CS 268: End-Host Mobility and Ad-Hoc Routing

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Overview

- Wireless
- End-host mobility

Wireless

- 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 → non-congestion related loss
  - Signal fading: distance, buildings, rain, lightning, microwave ovens, etc.
- Non-congestion related loss →
  - Reduced efficiency for transport protocols that depend on loss as implicit congestion signal (e.g. TCP)

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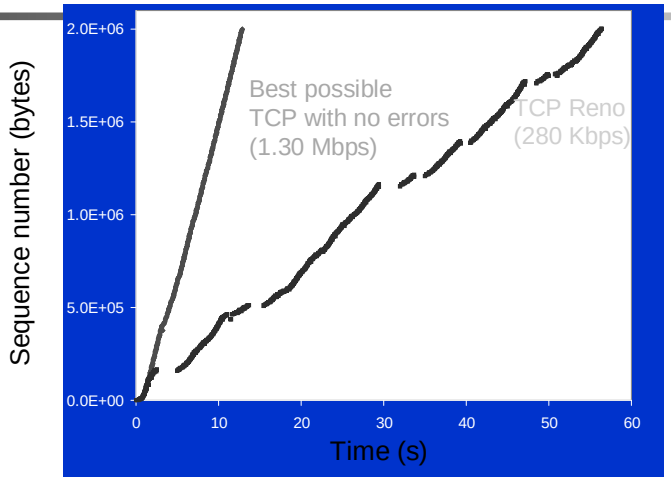
Problem



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

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Solutions

- Modify transport layer
- Modify link layer protocol
- Hybrid

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Modify Transport Protocol

- Explicit Loss Signal
  - 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?

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Modify Link Layer

- Advantages:
  - Limited changes: only link-layer affected
  - Preserve end-to-end (TCP) semantics
- Three types of losses
  - Total packet loss
  - Partial packet loss
  - Packet corrupted by bit errors
- Three methods to reduce packet loss
  - Packet retransmission
  - Forward error correction
  - Packet shrinking

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Retransmission

- Advantages:
  - Optimal overhead: only lost packets are retransmitted
- Disadvantages: “nasty” interactions between TCP control loop and link-level retransmission
  - Both TCP and link-layer can retransmit same packets
  - Can introduce packet reordering
  - Can introduce highly variable delays

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FEC

- 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

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FEC & Packet Shrinking

- Advantages:
  - No changes at end hosts or base-stations above link-layer
  - Decrease packet loss
  - Do not introduce variability
- Disadvantages:
  - Overhead can be quite high, e.g., packet segmentation/reassembly, encoding/decoding

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Flex [Eckhardt &Steenkiste '98]

- Combine the three types of error control → seven policies (three fixed and four adaptive)
- Most sophisticated : Flex
  - When two or more packets in a window of ten are truncated → reduces "safe" packet size by 15%
  - When three consecutive packets do not experience truncation → linearly increase packet size
  - When two or more packets in a window of ten cannot be decoded → decrease user data by 15% (more conservative coding)
  - When three consecutive packets can be decoded → increase user data linearly
- Note: adaptation exhibits a linear-increase multiplicative-decrease behavior

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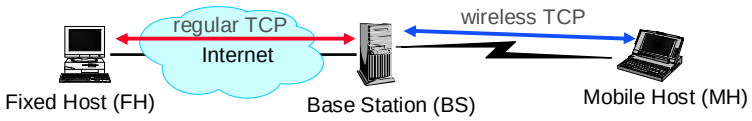
Hybrid: Indirect-TCP [Bakre & Badrinath '94]

- Split TCP connection into 2 TCPs
- Advantages
  - Optimize performance for wireless TCP
  - No changes to protocol for fixed hosts (transparent to fixed hosts)
- Disadvantages
  - Violate end-to-end TCP semantics (why?)
  - High overhead, because dual stack at BS
  - Might introduce high delays because packet buffering



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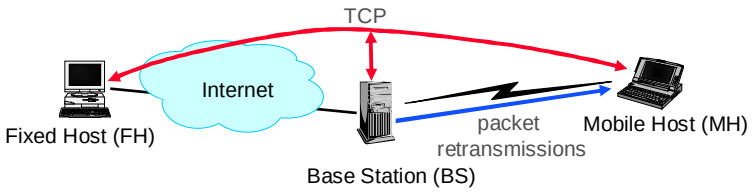
Hybrid: Snoop-TCP [Balakrishnan et al. ’95]

- Insert a “snoop agent” between fixed host (FH) and mobile host (MH)
  - Monitor traffic, retransmit packets and discard acknowledgements
- Notes:
  - Avoid violating end-to-end semantics
  - What about layering?



