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1. [1] Explain the most important function of TCP. Use the Internet Service Model as a reference frame.

   The most important responsibility of TCP consists of *reliable transmission* or providing guarantees of retransmitting lost packets and packets that contain errors and dropping duplicated packets.

2. [1] What fields of a TCP segment form their multiplexing key?

   Client IP, Client port, Server IP, Server port

3. [1] Explain the concurrency and performance transparencies of distributed systems

   Concurrency: The fact that several clients access a resource simultaneously doesn't affect the operations they execute when only one client is accessing it

   Performance: The performance of the distributed system gracefully degrades with offered load. Performance is consistent over varied situations, *i.e.,* under a wide range of loads, the system responds with promptness.

4. [1] What responsibilities are assigned to each of the three tiers in the 3-tier model

   - Presentation: Control the look of the output to the user, retrieve the data to be output and capture the data input by the user.
   - Business: The operations performed on the data that represent the *business* logic established at the company or institution that owns the considered 3-tier application
   - Persistence: To store the real data in non-volatile storage by using an advanced declarative programming language (SQL, for instance).

5. [1] Explain the fundamental factor that bounds the precision achieved when synchronizing host A's clock with host B over the Internet

   The size of the Round Trip Time ($Delay_{fwd}$ + $Delay_{bwd}$ + T_{resp}) and the disparity between $Delay_{fwd}$ and $Delay_{bwd}$ (the forward and backward path delays)

6. [1] Regarding the preceding question, explain the essential aspects about the Cristian's algorithm

   Some host A that reads the clock of another host B, achieves a precision that depends on the *current* Rtt. If host A wants to read B's clock with some desired *a-priori* probability of achieving a high precision, it should repeatedly read the clock a great *many* times.

7. [1] Explain the structure of the hosts involved int the NTP protocol: servers, clients, etc.

   Clock sources in NTP are organized according to their quality into various so-called Strata (The plural of Latin *stratum*). Stratum 1 hosts the highest quality clocks, typically comprised of atomic clocks, stratum 2 is comprised of Internet hosts that host clock servers directly connected to Stratum-1 clocks. NTP clients can be typically found at strata 3 and greater.

8. [1] From the systems standpoint, what software entities communicate in a distributed system?

   One *thread* of a server communicates with a *thread* of the client by using a socket.

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9. [4] Host A wants to synchronize its clock with host B's clock, to that end, it performs 10 time requests by using ICMP. The timestamps sent by B, in response to each timestamp request, are included in the table below. Compute the time that must be set at host B right after receiving the last timestamp so that this clock is synchronized with host A's clock. Explain the calculation process

Check out this document for the solution: **http://paloalto.unileon.es/ds/SG/SG-DS-Clocks-NTP.pdf**

10. [2] Depict a transmission diagram that illustrates the essential about the behavior of host A when the Nagel's algorithm is activated on the socket that connects host A and host B.

The behavior we are seeking for solving this question should happen only if Nagel's alg. is activated on host A's socket. Assume that at time t_0 host A is expecting 4 ACKs corresponding to segments TCP_A sent earlier. Assume that up to t_0 host A's transmission buffer is empty and that at t_0 a partial packet P builds up. Nagle's algorithm forbids sending P until after the time when the expected ACKs have all been received by host A.

At time t_1 the last expected ACK is received, then shortly afterwards, TCP proceeds to transmit *partial packet P* (P's size is less than MSS). If another partial packet built up at host A now (Later than t_1), TCP_A would have to wait for the ACK to packet P before sending that new partial packet.

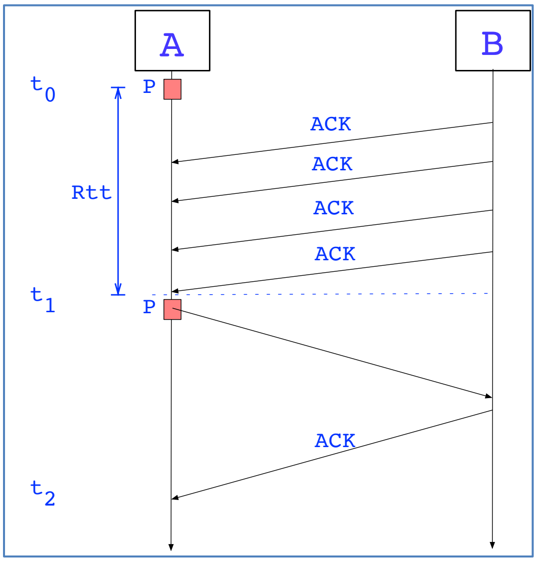

Figure 0: A possible solution to question no. 10

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11. [1] [M] Assume two Internet hosts C and S form a TCP connection. S sends a TCP segment to C containing the following relevant field values: ACK 12000, AWS 0. Mark the true statements about the foregoing TCP connection:

- ☐ a. The congestion control window size announced by C is 0
- ☐ b. The flow control window size announced by C is 0
- ☐ c. The Receive Buffer size of S cannot be 0
- ☐ d. The actual space free at the Receive Buffer of S is 0
- ☐ e. The actual space at the Receive Buffer of S can be other than 0

12. [2] [M] Consider TCP flow control and the channel comprised of the transmitter (C) and the receiver (S) in a TCP connection involving hosts C and S. Assume that the last segment sent by receiver S has the following field values: ACK 1001, WS 1000 and that this TCP uses no option. Which of the following options represent TCP valid messages that could be sent by C in the foregoing scenario.

