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“Investigations on TCP Behavior during Handoff”

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Outlook

1. Transport Control Protocol - TCP
   - Overview
   - TCP versions
2. Simulation scenarios
   - Local Handoff
   - Vertical Handoff
3. Simulation results
4. Conclusions

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Transport Control Protocol – TCP

- most reliable best effort transport protocol in today's Internet
- reliable end-to-end transport
  - positive acknowledgements
  - detection of packet loss ? retransmission
- end-to-end flow control
  - avoid network congestion and system overload
  - send packets with adaptive data rate
  - packet loss = congestion

TCP Tahoe

- all four versions
  - Slow Start, Congestion Avoidance
  - Fast Retransmit
  - Retransmission Timeout (RTO)
- TCP Tahoe:
  - loss of packets - send all following packets
  - after Fast Retransmit – Slow Start
  - same behavior like RTO, but no delay before the Slow Start

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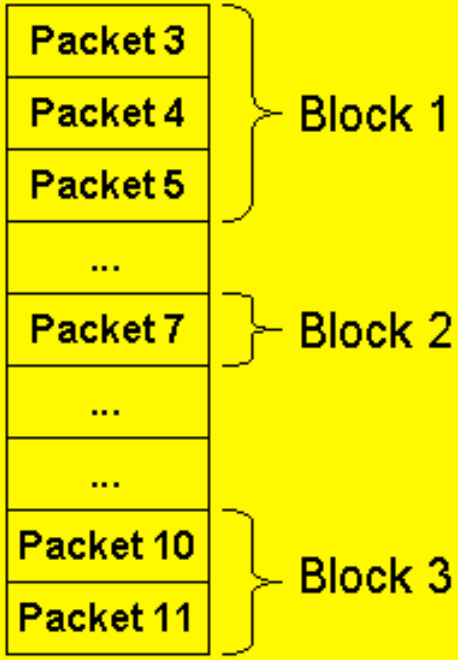
TCP Reno, TCP NewReno

- both support Fast Recovery
- different behavior, if more than one packet lost
  - TCP Reno
    - for each lost packet - three dup Acks necessary
  - TCP NewReno
    - after each Ack of a retransmitted packet send the following lost packet

TCP Sack

- Selective Acknowledgement (Sack)
- different Fast Recovery
  - controls the retransmission of the second and the following lost packets



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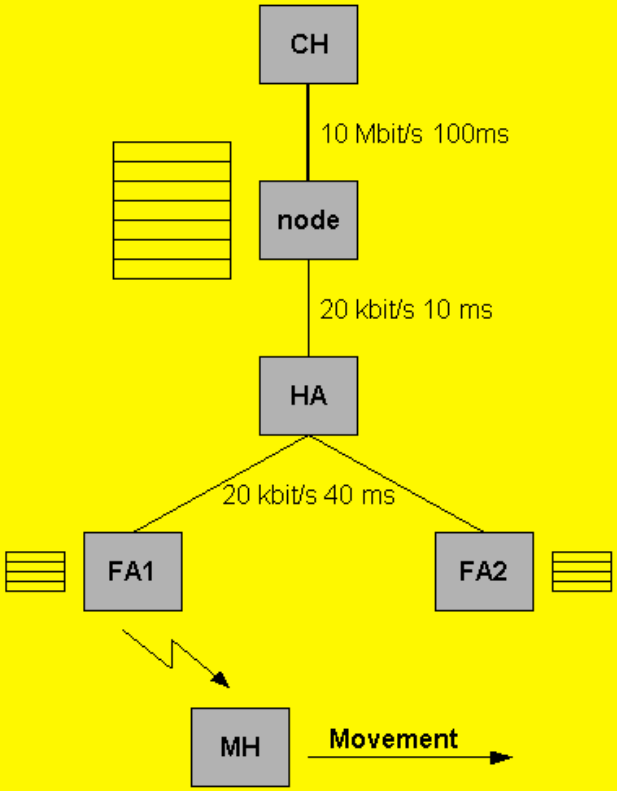
Model

- handoff in a cellular mobile network like GPRS/UMTS
- TCP Tahoe, TCP Reno, TCP NewReno, TCP Sack
- usage of flow control and packet forwarding
- different scenarios:
  - Local Handoff
  - Vertical Handoff with packet forwarding
  - Vertical Handoff without packet forwarding

