WTCP: A Simple Mechanism for Improving TCP performance for Wireless Users

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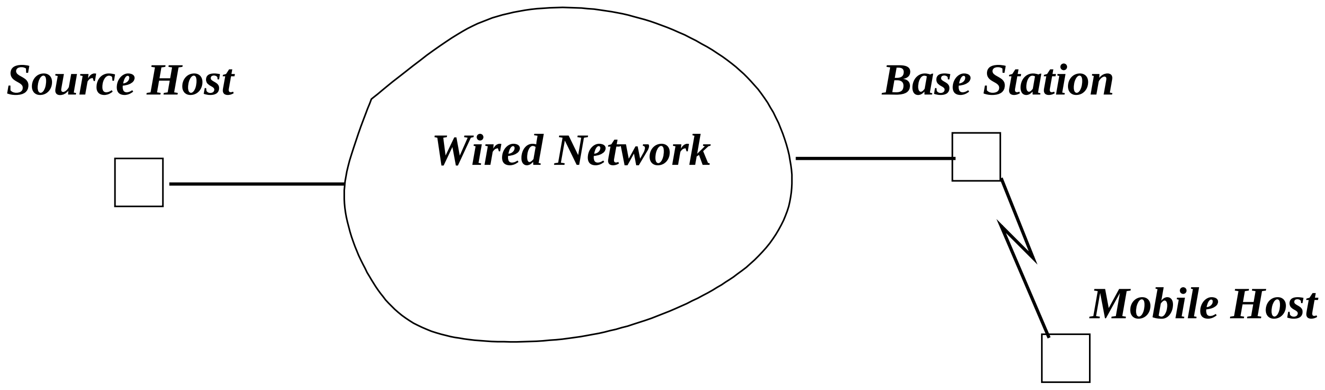
Wireless Access

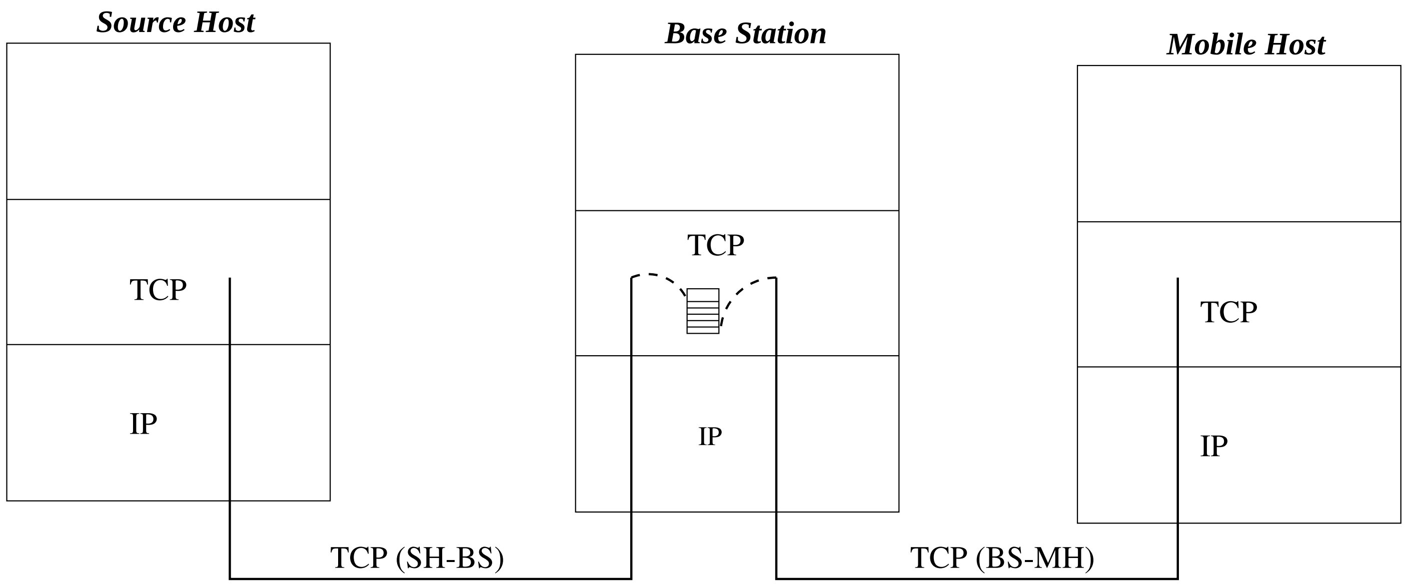


- Packet losses are due to congestion, transmission errors, mobility, etc.
- TCP assumes any loss is due to congestion
- **GOAL**: Hide wireless losses from TCP