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Overview

- Wireless
- End-host mobility

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Motivation and Problem

- Network Layer mobility
  - Movement = IP address change
- Problem:
  - Location
    - I take my cell phone to London
    - How do people reach me?
  - Migration
    - I walk between base stations while talking on my cell phone
    - I download or web surf while riding in car or public transit
    - How to maintain flow?

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Solutions

- Mobile IP (v4 and v6)
- TCP Migrate
- Other solutions

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Mobile IP

- Use indirection to deal with location and migration
- Point of indirection: Home Agent (HA)
  - Resides in Mobile Host's (MH) home network
  - Uses MH's home IP address
  - As MH moves, it sends its current IP address to HA
- Correspondent Host (CH) contacts MH through HA
- HA tunnels packets to MH using encapsulation
- MH sends packets back to CH
  - Tunnels packets back to HA (bi-directional tunneling)
  - Sends directly to CH (triangle routing)

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Mobile IP Properties

- Advantages
  - Preserves location privacy
  - CH does not have to be modified
- Disadvantages
  - Triangle routing and especially bidirectional tunneling increase latency and consume bandwidth
  - HA is single point of failure

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Mobile IP Route Optimization

- CH uses HA to contact MH initially
- MH sends its location directly back to CH
- CH and MH communicate directly
- Lose location privacy
- CH must be modified

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TCP Migrate [SB00]

- Location: uses dynamic DNS updates
  - When MH moves to new IP address, it updates its home DNS server with new hostname to IP address mapping
- Migration:
  - When MH moves, it sends update to CH
- Advantage
  - No new infrastructure
  - Incremental deployable
  - Efficient routing
- Disadvantages
  - Only works for TCP
  - Both CH and MH need new TCP implementation
  - No location privacy

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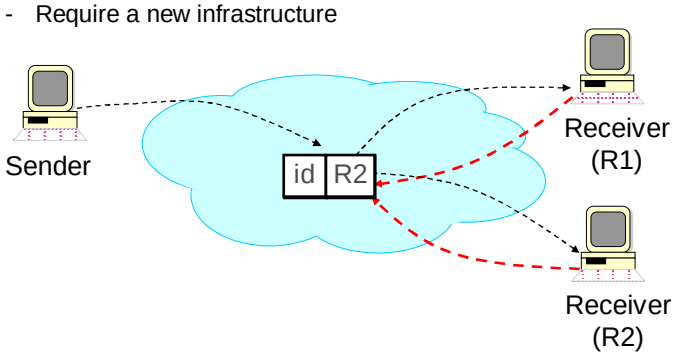
i3 Based Mobility (Z+03)

- Receiver R maintains a trigger (id, R) in the i3 infrastructure; sender sends packets to id
- Advantages
  - Support simultaneous mobility
  - Efficient routing: receiver can chose id to map on a close i3 server
  - Ensure privacy
- Disadvantage
  - Require a new infrastructure



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Other solutions

- Network specific mobility schemes
  - Cellular phones, 802.11b
  - Cannot handle mobility across networks (e.g. move laptop from cell phone to 802.11b) or between same network type in different domains (e.g. laptop from Soda Hall 802.11b to campus 802.11b)
- Other mobility models
  - Terminal/personal mobility:
    - e.g., accessing email through IMAP from different computers
  - Session mobility:
    - e.g., talking on cell phone, transfer call in progress to office phone

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Summary

- Not that important today
  - Few portable, wireless IP telephony devices
  - Cell phones have their own network-specific mobility schemes
  - IP-based wireless networks are not ubiquitous enough to be seamless
- Future
  - Cellular networks will become IP-based, need IP mobility scheme
  - PDA are becoming more powerful

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Project Presentations

- Eight minutes
- Five slides:
  - 1st slide: Title
  - 2nd slide: motivations and problem formulation
    - Why is the problem important?
    - What is challenging/hard about your problem
  - 3rd slide: main idea of your solution
  - 4th slide: status
  - 5th slide: future plans and schedule

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Presentation Schedule (Wed 3/15)

- Kirsten Chevalier
- Li Guan & Cindy Song
- Halldor Isak Gylfason
- Chris Baker, Daekyeong Moon & Jorge Ortiz
- Arsalan Tavakoli
- Zhangxi Tan, Wei Xu & Xiaofan Jiang
- Young Yoo
- Lilia Gutnik, Ted, Vijay

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Presentation Schedule (Mon 3/20)

- Peter Bodik
- Andrey Ermolinksiy, Daniel Chen, and Hovig Bayandorian
- Youwei Zhang and Libin Jiang
- Hemang Patel and Emad Salman
- Jeremy Rahe
- Artur Rivilis
- Mao Ye at al
- Jay Taneja
- Padmanabhan Vasu, Mark, Kye

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