Reliable Transport Protocols for Heterogeneous Wireless Networks

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Heterogeneous Wireless Networks

Characteristics:

- Widely varying bandwidths.
- High bit error rates (BER) in several parts.
- Large, varying latencies.
- User mobility $\Rightarrow$ variable delays, packet losses.
- More common reliable/pseudo-reliable link-level protocols in some parts.

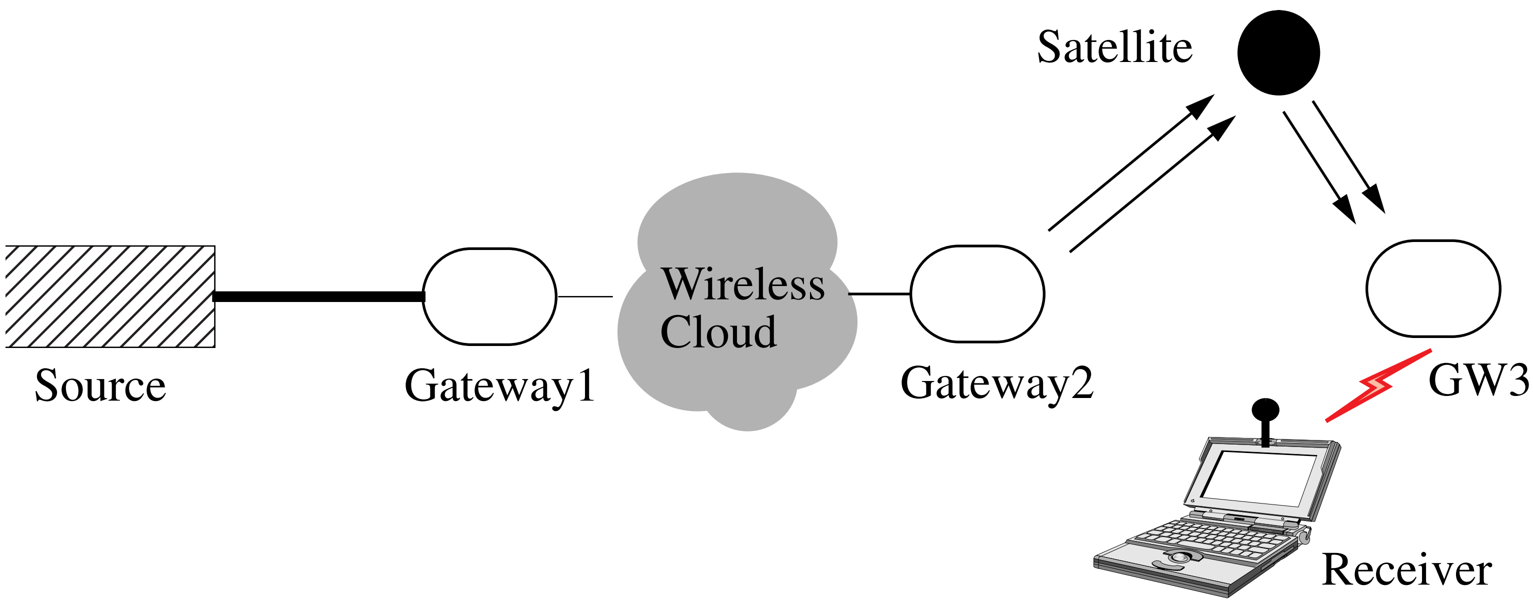
Problems with protocols like TCP:

- Wireless losses mistaken for congestion.
- Bulk losses cause (coarse-granularity) timeouts.
- Large round-trip time variances.

