CS 268: Wireless Transport Protocols

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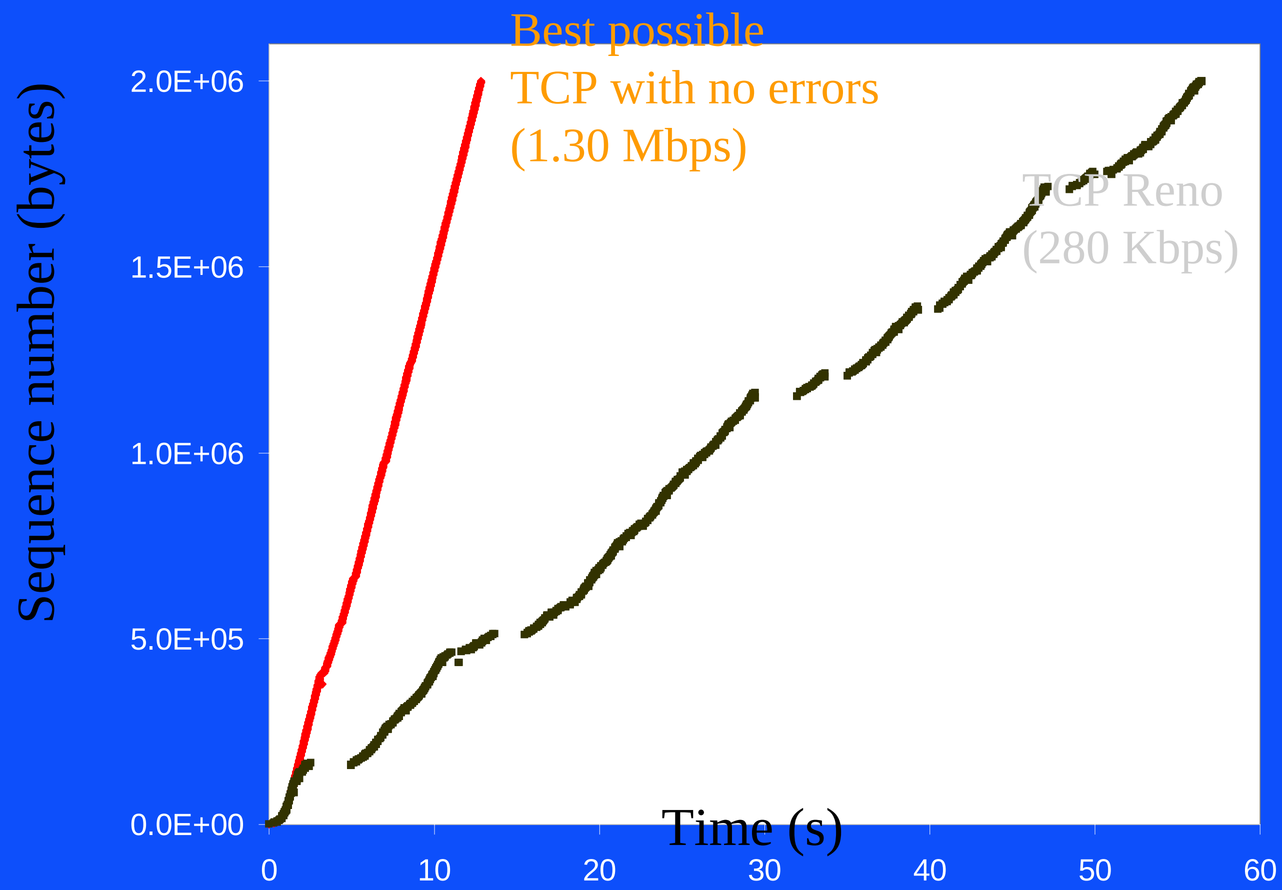
Motivation

- Wireless connectivity proliferating
  - Satellite, line-of-sight microwave, line-of-sight laser, cellular data (CDMA, GPRS, 3G), wireless LAN (802.11a/b), Bluetooth
  - More cell phones than currently allocated IP addresses
- Wireless $\rightarrow$ non-congestion related loss
  - LOS blocked (plane, bird), rain, lightning, microwave ovens, sunspots, EMP
  - signal fading: distance, buildings
- Non-congestion related loss $\rightarrow$
  - reduced efficiency for transport protocols that depend on loss as implicit congestion signal (e.g. TCP)

Problem



2 MB wide-area TCP transfer over 2 Mbps Lucent WaveLAN
(from Hari Balakrishnan)

Solutions

- Modify transport protocol
- Modify link layer protocol
- Hybrid

Modify Transport Protocol

- Explicit Congestion/Loss Signal
  - Distinguish congestion losses:
    - Explicit congestion signal
    - Congestion avoidance
    - Robust
    - Must be deployed at all routers
    - Still need end-to-end signal of congestion
  - Distinguish non-congestion losses:
    - Explicit Loss Notification (ELN) [BK98]
    - If packet lost due to interference, set header bit
    - Only needs to be deployed at wireless router
    - Need to modify end hosts
    - How to determine loss cause?
    - What if ELN gets lost?

Modify Transport Protocol

- TCP Westwood [CGM+01]
  - Use packet inter-arrival time as implicit congestion signal instead of loss
  - Allows congestion avoidance
  - Robustness is unclear
- TCP SACK
  - TCP sends cumulative ack only$\rightarrow$cannot distinguish multiple losses in a window
  - Selective acknowledgement: indicate exactly which packets have not been received
  - Allows filling multiple “holes” in window in one RTT
  - Quick recovery from a burst of wireless losses
  - Still causes TCP to reduce window

Modify Link Layer

- How does IP convey reliability requirements to link layer?
  - not all protocols are willing to pay for reliability
  - Read IP TOS header bits(8)?
    - must modify hosts
  - TCP = 100% reliability, UDP = whatever?
    - what about other degrees?
  - consequence of lowest common denominator IP architecture
- Link layer retransmissions
  - Wireless link adds seq. numbers and acks below the IP layer
  - If packet lost, retransmit it
  - May cause reordering
  - Causes at least one additional link RTT delay
  - Some applications need low delay more than reliability e.g. IP telephony

Modify Link Layer

- Forward Error Correction (FEC) codes
  - k data blocks, use code to generate n>k coded blocks
  - can recover original k blocks from any k of the n blocks
  - n-k blocks of overhead
  - trade bandwidth for loss
  - can recover from loss in time independent of link RTT
    - useful for links that have long RTT (e.g. satellite)
  - pay n-k overhead whether loss or not
    - need to adapt n, k depending on current channel conditions

Hybrid

- Indirect TCP [BB95]
  - Split TCP connection into two parts
  - regular TCP from fixed host (FH) to base station
  - modified TCP from base station to mobile host (MH)
  - base station fails?
  - wired path faster than wireless path?
- TCP Snoop [BSK95]
  - Base station snoops TCP packets, infers flow
  - cache data packets going to wireless side
  - If dup acks from wireless side, suppress ack and retransmit from cache
  - soft state
  - what about non-TCP protocols?
  - what if wireless not last hop?

Conclusion

- Which is most efficient?
  - not clear
  - uncomparable simulation results
    - different simulation parameters (error rate, RTT, etc.)
    - different protocols or different implementations
- Cellular, 802.11b
    - link level retransmissions
    - 802.11b: acks necessary anyway in MAC for collision avoidance
    - real time applications could have problems
      - not an issue yet (why?)
- Satellite: FEC because of long RTT issues
- Link layer solutions give adequate, predictable performance, easily deployable