1 Applications (6 points)

These questions are about application exchanges and only about this layer. The following is a sequence of messages that were intercepted in a network (each line corresponds to a message):

```
220 Welcome to file.srv.net.
USER anonymous
331 Please specify the password.
PASS alice@wonderland.org
230 Login successful.
SYST
215 UNIX Type: L8
CWD pub
250 Directory successfully changed.
PASV
227 Entering Passive Mode (156,42,2,1,10,28).
LIST
150 Here comes the directory listing.
226 Directory send OK.
TYPE I
200 Switching to Binary mode.
PASV
227 Entering Passive Mode (156,42,2,1,10,29).
RETR rabbit.txt
150 Opening BINARY mode data connection for rabbit.txt (28520 bytes).
226 File send OK.
QUIT
221 Goodbye.
```

1. What type of application and which application layer protocol do we see in this exchange of messages?

2. Who is the user of this service? Has the user authenticated him or herself?
2 Transport Layer (7 points)

1. UDP: What services does UDP provide to the application layer, beyond what is provided by IP? Explain their use.

2. Reliability:
   (a) What mechanisms are used at the transport layer in order to detect and recover from corrupted packets (packets that have bit errors)?

   (b) What mechanism is used at the transport layer in order to detect duplicate packets?

   (c) What mechanisms are used at the transport layer in order to deal with packet losses?

   (d) What mechanisms are used at the transport layer in order to allow the reliable delivery of large numbers of packets that are “in-flight” simultaneously?

3. Connections:
   (a) In the classic TCP/IP protocol stack, what is the role of routers in maintaining an end-to-end connection?

   (b) How does an application that functions over UDP maintain a connection?

   (c) Briefly describe how a connection is opened by TCP

   (d) Briefly describe two ways in which a connection is closed by TCP

   (e) A web browser connects to a web server to collect a HTML page of size 900 bytes. The “GET” command of size 100 bytes is used to retrieve the web page. As the receiver window is of size 1500 bytes and an MSS is 500 bytes, draw a chronogram below by indicating all the different TCP messages exchanged (with their type, the number of bytes sent, as well as the sequence and acknowledgement numbers).
3 Multi-protocol analysis (7 points)

Study the frame that is given in the Appendix 1 (page 7) and answer the following questions carefully justifying your answers. You also have the Appendix 2 (page 9) to help in the analysis.

1. Make a diagram of the different devices that are involved in sending this frame, including all the addresses and port numbers that appear in this frame.

2. What are the applicative commands that were necessarily issued prior to sending the frame?

3. Can you exhaustively list the content of the application layer message?

4. Was the application layer message sent through this single frame or were there several frames involved?

5. What should the receiver of the application layer message do to be aware of it? List all the possibilities and for one of them (you choose), give all application layer commands that will necessarily be used.

6. Give the hexadecimal encoding (dump) of the next frame that the sender of the frame will receive (you can put “XX” for bytes for which you can not calculate the value).
Appendix 2

Ethernet Frame Layout

without preamble/CRC:

+--48-bits--+--48-bits--+16b-+- - - - -+
<table>
<thead>
<tr>
<th>Destination</th>
<th>Source</th>
<th>Type</th>
<th>Data</th>
</tr>
</thead>
</table>
+-----------+--------+----+- - - - -+

A few types: 0x0800 = IPv4
0x0806 = ARP

IPv4 Packet Layout

Ver | IHL | Total Length |... Options...
+-----+-----+-------------+-----------------------+
|I D E N T I F I E R |F I|F O |
+-----------------------+-----------------------+
|T T L |P R O T O C O L |H E A D E R C H E C K S U M |
+-----------------------+-----------------------+
|S O U R C E A D D R E S S |
+-----------------------------------------------+
|D E S T I N A T I O N A D D R E S S |
+-----------------------------------------------+

ICMP Datagram Layout

Type | Code | Datagram Checksum
+-----+-----+-----------------------+
|V a r i a b l e |
+--------------------+

Options = series of options encoded as:
1 byte 00 = end of options (if needed)
1 byte 01 = no operation
1 byte with TLV fields

TCP Segment Layout

THL = TCP header length on 4 bits (32 bits words)

Options = series of options encoded as:

Options = series of options encoded as:

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Options = series of options encoded as:

Options = series of options encoded as:

A few ports associated services

ftp-data 20/tcp
dummy 21/tcp
telnet 23/tcp
domain 53/udp
www 80/tcp
smtp 25/tcp
snmp 161/udp
snmp-trap 162/udp