

Mobility in Wireless Networks

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CS 294-1

Lecture 7
October 11, 2000

Outline

- Project meetings next week:
 - M 10-11, Tu 9-11:30
- Mobile IP papers
 - Johnson, D. Scalable Support for Transparent Mobile Host Internetworking. In Mobile Computing, 1996
 - IP Mobility Support (RFC 2002)
 - Myles, A., Johnson, D.B., Perkins, C. A mobile host protocol supporting route optimization and authentication. IEEE JSAC, June 1995
- PCN location management paper
 - Akyildiz, I.F., Ho, S.M. On location management for personal communications networks. IEEE Comm Mag., 1996

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2

Overview

- Mobility in the Internet
 - Basic mobile IP protocol
 - IMHP: route optimization in Mobile IP
 - Other issues
- Location Management for PCN
 - Mobility entities
 - Tracking mobile users
 - Call processing
 - Other issues

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Problems with Mobility in the Current Internet

- Assumption that a node's IP address uniquely identifies its point of attachment to the Internet
- Both routing and addressing scheme (network + node id) are unable to support mobility
 - Hierarchical addressing
 - Hierarchical, semi-static routing

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Mobility alternatives w/o Mobile IP

- On moving, change IP address
 - Infeasible if you want seamless roaming (changing location in transparent way for all IP protocols)
- MH sets the Loose Source Routing (LSR) bit when sending a packet to a CH
 - Each router that passes the packet adds its own address, so the CH can do source routing back to the MH because it knows the overall path
 - Problems:
 - Cannot use the flexible Internet routing: link failures?
 - Security vulnerability (protection based upon source address), so normally LSR is disabled in routers

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Mobility vs. Portability

- What is mobility used for?
 - Long lived sessions
 - Ex: Telnet, ssh, Voice over IP phone calls?
- What is portability used for?
 - Pop-up networking
 - Ex: E-mail access, web
 - Session-based redirection
 - Ex: Instant messaging, DHCP + dynamic DNS

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Mobile IP Goals

- Mobility support for hosts without the need to change IP address
- Mobile nodes should be able to communicate with hosts that don't implement Mobile IP
 - Permit incremental deployment
- Authentication of management packets
 - At least same authentication security as wired Internet
 - Can snoop packets on a shared Ethernet segment
 - Mobility → wireless → more security problems
- Minimizing the number of management packets
 - Major scalability issue!
- No additional constraints on IP address space

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Functional Entities in Mobile IP

- Entities:
 - Mobile Node (the host that moves)
 - Home Agent (the node that supports MH's)
 - Foreign Agent (access basestations)
 - Correspondent Host (any other node)
- Each mobile node is assigned a unique home address within its home network (subnet)
- When away from home network, it is assigned a care-of address either by:
 - Registering with a Foreign Agent
 - Obtaining a temporary IP address (e.g., DHCP)
 - Pop-up mode

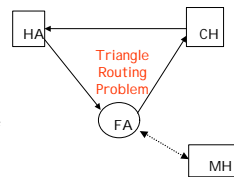
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Basic Mobile IP

- MH registers with local FA
- HA tracks each MH's location
- CH sends info to MH's address (HA)
 - HA proxy ARPs for its MHs
 - Hosts that don't support Mobile IP are able to communicate with Mobile IP hosts
- HA forwards it to the real location of the MH (the Care-of Address)
 - Using tunneling



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Protocol Overview

- Foreign Agent Discovery
- Registration with Home Agent
- Tunneling packets from HA to MH

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Foreign Agent Discovery

- Extension of ICMP Router Discovery protocol
 - Used by mobile nodes to discover Foreign Agents and to detect movement from one subnet to another
 - Operates under IP (no address yet!)
- Mobility Agents (HA's and FA's) periodically broadcast agent advertisements to detect movement / each other
 - Mobile node expects to receive periodic advertisements
 - If it doesn't receive them, it deduces that either
 - It has moved out of coverage, OR
 - Its agent has failed
- Mobile node can also broadcast Agent Solicitation messages (like DHCP solicitations)

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Registration with Home Agent

- Mechanism by which MH communicates location information to its HA
- Registration messages create or modify a mobility binding at a HA, which is then valid for a certain lifetime period (lease)
 - Most be periodically renewed
 - Set to 0 when in home network
- Uses 2 control messages sent over UDP
 - Registration Request
 - Registration Reply

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Registration Authentication

- Concern:
 - Forged registrations permit malicious hosts to remotely redirect packets destined for the mobile host
- Default authentication between MH and HA uses keyed MD5 with a shared secret key
 - Apply hash to secret key and important fields to generate a verification checksum
 - How to set secret key?
- No authentication between MH and FA
 - Problems?

