TECHNISCHE UNIVERSITÄT BERLIN
Fakultät IV – Elektrotechnik und Informatik
Fachgebiet Intelligente Netze
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3rd Assignment: Network Protocols and Architectures, WS 20/21

Question 1: $(4 + 3 + 3 = 10$ points) *VoIP over TCP*

(a) **Describe briefly** how TCP reacts to packet loss.

(b) Assume a Voice over IP (VoIP) session was established over TCP and a packet gets lost. **What will happen? How would the user experience be affected?**

(c) In your opinion, **is TCP the best choice for VoIP?**

Question 2: $(8 + 4 + 4 + 4 = 20$ points) *TCP's RTT Estimation*

Consider the TCP procedure for estimating Round Trip Time (RTT).

Let $\texttt{SampleRTT}_{\texttt{new}}$ be the most recent sample RTT and $\texttt{EstimatedRTT}_{\texttt{old}}$ the RTT estimated after the previous sample. The new estimated RTT $\texttt{EstimatedRTT}_{\texttt{new}}$ [1] can then be expressed as:

$$\texttt{EstimatedRTT}_{\texttt{new}} = (1 - \alpha) \cdot \texttt{EstimatedRTT}_{\texttt{old}} + \alpha \cdot \texttt{SampleRTT}_{\texttt{new}} \tag{1}$$

Note: After the first $\texttt{SampleRTT}_{\texttt{new}}$, the $\texttt{EstimatedRTT}_{\texttt{new}}$ is set to the $\texttt{SampleRTT}_{\texttt{new}}$.

(a) Assume that $\alpha = 1/8$ and a TCP connection has measured the following SampleRTT values in this order: First $40ms$, then $42ms$, then $38ms$. **What is the $\texttt{EstimatedRTT}_{\texttt{new}}$ after the arrival of the third packet? Justify your answer with short calculations.**

(b) Why is this averaging procedure called an exponential weighted moving average?

(c) Why does TCP not use a simple arithmetic average?

(d) Why does TCP avoid measuring the SampleRTT for retransmitted segments?

Question 3: $(10 + 10 = 20$ points) *TCP Sequence Number Space*

Consider transferring a very large file of L bytes from host A to host B using a single TCP connection.

(a) Assume that the file is transferred in a single TCP connection. What is the **maximum value of L** (the maximum file size) such that TCP sequence numbers do not need to wrap around? **How many GB is this?**

Hint #1: Recall that the TCP sequence number field is 4 bytes.

Hint #2: Be careful with the conversion factor - 1 Gigabyte is ~~not~~ 1000 Megabyte!

(b) Assume a Maximum Segment Size (MSS) of 1434 bytes, a total of 66 bytes of transport, network, and data-link header added to each segment, and a constant bandwidth of 60 Mbit/s. For simplicity, ignore flow and congestion control, i.e., A can pump out the segments back to back and continuously. For the L just obtained, indicate **how long it takes to transmit the file**.

Hint: Again, be careful about converting Mbit/s to Bytes/s!

Please turn!

[1] See SRTT calculation in section 2.3 of RFC6298: https://tools.ietf.org/html/rfc6298

Question 4: $(5 + 5 = 10$ points) *TCP Sequence Numbers*

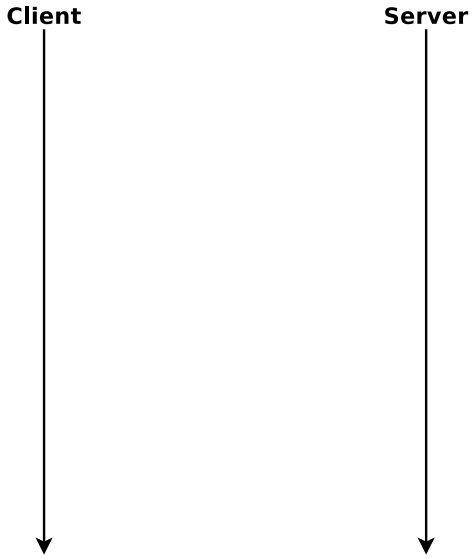
Suppose host A sends two TCP segments back-to-back to host B over a TCP connection. The first segment has sequence number 3851; the second has sequence number 4317.

(a) How much data (in bytes) is in the **first segment**?

(b) Suppose the first segment is lost but the second segment arrives at B. In the acknowledgment that B sends to A, what will be the **acknowledgment number**? Please briefly explain why.

Question 5: $(20 + 20 = 40$ points) *TCP Handshake and Teardown*

TCP is a connection-oriented transport protocol. In this question we will have a closer look at TCP's connection management. **Both questions should be answered by drawing one diagram like the following:**



(a) Enter a **successful connection setup** into a diagram as presented above. Label the arrows with the relevant parts of the TCP header (flags, sequence number, acknowledgment number). The initial (randomly chosen) sequence numbers of client and server are 73541 (Client) and 28400 (Server).

(b) Enter the **successful connection teardown** into another diagram as the one presented above. Assume that the client closes the connection first and that the server does not send any additional data after that.

Again label the arrows with the relevant parts of the TCP header (flags, sequence number, acknowledgement number). Assume that after the connection setup from part (a) some data was transferred: 1500 bytes from client to server, and 15000 bytes from server to client. Consider these values when determining sequence and acknowledgment numbers.

Due Date: Wednesday, December 2nd 2020 11.59 pm (end of day)

- **As PDF files (no MS Office or OpenOffice files)**, uploaded via ISIS: `https://isis.tu-berlin.de/course/view.php?id=21979`
- Put the names and Student ID numbers (Matrikelnummer) of **all** your group members **and** the tutorial slot on your solution!