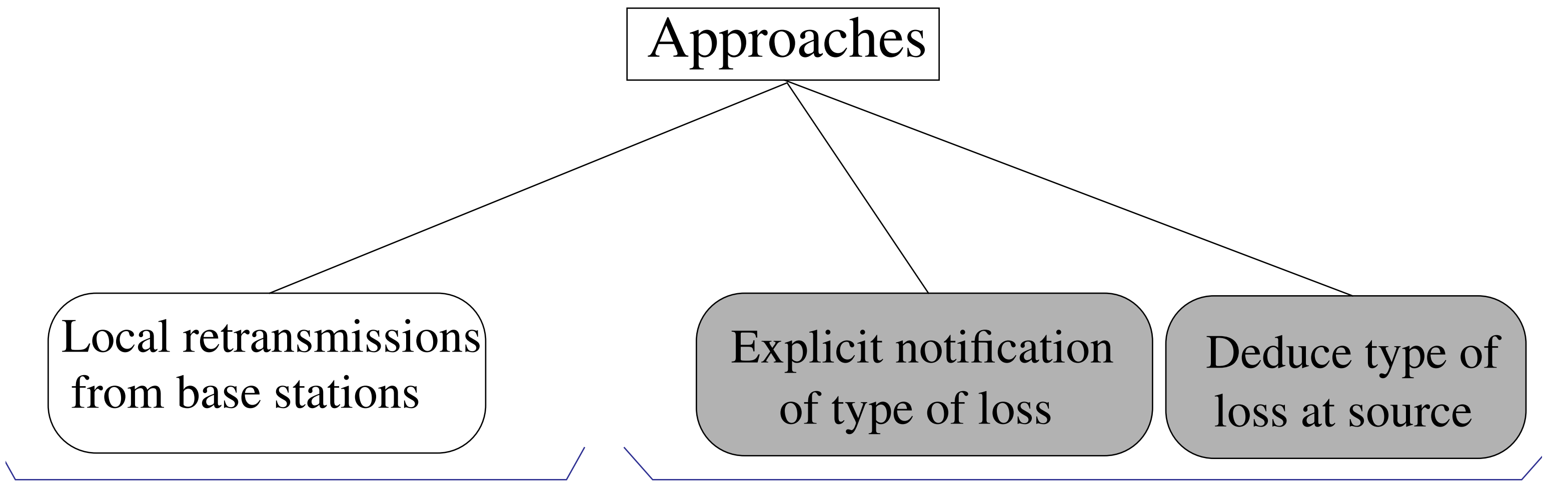
The Problem

General Problem: Getting the best transport protocol performance in networks with wired and wireless links.

Issues: Differing loss characteristics, asymmetry, combinations of “cooperative” and uncooperative” networks, etc.



Possible Solutions



Hide wireless from sender

Sender aware of wireless link
End-to-end schemes

Alternatives:

1. Link-layer protocols.

2. Split TCP (E.g., I-TCP).

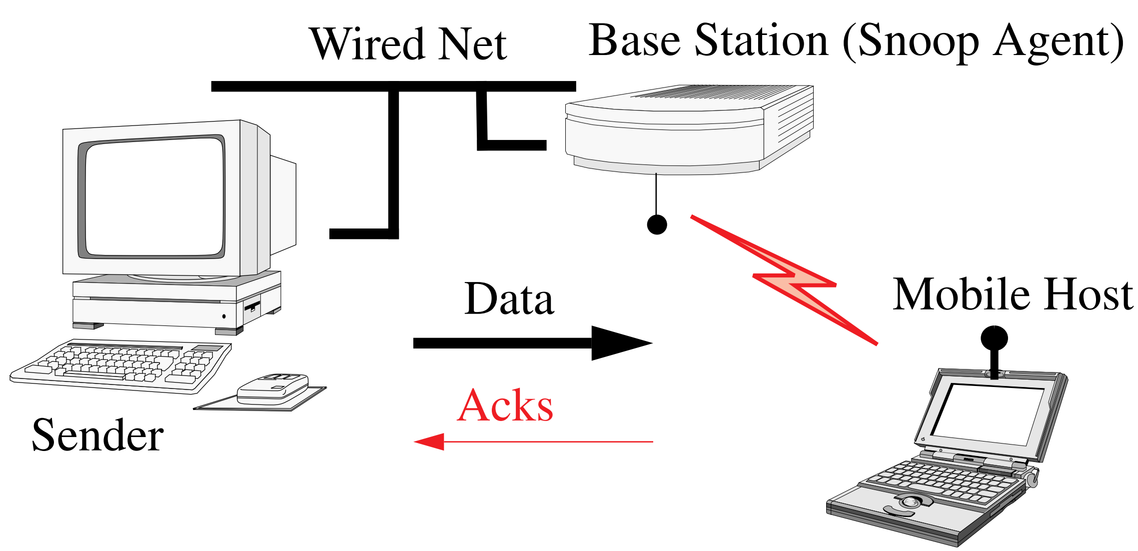
3. TCP-aware agent at base station, maintain end-to-end semantics.

