Surname Name:	Pimenov Gleb
ID:	1820243077
Chapter:	6
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Computer Networks
Assignment Chapter №6

Task 1. *The Wireshark capture below shows a hex stream of an Ethernet frame generated by an application.*
34c93d1de1e7f033e57acfed08004500003 47bc740007d0645090a0006ca0a3e21ec01bb0dcd7e8204765806bbc480120839838e000002
Examine the frame and answer the following questions:
(a) What are the source and destination MAC addresses (in Hex)?
(b) What are the source and destination IP addresses (in dotted decimal)?
(c) What protocol type is the payload carried by IP packets?
(d) What is the source port number? How would you classify the source port?
(e) What is the destination port number? How would you classify the destination port?

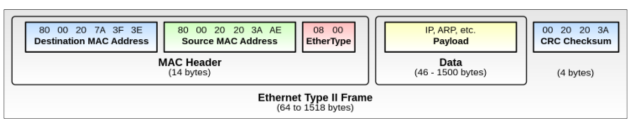

Fig 6-0-1 IPv4 Header Structure Diagram (Task 1)

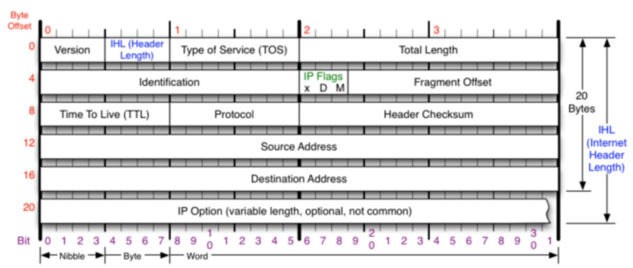

Fig 6-0-2 Forwarding table (Task 1)

Solution. a) Source and destination MAC addresses
Destination MAC: 34:c9:3d:1d:e1:e7
Source MAC: f0:33:e5:7a:cf:ed
(b) Source and destination IP addresses
The IP header starts after the Ethernet type field (0800) at offset 14 in the hex stream. The IP header length is fixed at 20 bytes.
Source IP: 10.0.6.202 (0a:00:06:ca)
Destination IP: 10.62.33.236 (0a:3e:21:ec)
(c) Protocol type
The protocol type field in the IP header is 06, which corresponds to TCP.
(d) Source port number and classification
The source port is the first field in the TCP header.
Source port: 44347 (0xadc7 in hex)

Classification: Ephemeral port (typically for outgoing connections)
(e) Destination port number and classification
The destination port is the second field in the TCP header.
Destination port: 80 (0x0050 in hex)
Classification: Well-known port (for HTTP traffic)

□

Task 2. *You are hired to design a reliable byte-stream protocol that uses a sliding window (like TCP). This protocol will run over a 1-Gbps network. The RTT of the network is 100 ms, and the maximum segment lifetime is 30 seconds. How many bits would you include in the AdvertisedWindow and SequenceNum fields of your protocol header?*

Solution. 1 Gbps = 1 000 000 000 bits per second
Bandwidth-Delay Product (BDP) = $Bandwidth \cdot RTT = 1000000000bps \cdot 0.1s = 12500000$ bytes
AdvertisedWindow size: Needs to be able to represent up to 12.5 MB
$log_2(12500000) =>$ 24 bits
The sequence number space should cover the maximum segment lifetime (MSL)
With 1 Gbps bandwidth and MSL of 30 seconds, the maximum sequence number range needed can be calculated as $MaxDataSentinMSL = Bandwidth \cdot MSL$
Bandwidth = 1 Gbps = 10^9 bits per second
MSL = 30 second
$MaxDataSentinMSL = 10^9 bps \cdot 30s = 3.75 \cdot 10^9$ bytes
Number of Bits for Sequence Number: $log_2(3.75 \cdot 10^9) =>$ 32 bits

Summary:
AdvertisedWindow Field: 24 bits
SequenceNum Field: 32 bits

□

Task 3. *Consider Fig. 6-1. Assuming TCP Reno is the protocol experiencing the behavior shown above, answer the following questions. In all cases, you should provide a short discussion justifying your answer*

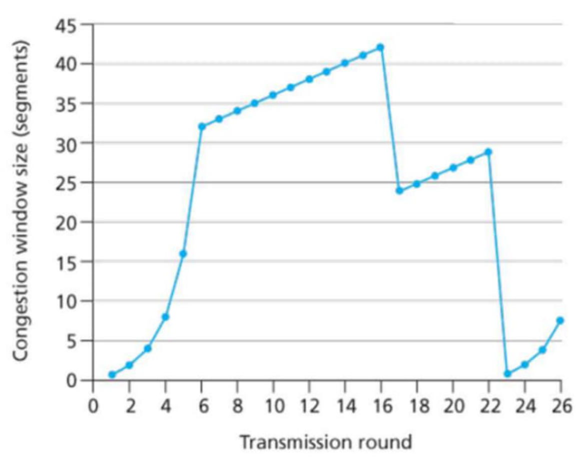

Fig 6-1 Forwarding table (Task 3)

