Mobile IP
Part I: IPv4

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Audio/Video recordings of this lecture are available at:

http://www.cse.wustl.edu/~jain/cse574-08/

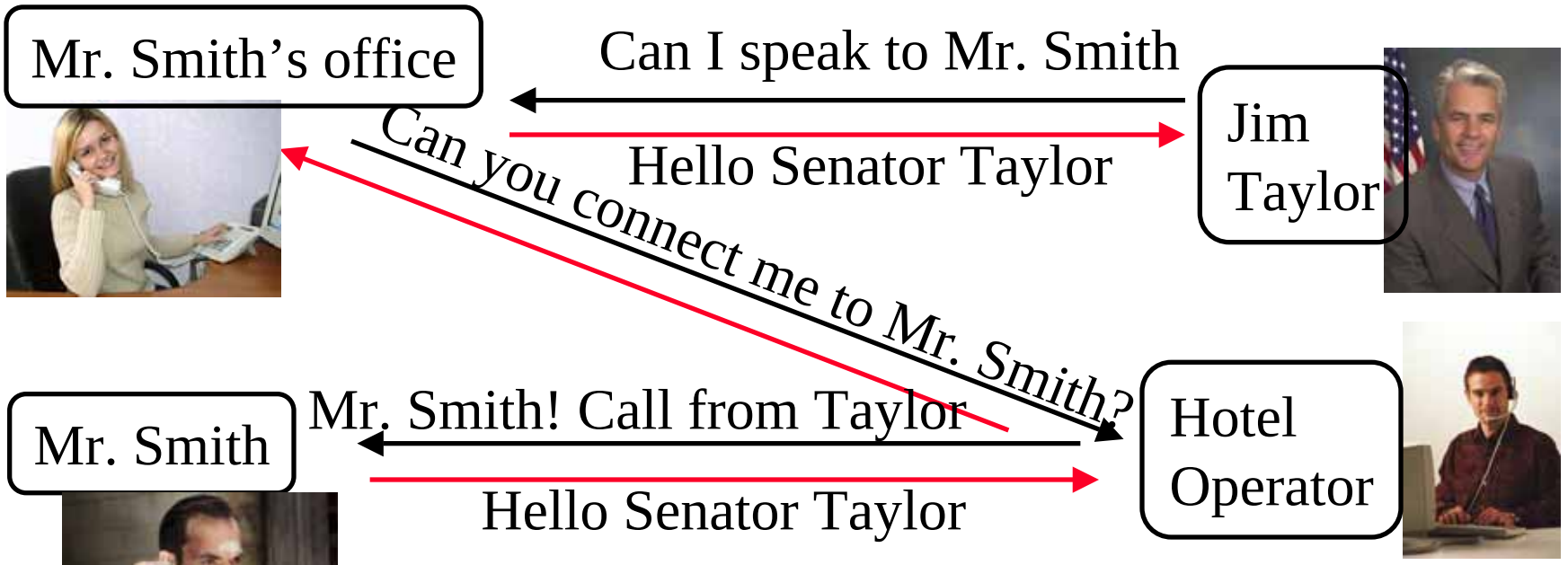
Overview

- 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

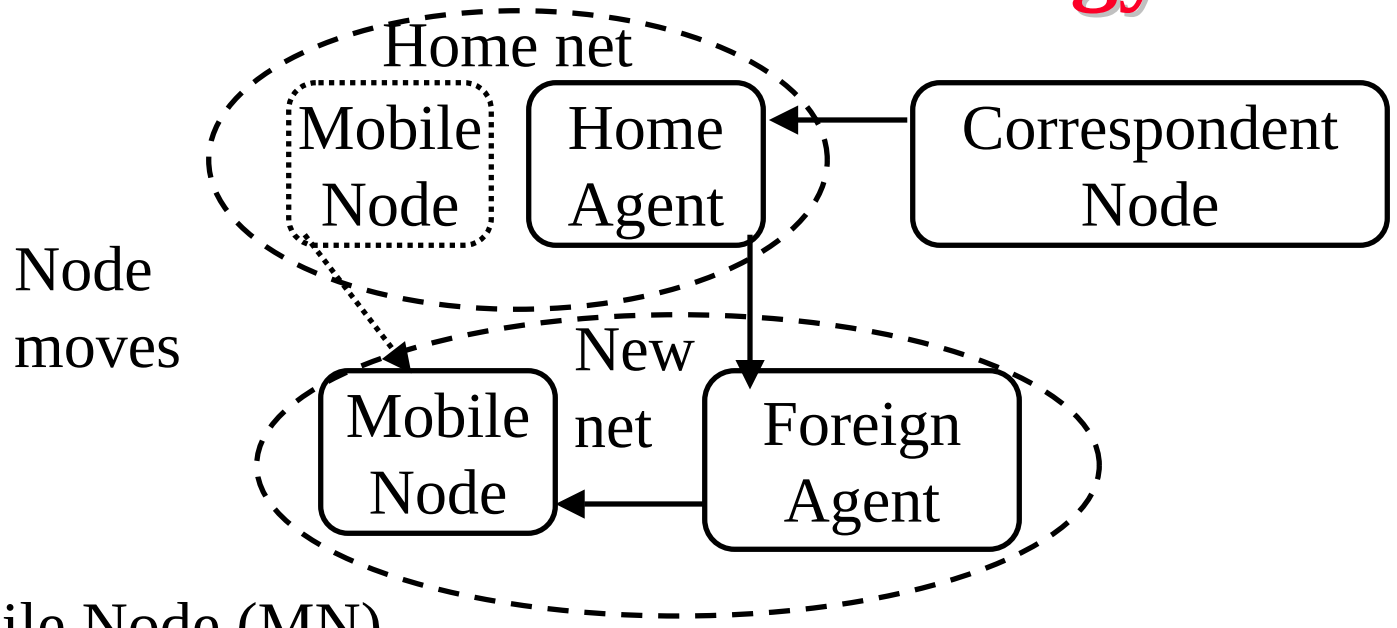
- You can take you notebook to any location
- Your TCP connection can continue. TCP connections are from one IP address to another IP address
  $\Rightarrow$ TCP is unaware of the mobility
- Continuous access to your home resources
- Access to local resources: Printers
- Finds nearby IP routers and connects *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

Mr. Smith Goes to Washington



