Improving TCP/IP Performance over Wireless Networks

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Wireless Networks

Characteristics:

- Low bandwidth.
- High bit error rates (BER).
- User mobility $\Rightarrow$ variable delays, packet losses.
- More common reliable/pseudo-reliable link-level protocols.

Problems with TCP

- Wireless losses mistaken for congestion.
- Bulk losses cause (coarse-granularity) timeouts.

Possible Solutions

Approaches

- *Hide wireless from sender*
  - Local retransmissions from base stations
- *Sender aware of wireless link*
  - Explicit notification of type of loss
  - Deduce type of loss at source

Alternatives:

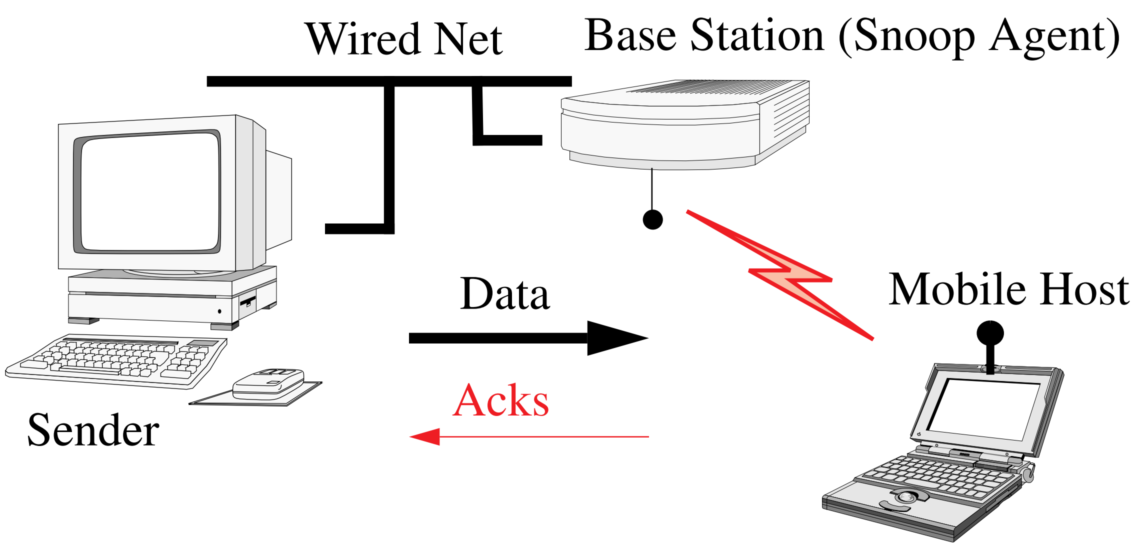
1. Link-layer protocols.
2. Split TCP (E.g., I-TCP).
3. TCP-aware agent at base station, maintain end-to-end semantics.