Previous Approaches and their Shortcomings

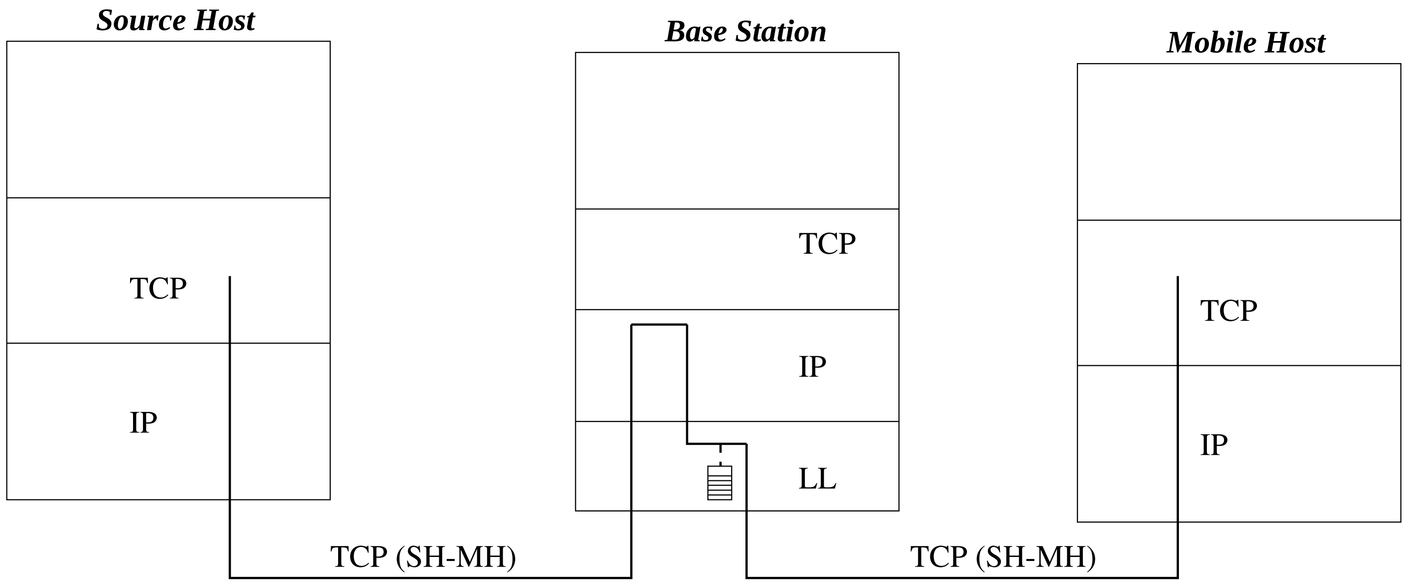
- All rely on local retransmission from base station
- I-TCP [Bakre *et al.* '95], MTCP [Brown *et al.* '96]
  - Does not maintain end-to-end semantics
- Snoop [Balakrishnan *et al.* '95]
  - Does not completely shield all wireless losses

Previous Approaches: I-TCP [Bakre *et al.* '95]



