Congestion Control

11.1 Fairness

Consider the situation in which two hosts, A and B, are concurrently using a 1 Mbps link with a Maximum Segment Size (MSS) of 100 kb.

Assuming that B starts with 500 kbps and A with 200 kbps (see left picture). Describe the evolution of the throughput of the two hosts when:

a) A and B rely on Additive Increase Multiply Decrease (AIMD).

b) A and B rely on Multiplicative Increase Additive Decrease (MIAD).

Assume now that only A is malicious, and wants to cheat congestion control to get more throughput. Describe two distinct ways A could do so and what would be the net effect on B's throughput.
11.2 Congestion Window

Consider the following plot which depicts the evolution of the size of the TCP congestion window of the sender.

![Plot of TCP congestion window evolution](image)

What kind of network conditions is this flow seeing?

Describe briefly:

a) What happens at point B?

b) Does the event happening at point B require the network to discard packets? Why or why not?

c) What happens at point E?

d) Does the event happening at point E require the network to discard packets? Why or why not?

Consider that the Maximum Segment Size (MSS) of the connection is 1 kB and the Round-Trip Time (RTT) between the two end points is 100 milliseconds. The sender opens the connection at time $t = 0$. Transmission delay in this network is negligible, so you should only consider the propagation delay in the following.

e) How much time has elapsed at point A?

f) How much time has elapsed between point C and D?

g) How much time has elapsed between point F and point G?

Briefly explain how come point D is higher than point B. Would you expect this to happen often?
In this task, you will draw the Congestion Window (CWND) evolution in reaction to the available capacity of a link in a network. The CWND follows the well-known TCP congestion control algorithm using slow-start. Whenever the CWND value exceeds the current link capacity, the CWND algorithm will react in the following way:

1. The current CWND value is kept for the entire next RTT (no increase or decrease);

2a. If the current link capacity was exceeded by at most 2 kBs, the CWND algorithm will observe three duplicate ACKs during the next RTT and will react appropriately (see the figure above on the left);

2b. If the current link capacity was exceeded by more than 2 kBs, the CWND algorithm will reach its timeout during the next RTT and will react appropriately (see the figure above on the right right).

Draw the CWND evolution directly into the figure on the next page in reaction to the link capacity indicated with the continuous line. Start at the bottom left corner (RTT 1, CWND 1 kB) and assume that the CWND corresponds to a flow that just started, e.g. you are in the slow-start phase. You can stop once you reach RTT 22. To help you, a correct portion of the CWND is plotted between RTT 11 and 14 (dashed line).
11.4 File Transfer over TCP

Consider the topology shown on the left-hand side. Host A opens a TCP connection to host B, and starts sending a file of size $F=10$ bytes, in segments of size $MSS=1$ byte each. As a result of a faulty link, the 5th packet transmitted by A (without counting the SYN packet in the TCP handshake) is lost.

Assumptions:

- The transmission delay for packets is negligible.
- The round-trip time between A and B is $RTT_1$.
- The transmission timer of host A has a fixed duration equal to $2 \cdot RTT_1$.
- TCP has Fast Retransmit disabled.
- A TCP receiver sends an ACK for each packet it receives.
- Host A does not send a separate ACK to acknowledge the SYN-ACK, but instead starts sending the first data segment.
- The first segment that A transmits will have a sequence number of 1.
- Host B stores (does not discard) all out-of-order packets.

Tasks:

a) Complete the sequence diagram on the next page with all packets exchanged between A and B (we have completed part of the diagram to help you get started).

b) Calculate how much time it takes for B to finish receiving the file (Note: The one-way propagation delay from A to B is $RTT_1/2$).
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<tbody>
<tr>
<td>1</td>
<td>=</td>
<td>-</td>
<td>A SYN, SEQ = 0</td>
<td>B SYN, ACK = 1</td>
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Now, assume A uses an application-layer proxy P to transmit the file to B, as shown on the left-hand side figure.

When P receives a connection request from A, it connects a TCP socket with B. After that, the proxy application receives data from the TCP socket connected to A (the input socket), and writes data out to the TCP socket connected to B (the output socket). P forwards these packets to the output socket the moment it can read them from the input socket. The proxy’s operations do not incur any processing delay.

P is located exactly in the middle of the path between A and B, such that the round-trip times between A and P, and between P and B are both equal to \( \text{RTT}_2 = \frac{\text{RTT}_1}{2} \).