- We need:
  - An agent at home office: Home Agent
  - An agent at foreign office: Foreign Agent

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

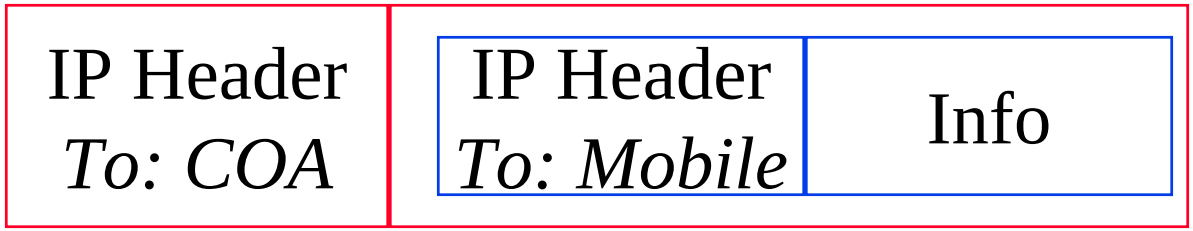
- **Agent Discovery**: To find agents
  - Home agents and foreign agents advertise periodically on network layer and optionally on datalink
  - They also respond to solicitation from mobile node
  - Mobile can send solicitation to Mobile agent multicast group 224.0.0.11
  - Mobile selects an agent and 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 $\Rightarrow$ Deregistration
- Deregistration with foreign agents is not required.
  Expires automatically
- Simultaneous registrations with more than one COA allowed (for handoff)