The Snoop Agent

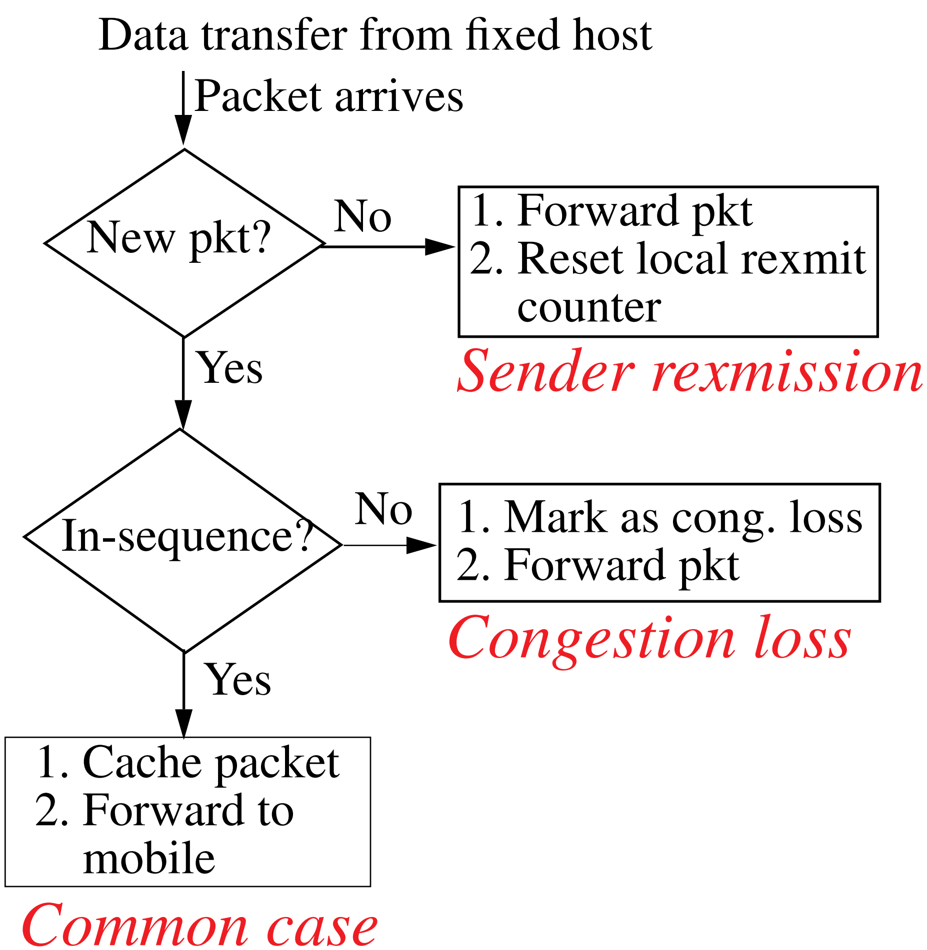
Snoop agent runs at the base station.

Cache unacknowledged packets at base station.

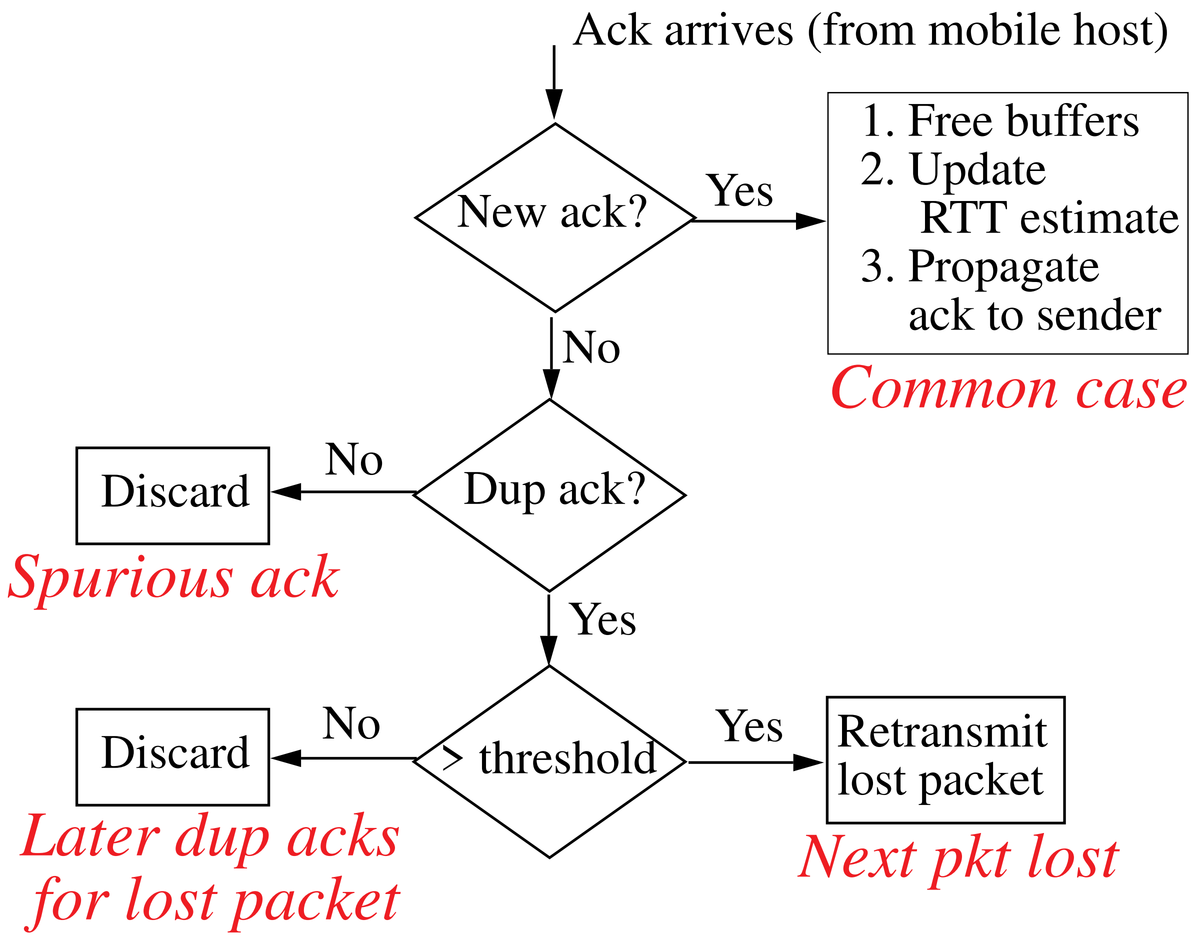
Perform local retransmissions based on duplicate acknowledgments and timeouts.