Single Wireless Hop: The Snoop Agent

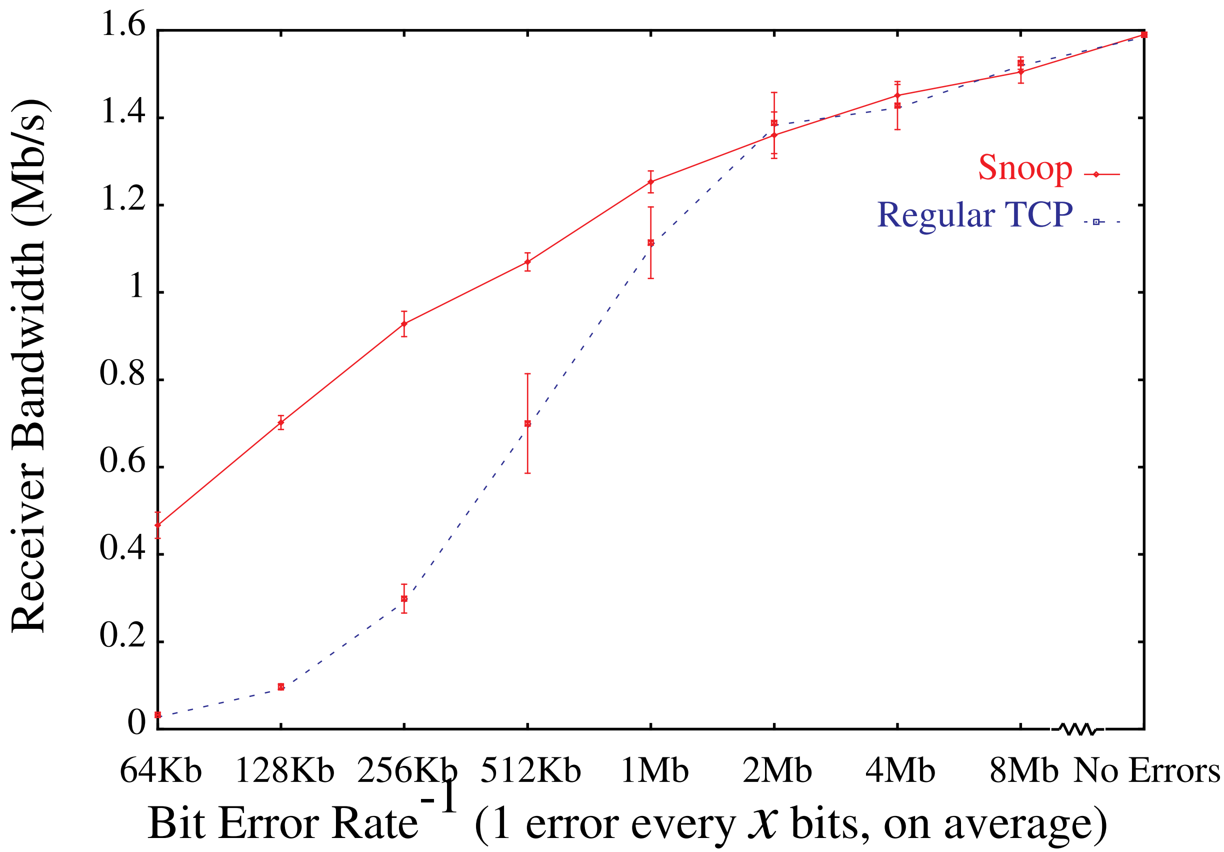
Snoop agent runs at the base station.

Cache unacknowledged packets at base station.

Perform local retransmissions based on duplicate acknowledgments and timeouts (poster has details).