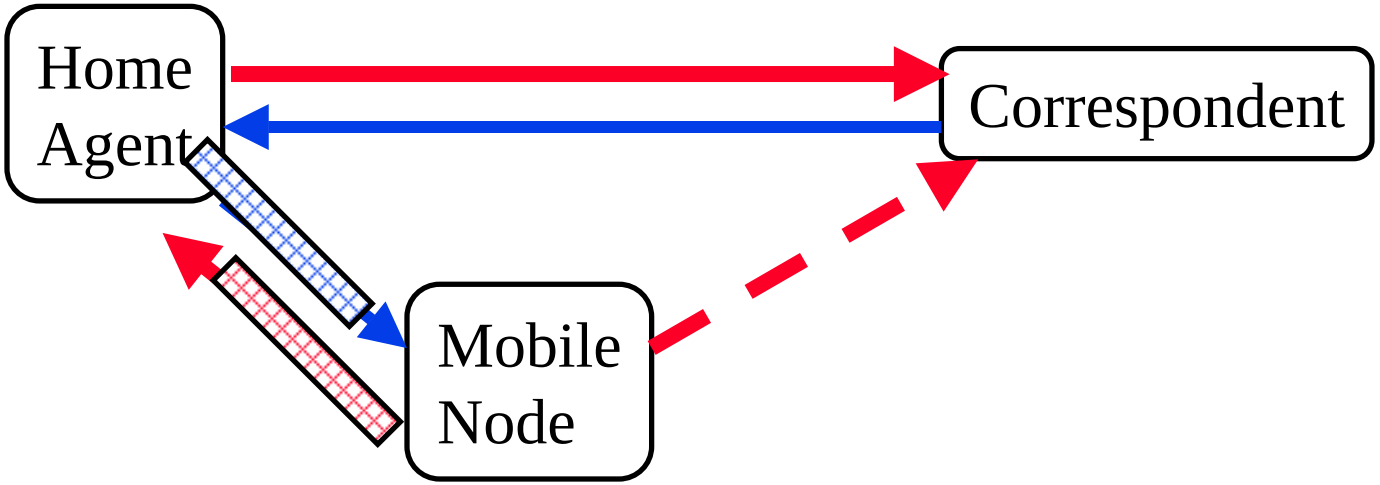
Encapsulation/Tunneling

- 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



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]



