

LECTURE 8

Mobile IP

What is Mobile IP?

- The Internet protocol in its native form does not support mobility
- Mobile IP tries to address this issue by creating an “anchor” for a mobile host that takes care of packet forwarding
- Does not discuss handoff initiation or decision process
- Does not discuss flushing or redirecting packets from an old visited network

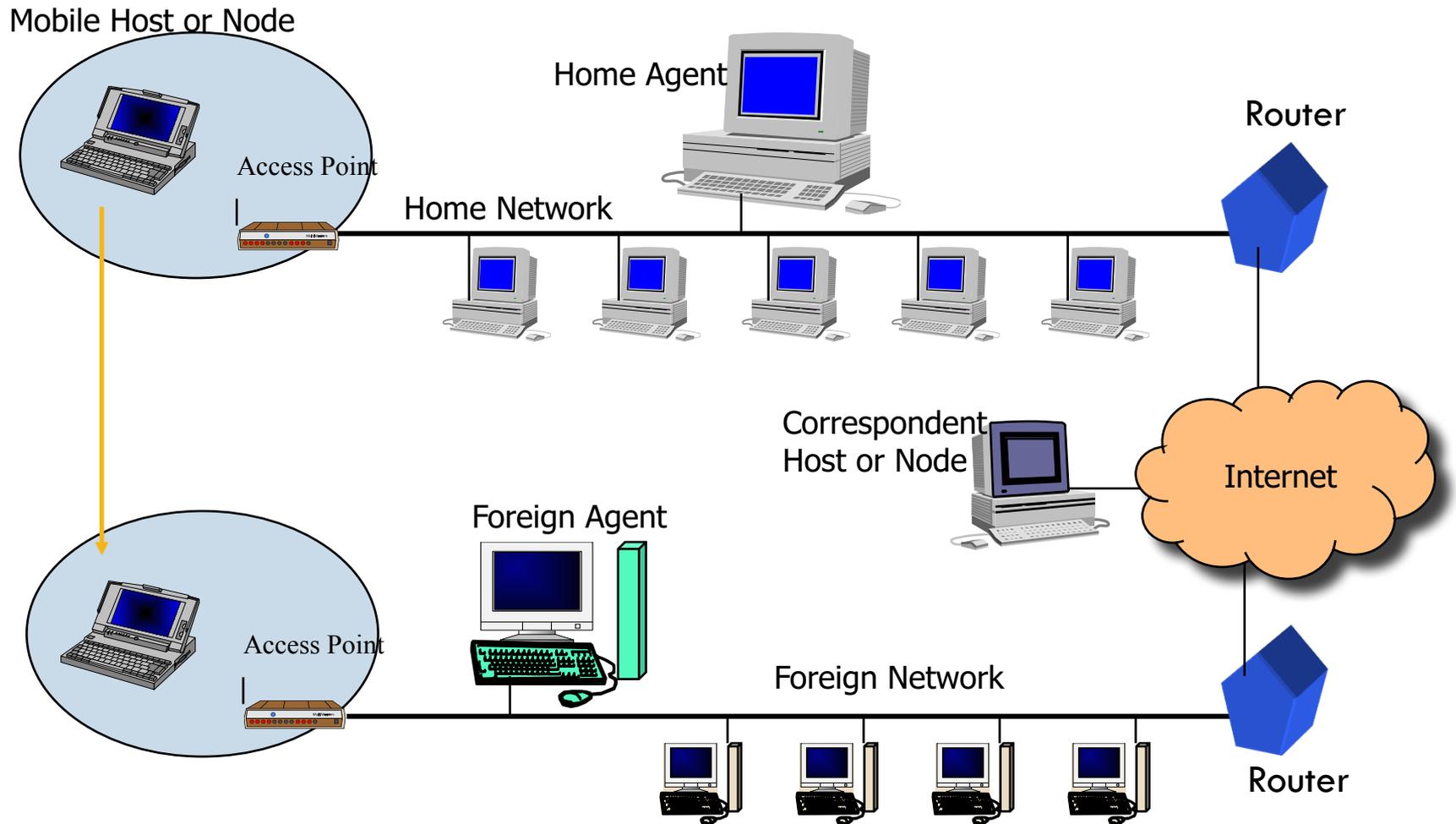
The Problem!