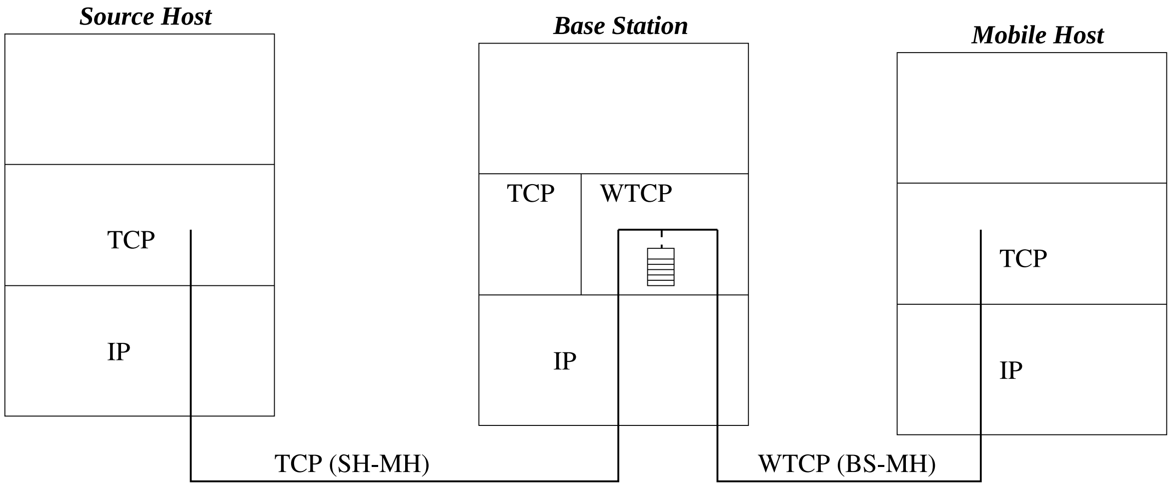
- Split connection:
  - TCP1: Source Host – Base Station
  - TCP2: Base Station – Mobile Host
- TCP's end-to-end semantics is violated

Previous Approaches: Snoop [Balakrishnan *et al.* '95]



- Link-level retransmission from base station based on duplicate acknowledgment, and timeout for retransmitted packets
- Does not completely shield wireless link errors

Our Approach: WTCP



- Does not require TCP code modification at source or mobile host
- Maintains end-to-end semantics
- Base station buffers TCP packets, and locally retransmit lost data to mobile host based on timeout and duplicate ack
- No congestion control on the wireless link
- Burst error state of the wireless link is detected and transmission is avoided
- Hides local recovery time from TCP-source

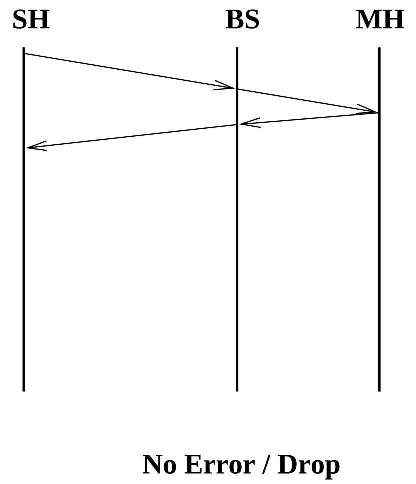
Window Control on Wireless Link

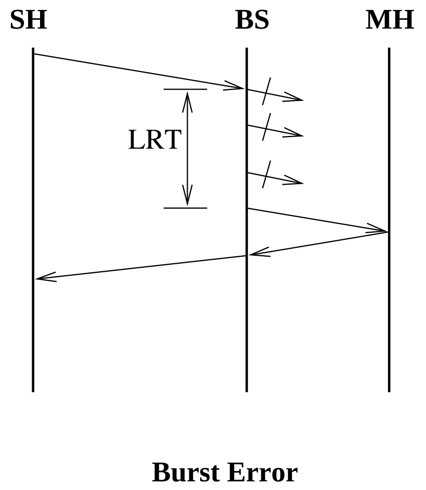
$$\text{WindowSize} = \min\,[\text{RcvrAdvrtsedWindow, ErrorWindow}]$$

$$\text{ErrorWindow} = \begin{cases} 1 & \text{if timeout} \\ \text{RcvrAdvrtsedWindow} & \text{if ack or dupack received} \end{cases}$$

Problem: Local Recovery Time

- Losses on wireless link may cause several retransmissions from base station (*i.e.* packets are buffered longer)





LRT = Local Recovery Time
RTT = Round Trip Time
SH = Source Host
BS = Base Station
MH = Mobile Host