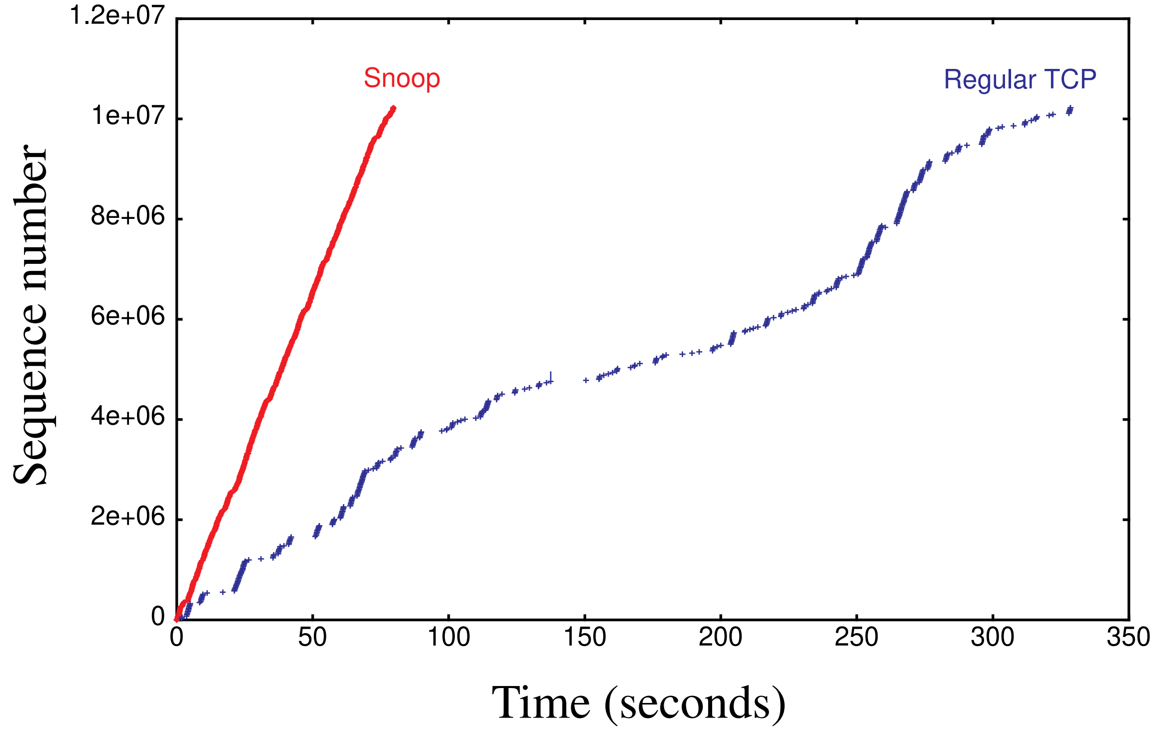


Performance



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}).

Multiple Wireless Hops

Wireless cloud at end of path; some link-level reliability (e.g., Metricom).

Problem 1: Large variations in latencies leads to large round-trip time variance.

- TCP's retransmission timeout = smoothed rtt + 4 * var.
- Fast retransmissions don't get invoked.

Problem 2: Reverse-channel traffic due to acknowledgments degrades performance.

- On Metricom: Unmodified TCP: 24 Kbits/s.
- Customized reliable datagram protocol with selective acks, delayed acks and rate control: 38 Kbits/s.
- Difference due to reverse channel traffic and asymmetry.

A Gateway-based Approach

Goal: To obtain good end-to-end TCP throughput in multi-hop wireless networks using an agent at the gateway.

Platform: The Metricom system.

Approach: Use an agent similar to Wavelan snoop agent.

- Local retransmissions for duplicate ack packets.
- Ideas for handling round-trip variations: force fast retransmissions.
- Need more information about how link-level reliability works.

Reliable Link-layer Protocols

ARQ-style link-level protocols: Go-Back-N, selective repeat.

Forward error correction: static and adaptive schemes.

Investigate interaction of these with TCP:

- Duplicate acknowledgments cause fast retransmissions.
- Timer interaction — currently not a major problem.

Current Work

Comparing some local alternatives to improve TCP performance in one-hop systems.

- Standard link-level schemes.
- Split connection approaches.
- Wavelan snoop agent.

Poster describes protocols and preliminary results.

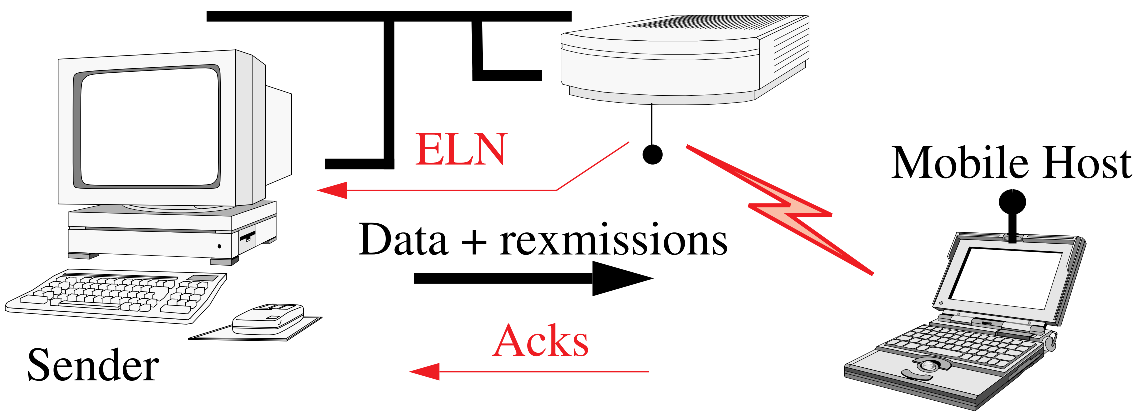
End-to-end Protocols

Both TCP and customized stream and datagram protocols: between proxy and mobile; reliable or pseudo-reliable.