- The IP address is used for dual purposes
 - ▣ For routing packets through the Internet
 - ▣ As an end-point identifier for applications in end-hosts
 - A socket consists of the following tuple <source IP address, source port, destination IP address, destination port>
 - A TCP connection cannot survive any address change
 - A domain name is converted to an IP address
- If the IP address is stable, packets get routed to the same place always
- If the IP address is changed, the connection breaks!
- How does a sender know the changed IP address?

Mobile IP Requirements

- **Compatibility**
 - ▣ Must not require changes to existing network protocols
 - ▣ Must not require a new LLC/MAC
- **Transparency**
 - ▣ Invisibility to higher layers (TCP through Application)
 - ▣ Invisibility to user
- **Scalability and Efficiency**
 - ▣ Not a great deal of additional traffic
 - ▣ No great increase in additional network elements
- **Security**
 - ▣ Security concerns due to changing locations of a mobile node

Mobile IP Architecture and Terminology



Terminology I

- Mobile Node (MN)
 - ▣ Host that can change its point of attachment
- Correspondent Node (CN)
 - ▣ The partner for communication (it can be a fixed or mobile node)
- Home Network
 - ▣ IP Network where the MN usually resides
- Foreign Network
 - ▣ IP network where the MN is visiting

Terminology II

□ Home Address

- ▣ A long term IP address assigned to the MN that is part of the home IP network.
 - It remains unchanged regardless of where the MN is
 - It is used for DNS determination of the MN's IP address

□ Care-of Address (COA)

- ▣ IP address in the Foreign Network that is the reference pointer to the MN when it is visiting the Foreign Network
 - This is usually the IP address of the Foreign Agent
 - Sometimes the MN can act as its own Foreign Agent in which case, it is called a co-located COA

Terminology III

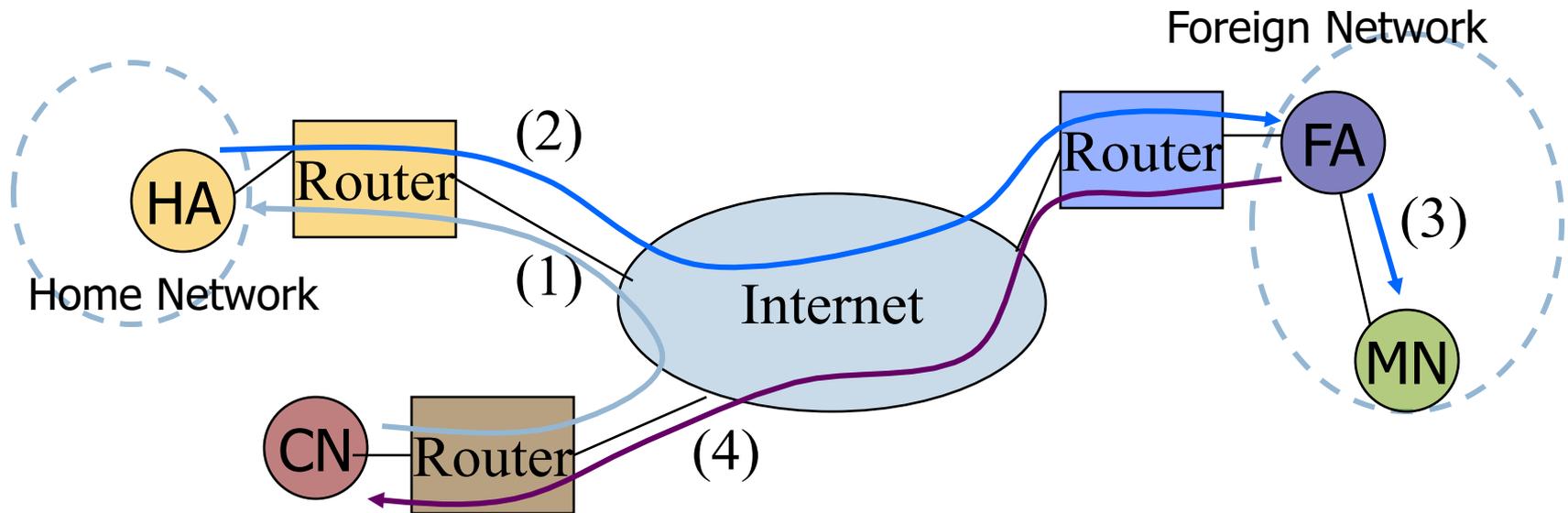
- Home Agent (HA)
 - ▣ It is the anchor point for the MN
 - ▣ Regardless of where the MN is (except if it is in its home network) packets addressed to it reach the HA
- Foreign Agent (FA)
 - ▣ It is the reference IP host for the MN in the Foreign Network