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Registration Authentication (cont'd)

- Replay Protection
 - Needed to ensure that registration messages are not replayed by a malicious host
- HA includes, in cleartext, a one-time random value (nonce) in registration replies
 - MH uses nonce in next message
 - Or could use timestamps

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Delivering Datagrams: Tunneling

- When the mobile host is away
 - HA intercepts packets addressed to the MH (using proxy ARP)
 - Timeout problems when MH returns to subnet
 - Tunnels them to the MH's care-of address
- The tunneling scheme could use either:
 - IP-in-IP Encapsulation
 - Adds 20 bytes for full IP header!
 - 'Minimal' Encapsulation
 - Only adds 8-12 bytes
 - Doesn't work if tunnel fragments IP packets

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Delivering Datagrams (cont'd)

- Broadcast Datagrams
 - A HA forwards a broadcast datagram only if the MH requested forwarding of broadcast datagrams (in the registration request)
- Multicast Datagrams
 - MH can use a local multicast router
 - Hard (locating mrouter), slow to join/leave
 - Or, can use the tunnel itself (inefficient)
- MH can use a bi-directional tunnel to its HA
 - For networks that don't support source addresses from home network
 - But, incredibly inefficient and slow

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Internet Mobile Host Protocol

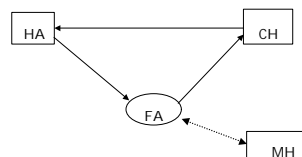
- Extensions to basic Mobile IP protocol
 - Route Optimization
 - Triangle routing is inefficient, creates a bottleneck at the HA (limits scalability), and creates artificial traffic in Internet
 - Authentication of management packets
- IMHP Entities
 - From Mobile IP:
 - Mobile Hosts, Home Agents
 - Local Agents (same as Foreign Agents)
 - New:
 - Cache Agents (can be contained within a node)

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Route Optimization (I MHP)



- Triangle Routing in basic Mobile IP
 - Limits performance transparency
 - Creates bottleneck at Home Agent

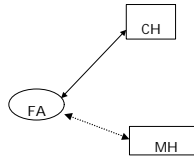
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Route Optimization

- Eliminates triangle routing
- Any IMHP-aware correspondent host can maintain a binding cache
 - CH tunnels datagrams directly to MH's care-off address
 - This action implies that CH participates in Mobile IP



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Binding Management

- Four message types:
 - Binding Warning (node should send BR)
 - Binding Request (inquiry for new info)
 - Binding Update (here is updated info)
 - Binding Acknowledge (ack for BU)
- Lazy notifications are used (except MH to HA and previous FA)
 - Limits the overhead caused by Resource Optimization management traffic
 - CH are notified of an MH's location only when they try to send it a packet

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Foreign Agent Smooth Handoff

- As part of registration, MH requests its new FA to notify its previous FA
 - New FA sends binding update to previous FA
 - Previous FA updates its binding cache entry for the MH and sends a binding ACK
 - Previous FA reforwards any new messages to the new FA
 - Alternative is dropping messages and implementing a timeout-based retransmission scheme (with or w/o retransmission, TCP would have problems)
 - If the new FA receives a packet forwarded from another FA, the former informs the HA or the CH about the change
- Authentication of binding update is based on a shared registration key

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Special Tunnels

- When a FA receives a tunneled datagram for a MH for which it has no entry, it is tunneled back to the HA in a special tunnel
- Gives the datagram one more chance of successful delivery
 - But, avoids possible routing loops

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Authentication in IMHP

- IMHP
 - Has simple authentication procedures which preserve the level of security in today's Internet
 - Is defined to make use of strong authentication
- MH to HA authentication
 - Strong authentication based on a shared secret
- General Authentication
 - A random number specified in binding request is echoed in the reply by the HA

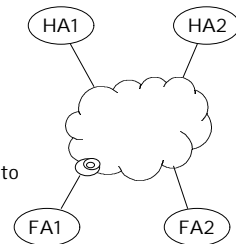
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IMHP Examples

- MH1 reg. with FA1, HA1
- MH2 reg. with FA2, HA2
- MH1 sends packet to MH2
 - MH1 → HA2 → FA2 → MH2
- HA2 sends BW to MH1
- MH1 requests and gets a binding update from HA2
- Future packets from MH1 to MH2 are tunneled
 - MH1 → FA2 → MH2



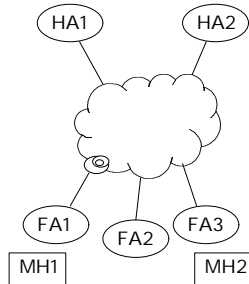
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I MHP Examples (cont'd)

- MH2 reg. with FA3, HA2
- MH2 notifies FA2
- MH1 sends packet to MH2
 - MH1 → FA2 → FA3 → MH2
- FA2 sends BW to MH1
- MH1 requests & gets new binding for MH2 from HA2
- Future packets from MH1
 - MH1 → FA3 → MH2



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Other Issues

- Scalability
 - Bottleneck at mobility agents?
 - Frequency of agent advertisements (smoothness of handoffs) ?
 - Binding notification backoff ?
- Security
 - Foreign network routers/firewall interpret packets from the MH as spoofing other networks
 - Source address blocking forces tunneling of ALL packets
 - MH → FA → HA → CH → HA → FA → MH

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More Issues

- What happens if the MH is temporarily disconnected?
 - Out of coverage (between cells)
 - No FA buffering (yet?)
 - UCB work includes buffering during handover
- Foreign network authentication
 - How to securely identify MH at a foreign network to perform access control?
 - How to pay for access?

