Jackson State University
Department of Computer Science
CSC 435/524 Computer Networks
Spring 2020
Instructor: Dr. Natarajan Meghanathan
Assignment 2 (Reading Assignment Quiz): Network Cables

Due: Quiz on February 27, 2020 (in-class; closed notes)
Maximum Points: 100

Task: *You will read the following materials on network cables and come prepared for an in-class quiz on February 27th, 2020, starting from 6 PM. The quiz will be on network cables and you can expect fill up the blanks, choose the correct answer and short answer questions. Also, pay attention to the figures and tables in the report. There will also be questions based on the figures/ tables. Sample questions are given in the last page of this handout.*

A majority of networked systems are linked together using some form of cabling. The cables used in the networking industry can be separated into three distinct groups: coaxial, twisted pair and fiber optic.

1. Coaxial Cable

Coaxial cable contains a central conductor wire surrounded by an insulating material and is in turn surrounded by a braided metal shield. The cable is referred to as Coaxial because the center wire and the braided metal shield share a common axis (see Figure 1).

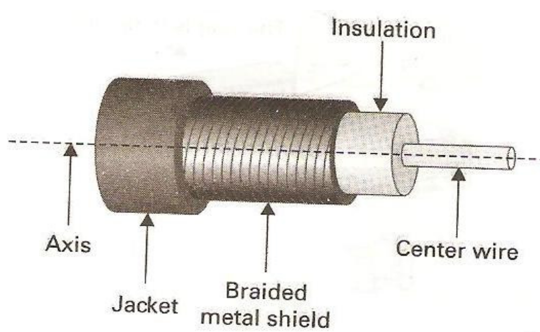

Figure 1: Cut-view of a Coaxial Cable

The above design of coaxial cables helps to shield data transmissions from electromagnetic interference (EMI). Devices in a typical office environment (e.g., lights, fans, copy machines, refrigerators, etc) generate magnetic fields. When a metal wire encounters these magnetic fields, electrical current is generated down the wire leading to misinterpretation of signals carried in the wire.

1.1 Ohm rating

An important measure of coaxial cables is their Ohm rating. The Ohm rating of a cable captures the impedance (i.e., how much a cable resists the flow of electricity) of that cable. Even though, it is natural to think that higher the Ohm rating, worse is the cable, network technicians use the following rule of thumb: Use cables with the same Ohm rating within a network; otherwise, there would be data loss and corruption. The Ohm rating of a coaxial cable is normally mentioned on its surface.

1.2 Types of Coaxial cables

There are three types of cables used: RG-8, RG-58 and RG-62. Figures 2, 3 and 4 show the three cables.

The RG-8 cable is one of the oldest coaxial cables in use and is usually referred to as the Thick Ethernet or Thicknet cable. The RG-8 cable is rated at 50 Ohms and is often yellow or orange/brown in color.
The RG-58 cable is the widely used coaxial cable today and is usually referred to as the Thin Ethernet or Thinnet cable. It is also rated at 50 Ohm, but has no standard color.

The RG-62 cable is virtually not used these days and one reasoning behind this is that it is rated at 75 Ohms.