Protocol Overview

- What does the protocol do?
 - ▣ Enables datagrams addressed to the MN at the home address to be delivered wherever the MN is
- Three phases:
 - ▣ Delivery to the home network
 - ▣ Forwarding to the foreign network
 - ▣ Delivery to the mobile node

Triangle Routing in Mobile IP

- CN transmits a datagram that is routed to MN's home network as usual (1)
- HA intercepts the packet, encapsulates and tunnels it to FA (2)
- FA decapsulates and forwards the packet to MN
- Packets from MN to CN are sent as usual (4)



Packet Interception by the Home Agent

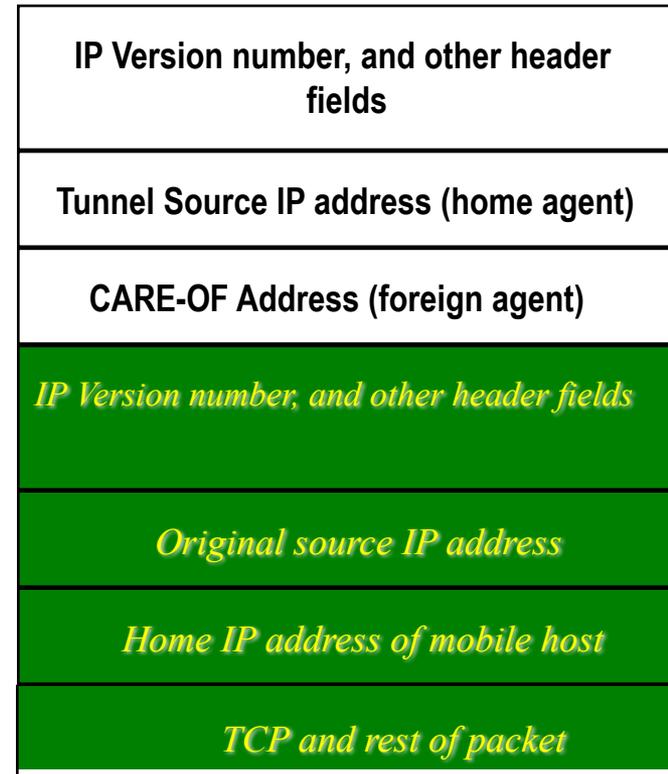
- HA performs a proxy ARP on behalf of the MN when it is away
 - ▣ If an ARP request is made to obtain the MAC address of the MN on the home network, the HA responds with its own MAC address
- The MN performs a gratuitous ARP when it returns to the home network
 - ▣ Unsolicited ARP reply that is broadcast to each node on the Home Network
 - ▣ Some networks do not trigger ARP cache updates based on gratuitous ARP => Mobile IP cannot be implemented correctly

Packet Encapsulation by HA

- Forwarding packets is achieved by encapsulation (tunneling)
 - ▣ Virtual pipe between tunnel entry point (HA) and tunnel termination point (FA)
- The datagram from the CN is made the payload of *another* IP packet
- Three types of encapsulation are provided
 - ▣ IP in IP encapsulation
 - ▣ Minimal encapsulation
 - ▣ Generic routing encapsulation
 - For protocols other than IP

IP-in-IP Encapsulation

- ❑ Mandatory implementation
- ❑ The outer header uses IP-in-IP as the protocol type
- ❑ The whole tunnel is equivalent to one hop from the original packet's point of view
- ❑ Overhead can be reduced since several fields are redundant



Minimal Encapsulation

- The header in the original packet is stripped of unnecessary information like length, version number, flags, etc.
- The Home Address of the MN and the original source address (of the CN) are retained
- Since the fragment offset field is also removed, it does not work with fragmented IP packets