(a) Identify the intervals of time when TCP slow start is operating.
(b) Identify the intervals of time when TCP congestion avoidance is operating.
(c) After the 16th transmission round, is segment loss detected by a triple duplicate ACK or by a timeout?
(d) After the 22nd transmission round, is segment loss detected by a triple duplicate ACK or by a timeout?
(e) What is the initial value of ssthresh at the first transmission round?
(f) What is the value of ssthresh at the 18th transmission round?
(g) What is the value of ssthresh at the 24th transmission round?
(h) During what transmission round is the 70th segment sent?
(i) Assuming a packet loss is detected after the 26th round by the receipt of a triple duplicate ACK, what will be the values of the congestion window size and of ssthresh ?
(j) Suppose TCP Tahoe is used (instead of TCP Reno), and assume that triple duplicate ACKs are received at the 16th round. What are the ssthresh and the congestion window size at the 19th round?
(k) Again suppose TCP Tahoe is used, and there is a timeout event at 22nd round. How many packets have been sent out from 17th round till 22nd round, inclusive.

Solution. a) Slow start is operating from 1 to 6 and from 23 to 26 transmission rounds where the congestion window (cwnd) increases exponentially
b) Congestion avoidance is operating from 6 to 16 and from 17 to 23 where cwnd increases linearly
c) After the 16th transmission round, the segment loss is detected using a triple duplicate ACK, because we see that the cwnd has not decreased to zero (decreased to half), which happens after a fast retransmission, which in turn happens after receiving 3 duplicate confirmations
d) After the 22nd transmission round, the segment loss is detected using a timeout, because we see that the cwnd has decreased to zero, which happens after timeout
e) The initial value of ssthresh at the first transmission round is 32 because after cwnd $==$ 32 congestion avoidance starts
f) The value of ssthresh at the 18th transmission round is cwnd / 2 = 42 / 2 = 21 (that is why from 16 cwnd grows linearly, cwnd starts there from 24)
g) The value of ssthresh at the 24th transmission round is cwnd / 2 = 28 / 2 = 14 (that is why from 23 cwnd grows exponentially)
h) The 70th segment sent during 7th transmission round because $1 + 2 + 4 + 8 + 16 + 32 + 33 = 96$ segments $>$ 70 segments (each term is one round)
i) Assuming a packet loss is detected after the 26th round by the receipt of a triple duplicate ACK, the values of the congestion window size and of ssthresh will be ssthresh = cwnd/2 = 8 / 2 = 4; cwnd = ssthresh = 4
j) Supposing TCP Tahoe is used (instead of TCP Reno), and assuming that triple duplicate ACKs are received at the 16th round, the ssthresh and the congestion window size at the 19th round are 21 and 4 respectfully. Because ssthresh is the same as with TCP Reno but congestion window size = 1 at 17th round and then slow start executed. 18th -> 2, 19th -> 4
k) Supposing TCP Tahoe is used, and there is a timeout event at 22nd round, from 17th round till 22nd round, inclusive, have been sent $1 + 2 + 4 + 8 + 16 + 32 = 63$ segments (packets). After round 22, the condition cwnd $>=$ sstresh should be met, but it is not yet fulfilled at round 22, so exponential growth

□

Task 4. *Assume that TCP implements an extension that allows window sizes much larger than 64 KB. Suppose that you are using this extended TCP over a 1-Gbps link with a latency of 50 ms to transfer a 10-MB file, and the TCP receive window is 1 MB. If TCP sends 1-KB packets (assuming no congestion and no lost packets):*
(a) How many RTTs does it take until slow start opens the send window to 1 MB?
(b) How many RTTs does it take to send the file?
(c) If the time to send the file is given by the number of required RTTs multiplied by the link latency, what is the effective throughput for the transfer? What percentage of the link bandwidth is utilized?

Solution. (a) RTTs until window opens to 1 MB
Starting from 1 MSS (1 KB), each RTT the window doubles until it hits 1 MB:
$log_2(\frac{1MB}{1KB}) = 10$ RTT's

(b) RTTs to send the file
Once the window is 1 MB, sending a 10 MB file will take:
$\frac{10MB}{1MB} = 10$ RTT's
Total RTTs: $10 + 10 = 20$ RTT's

(c) Effective throughput
Time to send the file: $20RTT's \cdot 50ms = 1$ second
Effective throughput: 10 MB
Percentage of bandwidth: $\frac{10MB}{125MB} \cdot 100 = 8$ %

$\square$