Solved exercises on Computer Networks and Distributed Systems

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1. Is TCP a secure transmission protocol?

No, TCP is a reliable transmission protocol, that is in the sense that TCP can compensate for the omission faults inherent to the Internet Model of Service, however, it does not incorporate any cryptographic algorithms which might confer it the character of secure protocol.

2. Explain what's the basic goal of the UDP protocol.

UDP is a simple transport multiplexer. It offers a multiplexing key composed of a single 16-bit unsigned integer known as port that serves for locating a receiving thread within the receiving host's stack.

3. Describe the components of the TCP multiplexing key

Src IP, Src Port, Dst IP, Dst Port

- 4. The following questions, all refer to the trace in Fig. 1.
 - a. What does the sequence of frames from no. 971 through 1441 represent? Explain your answer by describing the most remarkable patterns that appear on that frame sequence.

This frame sequence consists of a number of repeated connection-requests made by a client. Since the server is not responding to any of them, the client sends several back-to-back connection requests in the hope that the server will eventually respond. In this specific case, each SYN segment (A TCP connection request) sent by the sender (The client) starting with frame #979 is a retry of a connection request. As is usual in Computer Science, the mathematical function that governs the distance (In time) between each two successive retries follows an exponential law (Function). In the case of the considered trace, the inter-distance between each pair of successive frames is twice the preceding one. For example, in the case of frames [971: 979: 9891 we have. respectively:

[284.045661; 285.069382; 287.085273]

The resulting interdistances are: 1.023721 (First one and second one) and 2.015891 (Second one and third one). Clearly, the latter inter distance is double the former one, roughly, as it were. This pattern can be confirmed in all the remaining cases.

We observed this behavior in the practices about TCP analysis with Wireshark.

b. Tell which TCP states must the relevant client, welcome and delegate sockets be in

No connection established => Client SYN-Sent; Welcome socket: Closed; Delegate socket: closed The client socket must be in the Syn-Sent state. As to the Server Socket, we claim it is most likely in the Closed state since the server socket is not responding to the reception of Syn segments, however, we must also observe that it could also be in the Listening state with the backlog (Queue) of pending connections full. Solution Diagram 1 illustrates why the Server Socket (Passive or Welcome, also) could either be closed or created but yet not in the listen state. In both cases, the Passive Socket would not respond with Ack-Syn to receiving a new Syn from a client, which is the behavior we are observing in the TCP trace included in the present question.