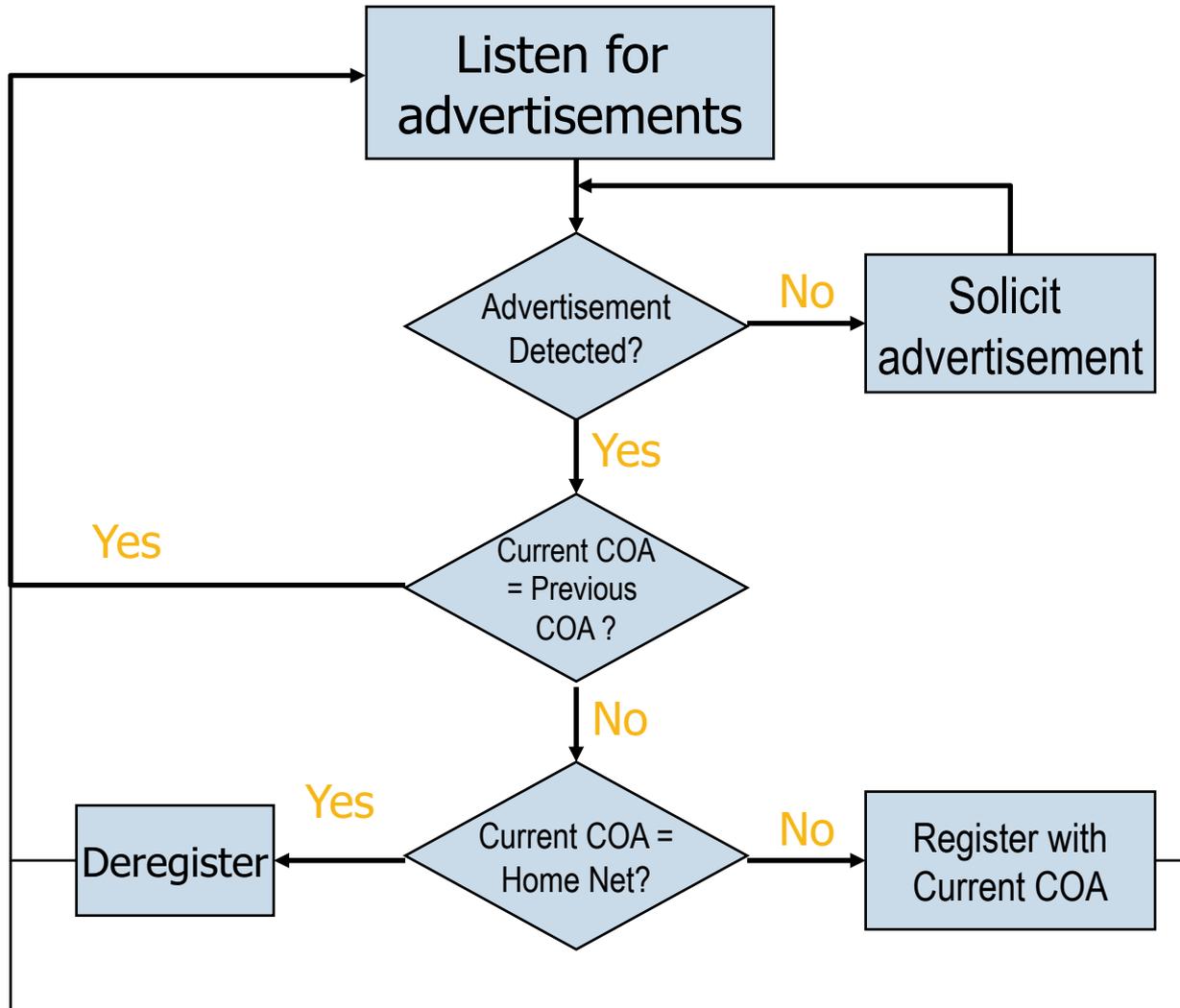
Agent Advertisement and Discovery

- How does a Mobile Node know that it has moved to another network?
 - ▣ In CDPD, the control messages broadcast on the forward channel provide this information
- How does a Mobile Node determine the address of a Home Agent or a Foreign Agent?
- Foreign agents and home agents periodically “advertise” their presence using agent advertisement messages
- This is similar to router advertisement using ICMP

