ECS-087: Mobile Computing

Mobile IP

Most of the slides borrowed from Prof. Sridhar Iyer

Effect of Mobility on Protocol Stack

- Application: new applications and adaptations
- Transport: congestion and flow control
- Network: addressing and routing
- Link: media access and handoff
- Physical: transmission errors and interference

Routing and Mobility

- Finding a path from a source to a destination
- Issues
  - Frequent route changes
  - Route changes may be related to host movement
  - Low bandwidth links

Routing and Mobility (contd)

- Goal of routing protocols
  - decrease routing-related overhead
  - find short routes
  - find “stable” routes (despite mobility)

Mobile IP (RFC 3344): Motivation

- Traditional routing
  - based on IP address; network prefix determines the subnet
  - change of physical subnet implies
    - change of IP address (conform to new subnet), or
    - special routing table entries to forward packets to new subnet

Quick Solution

- Changing of IP address
  - Use DHCP to have a new IP address when mobile device moves to a new subnet
    - but then the new address may not be known to anyone
  - Take help of DNS to update the entry
    - DNS updates take long time
  - TCP connections break
  - security problems
- Changing entries in routing tables
  - change routing table entries as the MN moves from one network to another
    - does not scale with the number of mobile hosts and frequent changes in the location
    - security problems

Mobile IP requirements

- Solution requirements
  - Compatibility
    - The new standard cannot introduce changes to applications and network protocols in use
    - Should be compatible with lower layers
      - use same layer 2 protocols
  - Transparency
    - New protocol should be transparent to higher layer
      - For TCP it means the MN should retain same IP address
  - Scalability
    - Enhancing IP for mobility should not generate too many messages
    - Should scale when there are a large number of MNs
  - Security
    - Management messages should be authenticated

Mobile IP: Terminology

- Mobile Node (MN)
  - node that moves across networks without changing its IP address
- Correspondent Node (CN)
  - host with which MN is “corresponding” (TCP)
- Home Agent (HA)
  - host in the home network of the MN, typically a router
  - registers the location of the MN, tunnels IP packets to the COA

Terminology (contd.)

- Foreign Agent (FA)
  - host in the current foreign network of the MN, typically a router
  - forwards tunneled packets to the MN, typically the default router for MN
- Care-of Address (COA)
  - address of the current tunnel end-point for the MN (at FA or MN)
  - actual location of the MN from an IP point of view

Mobility: Vocabulary

home network: permanent "home" of mobile (e.g., 128.119.40/24)

home agent: *entity that will perform mobility functions on behalf of mobile, when mobile is remote*

Permanent address: address in home network, *can always* be used to reach mobile e.g., 128.119.40.186

Correspondent node:

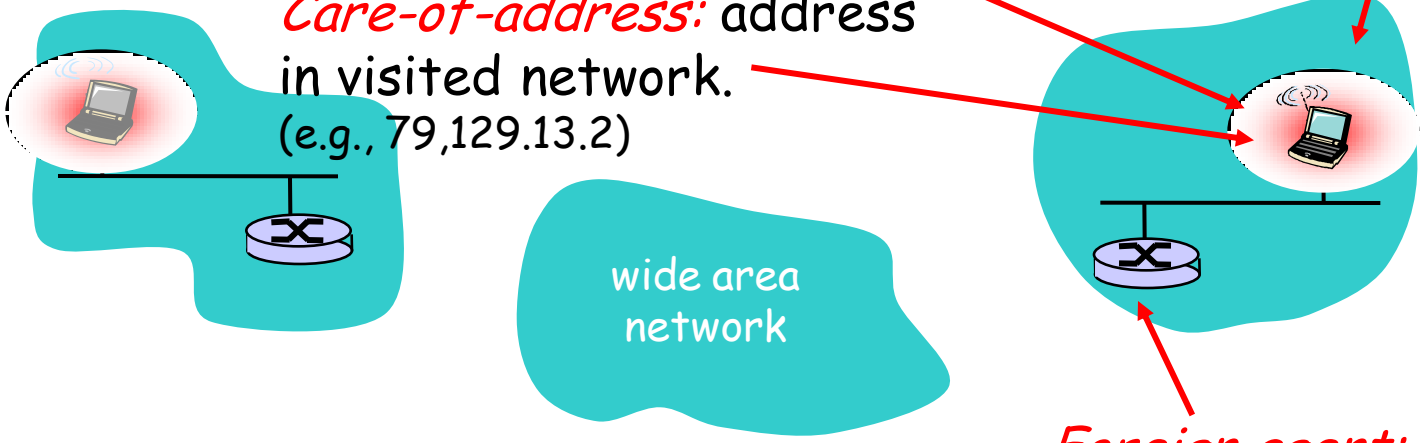
Source: Jim Kurose's slides

Mobility: more vocabulary

Permanent address: remains constant (e.g., 128.119.40.186)

visited network: network in which mobile currently resides (e.g., 79.129.13/24)

Care-of-address: address in visited network. (e.g., 79,129.13.2)



Foreign agent: *entity in visited network that performs mobility functions on behalf of mobile.*