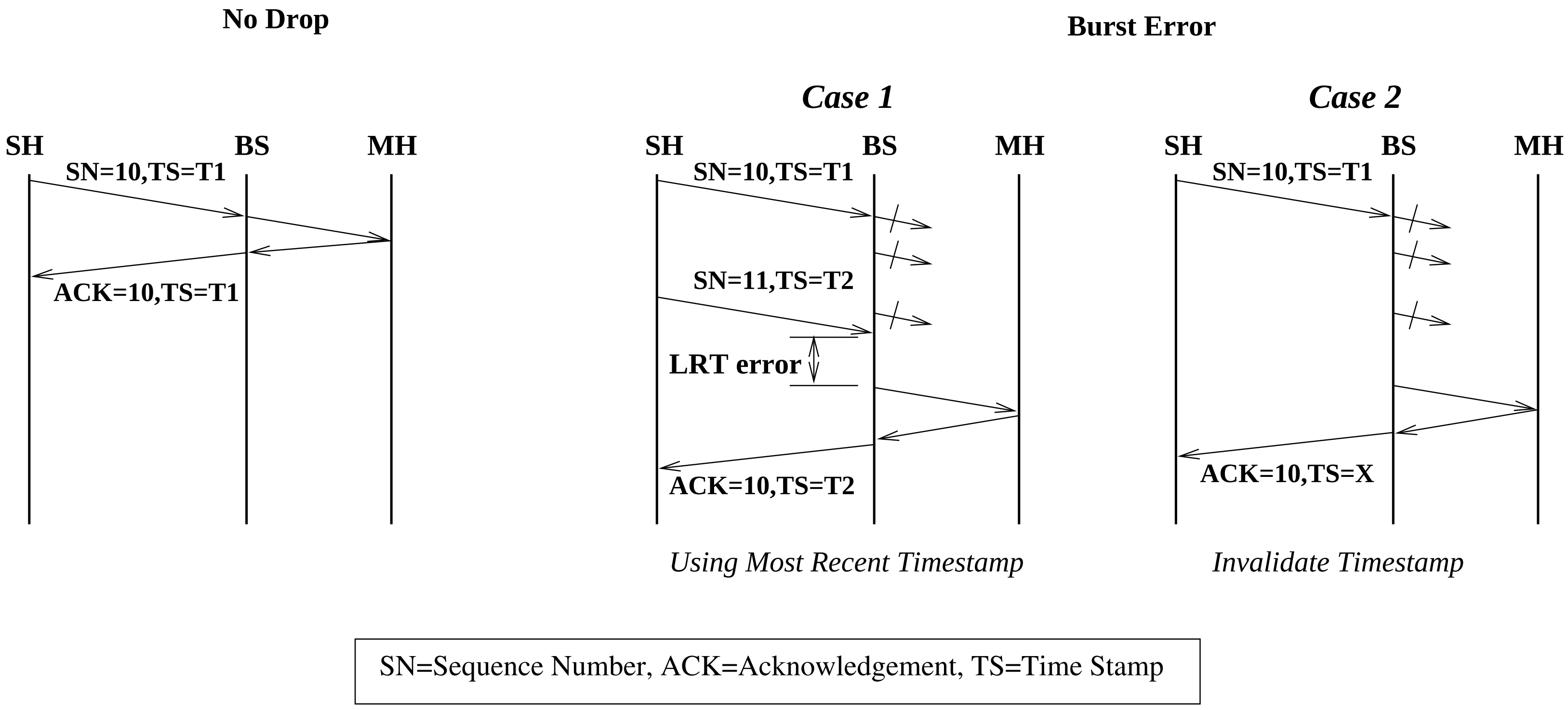
- This LRT affects the RTT estimated at the source

- Inaccurate RTT estimate hinders the source's ability to detect congestion losses on wired network

Solution: Hide Local Recovery Time

- **Ideal Solution:**
  - Base station subtracts actual LRT by modifying the timestamp field of each ack forwarded to source
  - *Not feasible!*
    Clock granularity of source and base station may not be identical