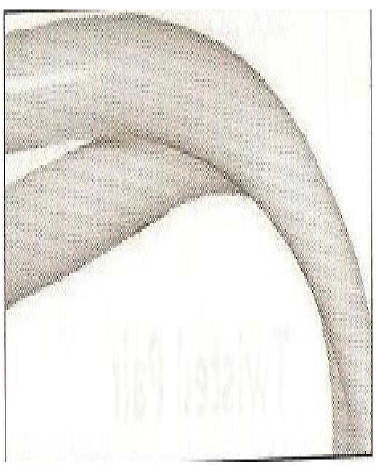

Figure 2: RG-8 cable

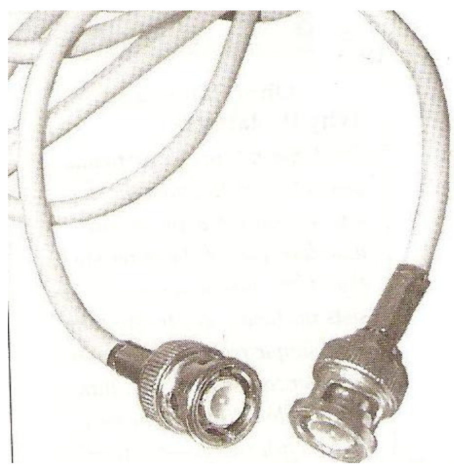

Figure 3: RG-58 cable

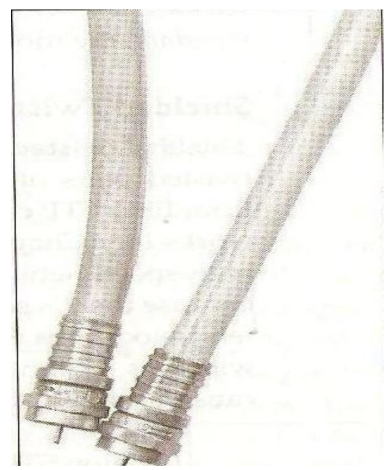

Figure 4: RG-62 cable

2. Twisted Pair Cables

Twisted pair cables are the most widely used cables in today's networks. A twisted-pair cable is composed of multiple pairs of wires, twisted around each other at specific intervals. The twists serve to reduce interference (also called crosstalk) – the more twists, the less crosstalk. Twisted pair cables come in two flavors: Shielded-twisted pair (STP) and unshielded twisted pair (UTP).

2.1 Shielded Twisted Pair

An STP cable consists of twisted pairs of wires surrounded by shielding to protect them from EMI. STP is very costly and is preferred only for locations with excessive electronic noise like near Air-Conditioners, electric motors, etc. Older versions of the IBM Token Ring networks used STP cables. Figure 5 shows such a cable.

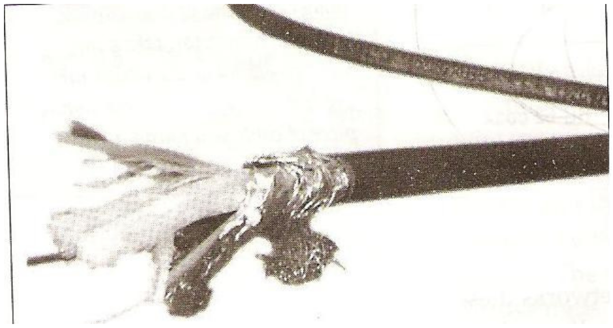

Figure 5: STP Cable

2.2 Unshielded Twisted Pair (UTP)

UTP is the most commonly used network cabling used today. An UTP cable consists of a twisted pairs of wires surrounded by a plastic jacket. The jacket does not provide any protection for the data from EMI. But, UTP cables are inexpensive and they provide are flexible for different types of networks. Not all UTP cables are the same. For example, they differ on the number of twists per foot, which determine how quickly data can propagate on the cable.

The networking industry uses the CAT ratings to indicate the different varieties of UTP cables. The CAT rating of a cable indicates the highest frequency bandwidth the cable can handle. The speed is indicated on a per-pair basis. Hence, to evaluate the speed of a cable, we need to know its CAT rating and the number of pairs that carry data in the cable. Table below shows the UTP cables and their CAT ratings.

CAT Rating	Bandwidth	Typical throughput in networks
CAT 1	< 1 MHz	Analog phone lines – not for data communication
CAT 2	4 MHz	Supports speeds up to 4 Mbps
CAT 3	16 MHz	Supports speeds up to 16 Mbps
CAT 4	20 MHz	Supports speeds up to 20 Mbps
CAT 5	100 MHz	Supports speeds up to 100 Mbps
CAT 5e	100 MHz	Supports speeds up to 1000 Mbps
CAT 6	200-250 MHz	Supports speeds up to 10000 Mbps

3 Ethernet Cabling Systems

We will now discuss the Ethernet cabling systems based on coaxial cabling (10Base5 and 10Base2) and twisted-pair (10BaseT) in more detail.

IEEE defines Ethernet standards in the following format: <Speed> <Signal Type> <Distance>

(i) The <Speed> indicates the channel bandwidth in Mbps

(ii) The <Signal Type> indicates the type of signaling used – Broadband transmissions involve multiple signals on the same channel, while baseband transmissions carry only a single signal on the channel.

(iii) The <Distance> indicates the length of the cable (in 100s of m). For twisted-pair cables, instead of distance, we have T to indicate the cable is a twisted pair.

A segment is a single physical connection terminated on both ends to which computers may connect to form a network.