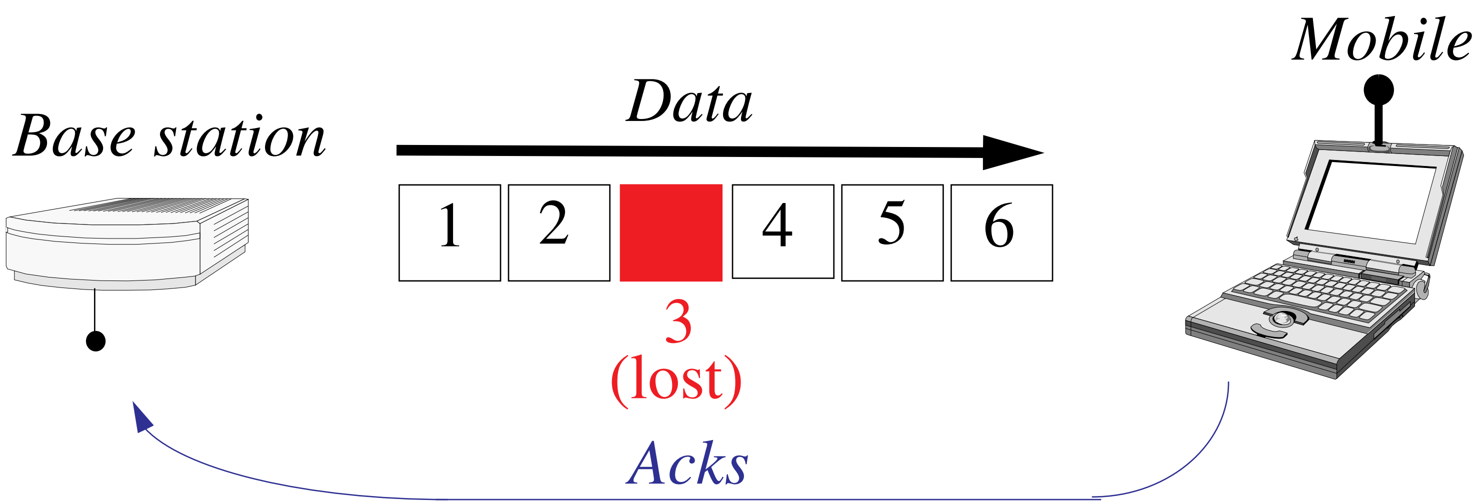
Data Processing



Acknowledgment Processing



Duplicate Acknowledgment Example



Acknowledgment sequence from mobile host seen at base station: 1, 2, 2, 2, 2

First time

Per-Connection State at Base Station

Buffers for unacknowledged packets.

Last packet transmitted to mobile host.