Our Solution to Hiding LRT



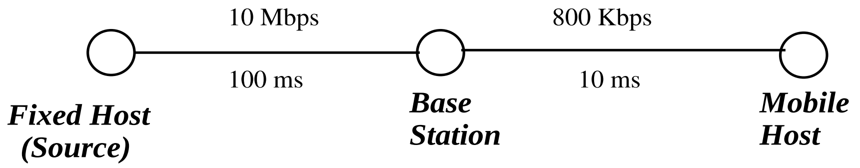
- After retransmission from BS, timestamp of packets transmitted to MH
  - replaced by timestamp of most recent packet received from source after the latest retransmission
  - invalidated if no packet is received from source after retransmission

Simulation Model

ns 1.2a3 (from LBL) extended to

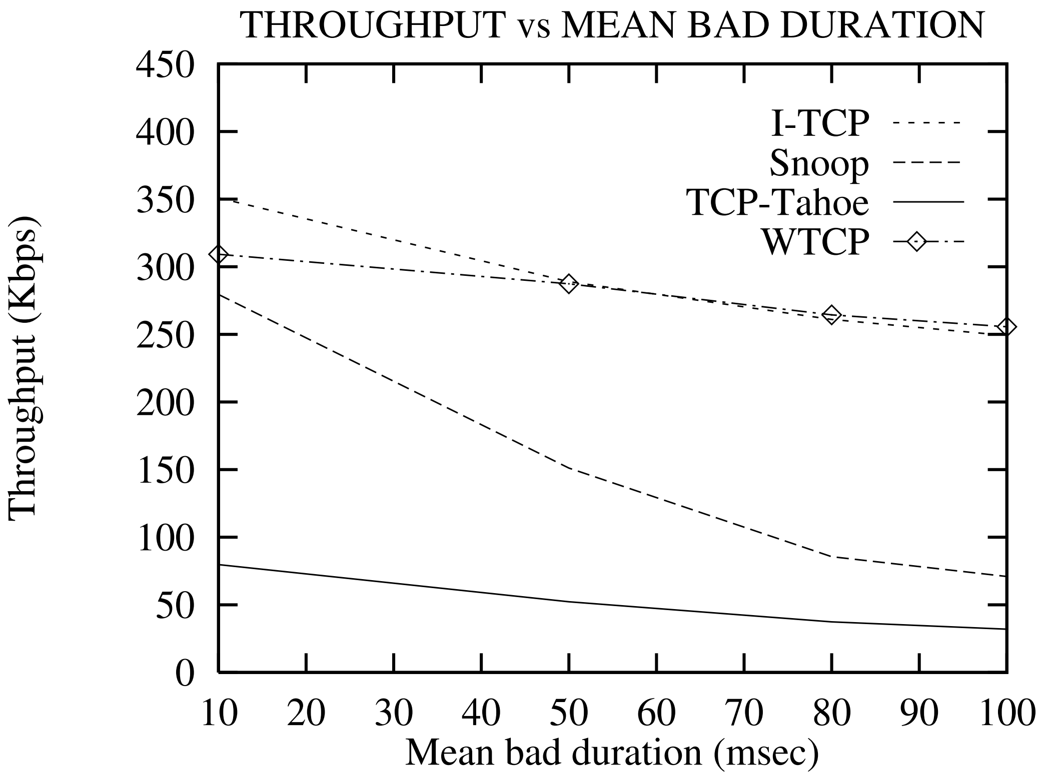
- simulate a base station node implementing WTCP, I-TCP, Snoop
- modify packet header to include receiver window advertisement
- model errors on wireless link:
    - two-state Markov model: *good state* and *bad state*
    - bit error rate (BER) is low in *good state*, and high in *bad state*
    - time spent in each state is exponentially distributed

Simulated Network



Parameter	**Value**
Maximum window size	10 Kbytes
Buffer size at base station	20 Kbytes
Segment size (including header)	1 Kbyte
BER in good state	10^{-6}
BER in bad state	10^{-2}
Mean good period	1 sec
Source clock granularity	100 ms
Base station clock granularity	10 ms