Agent Advertisement II

- A “mobility extension” to ICMP contains the relevant information
 - Is it a Home Agent or a Foreign Agent?
 - COA associated with the FA
 - Busy or not
 - Whether minimal encapsulation is permitted
 - Whether reverse tunneling is permitted (later)
 - Whether registration is mandatory
- The Agent Advertisement packet must be a broadcast message on the link
- The same agent may act as both a HA and a FA
- If the MN gets an advertisement from its HA, it must deregister its COA's and enable a gratuitous ARP
- If a MN does not “hear” any advertisement, it must solicit an agent advertisement using ICMP

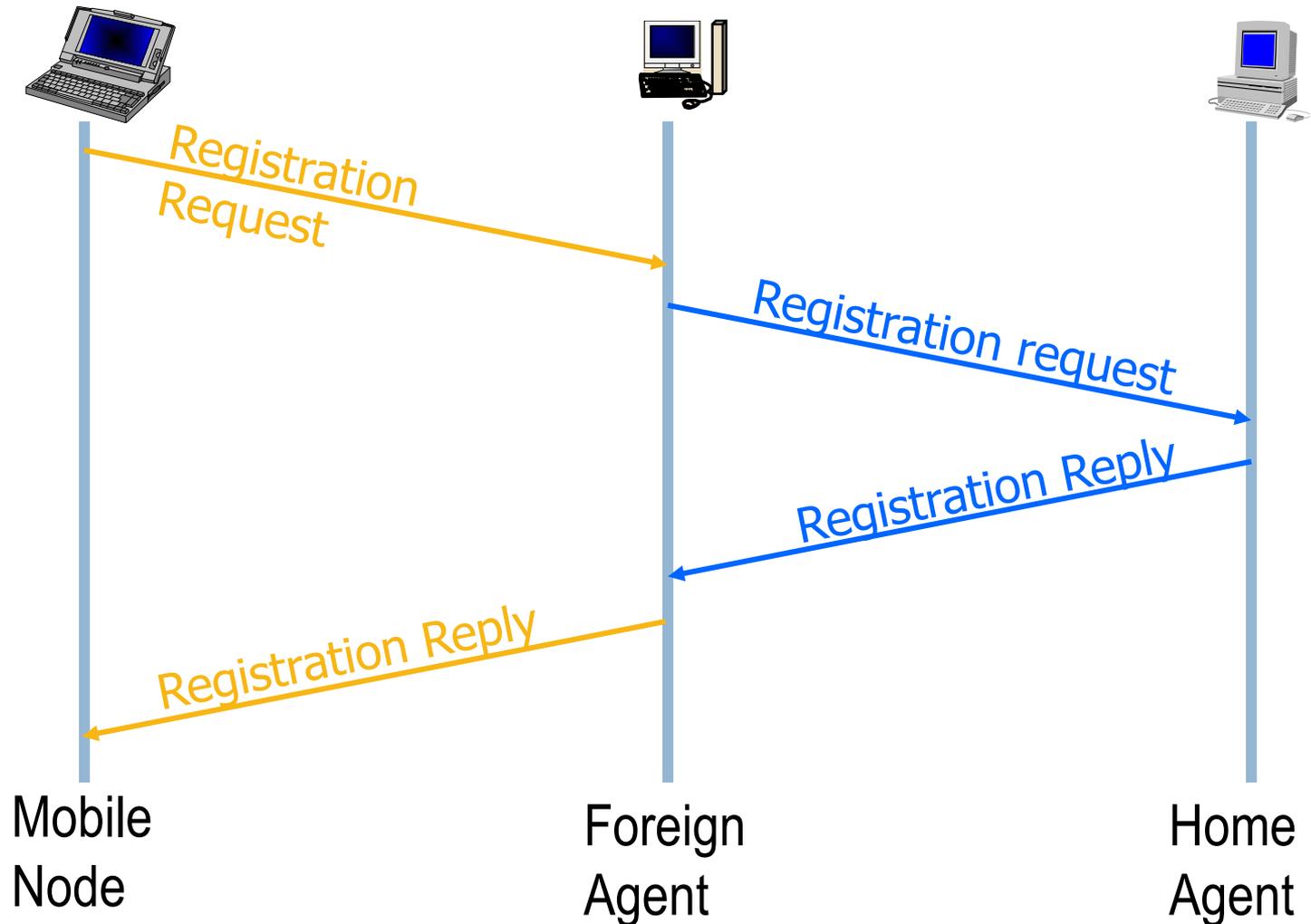
Connection Search Flow Chart



Registration

- Purpose:
 - ▣ Inform the HA about the COA
 - ▣ FA can obtain approval from the HA to provide service to the MN
 - ▣ Authenticated to prevent malicious attacks

Registration in Mobile IP II



Registration III

- UDP packets are used for registration (port 454 in the HA)
- A nonce called an identification field is used in the request and another in the reply to prevent replay attacks
- If the COA is the FA
 - ▣ MN sends registration request to FA
 - ▣ FA forwards it to the HA
 - ▣ Else
 - ▣ MN directly sends the request to the HA
- HA creates a binding between the MN's home address and the current COA