Last packet acknowledged by mobile host.

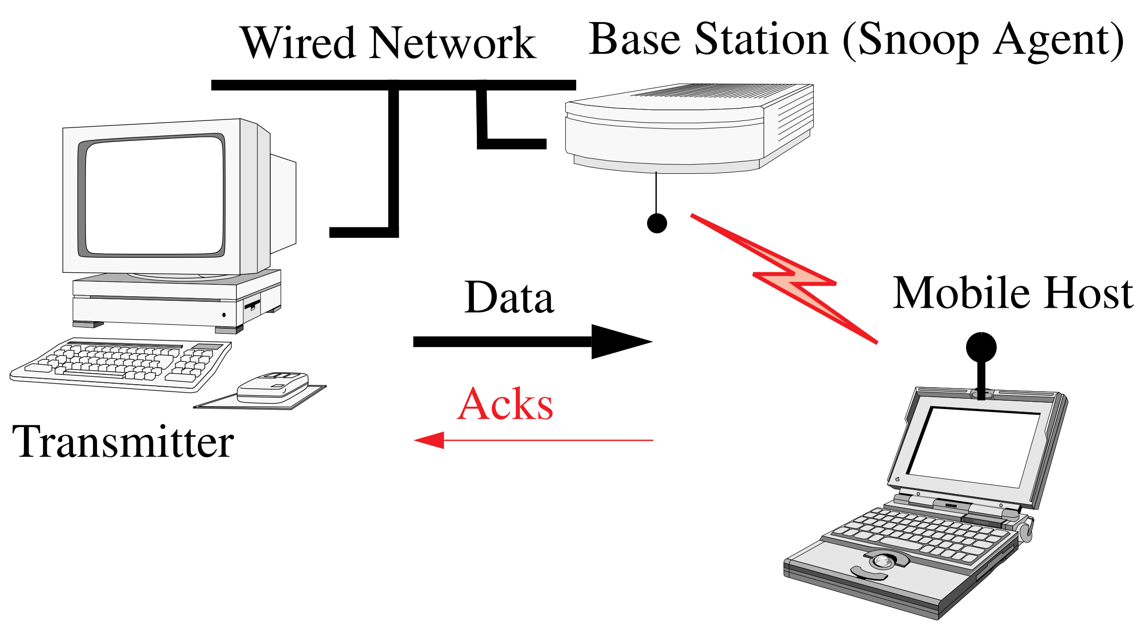
Next expected acknowledgment and expected number of duplicate acknowledgments.