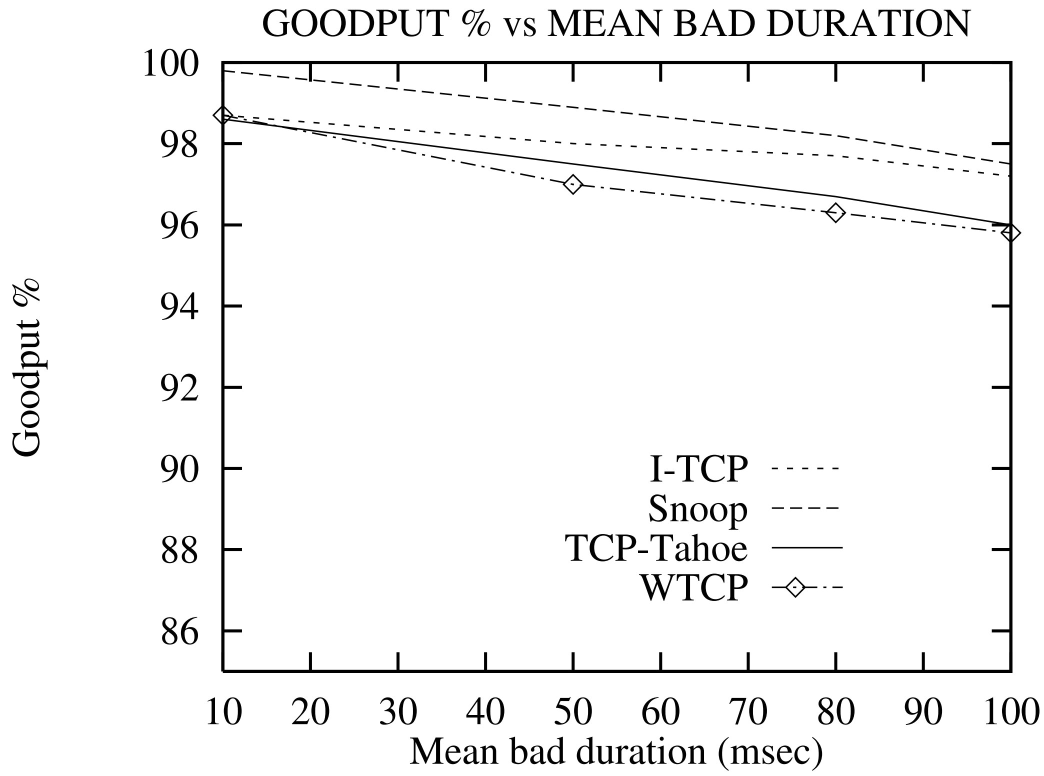
Simulation Results



- WTCP throughput is 4-8 times higher than TCP-Tahoe

- For long bad duration, WTCP is as good as I-TCP

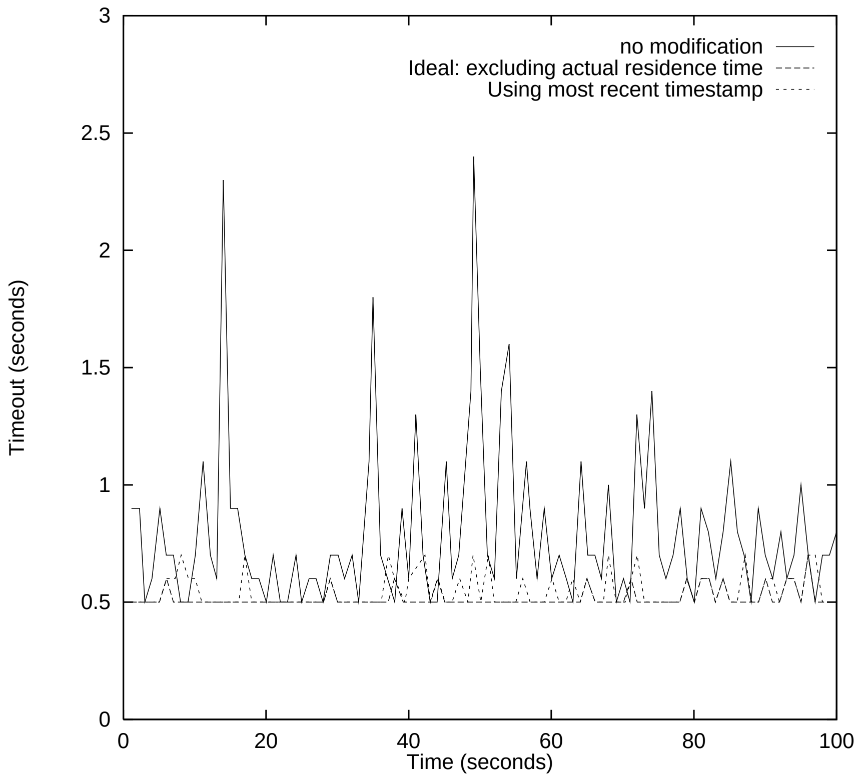
Simulation Results (cont'd)