3.1 10Base5

10Base5 is referred to as Thick Ethernet or Thicknet as the RG-8 coaxial cable used is a thick yellow cable. The name indicates the Ethernet runs at 10 Mbps, with baseband signaling and a maximum cable length of 500m. In 10Base5 networks, a node is not directly connected to the cable. Instead, the 10Base5 Network Interface Cards use a 15-pin AUI connector that connects to a transceiver attached to the RG-8 coaxial cable. The cable connecting the AUI connector to the transceiver is at most 50m long and is physically identical to the MIDI and Joystick connectors found on many sound cards. The external transceivers have to be placed exactly 2.5 m apart. Because, the 10Base5 cables are stiff and use external connectors, the maximum number of nodes attached to a Thicknet segment can be at most 100.

Figure 6: An AUI connector (center) on a 10Base5 NIC

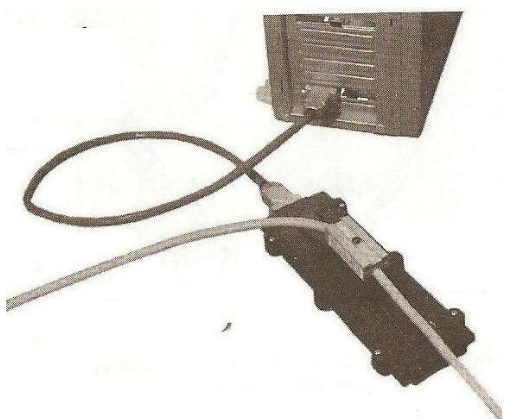

Figure 7: A 10Base5 transceiver connected to a NIC drop cable

3.2 10Base2

10Base2 Ethernet (also called Thin Ethernet or Thinnet) uses RG-58 coaxial cable. It is thin, less expensive compared to the RG-8 cable, but its shielding (though less) is adequate for most installations. The name indicates the network has a bandwidth of 10Mbps, uses baseband signaling and the maximum cable length per segment is 200m (actually 185m). Nodes have to be placed at least 0.5 m apart. There can be at most 30 computers per segment.

10Base2 NICs have a built-in transceiver and connect to the bus cable using a BNC connector and T-connector. The BNC connector separates the center wire that carries the data from the outer shield that protects the center wire from interference. The connector needs to be properly crimped on to the wire; otherwise there can be a short-circuit allowing the flow of electricity between the center wire and the shield. The stem of the T-connector plugs into the NIC and the ends of the coaxial cable with the BNC connector are plugged to the either end of the T-connector as shown in the following figures.