correspondent: *wants to communicate with mobile*

Source: Jim Kurose's slides

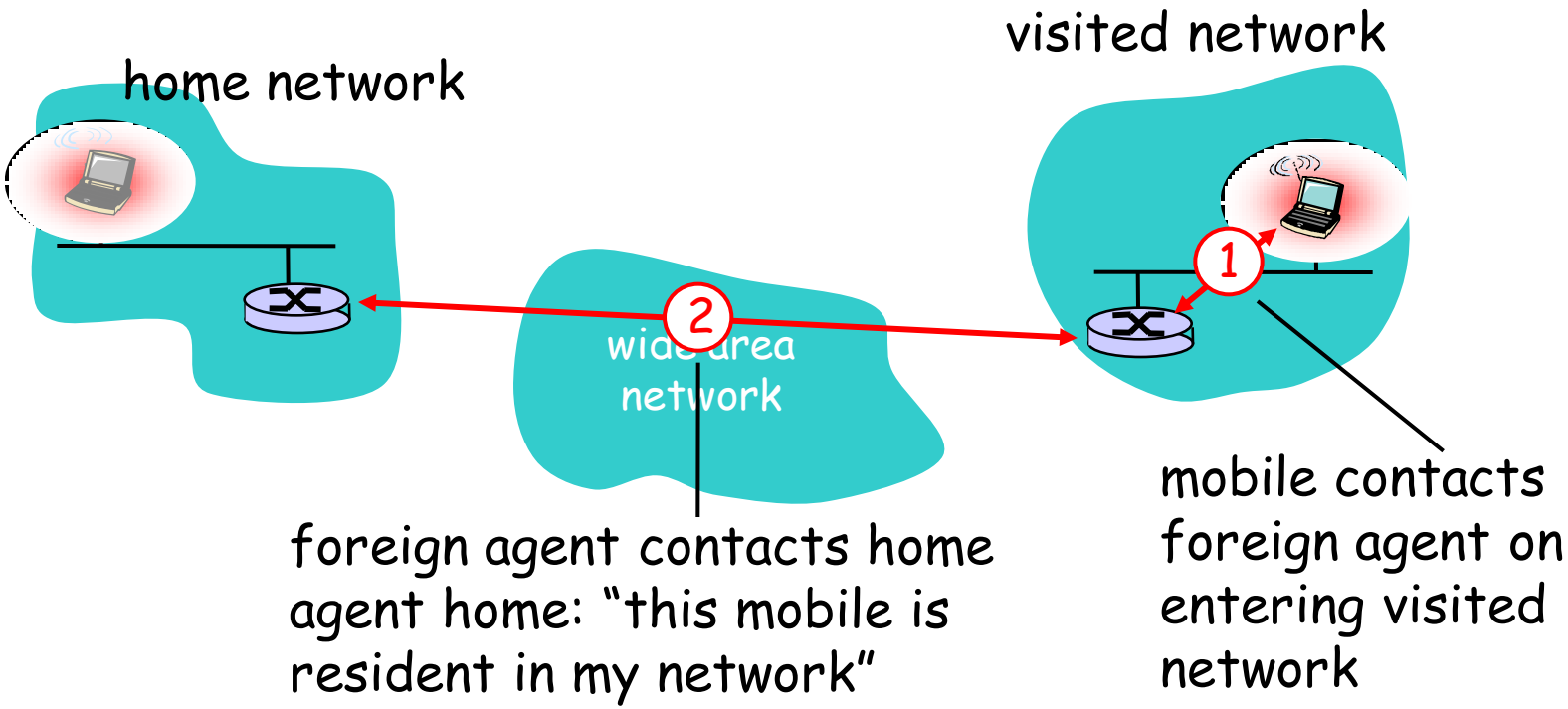
Mobility: approaches

- *Let routing handle it:* routers advertise permanent address of mobile-nodes-in-residence via usual routing table exchange.
  - routing tables indicate where each mobile located
  - no changes to end-systems
- *Let end-systems handle it:*
  - *indirect routing:* communication from correspondent to mobile goes through home agent, then forwarded to remote
  - *direct routing:* correspondent gets foreign address of mobile, sends directly to mobile