- ☐ a. 0-Byte segment having SN = 2001, ACK =3200, WS = 700
- ☐ b. 0-Byte segment having SN =1000, ACK =3200, WS = 700
- ☐ c. 1001-Byte segment having SN = 1001, ACK =1249, WS = 0
- ☐ d. 20-Byte segment having: SN = 1982, ACK =1850, WS = 700
- ☐ e. 1001-Byte segment having SN = 1000, ACK =1850, WS = 0
- ☐ f. 498-Byte segment having SN = 1500, ACK =1851, WS = 699

13. [1] [M] Consider a TCP connection between client C and server S. Assume S sends a segment containing no data which ACK bit is activated and having ACK SN = 2000 (TCP field ACK Sequence Number). This segment is lost. Tick the true statements among the following:

a. ❑ This lost segment could cause the receiver C to send a NAK (Negative acknowledgement)
b. ❑ A TCP RTO timer event could retransmit the lost ACK segment
c.❑ Receiver S has received bytes through byte number 1999 in order and without errors
d. ❑ Receiver S has received a total of 2000 Bytes in order and without errors
e. ❑ A TCP RTO timer at C could retransmit the lost ACK segment

14. [2] [M] The client, C, of a TCP connection receives a segment from the server, S, which contains the following field values: ACK bit set, ACK SN = 2000 and AWS = 5000. Tick all the true statements about what could happen at this time point in the TCP connection (Assume no TCP option has been enabled).

a. ❑ Determining how many bytes S could send now entails knowing the MSS
b. ❑ Determining the number of bytes that S could transmit now, would entail our knowing the Window Size Scaling Factor
c. ❑ C could transmit a window of 5000+2000 Bytes
d. ❑ C could transmit at most a window of 5000 Bytes
e. ❑ The most advanced ACK that S could send to C as a response to a correct segment sent from C to S, would contain an ACK SN = 2000+5000+1=7001
f. ❑ The most advanced ACK that S could send back to C as a response to a correct segment sent from C to S, would contain an ACK SN = 2000+5000=7000

15. [2] [M] Tick the true characterizations of a TCP connection when a TCP module sends ACK and ACK SN = 2000

- ☐ a. The last received segment carried data through SN 1999; the SN of the next expected segment is 2000
- ☐ b. That TCP module has successfully received all the segments containing data bytes through SN 2000 and the next expected SN is 2001
- ☐ c. The last received segment contained data bytes through SN 2000
- ☐ d. The TCP module has received all the data bytes from sequence number 0 through SN 2000
- ☐ e. The TCP module has received all the data bytes from the Initial Sequence number through SN 1999
- ☐ f. The last received segment contained the SN 1999
- ☐ g. None of these former options is true

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16. [2] Figure 1 represents a 3-way handshake initiated by host A with host B. Tick all the statements that are true:

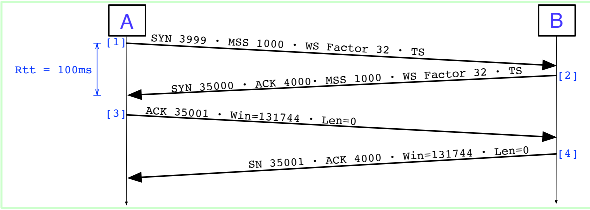

Figure 1. Question no. 16

Solution note:

131744 / 2 = 32936;
131744 / 8 = 16468;
131744 / 32 = 4117

- The "Win" legend means Win=131744 as in Wireshark, *i.e.* the actual Window Size is 131744 bytes --not the contents of the Window field!

- ☐ a. The value contained in the Window field of segment [3] is 4117
- ☐ b. The value contained in the Window field of segment [3] is 131744
- ☐ c. The value contained in the Window field of segment [3] is 32
- ☐ d. Both hosts, A and B can measure the Rtt of each transmitted segment
- ☐ e. The Initial Sequence Number used by host A for numbering its byte stream is 3999
- ☐ f. If host B sent a data segment after this handshake, the sequence number of its first byte would be 35001
- ☐ g. The Initial Sequence Number used by host B for numbering its byte stream is 35001
- ☐ h. Per the TCP options set in the handshake, we can claim that host A has the Algorithm of Nagle activated

17. Assume that, after the handshake depicted in Figure 1, the transmissions depicted in Figure 2 take place. The values contained in fields TSVal and TSecr are the fixed comma integers X0 through X7 (The concrete values are irrelevant, that is he reason why we are representing them symbolically). Respond to the related questions below:

a. [1] What's the value of X5 as a function of TSval and Tsecr?

