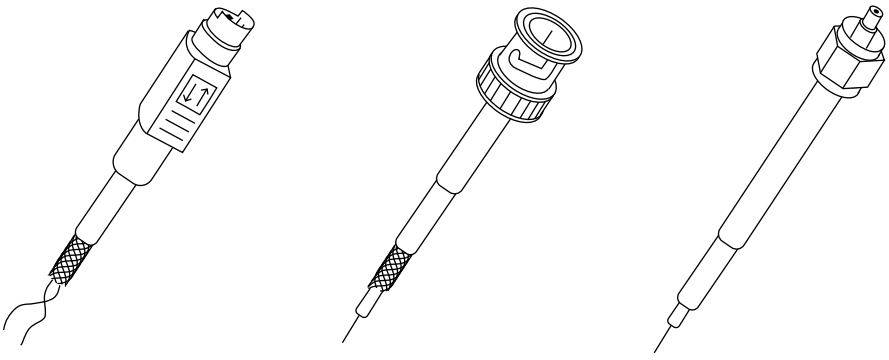

Figure 1 – Three examples of the most common guided media: LocalTalk shielded twisted pair with a DIN 3 connector (left), Thinnet coaxial with a BNC connector (center) and fiber optic cable with a Type 906 connector (right).

[1]Guided media refers to cables. Unguided media refers to transmission of data via microwave or infrared signals. This may take place over short distances or even via satellite.

[2]Three cables have '10 Base' as part of their name: 10 Base T, 10 Base 2, and 10 Base 5. These names describe not only the cable, but also the Ethernet network and protocol for which these cables are used. The '10' refers to a bandwidth of 10 megabits per second (mbps). 'Base' refers to fact that these cables are used in a baseband network. (With baseband only one signal is transmitted at a time along the wire. With broadband many signals are transmitted at once.) The T in 10 Base T stands for twisted pair. The '2' and the '5' in 10 Base 2 and 10 Base 5 refer to the maximum length of a network segment (200 meters and 500 meters respectively).

The wires in a network only tell a small part of the story. It is possible for networking methods of entirely different types to run on the same cable.

Bandwidth and throughput

While engineering professors might squirm at the thought, in networking circles, the term bandwidth is commonly used to describe the theoretical limit of data that a cable can carry. Bandwidth is measured in bits per second (bps), and sometimes (if it is fast enough) kilobits per second (kbps), megabits per second (mbps), or even gigabits per second (gbps).

The bandwidth of a network depends on the guided media as well as the network protocols. In general, experts have said that twisted pair has a limited bandwidth in comparison to coaxial cable or optical fiber. However, that type of generalization can be misleading unless you consider the network protocols. For example, Ethernet can run on both twisted pair and coaxial cables, and no matter what cable is used the bandwidth is 10 mbps.

Throughput is the network speed that users experience. For example, theoretically, a LocalTalk® network has a bandwidth of 230.4 kbps, and so it should be able to transmit a 1 megabyte (MB) file in about thirty six seconds, but under actual conditions, this file may take significantly longer to transmit.[3] Why? Data will only move as fast as the slowest part of a connection. A hard drive with slow access times may not be able to supply data to the network quickly enough. A printer or raster image processor may not be able to accept the data as quickly as the network supplies it. Activity on the network may also play a role. As the number of devices (or nodes) on a network increases, the performance of that network may drop. In addition poor connections, or networks set-ups that ignore maximum length recommendations may also cause transmission disruptions.

[3]Some studies have shown that the actual throughput rate of a LocalTalk network is closer to 80 mbps. Of course, this depends on the operating conditions of the particular network.

There is also a certain amount of overhead that a network requires to perform its work. Therefore, though your job may only be a certain size, headers attached to the file representing network protocols, can actually increase the size of your file. Finally, even a network with no files being transmitted has a certain level of activity taking place on it. Devices on the network may be communicating with each other, for example, checking the network to see if all is clear to send a message.

