

# Technical University of Cartagena



**Telecommunications Engineering School**

## **FUNDAMENTALS OF TELEMATICS**

**Laboratory Content 3B. Ethernet: Study of the  
Physical and Link Levels**

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## 1. Objectives

- Analyze the different telematic aspects which take part in the communications among PCs interconnected through Ethernet network.
- Understanding and analyze the functionality of an Ethernet card.
- Knowledge about the network connections in the case of connecting several PCs.
- Observe the physical level by means of a digital oscilloscope.
- Observe the link level through a network analyzer.
- Observe the frame encapsulation of different protocols.

## 2. Elements

- PC's acting as client/server in the Windows SO.
- Ethernet Network Interface Card installed in bus PCI.
- Communication Network of the laboratory.
- POD's RJ-45 for the study of the physical level.
- 1 *switch* including 24 ports.
- 1 digital oscilloscope YOKOGAWA.
- 1 *hub* composed by 8 ports.
- Cables UTGP cat. 5 with terminals RJ-45 and pin-to-pin connection.

Data terminal equipment (DTE) are formed by PCs connected to the laboratory network. The RJ-45 jacks of each of the workplaces are connected, through the internal wiring of the laboratory, to the corresponding jacks of the Rack. Each of the workplaces is formed by 3 RJ-45 jacks in accordance with the same number of jacks in the Rack. The identification of the jacks of every workplace is simple due to that in the Rack the jacks are numbered according to its corresponding workplace.

Using the appropriate cables of connection, it is possible accomplish a point-to-point connection between PCs, or to connect the computers to the *switch* to create a network for multiple users.

### 1. The Laboratory.

Concerning networks, the laboratory is equipped with two structured cabling networks. It also has telematics instrumentation, which, in the case of this laboratory content, will be composed by a digital oscilloscope and an analyzer of software networks.

#### 1.1 UPCTNet.

The first is the general network of the building, not used in these laboratory sessions. Through this network, each workplace has two jacks for RJ-45 connectors to connect cables composed by four pairs cat. 5. Through these jacks, the communications central of the building can offer us different services such as analog telephony, ISDN and the access to the network of the building.

#### 1.2 Internal Network.

This helps us to perform different configurations during the laboratory sessions. This network architecture is identical to any other network communications, for example, the architecture of the building. This internal network connects each of the jacks that are in workplaces with their pairs (jacks) in the Rack. Each of the PCs of the workplaces can be connected to three RJ-45 jacks. Each of these

jacks is connected to another, which is located in the Rack, through a cable formed by four twisted pairs cat. 5. To carry out these connections, it will have the corresponding cables along with connectors and appropriate connections.



**Jacks of the internal network.**



**Connections of the internal network**

## **Rack**

In this rack, we find different jacks that correspond to each of the jacks of the workplaces. There are 48 additional RJ-45 jacks that are connected to the switchboard of the laboratory. These lines support the service of the ISDN and analog telephony networks. Furthermore, these lines are distributed among jacks in the following manner:



**Rack**

- 8 free jacks without connection.
- 16 jacks correspond to the 16 phone lines.
- 24 jacks correspond to 8 ISDN lines. Each ISDN lines is connected to 3 jacks.



**Hub composed by 8 ports.**

In the Rack, we find a 16 port *hub* and a configurable 24 port *switch* configurable by software. These elements will allow us to build different configurations of LAN in the laboratory. In addition, each workbench will also have 8 port *hub*.

During the laboratory sessions, the student will have twisted-pair cables cat. 5 with RJ-45 connectors to carry out the appropriate connections in (i) each of the *hubs* of the workbenches and in (ii) the rack with the goal of having different network configurations. The cables to be used in the laboratory sessions are of two types: pin-to-pin (usual) connection and crossover connection. The student will take into account the selection of the cable in accordance with the communication to furnish. Note that in the case of using the *hub*, it can accomplish a crossover connection appropriately using the jack 8.

### 1.3 Software Network Analyzer

The network analyzer consists of a PC running the **Wireshark** software. This program analyzes the frames from the MAC level to the upper layers, therefore it is the suitable software to accomplish the laboratory sessions. Clicking the **Wireshark** icon in the desktop starts the application.

Then, using the menu “Capture”, we can select one of the different network interfaces installed in the PC. In particular, we are interested in the network device.

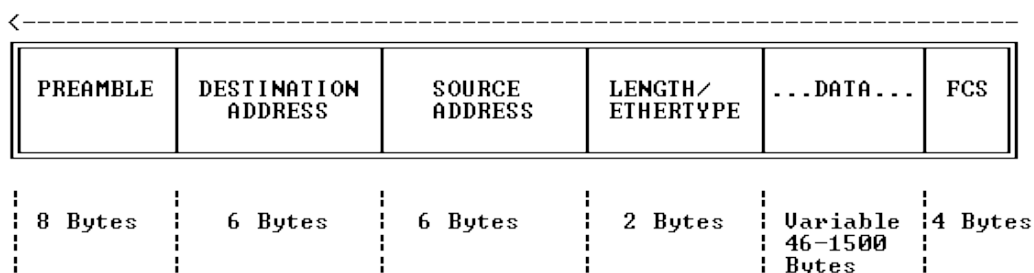
In capture mode, we visualize all the frames transmitted in the network. We select the frame which we are interested to analyze in detail.