Diwakar Yagyasen

Source: Jim Kurose's slides

Mobility: registration

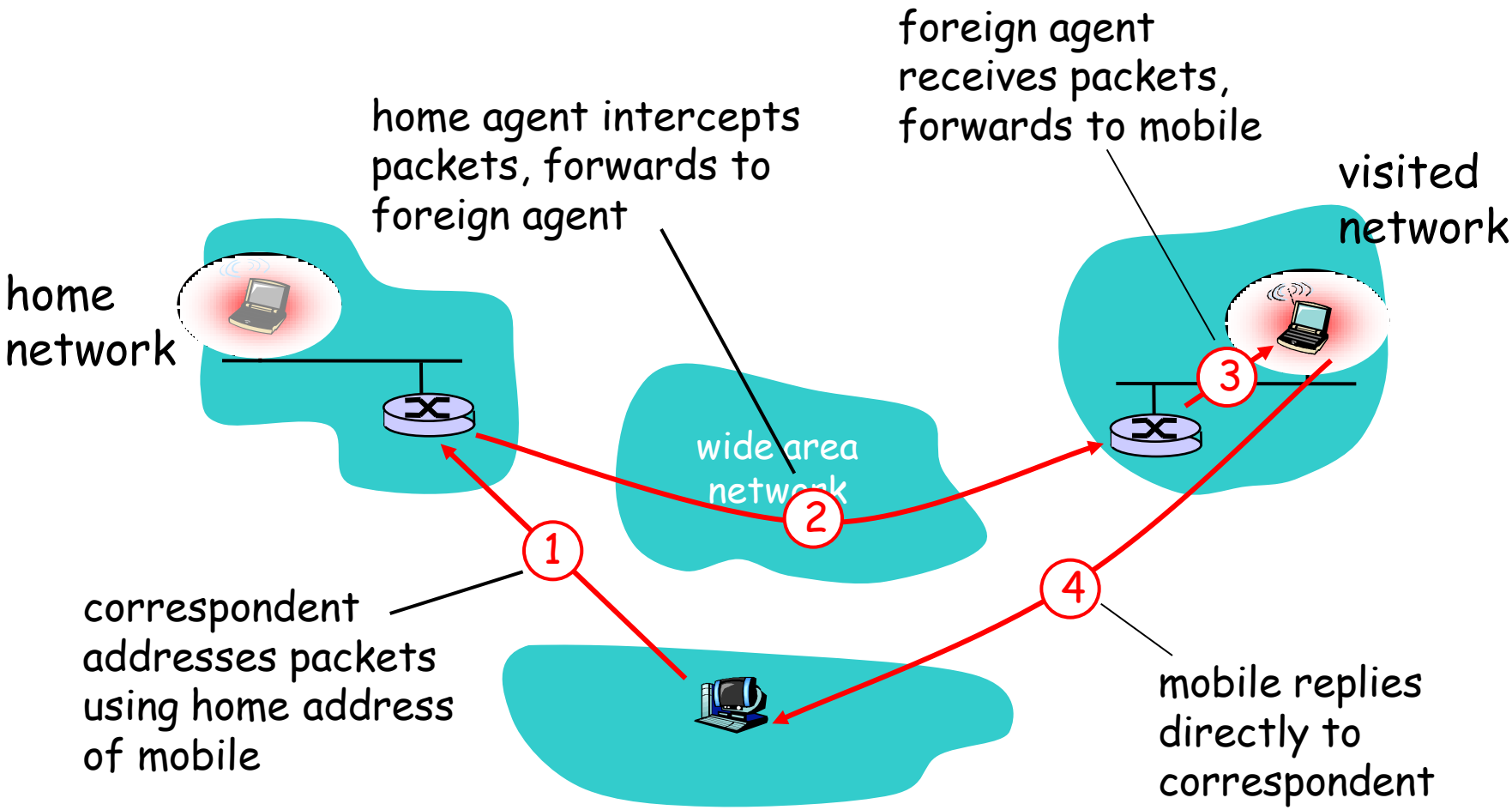


End result:

- Foreign agent knows about mobile
- Home agent knows location of mobile

Source: Jim Kurose's slides

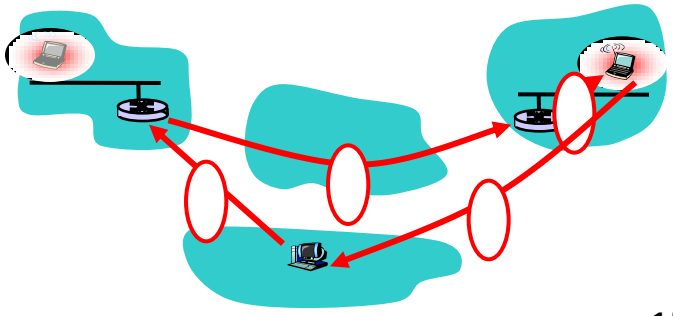
Mobility via Indirect Routing



Source: Jim Kurose's slides

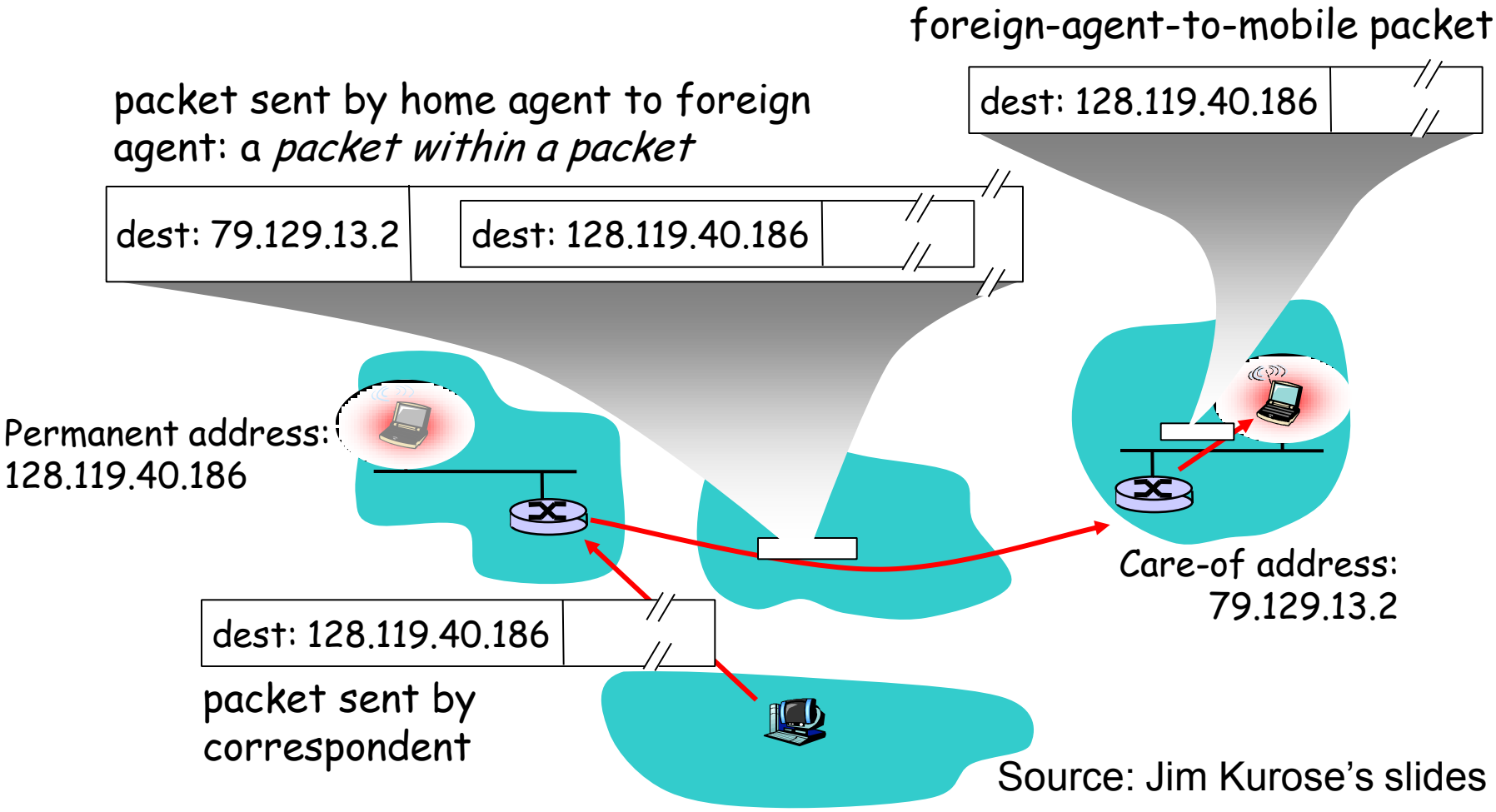
Indirect Routing: comments

- Mobile uses two addresses:
  - permanent address: used by correspondent (hence mobile location is *transparent* to correspondent)
  - care-of-address: used by home agent to forward datagrams to mobile
- foreign agent functions may be done by mobile itself
- triangle routing: correspondent-home-network-mobile
  - inefficient when correspondent, mobile are in same network



