Lab 4
Ethernet Physical Layer and Frame Format

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Due: Start of lab Friday, February 20

Name:	
Name:	

Introduction

In this lab you will accomplish several goals:

- Study the Ethernet physical layer and, optionally, create your own Ethernet cable
- Conduct experiments to determine which devices perform auto-sensing
- Explore the Ethernet frame format

Work in pairs for this lab using the equipment at your desk. Distribute the work evenly to make sure both group members know the material, as you will be required to know the material for evaluation.

1 Prelab [20 Points]

A common Ethernet medium is Unshielded Twisted Pair (UTP) cables. UTP cables consist of eight copper wires, each covered in an insulating material, encased in a protective sheath. The wires are grouped into pairs and each pair is twisted to reduce the effect of interference. Common Ethernet devices use four of these wires (one pair in each direction) to transmit information and the other four wires are left unused. (Ethernet fast than 100 Mbps uses all eight wires.)

Ethernet uses two types of UTP cables: straight-through and crossover. Two cable types are used because **end devices (computers and routers)** transmit and receive on different pins than **network devices (switches and hubs)**. Straight-through cables are used between *different* device types while crossover cables are used between *like* devices. A diagram in the networks lab indicates how these cables are wired. If you use the incorrect cable, the devices will not be able to communicate.

You can determine if the devices are able to communicate by checking their link status. On the routers and switches in lab, a link light near the Ethernet port lights up when the device considers the connection established. The PCs also have a link light, but it can be hard to view on the back of the PC. An easier way to determine the link status of the PC is to check the output of the `ip addr` command. When the PC considers the link established it will display the UP state and UNKNOWN or DOWN when the link is invalid. **In order to communicate in both directions, both devices must consider the link established.**

Many devices perform auto-sensing (automatically determine the cable type) and make cable choice irrelevant, but some devices require the correct cable to send or receive data. **If either device performs auto-sensing, then the link will be established independent of the cable type.** You need to determine which of the lab devices perform auto-sensing by designing a set of experiments and then running them on the lab equipment. Answer the following questions to develop you experimental procedure.

1. Given any pair of devices, how can you prove that **at least one** of them performs auto-sensing?

2. Describe how you can prove that a device **does not** perform auto-sensing? (HINT: You have multiples of each device.)

2 Ethernet Physical Layer [30 Points]

Ethernet uses a variety of mediums at the physical layer. In this section, you'll learn about the two most common: copper cables and optical fiber.

2.1 Ethernet UTP Cables

In the networking lab, we have both straight-through and crossover cable. Straight-through cables have blue insulation and black ends and crossover cables have white insulation and blue ends.

Using the experimental procedures from the Prelab, complete the table below to indicate which lab devices perform auto-sensing and which do not.

Device	**Auto-sensing (Y/N)**
PC	
Router	
Switch	

If you wish, you may create and test your own cable by following the steps below. When making your cable, complete the following steps on one end and then follow them for the other end. NOTE: You may complete this part at a later time, so if other students are using the lab tools, continue on to the next part and come back to this later.

To create and test your cable:

1. Cut a segment of cable about three feet in length from the supply.
2. Strip about one inch of protective sheath from a cable end. Pull on the nylon fibers to expose an additional inch of wires.
3. Spread out and untwist the wires to match the wiring diagram.
4. Cut the wires so they all have the same length, leaving a half an inch of wires exposed outside the protective sheath.
5. Slide the new cable terminal onto the wires. Make sure the wires remain in the proper order and that you set pin 1 correctly.
6. Crimp the cable terminal onto the wires.
7. Complete steps 2–6 for the other cable end.
8. Test your cable using the cable tester.

2.2 Ethernet Optical Cables

Optical fiber is an alternative to UTP for use in Ethernet networks, but is only used at speeds of 1Gbps and higher. Your switches have four ports that can use optical transceiver modules. One should be installed already on one switch per desk.