Connecting networks

Four devices may be used to connect networks: repeaters, bridges, routers, and gateways. Each of these devices is increasingly sophisticated and encompasses the functionality of the previous one. Therefore the gateway, the most sophisticated connecting device, not only has its own functions, but also contains the ability of repeaters, bridges, and routers.

- **Repeaters** – A signal on a network can only be sent so far before it starts to weaken. Just how far this distance is depends on the type of cable and the strength of the signal. For example, on a LocalTalk network (see below) the maximum distance a signal can be sent is around 300 feet. A repeater can amplify and re-transmit a signal and allow it to travel further. A repeater may be used to connect local area networks that are not to distantly separated, and, which are both running the same protocols and cabling schemes.
- **Bridges** – A bridge connects two networks of the same type. A bridge may be necessary where the amount of network traffic is greater in one section of the network to keep the increased level of traffic in one portion from degrading network performance in other areas of the network.
- **Routers** – A router selects the path over which data passes through a network. It offers more intelligence and traffic control than a bridge. A router may be particularly appropriate for connecting more than two local area networks (LAN). The term ‘brouter’ has been coined to describe a

device that performs the functions of both a bridge and a router, but in fact the term is misleading and should be avoided.

Routers are particularly common in the graphic arts because of the predominance of networks running EtherTalk and laser printers running LocalTalk. An example of this is Apple Computer's Internet Router.®

- **Gateways** – A gateway is sophisticated device that connects two networks of very different types together and performs complex translation between the networks to make inter-network communication possible (even when the networks are using completely different architecture and protocols).

Network topologies

The way that the cables are arranged in a network is called the network topology. The most common ones are: bus, ring, and star. (See Figure 2.)

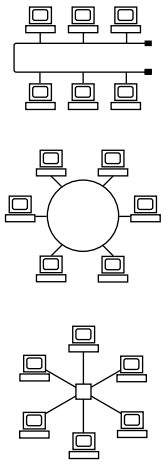

Figure 2 – Network topologies: bus (top), ring (center) and star (bottom).

Bus – A bus network uses a line of cable with a beginning and an end (rather than a loop). All messages are broadcast the entire length of the cable. A device will grab a message if one happens to be addressed to it. The term 'bus' is sometimes also used to describe the internal pipeline within a computer. A 'daisy chain' is a type of bus network in which devices are linked to one another in a chain. (Generally in a bus network, devices on the network are tapped into the bus rather than chained in this fashion.) In a bus network, both ends of the cable must be terminated (i.e., capped with a terminating resistor). Examples: LocalTalk, Ethernet.

Ring – A ring network is formed, obviously, in the shape of a ring. Messages are passed from one destination (node, computer, peripheral) to the next. If a device sees that the message is addressed to it, it removes the message from the ring. Example: Token Ring®.

Star – In a star network, all of the nodes radiate from a central node. Messages may be sent directly from the central node to any device on the network. (Commonly used for phone links.)

Common networks

Within the graphic arts, two networks are particularly common:

- **LocalTalk** – The built-in networking system for every Apple Macintosh® computer is called LocalTalk. LocalTalk uses shielded twisted pair cables and has a bandwidth of 230.4 kbps. The longest that a signal can be sent (without a repeater) is 300 feet.
- **EtherTalk** – EtherTalk® is Apple Computer's version of Ethernet. EtherTalk comes in three types: 10 Base T, 10 Base 2 (Thinnet), and 10 Base 5 (Thicknet). EtherTalk networks have a bandwidth of 10 mbps, and a maximum cable length of 3000 ft (without repeaters).

Token Ring is used in many IBM networks, but is more common in business rather than in graphics applications.

OSI

Although an extended discussion of the Open System Interconnection (OSI) network model is beyond the scope of this document, OSI™ is important because it provides a standard used by many networks. OSI is a seven-layered network model that is a standard of the International Standards Organization (ISO). (See Figure 3.) Newcomers to OSI may find it easier to think of only three basic layers:

- **Application** – Made up of the Application and Presentation layers from the OSI model. This is the layer in closest contact with the network user.
- **Network** – Made up of the OSI Session, Transport, and Network layers.
- **Physical** – Made up of the OSI Data Link and Physical layers.