Source: Jim Kurose's slides

Forwarding datagrams to remote mobile



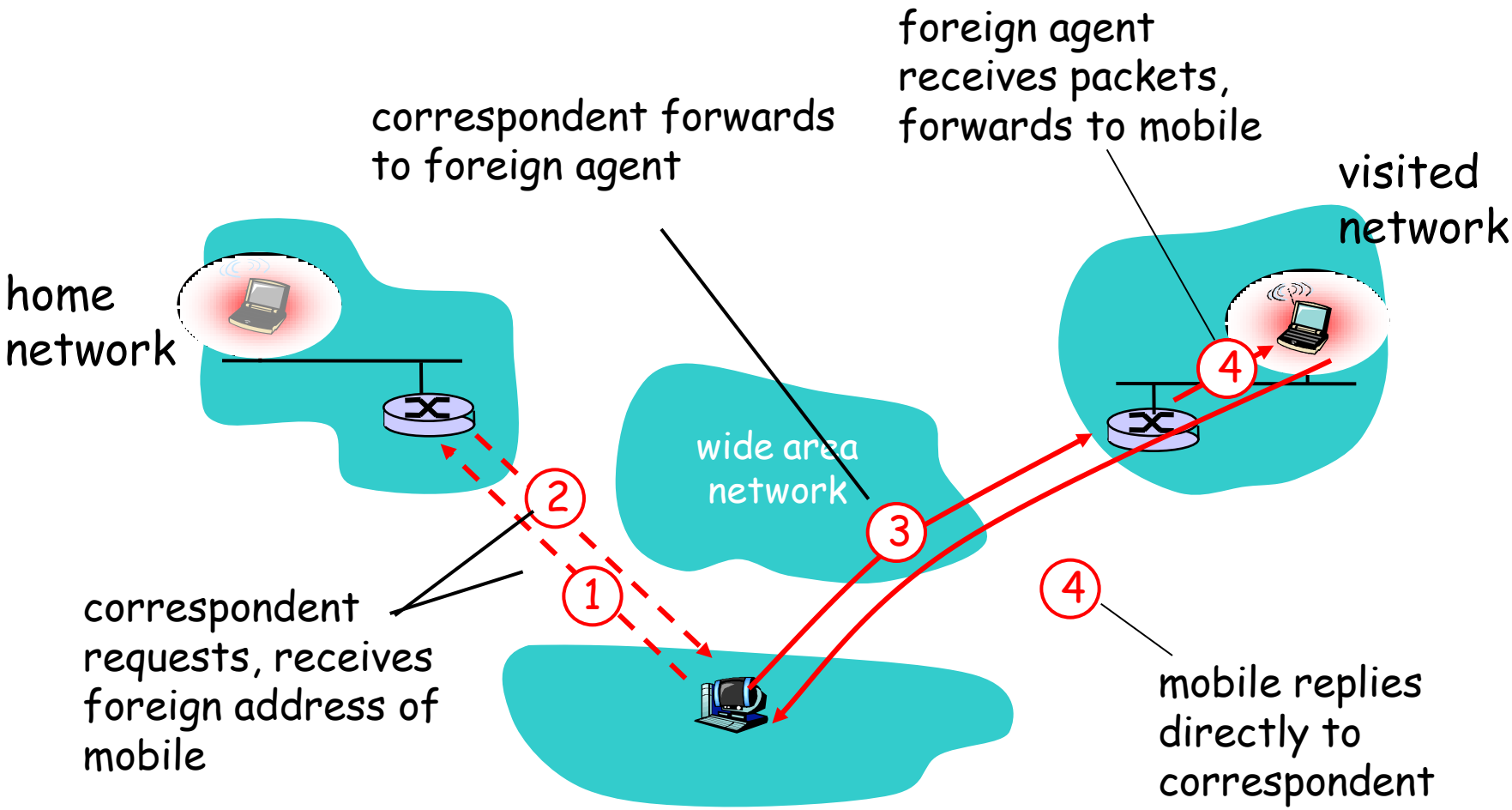
Source: Jim Kurose's slides

Indirect Routing: moving between networks

- suppose mobile user moves to another network
  - registers with new foreign agent
  - new foreign agent registers with home agent
  - home agent update care-of-address for mobile
  - packets continue to be forwarded to mobile (but with new care-of-address)
- Mobility, changing foreign networks transparent: *on going connections can be maintained!*

Source: Jim Kurose's slides

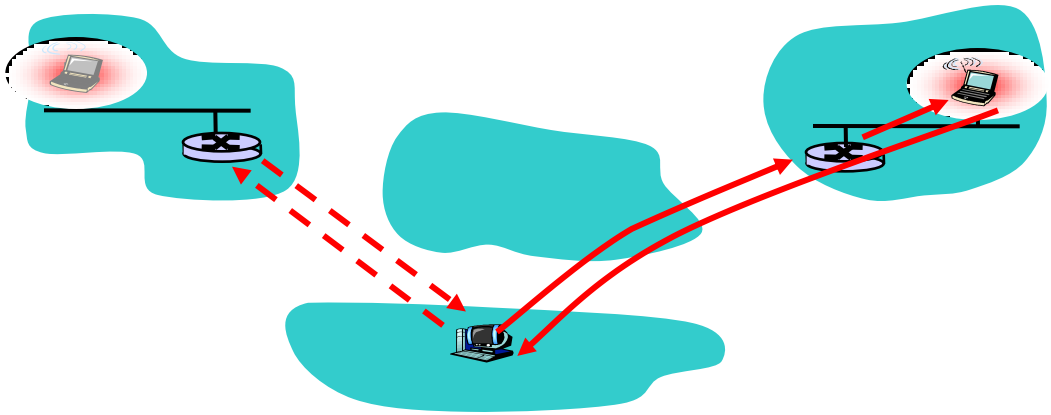
Mobility via Direct Routing



Source: Jim Kurose's slides

Mobility via Direct Routing: comments

- overcome triangle routing problem
- non-transparent to correspondent: correspondent must get care-of-address from home agent
  - What happens if mobile changes networks?