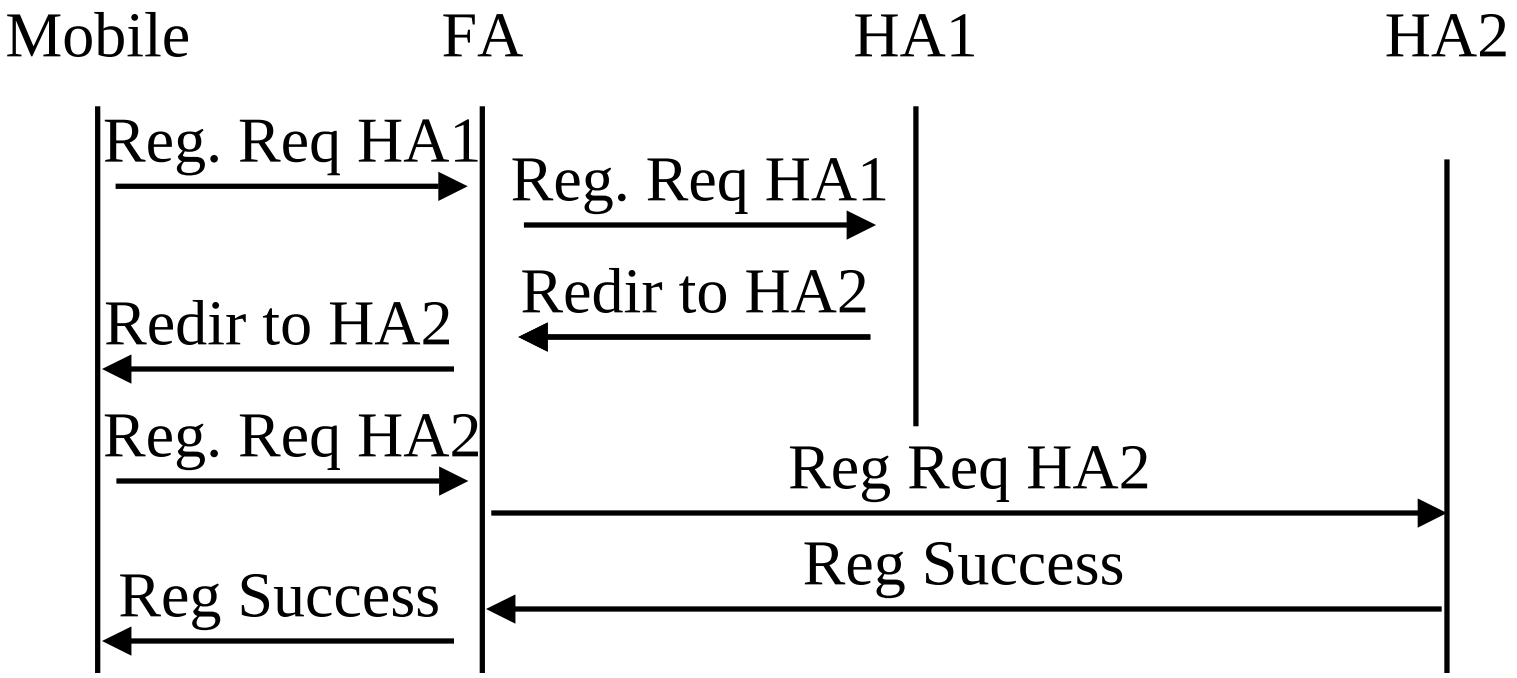
Home Networks with Dynamic IP Address

- 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

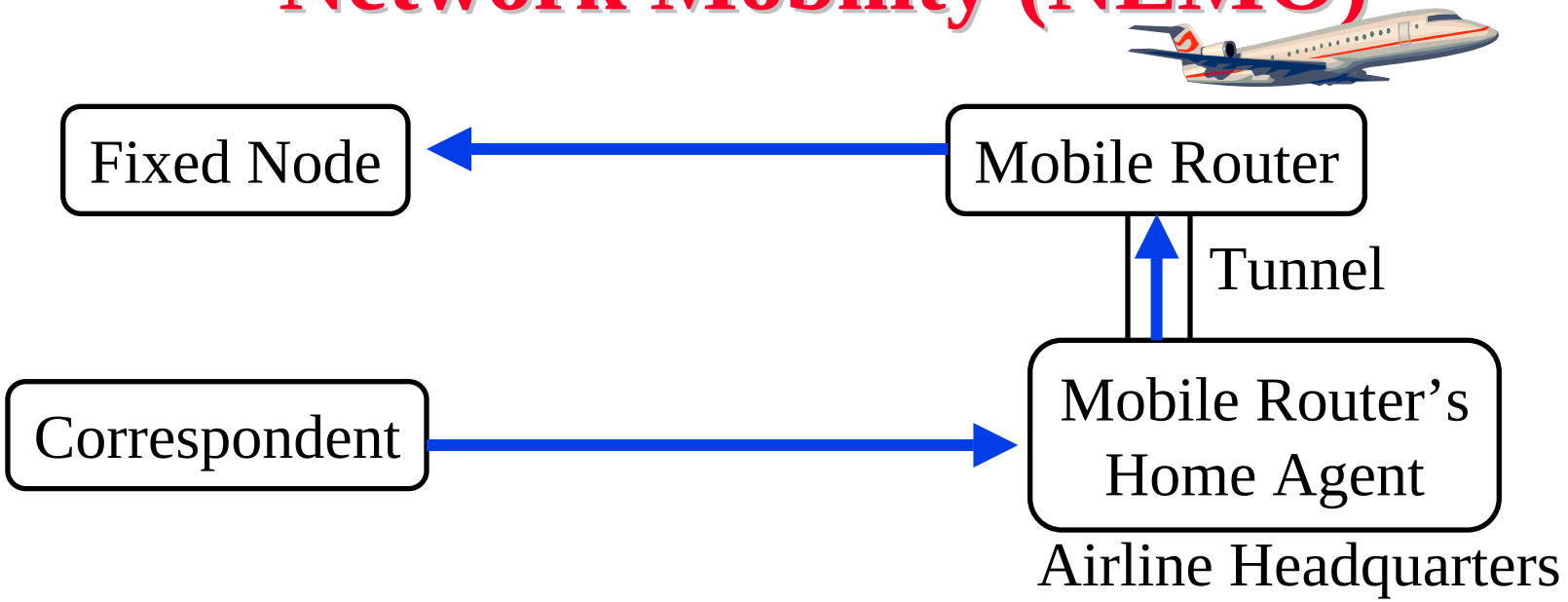
- RFC 4332, Cisco's Mobile IPv4 Host Configuration Extensions