To give a simple example of how these more basic layers work, consider the procedure you would go through to install a network to coexist with an

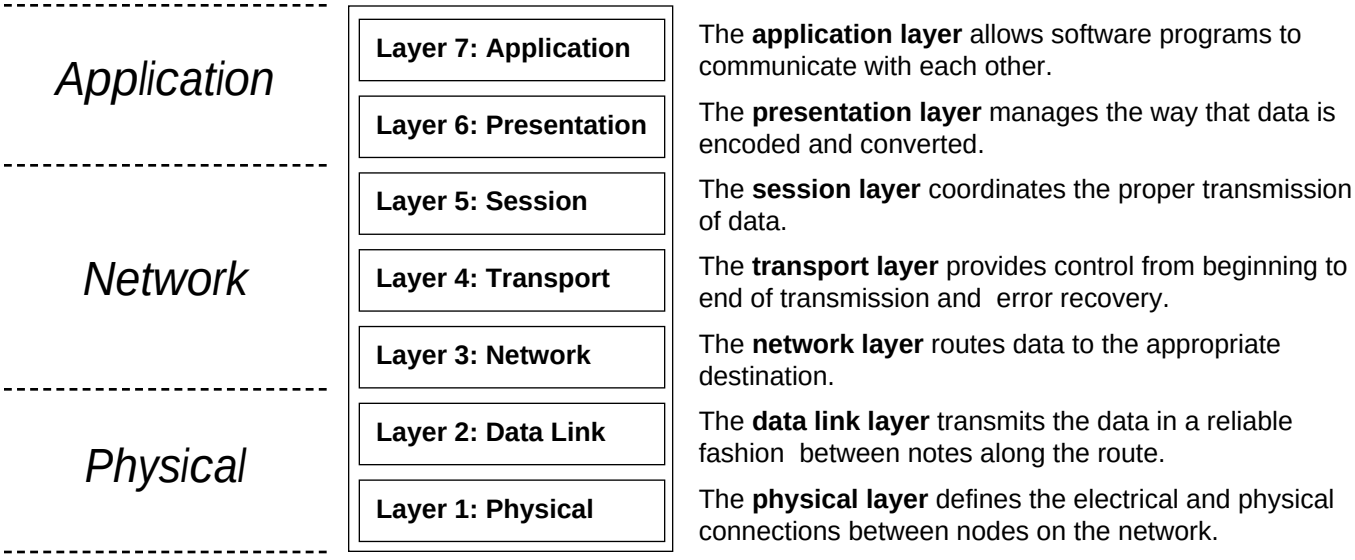

Figure 3 – The different layers of the OSI standard define how communication is maintained between network users.

existing network. First, on the physical layer, the cables and connectors must be able to connect to each other. Second, on the network layer, the network software must be compatible with the range of computers on the network. If some computers are running AppleTalk protocols while others are running TCP/IP(Transmission Control Protocol/Internet Protocol), there will be problems. Lastly, on the application lever, if users are to be able to trade files in a useful fashion they must be able to open and read those files. And so, file formats must be readable, or at least able to be converted to a format that can be opened. And so the network has far reaching effects, from the level of the user's software application all the way down to the cables.

Conclusion

Many topics have been left uncovered in this brief overview of networking basics. For those of you who are interested in pursuing this topic, please consider looking to the references shown below.

References

The following references provide a range of information on networking:

- For those of you who have a Macintosh, HyperCard 2.1 and a CD player, Apple Computer offers an electronic tutorial called the *Apple LAN Primer.* It costs $100 and is available from the Apple Catalog (1-800-795-1000).
- *Data and Computer Communications* is an excellent engineering textbook by William Stallings which is published by Macmillan Publishing Company.
- *The Computer Glossary,* 6th edition, by Alan Freedman, provides a wide range of computer information. It is available from The Computer Language Company, 1-215-297-5999.

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