CS 168 Section 7: Advanced Congestion Control

1. TCP Fast Recovery

Consider a TCP connection, which is currently in Congestion Avoidance (AIMD).

- The last ACK sequence number was 101 (the receiver expects the packet #101 for next).
- The CWND size is 10 (in packets).
- The packets #101-110 were sent at \( t = 0, 0.1, ..., 0.9 \) (sec), respectively.
- The packet #102 is lost for its first transmission.
- RTT is 1 second.

Fill in the tables below, until the sender transmits the packet #116.

(a) Without Fast Recovery

- *On new ACK*, \( CWND = CWND + \frac{1}{\text{CWND}} \)
- *On triple duplicate ACK*, \( SSTHRESH = CWND/2 \), then \( CWND = SSTHRESH \)

<table>
<thead>
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<th>CWND</th>
<th>xmit</th>
</tr>
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<tr>
<td>1.0</td>
<td>102 (101)</td>
<td>10+1/10</td>
<td>111</td>
</tr>
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<td>1.2</td>
<td>102 (103)</td>
<td>10+1/10</td>
<td>-</td>
</tr>
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</table>
(b) Fast Recovery

- **On triple duplicate ACK,** $SSTHRESH = CWND/2$, then $CWND = SSTHRESH + 3$, and enter fast recovery
- **In fast recovery,** $CWND += 1$ on every duplicate ACK
- **Exit fast recovery on new ACK,** setting $CWND = SSTHRESH$

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(c) Consider a scenario where two packets are lost: #102 and #107. What would happen, if we have Fast Recovery or not?
2. TCP Throughput Equation

The following equation provides a simple way to estimate the throughput of a TCP connection, as a function of the loss probability \( p \) and the round-trip time \( RTT \).

\[
\text{Throughput} = \frac{\sqrt{3}}{2} \frac{1}{RTT \sqrt{p}}
\]

(a) Derive the above equation yourself!

(b) Alice wants to send a large amount of data to Bob, over a network path with \( RTT = 100 \text{ms} \), \( p = 0.01 \), and \( \text{MSS} = 10,000 \text{bits} \). What is the expected throughput in Mbps? \( \left( \frac{\sqrt{3}}{2} \approx 1.22 \right) \)

(c) Alice has two options to improve the throughput: halving either the RTT or the loss probability \( p \). If the both options cost the same, which one is more cost effective?

(d) Food for thoughts: Considering how the equation is derived, what assumptions does it need for accurate prediction? When is it possible that they may not hold in reality?

- e.g., RTT is predictable. \( \leftarrow \) RTT may fluctuate at a short time scale, for example, due to queueing delay.