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]



Network Mobility (NEMO)



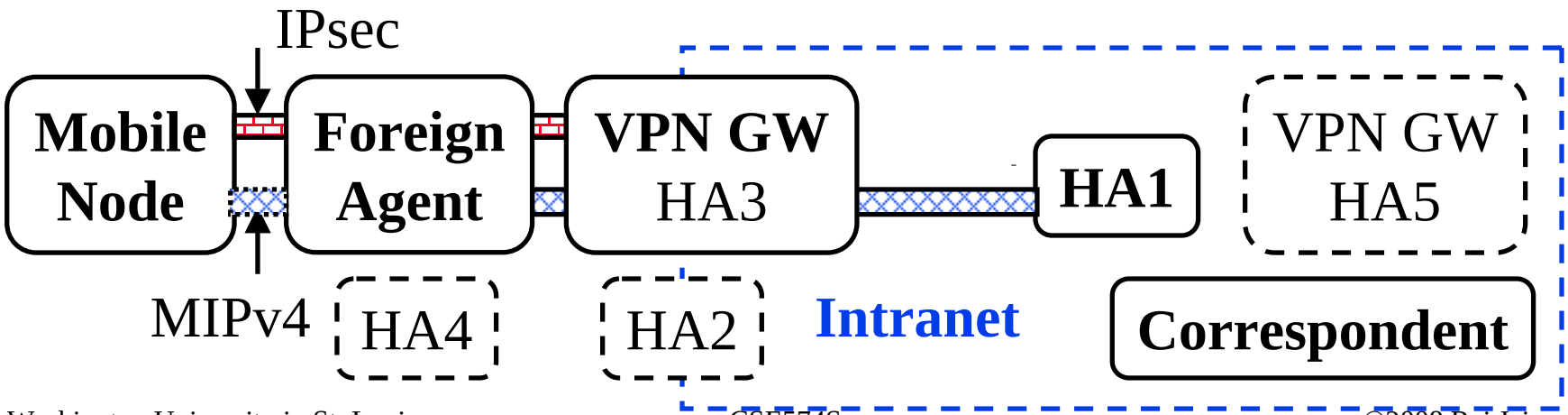
- Mobile router registers "network prefixes" with home agent
- All addresses with those prefixes are forwarded by home agent to Mobile router in a tunnel
- The reverse traffic is also tunneled.
- The mobile network may have visiting mobile routers or visiting mobile nodes.
- RFC 3963, Jan 2005

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
  $\Rightarrow$ Use reverse tunneling with COA as SA

Mobile IP and VPN

- Mobile IP ⇒ MIPv4 tunnel between Care-of-Address and Home Agent. COA at Foreign agent or co-located in Mobile.
- VPN ⇒ 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.