Local Handoff

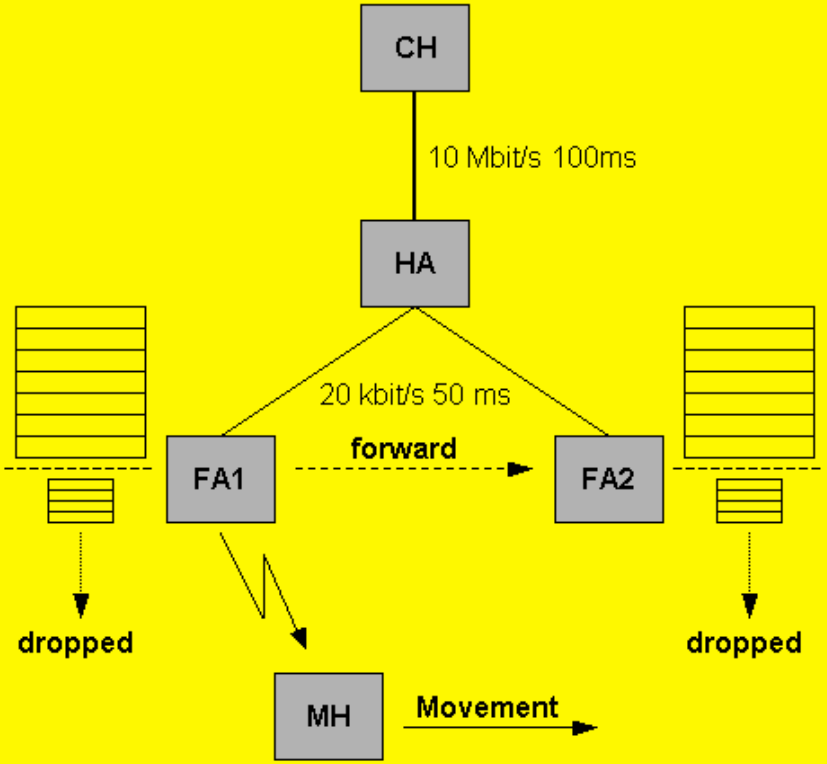
- usage of the flow control
  - loss of max. 6 packets
- big queue near the HA
- ? MH receives all queued packets before the retransmitted packets



CH - Correspondent Host, HA - Home Agent, FA - Foreign Agent, MH - Mobile Host

Vertical Handoff

- packet forwarding
- ? packet reordering
- MH receives out of order packets
- loss of max.6 or all packets (with or without PF)



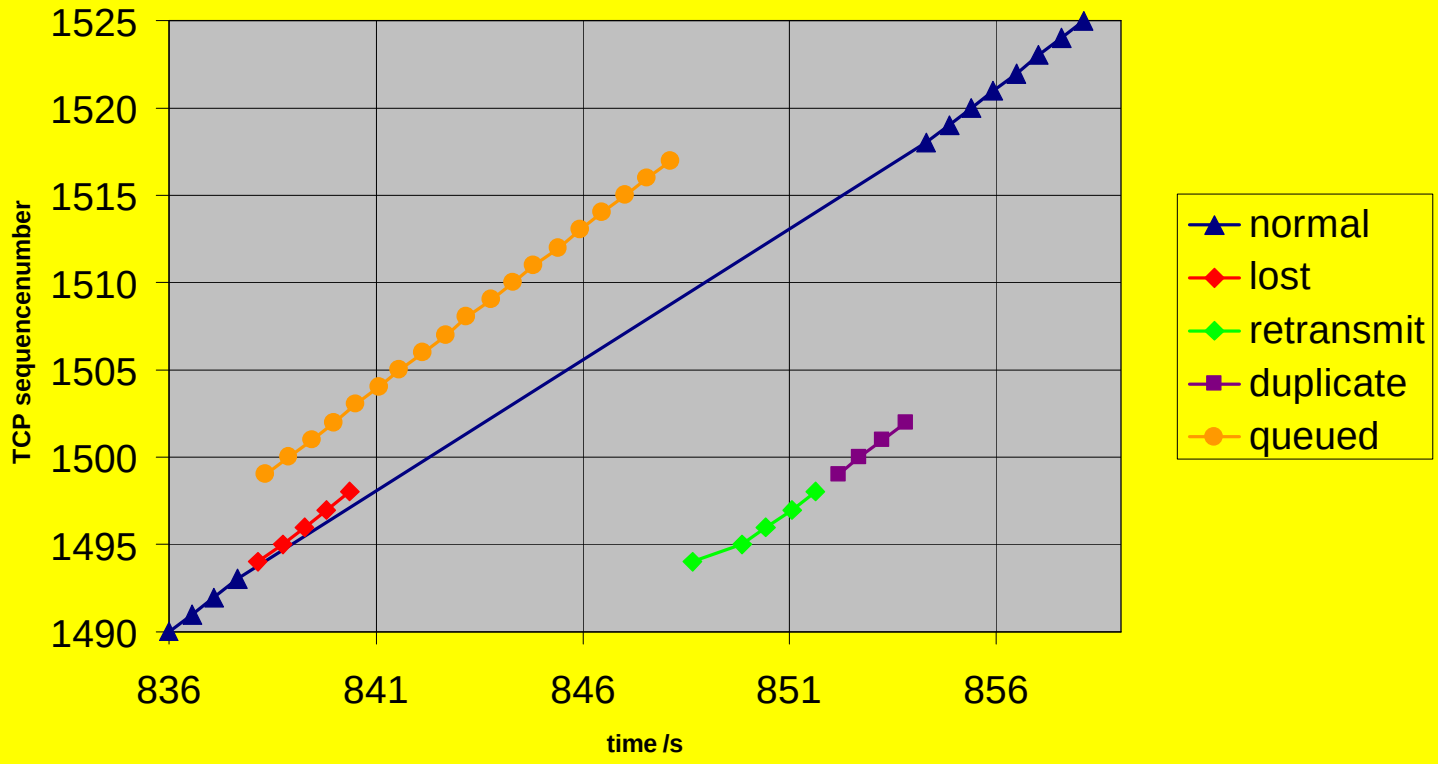
CH - Correspondent Host, HA - Home Agent, FA - Foreign Agent, MH - Mobile Host

