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

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(*based on Kevin Lai's slides)

Overview

- End-host mobility
- Ad-hoc routing

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?

Solutions

- Mobile IP (v4 and v6)
- TCP Migrate
- Multicast

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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Other solutions

- Multicast
  - Mobile host uses multicast address as its home address
  - Requires inter-domain multicast
- 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
  - PDA (e.g. palm pilot) are too weak to do handle long-lived flows
- Future
  - Cellular networks will become IP-based, need IP mobility scheme
  - PDA are becoming more powerful

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Overview

- End-host mobility
- Ad-hoc routing

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Motivation

- Internet goal: decentralized control
  - Someone still has to deploy routers and set routes
- Ad Hoc routing
  - Every node is a router
  - Better wireless coverage
  - Better fault tolerance (e.g. node bombed, stepped on, exhausted power)
  - No configuration (e.g. temporary association)
  - Dedicated router costs money

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Routing

- DSDV: hop-by-hop distance vector
- TORA: Temporally-Ordered Routing Algorithm
- DSR: Dynamic Source Routing
- AODV: Ad hoc On-demand Distance Vector
- TORA, DSR, and AODV are all on-demand routing protocols

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DSDV

- Hop-by-hop distance vector
- Routing table contains entries for every other reachable node
- Nodes pass their routing tables to neighbors periodically
- Routing tables are updates using standard distance vector algorithm
- Old routes are ignored using sequence numbers
- O(n) routing state / node, O(n*k) communication size / node / period
  - k = average node degree

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TORA

- Temporally-Ordered Routing Algorithm
- Interested in finding multiple routes from S→D
- Find routes on demand
- Flood query to find destination
- Flood query response to form multiple routes
- O(m) routing state / node, O(n*k) communication / node / route update
  - m = nodes communicated with, worst case O(n)

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DSR

- Dynamic Source Routing
- Packet headers contain entire route
- Flood query to find destination
- Intermediate nodes don't have to maintain routing state
  - Nodes listen for and cache queries, responses as optimization
  - Nodes gratuitously sends response packets to shorten paths when they hear packets with sub-optimal routes
- Some kind of retransmission?
- O(m) routing state / nodes, O(n*k) communication / node / route update
  - much smaller constant than other protocols
- $O(n^{1/k})$ space required in header

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AODV

- Ad Hoc On-Demand Distance Vector
- Flood query to find destination
- Reply is sent back to source along the reverse path
- Intermediate nodes listen for reply to set up routing state
- State is refreshed periodically
- O(m) routing state / node, O(n*k) communication / node / route update

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Results

- Avoid synchronization in timers
- TORA does not scale to 50 nodes at all
  - Suffers control traffic congestion collapse
- DSDV fails to deliver packets when movement is frequent
  - Only maintains one route/destination
- AODV has high routing overhead when movement is frequent
  - Combination of DSDV maintenance of state + flooding of DSR
- DSR does well compared to others
  - Designed by authors → not surprising!
  - [LJC+00] shows congestion collapse beyond 300 nodes

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Related Work

- Greedy Perimeter Stateless Routing (GPSR) [Karp and Kung, Mobicom 2000]
  - Separate addressing from naming
  - Assume everyone has GPS
  - Do Cartesian routing
  - Separate scalable, efficient, fault tolerant service to map from names to addresses
- How to deal with selfish users? [MGL+00]
  - listen to neighbors to make sure they are forwarding
  - convey black list information back to source
  - route around selfish nodes

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Conclusions

- Proliferation of wireless network interfaces provide ready market
- Ad hoc provides less configuration, more fault tolerance, better coverage, lower cost
- Many interesting and unsolved problems

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One Page Project Summary – due Feb 13

- The problem you are solving
- Motivation and challenges – why is the problem important/difficult?
- Your proposed solution and approach – what it is new?
- Your plan of attack with milestones and dates
- Any resources you might need to complete the project

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