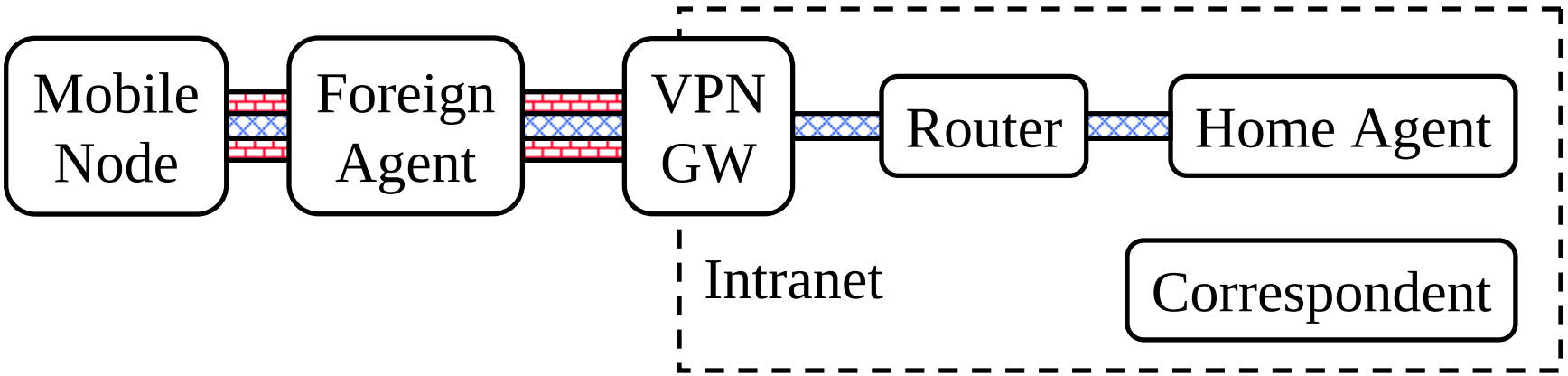
Foreign agent cannot be COA.

Co-located COA only.