- WTCP's aggressive retransmission policy slightly reduces goodput

- Throughput gain outweighs the loss in goodput

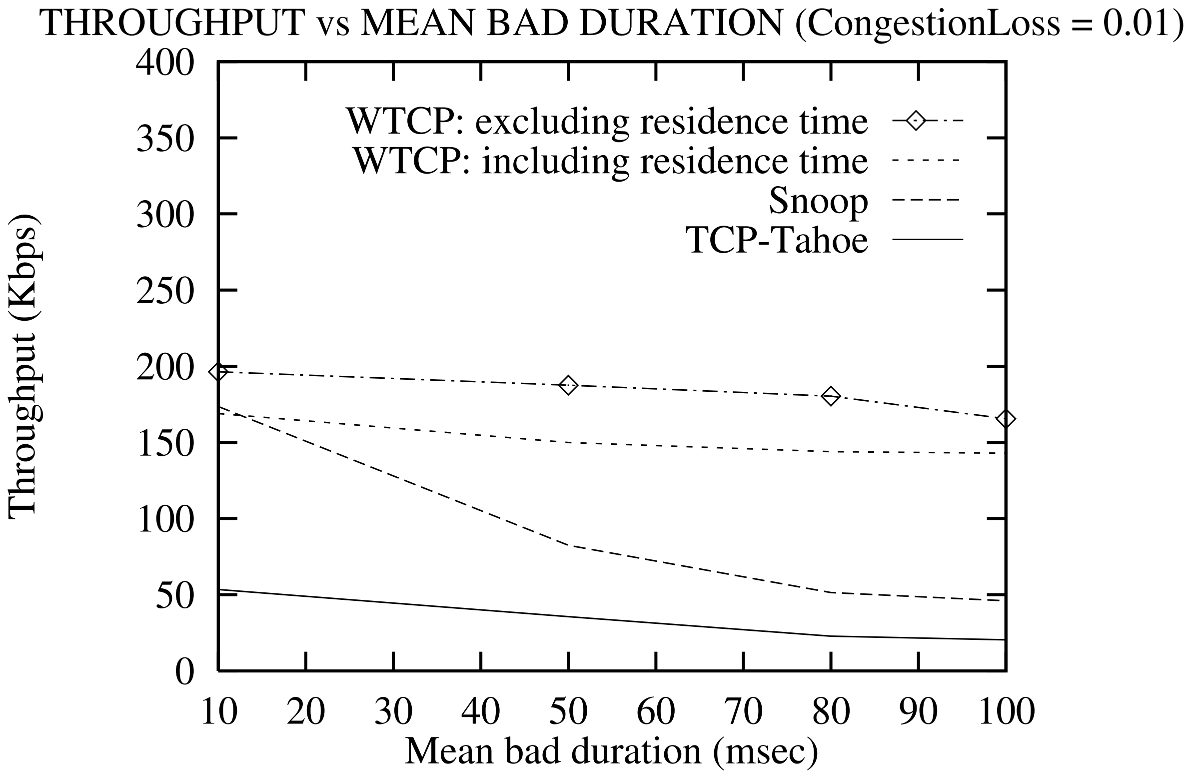
Effect of Hiding LRT



Mean bad duration = 100 msec.

- Using most recent timestamp is a *good* approximation to excluding exact LRT

Effect of Hiding LRT (cont'd)



Conclusion

- WTCP is an efficient mechanism for improving TCP over wireless links
- WTCP provides better or similar throughput compared to I-TCP, Snoop, TCP-Tahoe
- Hiding of local recovery time improves the ability to detect congestion losses in the wired network and hence the throughput

Future Work

- More complex scenarios
- Actual implementation and measurements