	Time	Source	Destination	Prote Ler	ngth Ir	nfo							
971	284.045661	192.168.1.99	192.168.1.4	TCP	76 3	37924 -	. 50001	[SYN]	Seq=0	Win=2920	0 Len=	0 MSS=:	1460
979	285.069382	192.168.1.99	192.168.1.4	TCP	76 [TCP R	etransm	ission	37924	→ 50001	[SYN]	Seq=0	Win
989	287.085273	192.168.1.99	192.168.1.4	TCP	76 [TCP R	etransm	ission	37924	- 50001	[SYN]	Seq=0	Win
002	291.117438	192.168.1.99	192.168.1.4	TCP	76 [TCP R	etransm	ission	37924	→ 50001	[SYN]	Seq=0	Win
025	299.309296	192.168.1.99	192.168.1.4	TCP	76 [TCP R	etransm	ission	37924	- 50001	[SYN]	Seq=0	Win
083	315.437421	192.168.1.99	192.168.1.4	TCP	76 [TCP R	etransm	ission	37924	→ 50001	[SYN]	Seq=0	Win
441	347.693409	192.168.1.99	192.168.1.4	TCP	76 [TCP R	etransm	ission	37924	→ 50001	[SYN]	Seq=0	Win
Frame 971: 76 bytes on wire (608 bits), 76 bytes captured (608 bits) on interface 0													
Linux cooked capture													
Internet Protocol Version 4, Src: 192.168.1.99, Dst: 192.168.1.4													
Transmission Control Protocol, Src Port: 37924, Dst Port: 50001, Seq: 0, Len: 0													
Source Port: 37924													
Destination Port: 50001													
[TCP Segment Len: 0]													
Sequence number: 0 (relative sequence number)													
[Next sequence number: 0 (relative sequence number)]													
Acknowledgment number: 0													
1010 = Header Length: 40 bytes (10)													
▶ Flags: 0x002 (SYN)													
Window size value: 29200													
[Ca	lculated wi	indow size: 29	200]										
Checksum: 0x4079 [unverified]													
[Ch	necksum Stat	us: Unverifie	d]										
Urgent pointer: 0													
v Options: (20 bytes), Maximum segment size, SACK permitted, Timestamps, No-Operation (NOP), Window scale													
▶ TCP Option - Maximum segment size: 1460 bytes													
	TCP Option	 SACK permitt 	ted										
. ►	TCP Option	- Timestamps:	TSval 2008981	6, TSecr	0								
▷ TCP Uption - No-Operation (NUP)													
	TCP Ontion	Window scale	e, 7 (multiply	hv 128)									
	971 979 989 002 025 083 441 rame inux rame Sou Tro Sou [Tro Sec [Net Acc] 107 C Che [Che [Che [Che [Che [Che [Che [Ch	Time 971 284.0565.0592.972 28.06932.972 28.06932.972 28.06932.972 28.06932.972 28.06932.982 28.072 2	Time Source 71 284.04566 192.168.1.99 997 283.065382 192.168.1.99 992 287.06527 192.168.1.99 990 27.012.1738 192.168.1.99 902 27.01738 192.168.1.99 983 315.437421 192.168.1.99 193.183.192 903 27.017 76 bytes on wire (financial optime) 192.168.1.99 1011 76 bytes on wire (financial optime) 192.168.1.99 1011 76 bytes on wire (financial optime) 101.77 1017 62 optime) 197.17 1017 62 optime) 197.17 1017 62 optime) 197.17 1017 62 optime) 101.17 1018 62 optime) 101.17 1019 60 optime) 10	Time Source Destination 71 284.04566 192.166.1.99 192.168.1.4 97 284.0561 192.166.1.99 192.168.1.4 99 287.06527 192.166.1.99 192.168.1.4 902 27.06527 192.166.1.99 192.168.1.4 902 27.06527 192.166.1.99 192.168.1.4 902 27.06527 192.168.1.99 192.168.1.4 903 27.06527 192.168.1.99 192.168.1.4 913 17.76 bytes on wire (608 bits), 76 101.000, 57 Inux cooked capture 102.168.1.99 termet Protocol Version 4, Src: 192.168.1 102.168.1.91 Source Port: 3724 102.168.1.91 Sequence number: 0 101 Sequence number: 0 (relative sequence Next sequence number: 0 (relative sequence Nordow size value: 20200 (checkum: wadP3 [unverified] (Checkum isvalue: Vurerified] (Checkum isvalue: Suprefied) Urgent pointer: 0 90tions : (20 bytes), Maximum segment size: 146 N TCP Option - Maximum segment size: 146 N TCP Option - Maximum segment size: 146 N TCP Option - Maximum segment size: 146 N TCP Option - Nocoperatived	Time Source Destination Pott Lat 70 284,0560,01 592,168.1.4 TCP 977 285,06392,192,168.1.9 192,168.1.4 TCP 978 285,06392,192,168.1.9 192,168.1.4 TCP 982 270,0527,312,124,183,189,122,168.1.4 TCP 982 270,9527,912,124,183,189,122,168.1.4 TCP 983 315,437421 192,168.1.9 192,168.1.4 TCP 983 316,1071 192,168.1.9 192,168.1.4 TCP 983 316,1071 192,168.1.9 126,168.1.9 TCP 1076 504071 192,168.1.9 108,109 108 1076 504071 192,168.1.9 107 108,109 1076 504071 192,168.1.9 107 <td< td=""><td>Time Source Destination Prot Lempth 71 284.05650 192.168.1.4 TCP 76 977 285.06932 192.168.1.4 TCP 76 978 285.06932 192.168.1.4 TCP 76 978 285.06932 192.168.1.4 TCP 76 978 285.06932 192.168.1.4 TCP 76 982 270.05273 192.168.1.9 192.168.1.4 TCP 76 982 370.5273 192.168.1.9 192.168.1.4 TCP 76 983 375.47421 192.168.1.9 192.168.1.4 TCP 76 983 375.47421 192.168.1.9 192.168.1.4 TCP 76 973 77 76 bytes on urre (688 bits), 76 bytes capture inax cooked capture 76 76 76 973 77 76 oytes on urre (688 bits), 76 bytes capture 107 58 76 1077 6signet Tote Protocol, Keront a, Src: 192.168.1.9 177 59 76 57 1087 cagnet Tote Protocol, Keront a, Src: 192.168.1.9 107 58 76 76 1087 cagne</td><td>Time Source Destination Prot: Length Info 71 284.06563 192.166.1.4 TCP 76 73.924. 797 285.06332 192.166.1.4 TCP 76 73.924. 978 285.06332 192.166.1.4 TCP 76 76.724. 978 285.06332 192.166.1.4 TCP 76 TCP AR 978 285.06332 192.166.1.4 TCP 76 TCP AR 982 270.9527.0512.051.4 TCP 76 TCP AR 982 370.9527.0512.051.61.4 TCP 76 TCP AR 983 315.437421 192.166.1.9 32.166.1.4 TCP 76 TCP AR 983 315.437421 192.166.1.9 32.166.1.4 TCP 76 TCP AR 77.17 76 TCP AR 77.77 77.77 76</td><td>Time Source Destination Prot: Length Info P71 284.46561 192.166.1.4 TCP 76 37924 - 50601 979 285.66332 192.166.1.9 192.166.1.4 TCP 76 [TCP Fetrans 992 287.66372 192.166.1.9 192.166.1.4 TCP 76 [TCP Fetrans 992 287.66372 192.166.1.9 192.166.1.4 TCP 76 [TCP Fetrans 982 287.66372 192.166.1.9 192.166.1.4 TCP 76 [TCP Fetrans 983 315.437621 192.166.1.9 192.166.1.4 TCP 76 [TCP Fetrans 983 315.437621 192.166.1.9 192.166.1.4 TCP 76 [TCP Fetrans name 371: 76 bytes on wire (608 bits), 76 bytes captured (608 bits) 107 76 [TCP Fetrans name 371: 76 bytes on wire (508 bits), 76 bytes captured (508 bits) 107 76 [TCP Fetrans Source Ontol Porticol, Scr Port: 3724, Bst Port: 50801, Segi Source ontol Porticol Source number: 0 [TCP sequent Len; 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Figure 1. Wireshark trace.