Every COA change ⇒ New VPN tunnel

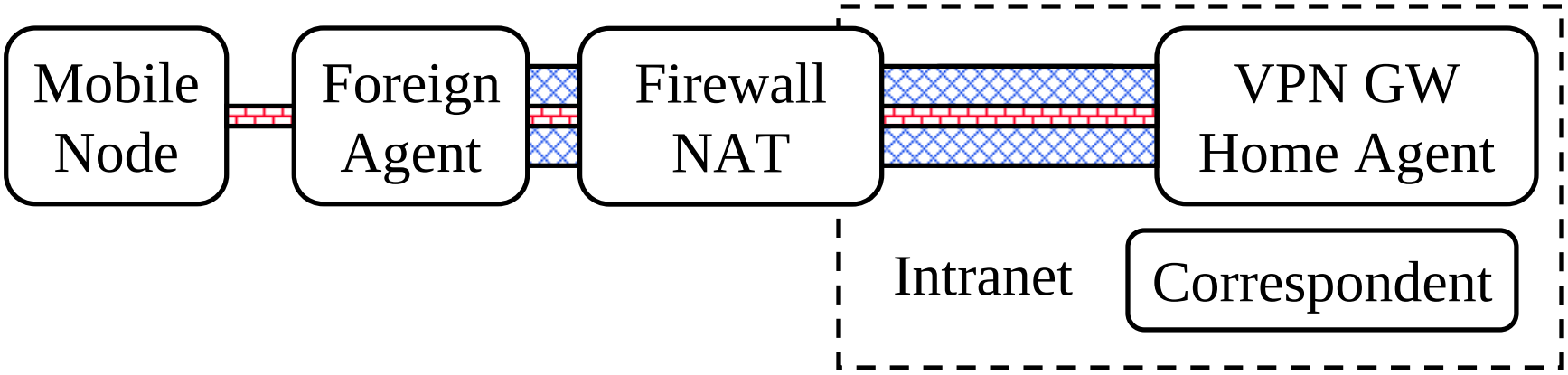
This is the most common configuration

⇒ Requires modifications to MIPv4

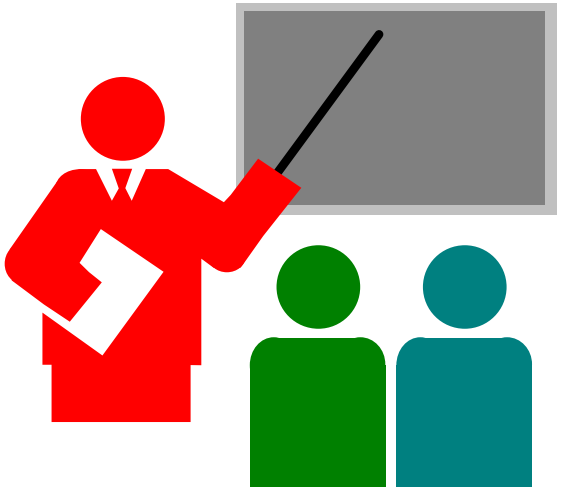


Mobile IP and VPN (Cont)

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



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

IETF Working Group:
http://www.ietf.org/html.charters/OLD/mobileip-charter.html

Other Papers:

- Y. Chen, "A Survey Paper on Mobile IP," http://www.cse.wustl.edu/~jain/cis788-95/mobile_ip/index.html
- Charlie Perkins, "Mobile IP," IEEE Communications Magazine, May 2002, pp. 66-82 (also May 1997 pp.84-99)

References: Mobile IPv4 RFCs

Key RFCs:

- **RFC 2005 "Applicability Statement for IP Mobility Support," October 1996.**
- **RFC 3344 "IP Mobility Support for IPv4," August 2002.**
- **RFC 4988 "Mobile IPv4 Fast Handovers," October 2007.**
- **RFC 3024 "Reverse Tunneling for Mobile IP, revised," January 2001.**
- **RFC 4433 "Mobile IPv4 Dynamic Home Agent (HA) Assignment," March 2006.**
- **RFC 4093 "Problem Statement: Mobile IPv4 Traversal of Virtual Private Network (VPN) Gateways," August 2005.**

References: Mobile IPv4 RFCs (Cont)

Secondary RFCs:

- RFC 2006 "The Definitions of Managed Objects for IP Mobility Support using SMIv2," October 1996.
- RFC 2290 "Mobile-IPv4 Configuration Option for PPP IPCP," February 1998.
- RFC 2356 "Sun's SKIP Firewall Traversal for Mobile IP," June 1998.
- RFC 2794 "Mobile IP Network Access Identifier Extension for IPv4," March 2000.
- RFC 2977 "Mobile IP Authentication, Authorization, and Accounting Requirements," October 2000.
- RFC 3115 "Mobile IP Vendor/Organization-Specific Extensions," April 2001.

References: Mobile IPv4 RFCs (Cont)

- RFC 3519 "Mobile IP Traversal of Network Address Translation (NAT) Devices," May 2003.
- RFC 3543 "Registration Revocation in Mobile IPv4," August 2003.
- RFC 3583 "Requirements of a Quality of Service (QoS) Solution for Mobile IP," September 2003.
- RFC 3846 "Mobile IPv4 Extension for Carrying Network Access Identifiers," June 2004.
- RFC 3957 "Authentication, Authorization, and Accounting (AAA) Registration Keys for Mobile IPv4," March 2005.
- RFC 4004 "Diameter Mobile IPv4 Application," August 2005.
- RFC 4064 "Experimental Message, Extensions, and Error Codes for Mobile IPv4," May 2005.

References: Mobile IPv4 RFCs (Cont)

- RFC 4332 "Cisco's Mobile IPv4 Host Configuration Extensions," December 2005.
- RFC 4636 "Foreign Agent Error Extension for Mobile IPv4," October 2006.
- RFC 4721 "Mobile IPv4 Challenge/Response Extensions (Revised)," January 2007.
- RFC 4728 "The Dynamic Source Routing Protocol (DSR) for Mobile Ad Hoc Networks for IPv4," February 2007.
- RFC 4784 "Verizon Wireless Dynamic Mobile IP Key Update for cdma2000(R) Networks," June 2007.
- RFC 4857 "Mobile IPv4 Regional Registration," June 2007.
- RFC 4881 "Low-Latency Handoffs in Mobile IPv4," June 2007.