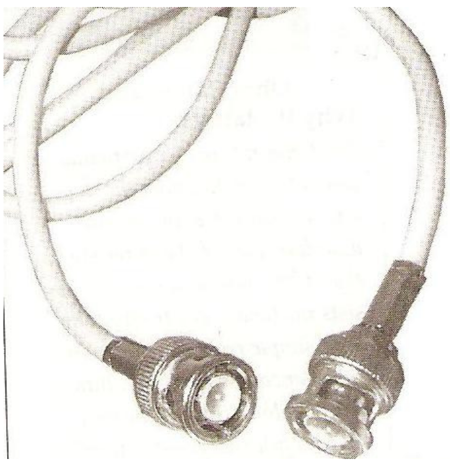

Figure 8: A piece of RG-58 cable with BNC connectors

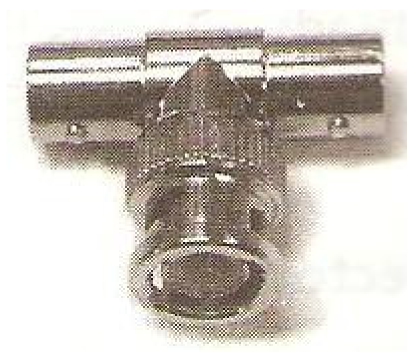

Figure 9: A T-connector

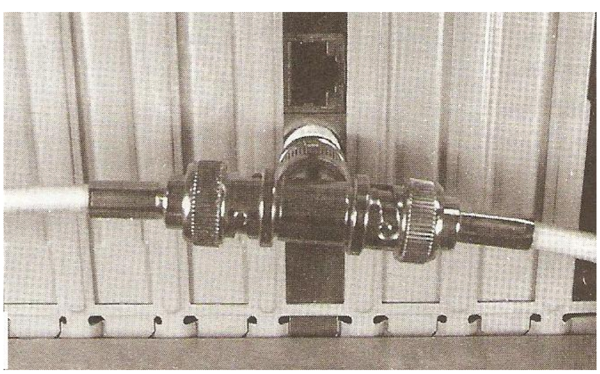

Figure 10: A T-connector with an RG-58 cable attached to either side

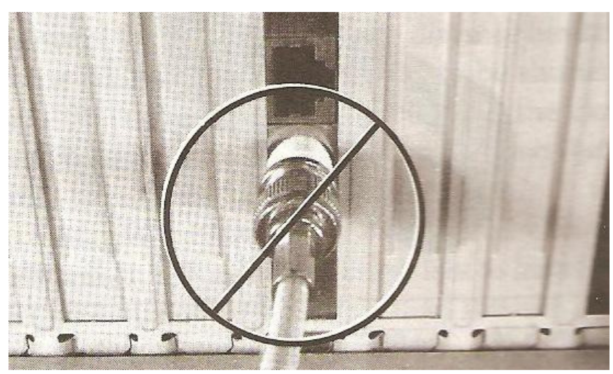

Figure 11: A BNC connector should never be directly attached to the NIC

<u>Note on Terminating Resistors:</u>

When an electrical signal travels down the copper wire, some of it gets radiated out the wire, while some of it gets reflected back. These reflections can affect signals propagating in the wire. Hence, we have terminating resistors to absorb the reflections at either end of any Ethernet segment. Figure 12 shows a T-connector with a terminating resistor attached on its right side.

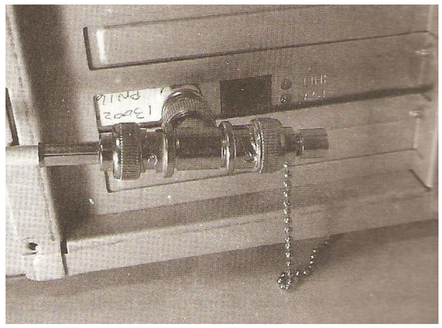

Figure 12: A T-connector with a terminating resistor attached

4. Extending the network

Some organizations may need longer distance limits, more computers (than the ones offered by a single 10Base5 or 10Base2 segment), more fault tolerance and/or the capability to interconnect different cabling types. This motivated the need for extending the network with repeaters and bridges.

4.1 Repeater

A repeater is a device that takes in data received from one Ethernet segment and transfers them to another segment. A repeater takes the incoming electrical signals, translates them into binary code and then retransmits them as electrical signals. It never amplifies the signals. A repeater offers the following advantages: (1) extends the distance a network can cover (2) If a segment breaks, the other segments connected to the repeater will continue to function and (3) one can link Ethernets of different cabling types.

The disadvantage is that a repeater simply forwards an incoming signal from one segment to all its other outgoing Ethernet segments. This puts all the Ethernet segments attached to a repeater in the same collision domain.

Figure 13: A typical Ethernet repeater

Figure 14: An Ethernet repeater with AUI connectors for 10Base5 and BNC connectors for 10Base2

A common rule of thumb (popularly called the 5-4-3 rule) for extending networks is that no two nodes in the extended network may be separated by more than 5 segments, 4 repeaters and 3 populated segments.