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Mobile IP Status

- Very limited deployment
 - Cross-domain authentication issues
 - Mobility versus portability issue
 - DHCP has solved many problems
- IPv6 has Mobile IP support
 - But, NAT and DHCP solve most problems
 - So, IPv6 has not been deployed

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5-minute Break

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Location Management for PCNs

- Akyildiz, I.F., Ho, S.M. On location management for personal communications networks. IEEE Comm. Mag., Sept. 1996
- Missed projection: 86M in 12/99 vs 60M in '05
- Centralized approach to user mobility mgmt
 - How to locate a Mobile Terminal, MT (i.e., a MH) so calls can be forwarded to it
- Based on a minimum degree of trust between participants
 - Contrast with the Internet (fully distributed, no trust at all)

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Review: Architecture

- Overlapping cells with a Base Station (BTS) in the middle of each cell
- Several BTSs depend on a Base Station Controller (BSC)
- Many BSCs depend on a Mobile Switching Center (MSC)
- Two mobility management schemes:
 - IS-41 used by AMPS, IS-54, IS-136, PACS
 - GSM Mobile Application Part

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Mobility Schemes

- Fixed wireline telephony uses hierarchical routing for most phones
 - Simple, fairly static table maps NPA XXX to a specific service provider's central office
- Example of non-hierarchical?
- Several cases
 - 800, 888, 877, 866, ...
 - Future number portability across providers
 - Requires dynamic database lookup to complete calls
- Mobile telephony is harder
 - Tracking location of phones (location registration)
 - Delivering calls to moving phones (call delivery)

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Mobility Entities

- Home Location Register (HLR)
 - Contains information about all the users controlled (owned) by an MSC (the mobile svc provider)
 - Like a Home Agent, but centralized
- Registration Area (RA) or Location Area (GSM)
 - May be smaller than area covered by an MSC
 - HLR stores a user's RA
- Binding
 - Pair of <user ID, user location>
- SS#7
 - Protocol used to control the location register
 - Unprotected, hierarchical network (because it is private!)

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Mobile Terminal Tracking

- Each MSC has an associated Visitor Location Register (VLR)
 - VLR is like a Foreign Agent, but is centralized
- MT moves from one cell to another
 - Informs the BTS, which informs the BSC, which informs the MSC, if needed
 - If the MT remains in the same RA, VLR is not affected
 - If the MT changes RA, ...

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Entering a New RA

- The VLR updates the MT's location
 - Also locates the HLR using the MT's Mobile Identification Number and Global Title Translation and sends it a location update
- HLR authenticates MT and saves VLR ID
 - Sends cancellation message to the old VLR
 - Sends registration ack to new VLR
 - Waits for cancellation ack from old VLR

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Call Processing

- Ask the MT's HLR for the MT's current location
 - HLR sends route request message to VLR
- MSC for VLR assigns MT a Temporary Directory Location Number (TDLN) to use while in the RA
 - TDLN is returned to originating CO
- CO requests call setup using the TDLN

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Locating an MT Within an RA

- Process is called paging or alerting
 - Broadcasting for location of MT within RA
- First, look at the closest BSC
- Next, check the MSC
- Finally, go back to home MSC

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Control Traffic Issues

- High location registration traffic
 - Can use pointer forwarding up to preset length
 - Has higher call delivery control traffic / delay
 - Can use static/dynamic local anchoring
 - Can have higher call delivery traffic
- High call delivery control traffic
 - Can use per-user location caching
 - Depends on Local Call-to-Mobility Ratio
 - Can use user profile replication
 - But, has higher location registration traffic

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Alternate Database Architectures

- Can use a distributed database
- Multi-level hierarchy replaces 2-level
- But, there are significant challenges
 - How to partition?
 - How to handle longer "path" for location updates and call deliver?
 - Performance depends upon mobility and call arrival patterns

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Other Issues

- Location update schemes
 - Time-based (periodic)
 - Fixed or declining exponential, if no motion
 - Movement-based (number of movements across cell boundaries)
 - Distance-based
- Challenge of guessing a user's trajectory through cells and RAs
 - Implement flexible RA boundaries?

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Comparison

- Can we combine both PCN location management and Mobile IP?

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