 - ▣ This binding has a fixed lifetime
 - ▣ MN should re-register before the expiration of the binding

Registration IV

- The Home Agent may maintain multiple COA for a mobile node upon request
 - ▣ Most implementations do not support this
- Broadcast datagrams are NOT tunneled unless explicitly requested by the MN
- Deregistration involves “registering” the home address with the HA
- Deregistering one of the multiple COAs is done by registering it with zero lifetime
- If multiple COAs are not explicitly requested, each new registration request wipes out the previous binding.

Registration V

- Registration reply indicates whether the registration is successful or not
- Rejection is possible by either HA or FA
 - ▣ Insufficient resources
 - ▣ Header compression not supported
 - ▣ HA unreachable
 - ▣ Too many simultaneous bindings
 - ▣ Failed authentication
- Directed broadcast
 - ▣ If a MN cannot reach its HA, it will send a broadcast registration request to its home network
 - ▣ This is rejected by every (other) valid HA on its home network
 - ▣ The MN uses one of the HA addresses in the reject message to make a valid registration request (with proper authentication credentials)

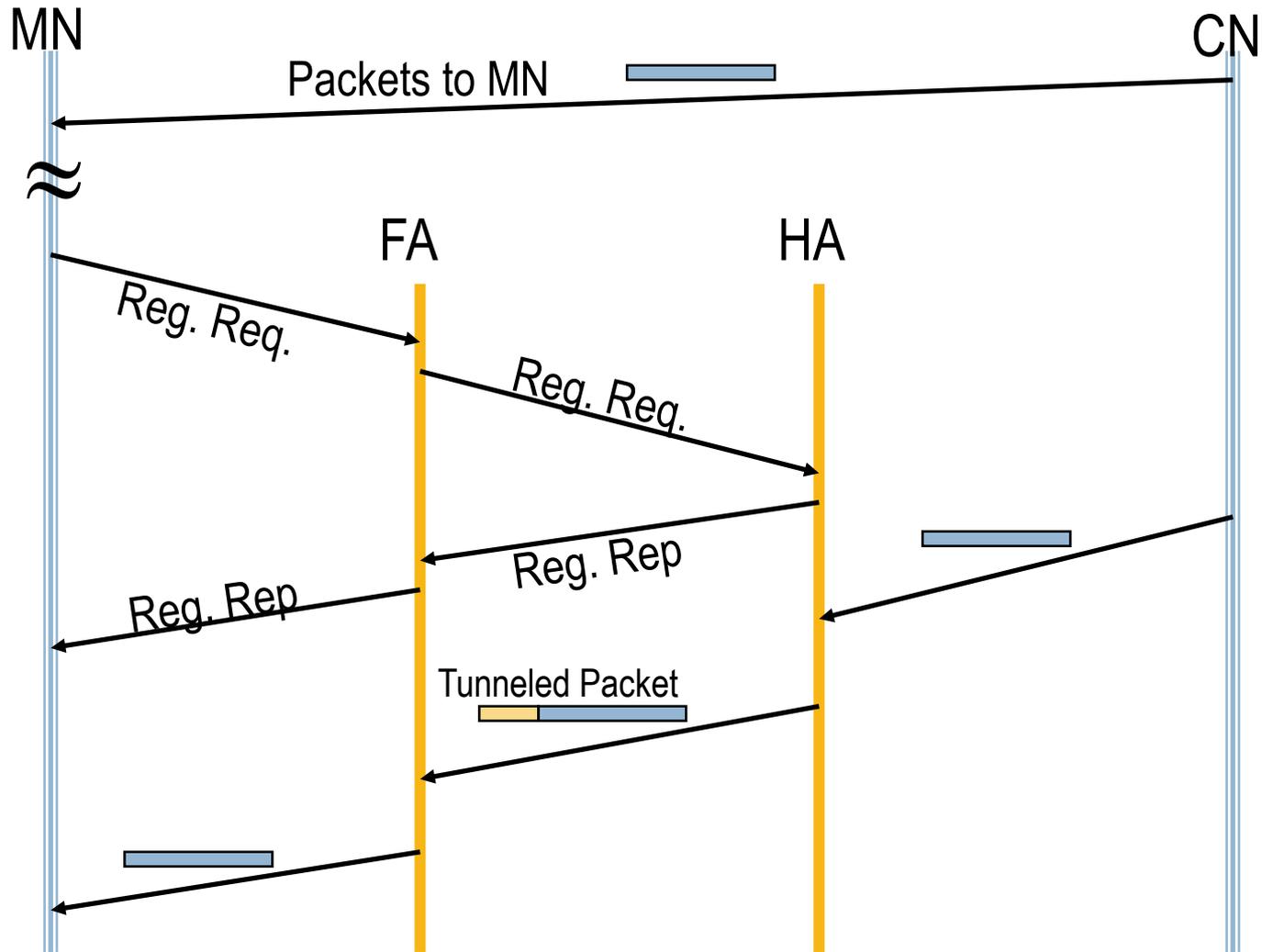
Mobility Binding List at the HA (CF: Location Directory)