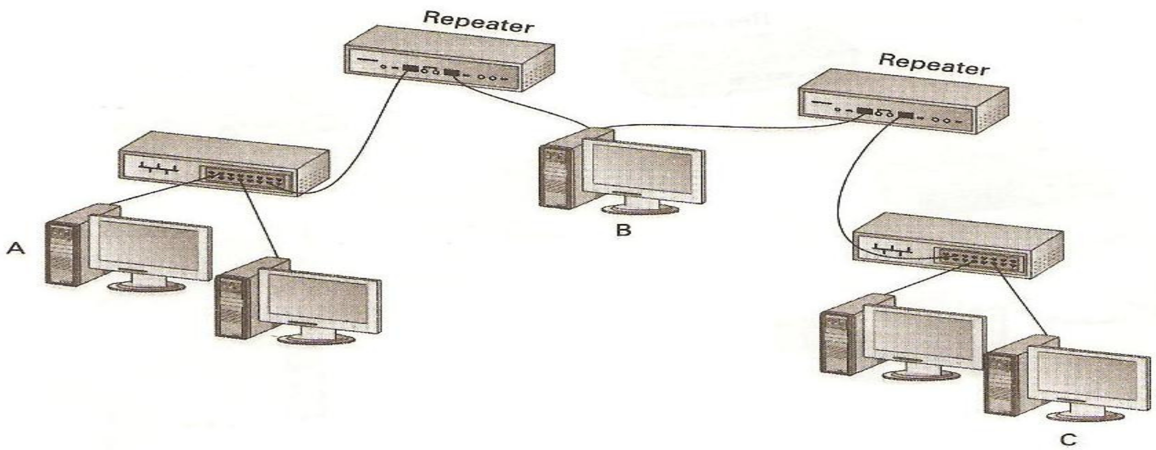

Figure 15: A network with 5 segments, 4 repeaters and 3 populated segments

5. 10BaseT Topology

10BaseT networks differ from those of 10Base5 and 10Base2 only in the type of cabling and topology. 10Base5 and 10Base2 network, each use a physical bus topology with the cables winding around the network and terminators sitting at either end. In a 10BaseT network, each node is connected to a central hub (physical star topology) and the segment is shrunk into the hub. The cable connecting the node with the hub is UTP cable. Figure 18 shows a typical UTP cable.

A hub is basically like a multi-port repeater with signals received from one node forwarded to all the other nodes. If the cable connecting a hub and a computer breaks, the rest of the network can still function. On the other hand, if the hub (or the segment inside the hub) breaks, the entire network comes down.

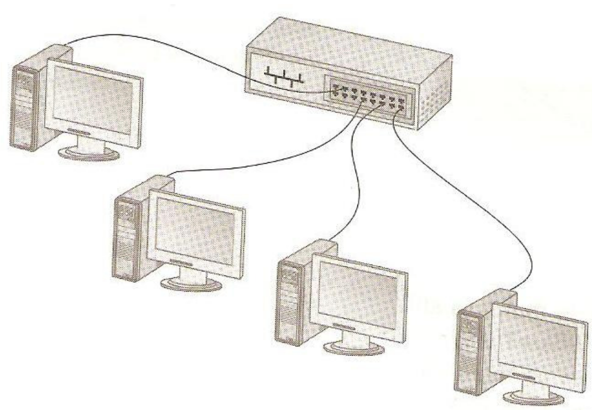

Figure 16: A 10BaseT network with each node connected to the hub

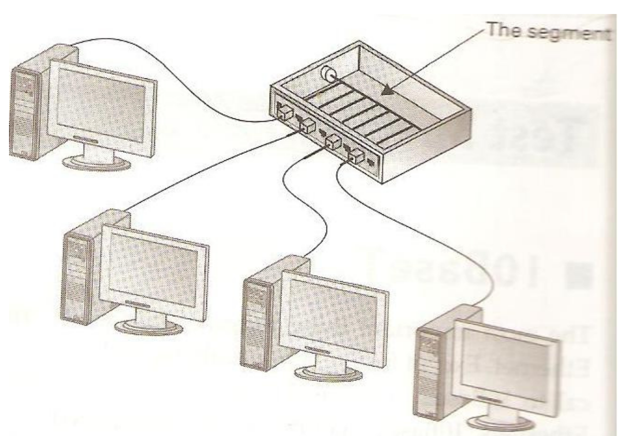

Figure 17: A 10BaseT hub contains the segment

5.1 RJ-45 Connectors

The RJ-45 connector connects a 10BaseT cable to the NIC. Each pin on the RJ-45 connects to a particular single wire in the cable and thus enabling the devices to put the appropriate signals/voltages on the individual wires.

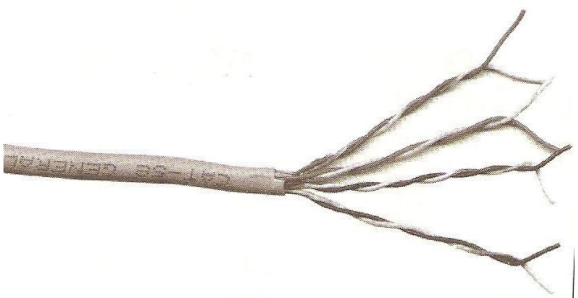

Figure 18: A typical CAT-5e UTP cable

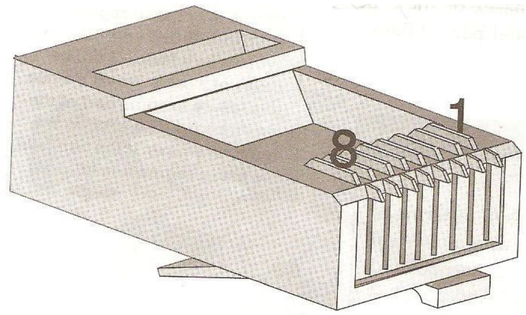

Figure 19: The pins on an RJ-45 connector numbered from 1 through 8

As shown in Figure 19, the pins on the wire are numbered from 1 to 8. 10BaseT uses only the pairs 1 and 2 to send data and pairs 3 and 6 to receive data. The other pairs are not used. Even though separate pairs of wires are used to send and receive data, a 10BaseT cable cannot send and receive simultaneously.