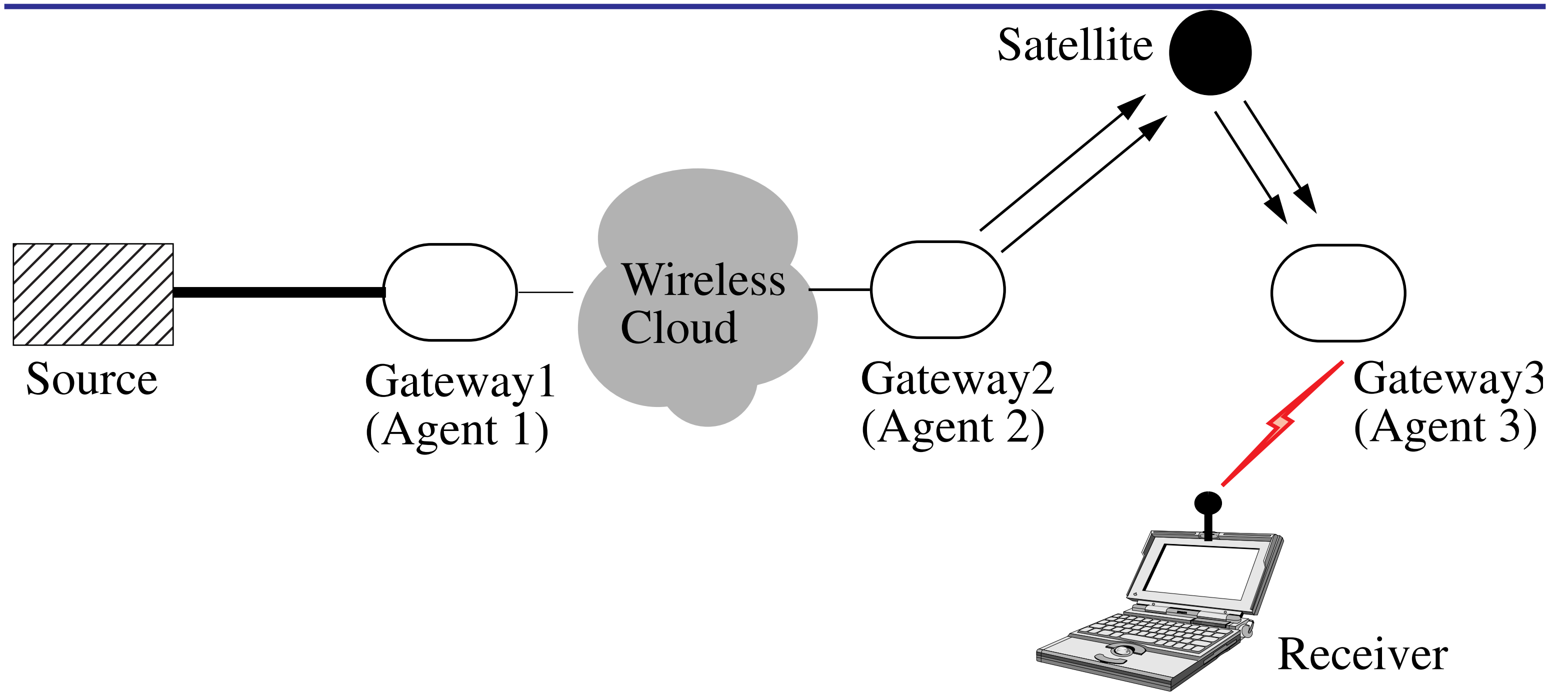
Selective acknowledgment policies, delayed acks.

Explicit (Wireless) Loss Notification (ELN):

- Enables sender retransmissions without reducing congestion window.
- ELN generated by agent at base station.



The General Case



End-to-end transport protocol uses selective ack mechanism, delayed acknowledgments, and ELN information.

Network-specific agents perform local caching, ELN generation, etc; "mix-and-match" higher and lower layers.

Need to handle asymmetry in paths and characteristics.

Some Open Issues

Combination of agent-based and end-to-end approaches.

Need good mechanisms to handle inherent asymmetry — both in paths and in characteristics.

Low bandwidths of connections renders TCP fast retransmissions ineffective; need to distinguish between losses and reordering of packets correctly.

Need to know lower layer protocol for best performance.

What happens on a handoff between different overlays?

- Multicast solves problem, but it's not scalable.
- May need explicit communication between old and new agent (a performance enhancement, not crucial).