X0. The reason is that, according to RFC 7323, the Rtt measured by host A should include any *delack* that might have been inserted by the receiver, B. The delack-inflated Rtt is preferred to the tiny Rtt that would result if the Rtt sample were taken by using the latest unacknowledged segment instead of the earliest one. The answer is X0.

b. [1] Explain what procedure is used by host A to measure the current RttSample of 100 ms at time point [4]

$TimeOfDay_A - T_{secr} = TimeOfDay_A - X0$

c. [1] Just before time point [4] the current EstimatedRtt is 102,1 ms. What RTO time length is host A scheduling for protecting the retransmission of the segment transmitted at time point [5]? Assume TCP is executing the Karn-Partridge algorithm with $\alpha = 0{,}8$.

$EstimatedRtt[n+1] = 0.8 \cdot EstimatedRtt[n] + 0.2 \cdot RttSample[n]$
$EstimatedRtt[n+1] = 0.8 \cdot 102.1\ ms + 0.2 \cdot 100\ ms$
$EstimatedRtt[n+1] = 101.68\ ms$

$RTO[n+1] = 2 \cdot EstimatedRtt[n+1] = 2 \cdot 101.68\ ms = 203.360\ ms$

d. [1] In which of time points [4] or [5] will host A start the Retransmission Timer?

The RTO will be *restarted* at time point [4] since the received ACK does advance snd.una.

e. [1] Assume that the segment transmitted at time point [5] is lost and that host A transmits another two segments containing data afterwards. Demonstrate whether the retransmission of the segment sent at [5] happens as the result of a 3-DUP or of an RTO.

Since the number of segments transmitted after segment [5] (2 segments) cannot cause a 3-DUP, it will be the RTO timer expiring event that will cause the retransmission of [5], in this concrete case, the RTO value set is 203.360 ms (See above).

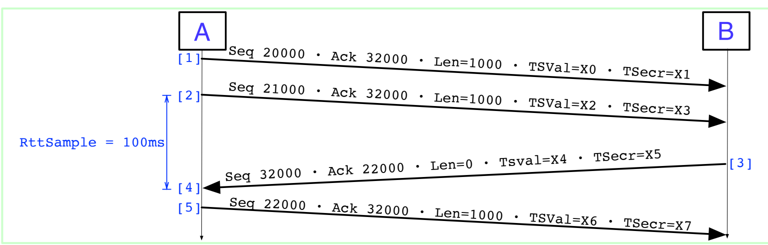

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Figure 2

18. The segment transmissions depicted in Figure no. 3 are taking place after a normal 3-way handshake that happened earlier and which MSS option is set to 1040. Respond to the following questions related with the foregoing scenario:

  a. [1] Is the Nagle's algorithm activated at host A connection side? Explain your answer.

  Nagle's algorithm cannot have been activated at A's side since host A is transmitting a partial segment (The second segment, which size is 1000 whilst the MSS is 1040) at a time when the ACK to the partial segment at [0] sent has not yet been received).

  b. [1] Explain how many of the segments in Figure 3 don't have the flag ACK activated.

  Since all of the segments contain data and are transmitted ever after the 3-way handshake, all must have the flag ACK set.

  c. [1] What ACK Sequence number would host B have to include in the segment that ACKs the block of data contained in segment [0] and [1].

  ACK SN = 6000

  d. [1] Is the situation explained in the preceding question acceptable by TCP, namely that the TCP is acking a two-segment of in-order block of data by sending only one segment? Justify your answer.

  Yes, this situation corresponds to the Delayed Ack TCP concept.

  e. [1] How many of the segments in Figure 3 have the SYN flag set?

  Since the 3-way handshake took place before the data transfers depicted in Figure 3, no further segment can have the SYN flag set.

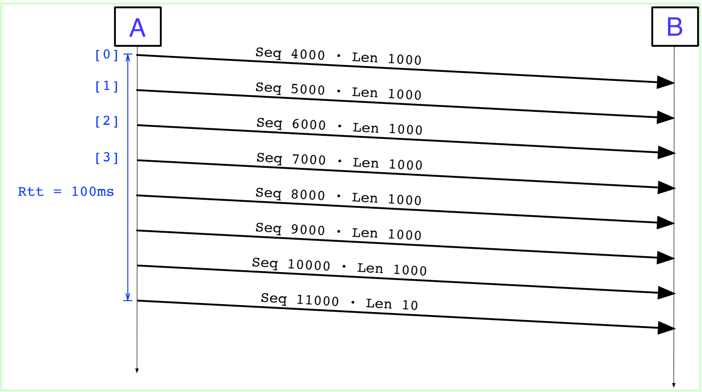

Figure 3