Mobile IP
Part I: IPv4

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These slides are available on-line at:
http://www.cse.wustl.edu/~jain/cse574-06/
Overview

- Mobile IP: Terminology
- Processes: Registration, Advertisements, ..
- Security Issues
- Reverse Tunneling
- Home Networks with Dynamic IP Address
- Dynamic Home Agent Assignment
- Network Mobility (NEMO)
- Mobile IP and VPN
Mobile IP: Features

- You can take your notebook to any location.
- Your TCP connection can continue. TCP connections are from one IP address to another IP address. TCP is unaware of the mobility.
- Continuous access to your home resources.
- Access to local resources: Printers.
- Finds nearby IP routers and connects *automatically*.
- Your IP messages are delivered to your new location.
- Only "Mobility Aware" routers and mobile units need new s/w.
- Other routers and hosts can use current IP.
- No new IP address formats.
- Secure: Allows authentication.
Mobile IP: Terminology

- Mobile Node (MN)
- Home Agent (HA), Foreign Agent (FA)
- Care-of-address (COA): Address of the end-of-tunnel towards the mobile node
- Correspondent Node (CN)
- Home Address: Mobile’s permanent IP address
Terminology

- **Home Address**: Long-term IP address of the mobile on the home network
- **IP Access Address**: Local IP address of the mobile on the foreign network
- **Care-of-Address**: Address to which the packets are sent by the home agent. Destination of the IP tunnel between home agent and the mobile. Generally COA=IP Access Address
- **Mobility Agent**: Home agent or foreign agent
- **Agent Advertisement**: Periodic advertisement from mobility agents
- **Correspondent Node**: The node communicating with mobile
- **Foreign Network**: Any network other than the home network
- **Gratuitous ARP**: Sent by home agent to update other node’s ARP cache
Terminology (Cont)

- **Mobility Binding**: Binding between home address and COA
- **Tunnel**: Path followed by an encapsulated packet
- **Mobile Router**: A router with changing point of attachment
- **Mobile Host**: A end host (not a router)
- **Mobile Node**: Mobile Host or Mobile Router
- **Mobile Network**: An entire network that changes its point of attachment
- **Mobile Network Node**: A node in a mobile network. May itself be mobile (visiting) or fixed (permanent) member of the network.
- **Roaming**: Getting connectivity from a foreign network based on a formal agreement between foreign and home network service providers
Terminology (Cont)

- **Handover**: Changing the point of attachment

- **L2 Handover**: Moving from one access point to another access point in the same IP network (same network prefix)

- **L3 Handover**: Moving from one IP network to another. Moving from one access router to another access router

- **Horizontal Handover**: Moving between same technology. WLAN to WLAN or 3G to 3G

- **Vertical Handover**: Moving between different technologies. WLAN to 3G.

- **Push Handover**: Previous access router initiates handover

- **Pull Handover**: New access router initiates handover
Terminology (Cont)

- **Make-Before-Break**: Make a new connection before disconnecting previous. Will communicate with both for some time.
- **Break-before-Make**: Disconnect previous and then connect with next.
- **Handover Delay**: Time between break and make.
- **Smooth Handover**: Minimize packet loss. Handover delay not critical.
- **Fast Handover**: Minimize handover delay. Packet loss not critical.
- **Seamless Handover**: No change in quality, security, or capability of service.
Terminology (Cont)

- **Diversity**: Ability to receive two signals at the same time.
- **Micro Diversity**: Two signals between the same subscriber and base station.
- **Macro Diversity**: Two signals from different base stations.
- **IP Diversity**: Packets from two IP networks.
- **Micro Mobility**: Mobility within a single network. No effect outside the network. a.k.a. Local Mobility.
- **Macro Mobility**: Mobility between networks. Requires Mobile IP type solution. a.k.a. Global Mobility.
Mobile IP: Processes

- **Agent Discovery**: To find agents
  - Home agents and foreign agents advertise periodically on network layer and optionally on datalink
  - They also respond to solicitation from mobile node
  - Mobile can send solicitation to Mobile agent multicast group 224.0.0.11
  - Mobile selects an agent and gets/uses care-of-address

- **Registration**
  - Mobile registers its care-of-address with home agent. Either directly or through foreign agent
  - Home agent sends a reply to the CoA
  - Each "Mobility binding" has a negotiated lifetime limit
  - To continue, reregister within lifetime
Processes (Cont)

- **Return to Home:**
  - Mobile node deregisters with home agent
    sets care-of-address to its permanent IP address
  - Lifetime = 0 ⇒ Deregistration
- Deregistration with foreign agents is not required. Expires automatically
- Simultaneous registrations with more than one COA allowed (for handoff)
Encapsulation/Tunneling

- Home agent intercepts mobile node's datagrams and forwards them to care-of-address.
- Care of Address can be the Foreign Agent or it can be co-located in the mobile host.
- Home agent tells local nodes and routers to send mobile node's datagrams to it.
- De-encapsulation: Datagram is extracted and sent to mobile node.