Simulations

- simulationtool – ns2
- MobileIPv4 architecture
- FTP connection from CH to MH (downlink)
- bandwidth of the wireless channel – 20 kbit/s or 320 kbit/s
- errorless wireless channel
- without ARQ

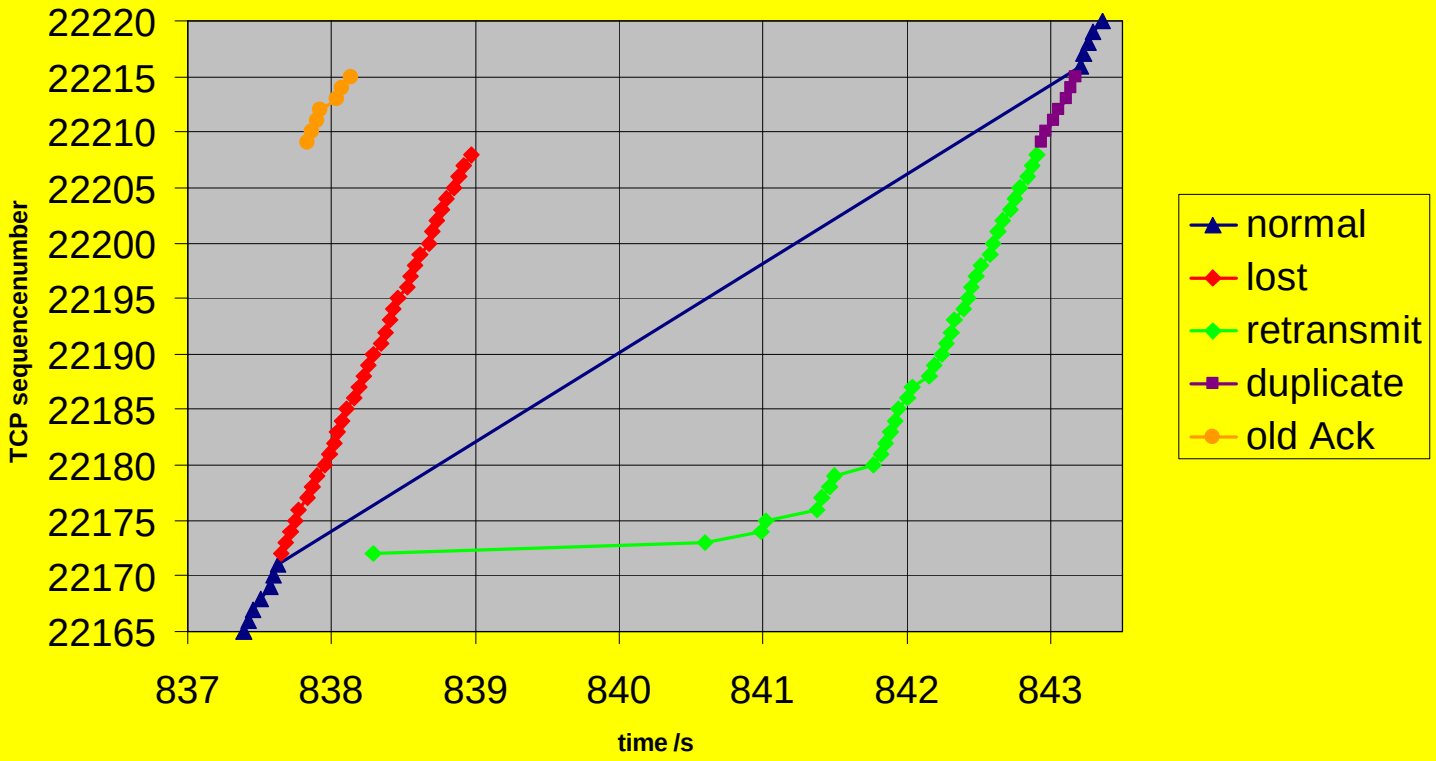
TCP Tahoe

- TCP Tahoe during Local Handoff with 20 kbit/s
- duplicate packets = lost packets - 1