- Upon a valid registration, the HA should create an entry for a mobile node that has:
 - ▣ Mobile node's care of address
 - ▣ Identification field
 - ▣ Remaining lifetime of registration

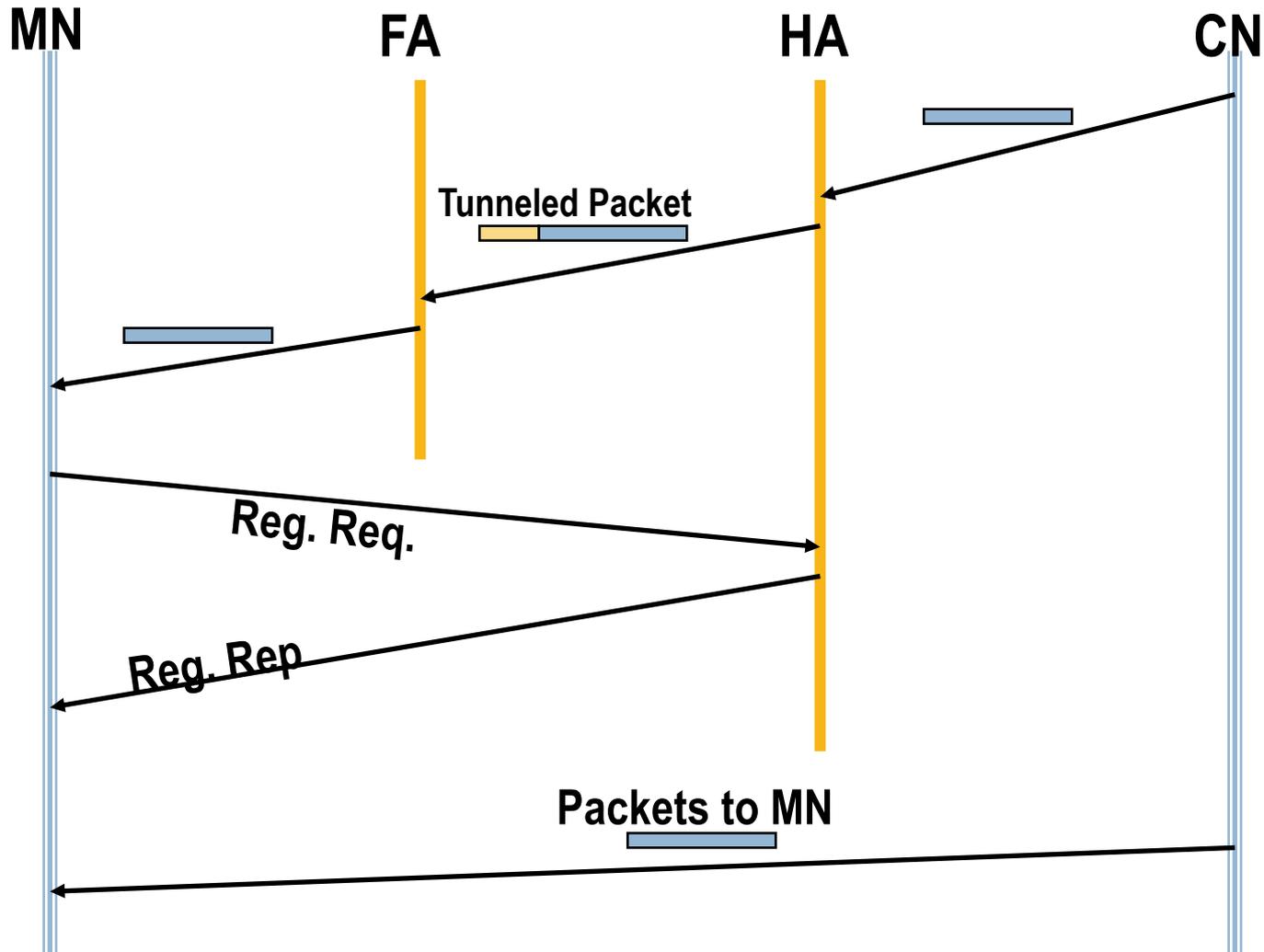
Visitor List at FA: CF Registration Directory