The faulty link described previously is now located on the part of the path between P and B. As such, the 5th packet transmitted on that part of the path is lost. No packet loss occurs on the part of the path between A and P.

Tasks:

\( c) \) Calculate the time it takes for the file transfer to be completed in this new setting (Note: Do not forget to adjust the timeout interval for the two TCP flows; from A to P, and from P to B. The timeout interval for the two flows is equal to \( 2 \cdot \text{RTT}_2 = \text{RTT}_1 \)).

\( d) \) Does the introduction of the application-layer proxy in the previous part improve or worsen the file transfer? Which features of TCP are responsible for this?

DNS

11.5 Local DNS server

You can perform DNS lookups with `dig` (Linux/Mac) or `nslookup` (Windows). First, perform a lookup for `nyu.edu` using your default DNS server by running the command `dig nyu.edu` or `nslookup nyu.edu`.

- What is the IP address of the server behind `nyu.edu`?

Now, perform the same lookup, but use one of the DNS root servers (e.g., `a.root-servers.net`) by running

`dig @a.root-servers.net nyu.edu`

`nslookup nyu.edu a.root-servers.net`

- Why does the answer differ compared to the one from your local DNS server?
- How would you proceed with this answer to find the IP address behind `nyu.edu`?

\(^1\)If the `nslookup` command does not yield helpful output for you, try adding `-type=soa` after `nslookup`. (For some, it may be the other way round—adding this option may hide the relevant part in the output.)
Assume you are the operator for the DNS sub-domain ee.ethz.ch. The responsible of the Networked Systems Group (NSG) reaches out to you as they want to create and independently maintain their own DNS sub-domain nsg.ee.ethz.ch. Among others, they want to create DNS names for:

- their group webpage www.nsg.ee.ethz.ch, pointing at 129.132.30.1;
- a project webpage fun.nsg.ee.ethz.ch, also pointing at 129.132.30.1;
- their chat room chat.nsg.ee.ethz.ch, pointing at 129.132.30.2; and
- a mail server mail.nsg.ee.ethz.ch, pointing at 129.132.30.3 and which should receive any email sent to a@nsg.ee.ethz.ch email address.

Unfortunately, the responsible of NSG does not seem to understand much about DNS. He needs your help to set this up.

You start by setting up two DNS name servers ns1.nsg.ee.ethz.ch and ns2.nsg.ee.ethz.ch which you host on 129.132.20.1 and 129.132.20.2, respectively.

a) Indicate the resource records that these two DNS servers should store. For each record, indicate its corresponding name, type, and value. Note you might not need all 6 records.

Record #1. Name: ____________ Type: ______ Value: ______________

Record #2. Name: ____________ Type: ______ Value: ______________

Record #3. Name: ____________ Type: ______ Value: ______________

Record #4. Name: ____________ Type: ______ Value: ______________

Record #5. Name: ____________ Type: ______ Value: ______________

Record #6. Name: ____________ Type: ______ Value: ______________

b) Indicate the resource records that need to be added (if any) to the name servers responsible for ee.ethz.ch. Briefly explain the usage of these extra records or why no such extra record is needed. Note you might not need all 4 records.

Record #1. Name: ____________ Type: ______ Value: ______________

Record #2. Name: ____________ Type: ______ Value: ______________

Record #3. Name: ____________ Type: ______ Value: ______________

Record #4. Name: ____________ Type: ______ Value: ______________
c) Indicate the resource records that need to be added (if any) to the name servers responsible for ethz.ch. Briefly explain the usage of these extra records or why no such extra record is needed. *Note you might not need all 4 records.*

Record #1. Name: ___________  Type: ____  Value: ________________

Record #2. Name: ___________  Type: ____  Value: ________________

Record #3. Name: ___________  Type: ____  Value: ________________

Record #4. Name: ___________  Type: ____  Value: ________________

d) While setting up the records, you observe that NSG wants to host two webservers (for www and fun) on the same IP address (129.132.30.1). Is that possible? If so, briefly explain how this works. If not, briefly explain why.

e) It looks like you underestimated NSG's popularity! It appears the two name servers ns1.nsg.ee.ethz.ch and ns2.nsg.ee.ethz.ch are completely overloaded with (legitimate) DNS requests.

Explain two *distinct* techniques you could use to scale the system further.