## 2. Connection of a PC to a LAN.

A priori, this part of the laboratory session is already configured. The student can verify it, opening a console in mode “DOS” and writing “ipconfig”.

### NOTE:

#### Ethernet Frame Format



- *Data*: It contains from 46 bytes up to 1500 bytes. This means that size of Ethernet frame is variable but enclosed between 64 bytes (lower limit and without Preamble) and 1518 bytes (upper limit and without Preamble).
- The *Preamble* consists of seven bytes all of the form 10101010, and is used by the receiver to establish bit synchronization (there is no clocking information on the Ethernet when nothing is being sent). The *Start frame delimiter* is a single byte, 10101011, which is a frame flag, indicating the start of a frame.
- *CRC (Cyclic Redundancy Check)*: It is used to detect errors in the transmission.
- *Frame Type*: It is used to learn about the type of information that encapsulates the upper protocol to be employed.



### 3. Development of the Laboratory Content

For the development of the laboratory sessions, the student will have to use the Network Analyzer and the Oscilloscope simultaneously. The objective is compare the information obtained by both devices.

#### 3.1 Checking of the communication

Before beginning with the study of the physical and link layers, we should check that the PCs of our workbench are appropriately configured and operate correctly. For this purpose, the student will open a MS-DOS console and will execute the command **ping <IP receiver>** observing the responses received [1]. Once verified that there are communication between both PCs, the student will open Windows Explorer searching for the PCs connected. To this end, the student will click the "My Network Places" icon. The student will check that both PCs are "seen" and, therefore, he/she will have accessed to their folders and printers.

#### 3.2 Study of the physical level

From the LAN installed in the workbench, the student will connect the RJ-45 POD between the *hub* and one of the PC's with the goal of puncturing the pairs 1-2 and 3-6 of the connector using the oscilloscope probes. Regarding the frames transmissions by the LAN, the student will use the utility "ping", which can be executed from a MS-DOS console. It is advisable to execute the *pings* from the PC connected to the *hub* through the POD and execute the *WireShark* program on the another PC.

Once done the connection between both PCs, we will have to observe the physical level, i.e., the voltage levels, the bit time, etc.

To analyze an *Ethernet frame* at physical level suitably, the student must set the oscilloscope in the following manner:

##### Timeline:

10 $\mu$ s/div

##### CH1:

V/div: 2V/div  
POSITION: Position to 2div  
INPUT: Coupling DC, probe 10:1, invert OFF,  
Acq HOLD OFF.

##### CH2:

V/div: 2V/div  
POSITION: Position to -2div  
INPUT: Coupling DC, probe 10:1, invert OFF,

##### TRIGGER:

TYPE: Edge  
MODE: Single  
LEVEL/SOURCE: CH1/ $\uparrow$ , CH1 level -1V  
POSITION/DELAY: trigger position to -4 div, trigger delay 0ns  
COUPLING: coupling DC, HF\_Rej OFF  
HOLD OFF: OFF

##### ZOOM:

ZOOM MODE: MainZoom

Thus, the oscilloscope will capture a complete frame and the student can observe the necessary details using the zoom window. Thanks to the oscilloscope, the student will determine:

- Pair used by the DTEs to transmit.
- Pair used by the DTEs to receive. [2]
- Voltage employed for the line coding.
- The line coding used.[3]
- Decoding a sequence of bits from the voltage that appears on the screen
  - Start and end of the frames.
  - Frame duration and bit time.
  - Decoding of the frame header. [4]

### 3.3 Study of the link level

To study the level of link corroborating with the physical level, it is proposed to study a frame that encapsulates a packet including a "ping" request. To carry out this experiment, the student must execute two times the *ping* command in the PC that has the transmission line punctured by the probes executing the sentence **ping <IP destino>. -n 1**. In another PC, the network analyzer program will be run. So, the origin PC updates its tables in the first *ping* and will not have to use ARP. In the second *ping*, it will be captured through the oscilloscope and the network analyzer to corroborate concepts using both tools. Once captured, the student will work with these data.

The first field showed by the analyzer are the destination and source physical addresses of the MAC frame [5]. Then, the following byte depends on the frame type [6]. Finally, data encapsulate the information of upper levels. [7] and [8]

### 3.4 Upper Protocols

In the case of delving into the frame to upper levels, the *WireShark* program allows a sharp analysis until the application level. To visualize frames from upper levels, we can accomplish a capture of frames by means of a FTP connection to a FTP server of the laboratory (the IP address of the server is 192.168.1.16).

To carry out this connection, we must connect the PC, which is executing the *WireShark* program, to the laboratory network and will write the command "ftp 192.168.1.16" in a MS-DOS command. So, the server ask us by a "login" (username) and a "password" (access code). In these laboratory sessions, we will write **IT1-PCxx** as username and **PCxx** as pass where xx is the workplace of the PC.

Once done the connection, the student will execute the command "ls" and will expect the reply. Then, the student will close the connection with the command "bye" and will analyze the captured frames by the *WireShark*. [8].