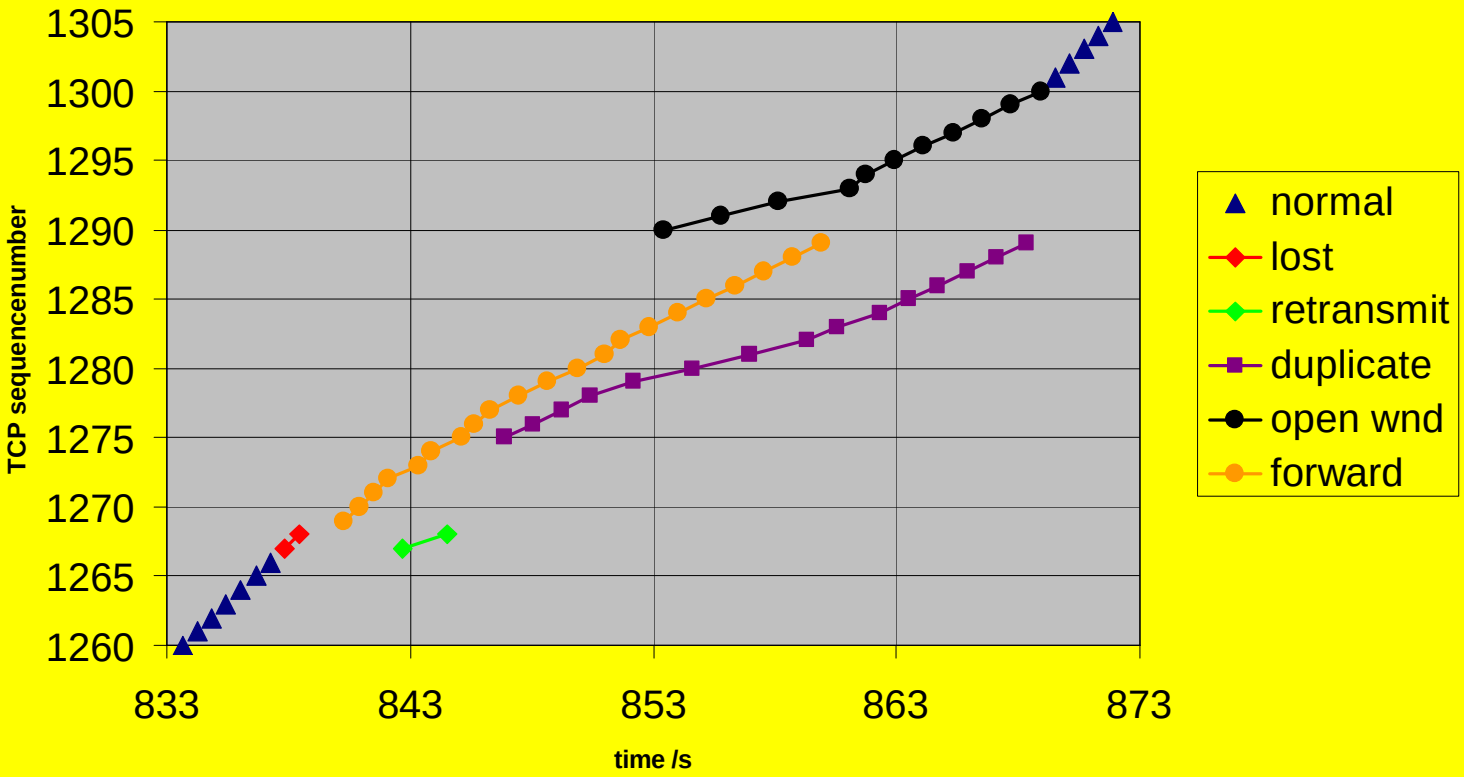
TCP Sack

- TCP Sack during Vertical Handoff without packet forwarding and 320kbit/s
- RTO, if lost packets > cwnd ? 0,5



TCP NewReno

TCP NewReno during Vertical Handoff with packet forwarding and 20kbit/s



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Conclusions

- each TCP version experiences performance degradation
- best performance: Local Handoff
- worst case: Vertical Handoff without packet forwarding
- usage of packet forwarding
  - number of duplicate packets minimized
    - mobile receives all forwarded packets before the last retransmitted packet
- SPF – spurious packet filter
  - no transmit of duplicate packets over wireless link (bottleneck)