Round-trip time estimate of wireless link

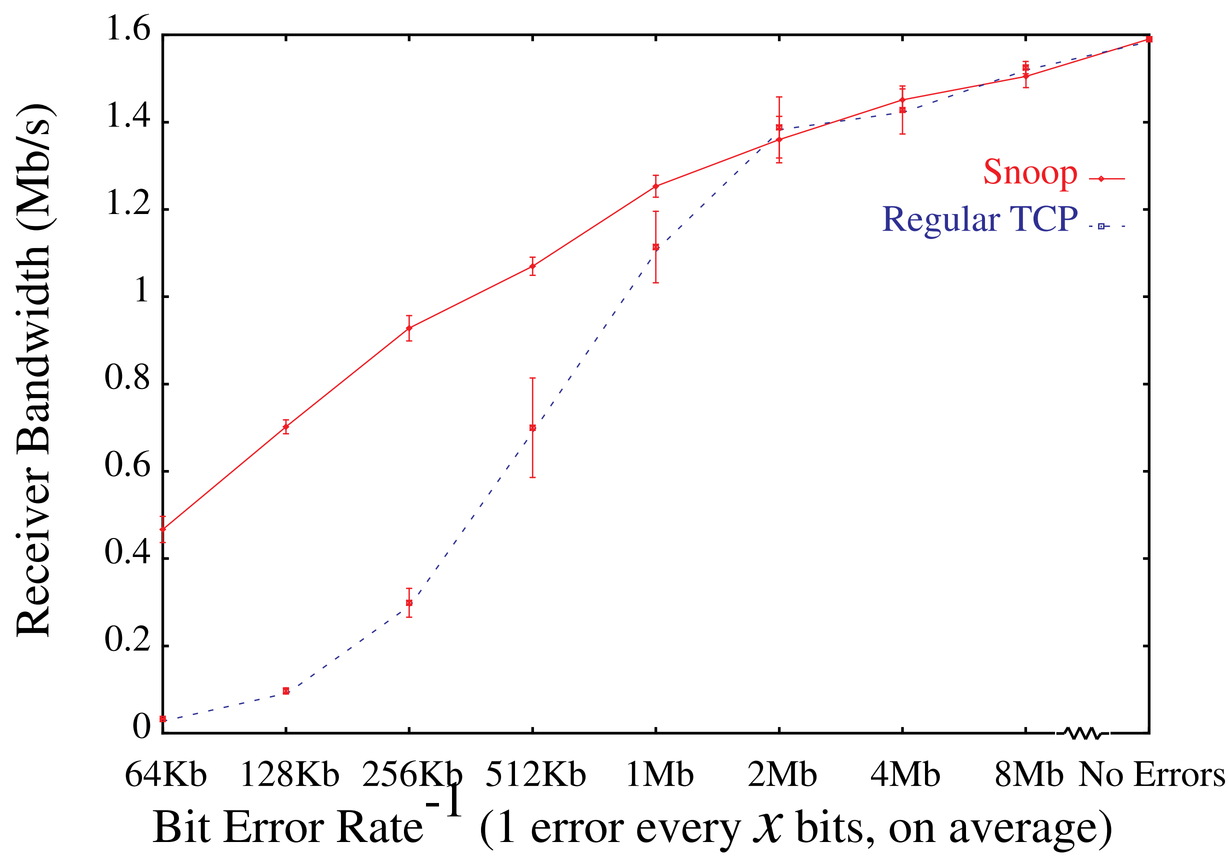
Implementation

Implementation Platform: IBM ThinkPad laptops, PC base stations, BSD/OS 2.0 from BSDI.