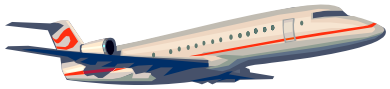
References: Mobile IPv4 RFCs (Cont)

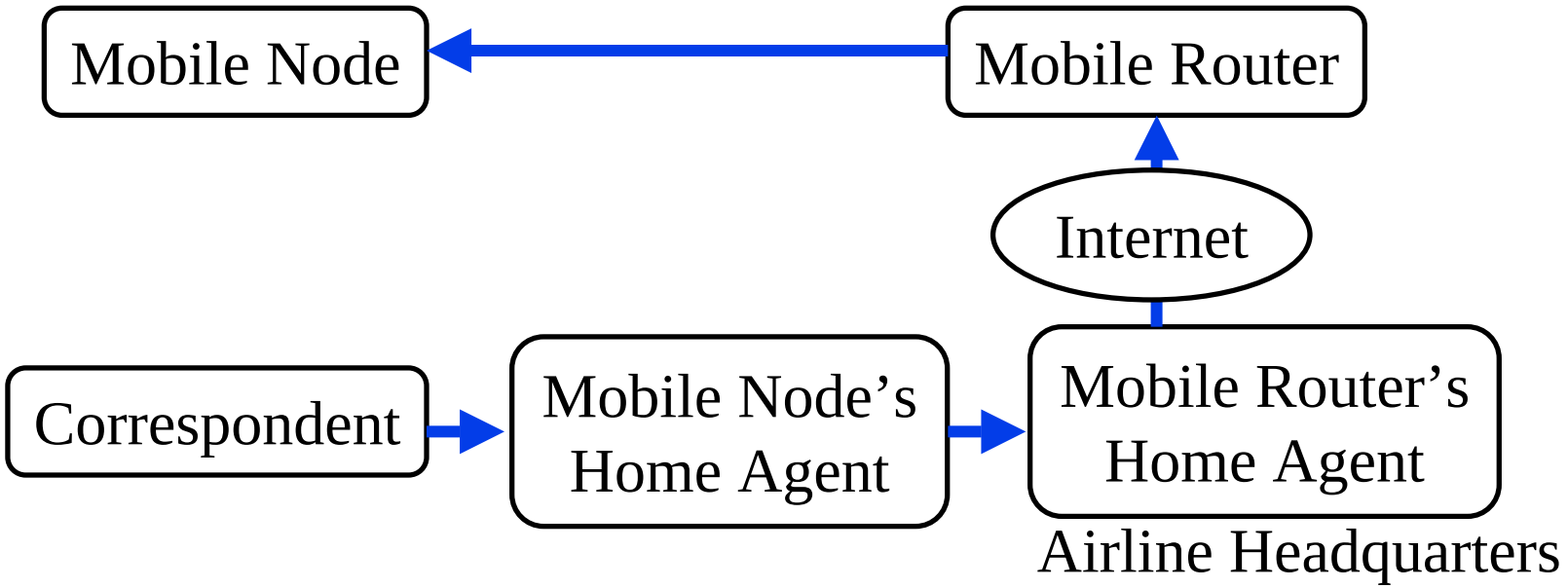
- RFC 4908 "Multi-homing for small scale fixed network Using Mobile IP and NEMO," June 2007.
- RFC 4917 "Mobile IPv4 Message String Extension," June 2007.
- RFC 5030 "Mobile IPv4 RADIUS Requirements," October 2007.
- RFC 5159, “Session Description Protocol (SDP) Attributes for Open Mobile Alliance (OMA) Broadcast (BCAST) Service and Content Protection," March 2008.

IETF Wireless Related Activities

- Mobile Ad-hoc Networks (manet), http://www.ietf.org/html.charters/manet-charter.html
- IPv6 over Low power WPAN (6lowpan), http://www.ietf.org/html.charters/6lowpan-charter.html
- Routing Over Low power and Lossy networks (roll), http://www.ietf.org/html.charters/roll-charter.html
- Ospf-wireless-design -- OSPF Wireless Design Team, https://www.ietf.org/mailman/listinfo/ospf-wireless-design

Homework





- 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.