The RJ-45 connector is also called crimp and the act of installing a crimp on to the end of a piece of UTP cable is called crimping. Each pair of wires consists of a solid-colored wire and a striped wire: blue/blue-white, orange/orange-white, brown/brown-white and green/green-white.

The Telecommunications Industry Association/ Electronics Industries Alliance (TIA/EIA) defines the 568A and 568B standard (the color standards are shown in Figures 20 and 21) for the correct crimping of four-pair UTP for 10BaseT networks.

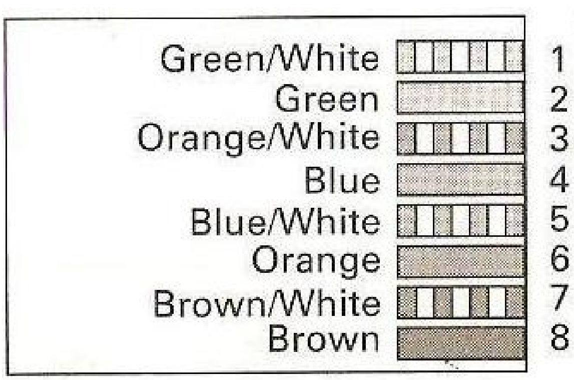

Figure 20: TIA/EIA 568A Standard

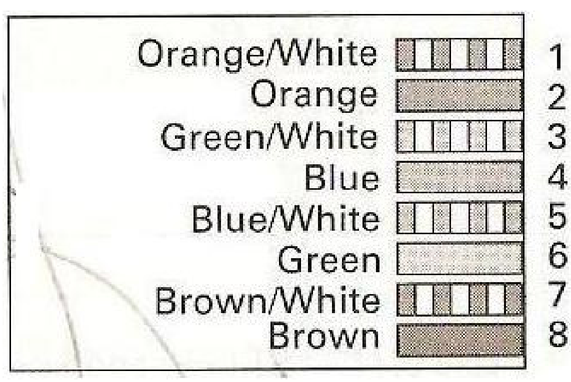

Figure 21: TIA/EIA 568B Standard

Straight-through cables are cables that have 568A or 568B coloring on both ends. A cable that has 568A coloring on one end and 568B coloring on the other end is said to be cross-over cable.

Sample Questions

1) What is meant by the ohm rating for a coaxial network cable?

2) What are the three common types of coaxial cables? Which of them has the highest ohm rating?

3) Is it better to use coaxial network cables with a higher ohm rating or a smaller ohm rating? Justify your answer.

4) What is the difference between a straight-through UTP cable and a cross-over UTP cable?

5) Consider two UTP cables A and B: Cable A is of type CAT 5 where as cable B is of type CAT 3. Which cable would be preferred for low bandwidth communication?

6) Why do network technicians suggest to you coaxial cables with the same ohm rating throughout a network?

7) Consider two twisted pair cables A and B. A has 40 twists per foot and B has 50 twists per foot. Which cable could be used to have less crosstalk?

8) What is meant by the CAT rating for a UTP cable?

9) The frequency bandwidth of a CAT 4 cable is 20 MHz. The number of twisted pairs of wires inside that cable is 10. What would be the maximum data bandwidth (in bps) that would be supported by this cable?

10) What is the difference between the Network Interface Cards (NIC) for a 10Base5 Ethernet and a 10Base2 Ethernet?

11) Complete the following table:

Ethernet Type of Cable	**Type of Connectors**	**Type of Topology**
10Base5 Ethernet		
10Base2 Ethernet		
10BaseT Ethernet		

12) What are the pairs used by a 10BaseT cable to (i) send data and (ii) receive data?

13) What are the two coloring standards used for the 10BaseT cables by the TIA/EIA? What is the difference between them?