- Each Foreign Agent maintains a visitor list containing the following information:
 - Link layer address of the mobile node
 - Mobile node's home IP address
 - UDP registration request source port
 - HA IP address
 - Identification field
 - Registration lifetime
 - Remaining lifetime of pending or current registration

MN moves from Home Network to Foreign Network



MN moves from Foreign Network to Home Network



Route Optimization

- Triangle routing is inefficient
 - German and Japanese in Boston
 - Vulnerability
 - Congestion
 - Bottleneck in the home agent
- In the future, intermediate routers and CNs can be expected to cache COA bindings and tunnel packets
 - Authentication?
 - Changes to the existing Internet entities?

Smooth Handoffs

- Suppose a MN changes its foreign network
- While a new registration request is in progress, data is being tunneled to the old FA
 - ▣ This data has to be resent by the CN!
 - ▣ The retransmitted data has to be tunneled again!
- If the old FA can tunnel packets it receives to the new FA, this can reduce delay and congestion
- If the old FA re-tunnels the packet back to the HA, it is called a “special tunnel”
 - ▣ Enables HA to detect a “loop” if a new registration request has not been enabled

Reverse Tunneling

- Sometimes packets will have to be tunneled through the HA
 - ▣ Firewalls drop outgoing packets that have an IP address that corresponds to another network
 - ▣ TTL considerations
 - Packets addressed to hosts on the home network with small TTL need to sense the internet as one hop

Mobility Support in IPv6

- Addresses “macro”-mobility (movement from one subnetwork to another). “Micro”-mobility to be handled by link-level mobility management (like WLANs)
- Every IPv6 node implements functions for mobility support (including corresponding hosts => no FA is needed)
- Mobile hosts have one home address and one or more care-of addresses
- There exists what is called “binding” between the home address and the primary care-of address

Mobility Support in IPv6 (Continued)

- Secure binding updates, binding acknowledgements and binding requests
 - enable packets to reach the MH through the HA
 - Extremely small role for the HA
 - enable the CH find out the current care-of address of the MH
 - enable intermediate routers find out the current care-of address of the MH
- The following advantages are perceived:
 - Congestion at the home agent will be reduced
 - Optimal routing of packets will be enabled

Optimized Mobile IP?