Can you tell for sure whether the client host and server host are located in the same network? Explain your answer. c.

We cannot tell for sure whether both hosts are located within the same IP network because we do not know the network mask (Or the CIDR prefix) to each IP address (Review ch. 3 of CN)

Can you calculate the average Rtt attained? Explain your answer. d.

We cannot calculate any of the Rtts because the sending host is not receiving Syn-Ack replies to the Syn segments sent

Explain each of the most important Transparencies of Distributed Systems 5.

Access, location, performance, scaling, faults, replication, concurrency, mobility

- 6. Tick the true characterizations of a TCP connection when a TCP module sends a segment with ACK set and <u>ACK SN = 2000</u>
 - 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
 - П 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 П
 - f. The last received segment contained the SN 1999 П
 - g. None of these former options is true П
- Host Ht sends a TCP connection request to host Hr. The connection evolves according to the chronogram in Fig. 2. For simplicity, the example is built 7. such as the only sending host is H_t. As required by TCP, data transmission is initiated in the TCP Slow Start dynamic state (SS) by sending a single full segment in the Rtt following the 3-way handshake. The Estimated Rtt before the first Rtt begins is 1 sec and the value of $\alpha = 0.8$. Relevant time points

mentioned in the following questions are marked with symbol: (N). Respond to the following questions regarding this TCP connection:

What is the maximum acceptable amount of bytes that the client can send in any single segment? Compose your solution with sufficient a. precision.

Server's MSS is 1000 as announced in the 3-way handshake

- When is the RTO timer created and started (Use a symbol \otimes)? b.
- Mark the points in time when the RTO timer is reset (Use a symbol ®) С.
- d. Mark the points in time when RTO timer is stopped (Use a symbol ©)
- Mark the points in time when RTO timer fires (Use a symbol [F]) e.
- f. Mark the points in time when the a new Rtt_{sample} is taken (Use a symbol >)

g. Assume that three samples of Rtt are taken along the evolution of the connection at time points 1, 2 and 4 which values are: RttSample[1] = 70 ms; RttSample[2] = 50 ms and RttSample[3] = 60 ms¹. Calculate the length of the RTO timer scheduled after RttSample[3] is taken and which will protect the loss of the segment sent after time point 5. The initial value of EstimatedRtt is 1 sec.

Index	EstimatedRtt[n+1]	0,8·EstimatedRtt[n]	0,2·RttSample[n]	RTO[n+1]
0	1	-	-	2
1	0,814	0,8 · 1	0,2 · 0,07	1,628
2	0,6612	0,8 · 0,814	0,2 · 0,05	1,3224
3	0,54096	0,8 · 0,6612	0,2 · 0,06	1,08192

α = 0,8

h. What's the value of TCP state variable snd.una in host Ht right after time point 4?

7001

i. Explain what is the maximum number of bytes that *can be* sent after ACK 3001 is received at time point 2, that is, within the Rtt just initiated?

$SS, 2 \cdot 2000 = 4000$

j. [1] Explain the situation marked by time point no. 3.

Stretch ACK worth [3001, 7000]

¹ Note that the index used for the samples represents the relative order of the samples, not the time points in the diagram when they were taken.



Figure 2. Transmission diagram for TCP connection

8. When a new TCP segment is received, the receiver copies the timestamp TSVal received into the ACK sent back field TSEcr, this will allow the transmitter to compute the Rtt achieved in the transmission. The text fragment in Fig. 3 was extracted from RFC 7323 (*TCP options for performance*), it specifies which value of TSVal should be copied into the ACK sent back when a that ACK has been delayed (A DelAck), and consequently covers two back-to-back segments. Read the fragment and explain the solution that it proposes. Include a diagram that illustrates the problem and that highlights the solution.

4.3. Which Timestamp to Echo

If more than one Timestamps option is received before a reply segment is sent, the TCP must choose only one of the TSvals to echo, ignoring the others. To minimize the state kept in the receiver (i.e., the number of unprocessed TSvals), the receiver should be required to retain at most one timestamp in the connection control block.

There are three situations to consider:

(A) Delayed ACKs.

Many TCPs acknowledge only every second segment out of a group of segments arriving within a short time interval; this policy is known generally as "delayed ACKs". The data-sender TCP must measure the effective RTT, including the additional time due to delayed ACKs, or else it will retransmit unnecessarily. Thus, when delayed ACKs are in use, the receiver SHOULD reply with the TSval field from the earliest unacknowledged segment.



Figure 3. Text fragment from RFC 7323, pg. 16.

Figure 3'. Solution