Problems of TCP in Wireless

• Congestion control algorithm has been designed for wired/fixed networks
  – In fixed networks a packet loss is an indication of congestion
  – In wireless networks packet lost is due to transmission errors or mobility

• TCP cannot distinguish between errors and congestion
  – TCP unnecessarily reduces window, resulting in low throughput and high latency

• Delay is often high
  – RTT can be very long and variable

• TCP's timeout mechanism may not work well
  – Links may be asymmetric
  – Delayed ACKs in the slow direction can limit throughput in fast direction
TCP Enhancements for Mobility

• Fast retransmission, fast recovery
• Indirect TCP
• Snooping TCP
• Selective retransmission
Slow Start and Additive Increase

- After a **timeout**
  - The threshold is cut to \( \frac{1}{2} \) of the current CWS
  - Slow start begins anew and continues until CWS = threshold
  - Then additive increase is used to continue to increment CWS until the next timeout
Fast Retransmit

- Retransmit before timeout
  - Receiver resends ACK of last packet received in sequence for each new (out of sequence) arrived packet.
  - When Sender receives 3 consecutive duplicate ACKs, it assumes next packet is lost and retransmits.
  - Sender uses slow start as if a timeout caused the retransmission
- **fast retransmit**
  - Does not change the shape of the congestion window growth curve
  - Only reduces the delay in restarting the slow-start process
Fast Recovery

• Slow start only when
  – A connection is established
  – A timeout occurs
• Additive increase / multiplicative decrease used at all other times
  – Specifically, when a fast retransmit occurs
  – Slow-start is omitted if no timeout occurs
  – Timeouts are still likely if multiple packets are lost, the time before the next retransmission is longer and slow start will occur
Selective Retransmission (SACKs)

- TCP acknowledgments are often cumulative
  - ACK n = correct and in-sequence receipt of packets up to n
  - If single packets are missing quite often a whole packet sequence beginning at the gap has to be retransmitted (go-back-n), thus wasting bandwidth

- Selective retransmission as one solution
  - RFC2018 allows for acknowledgments of single packets, not only acknowledgments of in-sequence packet streams without gaps
  - Sender can now retransmit only the missing packets
Indirect TCP

- Split a TCP connection at the FA to 2 TCP connections
  - No changes to the TCP protocol for hosts connected to the wired Internet
  - Optimized TCP protocol for mobile hosts
Indirect TCP handover

• During handover, the buffered packets, as well as the system state (packet sequence number, ACKs, ports, etc.), must migrate to the new agent.
Snooping TCP

- Snooping TCP
  - One TCP session.
  - The foreign agent snoops into the traffic and buffers packets for fast re-transmission.
  - **Transparent** extension of TCP within the foreign agent.

![Diagram of Snooping TCP](image)
## Summary

<table>
<thead>
<tr>
<th>Approach</th>
<th>Mechanism</th>
<th>Advantage</th>
<th>Disadvantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indirect TCP</td>
<td>Split TCP connection into two connections</td>
<td>Good isolation of wireless link</td>
<td>Loss of TCP end-to-end Semantics, higher handover latency</td>
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<tr>
<td>Snooping TCP</td>
<td>“snoop” TCP segments and ACKs and issue local retransmissions if necessary</td>
<td>Transparent for end-to-end connection</td>
<td>Does not work with Encryption, insufficient isolation of wireless link</td>
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<tr>
<td>Fast retransmit / fast recovery</td>
<td>Avoids slow start after single packet loss / roaming</td>
<td>Simple</td>
<td>No optimal isolation of wireless link, mixed layers</td>
</tr>
<tr>
<td>Selective retransmission</td>
<td>Retransmit only lost data</td>
<td>Very efficient</td>
<td>Slightly more complex, more buffer space needed</td>
</tr>
</tbody>
</table>
Question-1

• (a) When indirect TCP is applied, describe a scenario when the TCP end-to-end semantics can no longer hold.

• (b) When comparing indirect TCP and snooping TCP, which one has a higher handover latency (when the mobile host moves from one cell/foreign network to another)? Briefly justify your answer.
(c) Consider the plot of the TCP window size as a function of time shown in Figure 1. After the 16th transmission round, is segment loss detected by a triple duplicated ACK or by a timeout?
Question-1

- (d) What are the influences of encryption on the proposed schemes? Consider for example IP security that can encrypt the payload, i.e., the TCP packet.
Question 2

• Paper reading
  – MAUI: Making Smartphones Last Longer with Code Offload

• 802.11 has a special power-save mode (PSM), where the radio transmitter is put to sleep and then periodically woken up to receive packets.
  – What effect has the PSM on saving energy for data transfers?
  – How does this correlate with different RTTs?
Question 3 and 4

• What advantages does the use of IPv6 offer for mobility?
• List the differences and similarities between Mobile IP and SIP in terms of what they provide for mobility?
Exam question (mandatory)

• Your task is to create an exam question including a (correct) solution for one of topics of the wireless network part of the lecture.

• If your question is extraordinary, we might use (a modified version of) it in the actual exam.

• Please note the following facts:
  – The deadline to submit your exam question is May 8th.
  – Email your exam question either as pdf or as correct LATEX code to your assistants and Patrick.
  – It should be a non-trivial question (i.e., not a pure knowledge question).

• Good luck!