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**Diagram:**

- **Correspondent** → **Home Agent** → **Intermediate Routers** → **Care-of Address** → **Mobile Host**

**IP Headers:**

- **To: COA**
- **To: Mobile**

**Info**
Reverse Tunneling

- Normally, MN sends the packets directly to the correspondent with SA=Home Address, DA=Correspondent
- Problem: Such packets may be dropped by visited network’s firewalls since the source address is not on foreign network
- Solution: Reverse traffic is also sent via home agent [RFC 3024]
Home Networks with Dynamic IP Address

- Problem: DHCP based hosts do not have the initial IP address, DNS address on the home network
- Cisco’s Solution: The registration request to home agent includes a request for configuration
- The registration reply includes IP address, DHCP server’s address, DNS address

- RFC 4332, Cisco's Mobile IPv4 Host Configuration Extensions
Dynamic Home Agent Assignment

- Dynamic HA extension allows home agents to be assigned dynamically. Based on load balancing or other considerations.
- Example: Using CoA at foreign agent [RFC 4433]
Mobile router registers “network prefixes” with home agent
All addresses with those prefixes are forwarded by home agent to Mobile router in a tunnel
The reverse traffic is also tunneled.
The mobile network may have visiting mobile routers or visiting mobile nodes.

RFC 3963, Jan 2005
Security Issues

- Need to Authenticate: MN – FA, FA-HA, MN-HA
- Message Authentication Code: Use keyed-MD5
- Key Management: Need network key distribution
- Confidentiality: Use encryption IPsec ESP
- Replay Protection: Changing Identification field. Use time stamps as ID or Nonces
- Location Privacy: Reverse traffic is tunneled via HA
- Ingress Filtering: Firewalls drop outgoing packets with topologically incorrect source address
  ⇒ Use reverse tunneling with COA as SA
Mobile IP and VPN

- Mobile IP \(\Rightarrow\) MIPv4 tunnel between Care-of-Address and Home Agent. COA at Foreign agent or co-located in Mobile.
- VPN \(\Rightarrow\) IPsec Tunnel between Mobile and VPN Gateway
- Depending upon the location of home agent:
  - IPsec inside MIPv4 tunnel or MIPv4 inside IPsec tunnel
- RFC 4093 lists five possible locations for Home Agent
- Work in progress to modify Mobile IP for VPN
Mobile IP and VPN (Cont)

1. **Home Agent inside Intranet**: MIP inside IPsec.
   - Foreign agent cannot be COA.
   - Co-located COA only.
   - Every COA change ⇒ New VPN tunnel

This is the most common configuration
⇒ Requires modifications to MIPv4
5. Combined VPN Gateway and HA in the Intranet:
This works without any problems or modifications.
IPsec in MIPv4
Not scalable to thousands of mobile users

Mobile Node | Foreign Agent | Firewall NAT | VPN GW Home Agent
Intranet | Correspondent
Summary

- Mobile node gets its packet via a tunnel from the home agent to care-of-address
- Reverse tunnel from mobile to home agent is optional
- It is possible to dynamically assign home address and home agents
- Network mobility is supported. Requires reverse tunneling.
- Need to carefully position VPN gateway and home agents for proper nesting of IPsec and Mobile-IP tunnels
Reading Assignment

Text Books:
- Dixit and Prasad, Chapter 16, pp. 335-439.
- Murthy and Manoj, Section 4.3, pp. 158-172

Key RFCs:
- RFC 3344 IP Mobility Support for IPv4
- RFC 3753 Mobility Related Terminology

Other Papers:
Mobile IPv4: RFCs

Secondary RFCs:
- RFC 3024 Reverse Tunneling for Mobile IP
- RFC 2005 Applicability Statement for IP Mobility Support
- RFC 2041 Mobile Network Tracing
- RFC 2290 Mobile-IPv4 Configuration Option for PPP IPCP
- RFC 2356 Sun's SKIP Firewall Traversal for Mobile IP
- RFC 2794 Mobile IP Network Access Identifier Extension for IPv4
- RFC 2977 Mobile IP AAA Requirements
Mobile IPv4: RFCs (Cont)

- RFC 3012 Mobile IPv4 Challenge/Response Extensions
- RFC 3115 Mobile IP Vendor/Organization-Specific Extensions
- RFC 3519 Mobile IP Traversal of Network Address Translation (NAT) Devices
- RFC 3543 Registration Revocation in Mobile IPv4
- RFC 3583 Requirements of a Quality of Service (QoS) Solution for Mobile IP
- RFC 3846 Mobile IPv4 Extension for Carrying Network Access Identifiers
- RFC 3957 AAA Registration Keys for Mobile IPv4
- RFC 3963 Network Mobility (NEMO) Basic Support Protocol
- RFC 4004 Diameter Mobile IPv4 Application
Mobile IPv4: RFCs (Cont)

- RFC 4064 Experimental Message, Extensions, and Error Codes for Mobile IPv4
- RFC 4065 Instructions for Seamoby and Experimental Mobility Protocol IANA Allocations
- RFC 4093 Problem Statement: Mobile IPv4 Traversal of Virtual Private Network (VPN) Gateways
- RFC 4332 Cisco's Mobile IPv4 Host Configuration Extensions
- RFC 4433 Mobile IPv4 Dynamic Home Agent (HA) Assignment
A mobile node with home address in WUSTL.EDU is traveling in a plane with a router that serves as COA. But the router itself is mobile and has a home address at AA.COM. How many Mobile IP tunnels will be setup and indicate IP addresses of the end points of each tunnel. Hint: See RFC3344.