2 Mbit/s AT&T Wavelan.

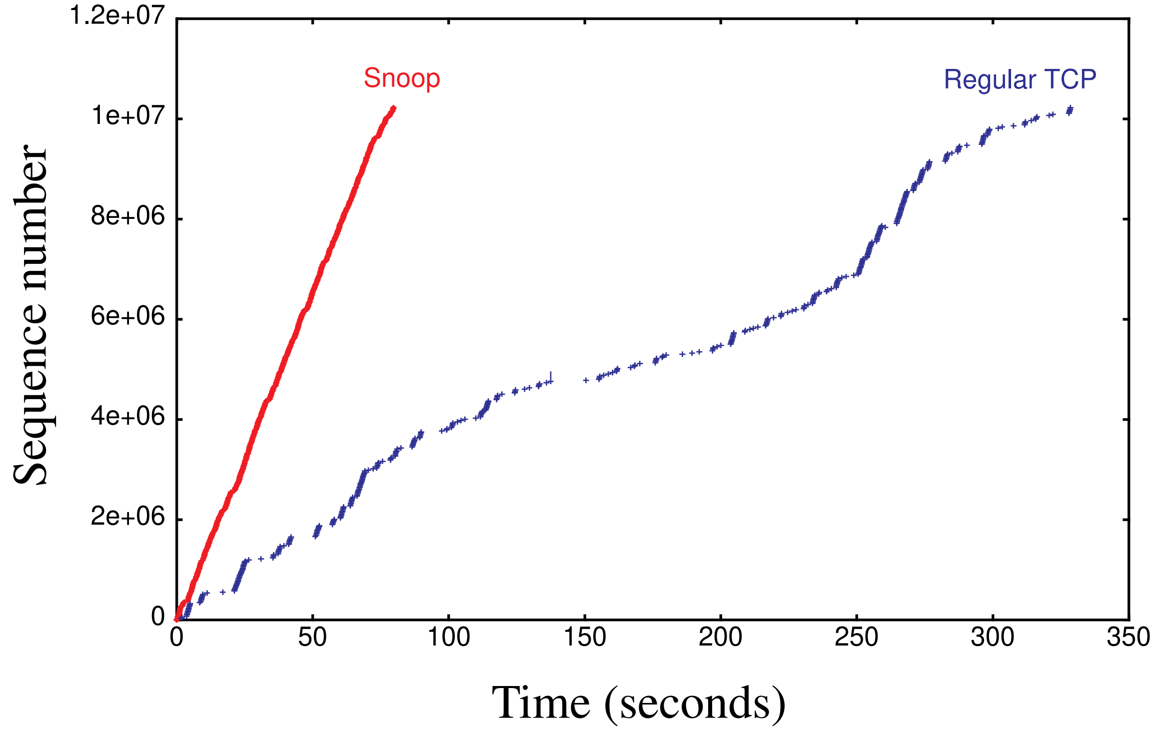


Performance



Packet size = 1400 bytes, window size = 64 KBytes

Performance (contd.)

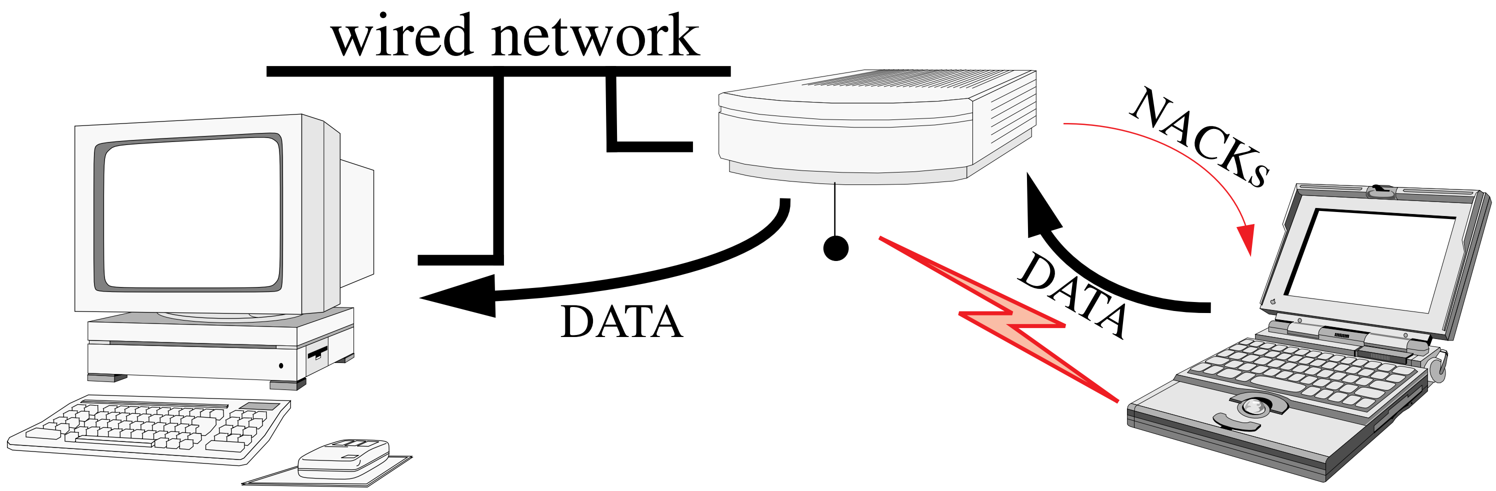


Sequence number trace for a 10 MByte transfer over a channel with an error rate of 1 error every 256 Kbits (3.8×10^{-6}).

Data Transfer from Mobile Host

Generate negative acks from base station for mobile host; mobile must now handle these NACKs.

Implementation using Selective Acknowledgments (SACKs).



Summary

Snoop agent for better end-to-end TCP performance.

Local caching and retransmissions by TCP-aware agent.

Bandwidth improvement between 1 and 20 across different bit-error rates.

Number of redundant wireless retransmissions $\rightarrow 0$.

Other Issues

Regions of high loss: Multi-hop wireless networks.

Sender interaction with local retransmission protocols.

Sender modifications for better performance: implicit deduction and explicit loss notification schemes.

TCP selective acknowledgments.