A single optical fiber carries information in only one direction (it is unidirectional). Therefore, optical fibers are paired to allow information to move in both directions. Each pair of unidirectional fibers creates a bidirectional link. Locate the optical port on your switch and notice that there are two openings for optical cables.

Optical cables and networks have very useful properties when compared to wired networks: low power communication, large bandwidth (and data rate), noise immunity, and fewer repeaters. However, there are some aspects to be aware of when working with optical networks. Most importantly, never look into the end of a fiber that is connected to a device. The frequencies are deep in the infrared, so you can't see the light, and some devices use sufficient power to damage your eyes. When using the optical cables, keep in mind that optical fibers are very small and fragile (the majority of the optical cable is sheathing to protect the optical fiber) and will break if the cable is bent too sharply.

Find an optical cable and examine it. The cable will likely have protective plugs at each end. Connect two switches with an optical cable and connect two hosts so that they communicate through the switches over the optical cable. You do not need to perform any configuration of the switches to use the optical ports.

When you have your systems communicating over the optical link, demo your network for credit. $\square$

After you demo the optical network, return the optical cable and connect your PCs to a common switch using UTP cables.

3 Ethernet Frames [50 Points]

We've studied the Ethernet frame format, which is shown below.

Destination	Source	Type/Length	Payload	CRC

This figure does not include some fields required by the physical layer, which you are unlikely to see outside the interface card. You also might not see the CRC on most systems.

3.1 Ethernet Address

The first two fields of an Ethernet header contain the source and destination addresses, with the destination first. Start Wireshark and capture some packets on your PC. Look at your packet traces to answer the following questions about the addresses in an Ethernet header.

1. How many bytes are in an Ethernet address?

2. What is the Ethernet address of PC1 for your workbench, in a standard format?

3. What is the broadcast address for Ethernet?

4. Why do you think Ethernet places the destination address first? Why not the source address first?

3.2 Ethernet Type/Length

Before IEEE defined Ethernet through the 802.3 standard, there were many Ethernet networks already deployed using a de facto standard. When IEEE created 802.3, they changed the frame format from the existing implementations. However, due to the widely deployed existing networks there was much confusion and potential interoperability problems. These issues come into play with the 16 bits after the addresses, the Type/Length field.

The original Ethernet networks used the 16 bits for a Type field, which indicated what protocol was encapsulated within the Ethernet frame (it was a multiplexing key). IEEE 802.3 defines the 16 bits as a length field. This may seem an irreconcilable difference, but fate had better plans for Ethernet. The Length field in 802.3 potentially covers packets up to $2^{16}-1$ Bytes long. However, due to physical layer limitations, Ethernet packets have a maximum size of about 1500 Bytes; this leaves a large number of values available. To reconcile these differences, IEEE defined the 16-bit field as a Length if it is less than 0x0800 (2048) and a Type if it is greater than 0x07FF. Welcome to the real world of backwards compatibility and standards organizations.

Look at your packet traces and determine how the field is used for the following protocol packets. If a Type is used, what is the Type value? If a Length is used, what is the length of the Ethernet frame?

Protocol	**Interpretation (Type/Length)**	**Field Value**
ARP		
STP		
IP		

4 Lab 4 Addresses

	Host Addresses	
Desk	**PC 1**	**PC 2**
A	10.11.50.101	10.11.50.201
B	10.11.50.102	10.11.50.202
C	10.11.50.103	10.11.50.203
D	10.11.50.104	10.11.50.204
E	10.11.50.105	10.11.50.205
F	10.11.50.106	10.11.50.206
G	10.11.50.107	10.11.50.207
H	10.11.50.108	10.11.50.208

	Host Addresses	
Desk	**PC 1**	**PC 2**
I	10.11.50.109	10.11.50.209
J	10.11.50.110	10.11.50.210
K	10.11.50.111	10.11.50.211
L	10.11.50.112	10.11.50.212
M	10.11.50.113	10.11.50.213
N	10.11.50.114	10.11.50.214
O	10.11.50.115	10.11.50.215