Source: Jim Kurose's slides

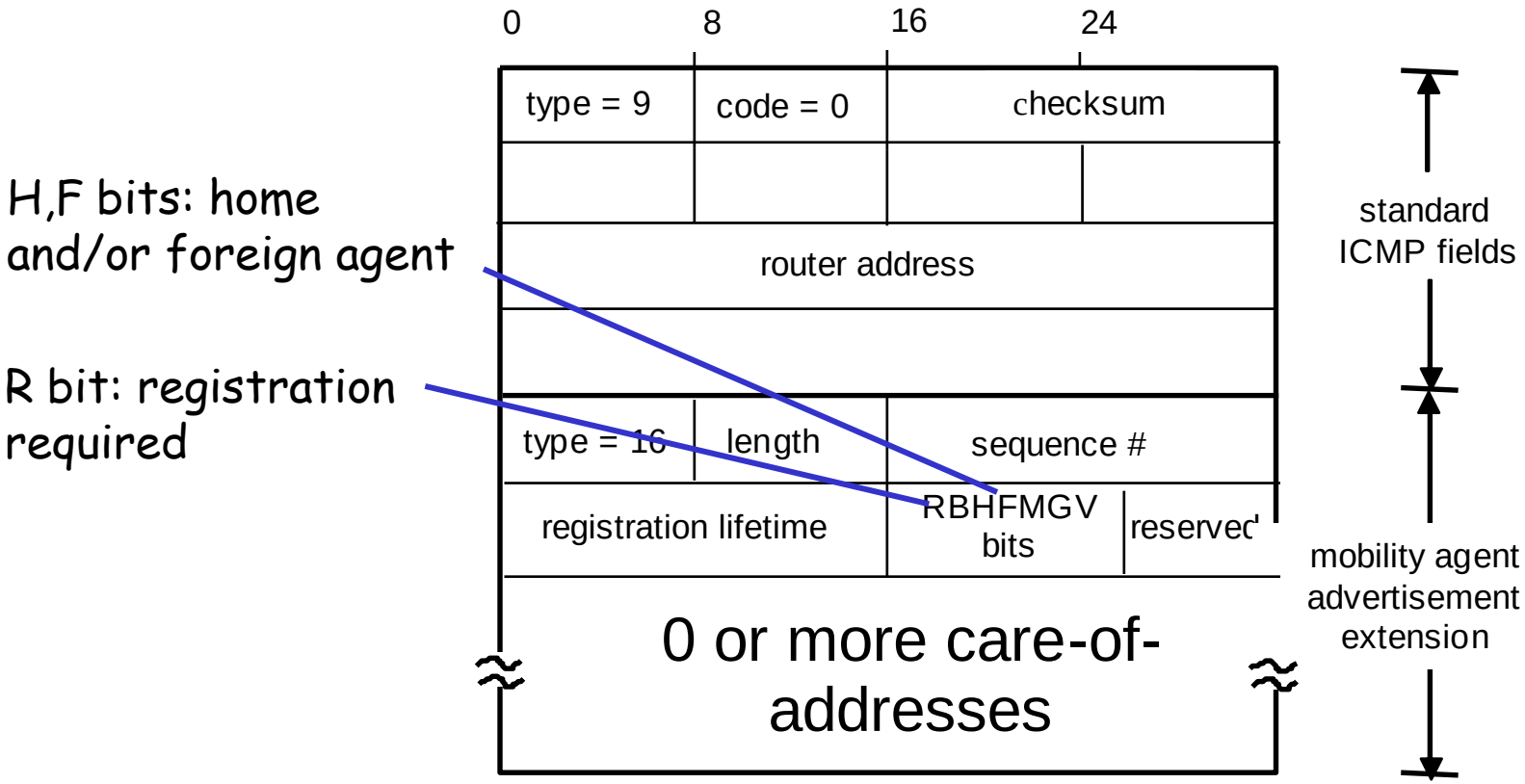
Mobile IP

- RFC 3344
- has many features we've seen:
  - home agents, foreign agents, foreign-agent registration, care-of-addresses, encapsulation (packet-within-a-packet)
- three components to standard:
  - agent discovery
  - registration with home agent
  - indirect routing of datagrams

Source: Jim Kurose's slides

Mobile IP: agent discovery

- agent advertisement: foreign/home agents advertise service by broadcasting ICMP messages (typefield = 9)

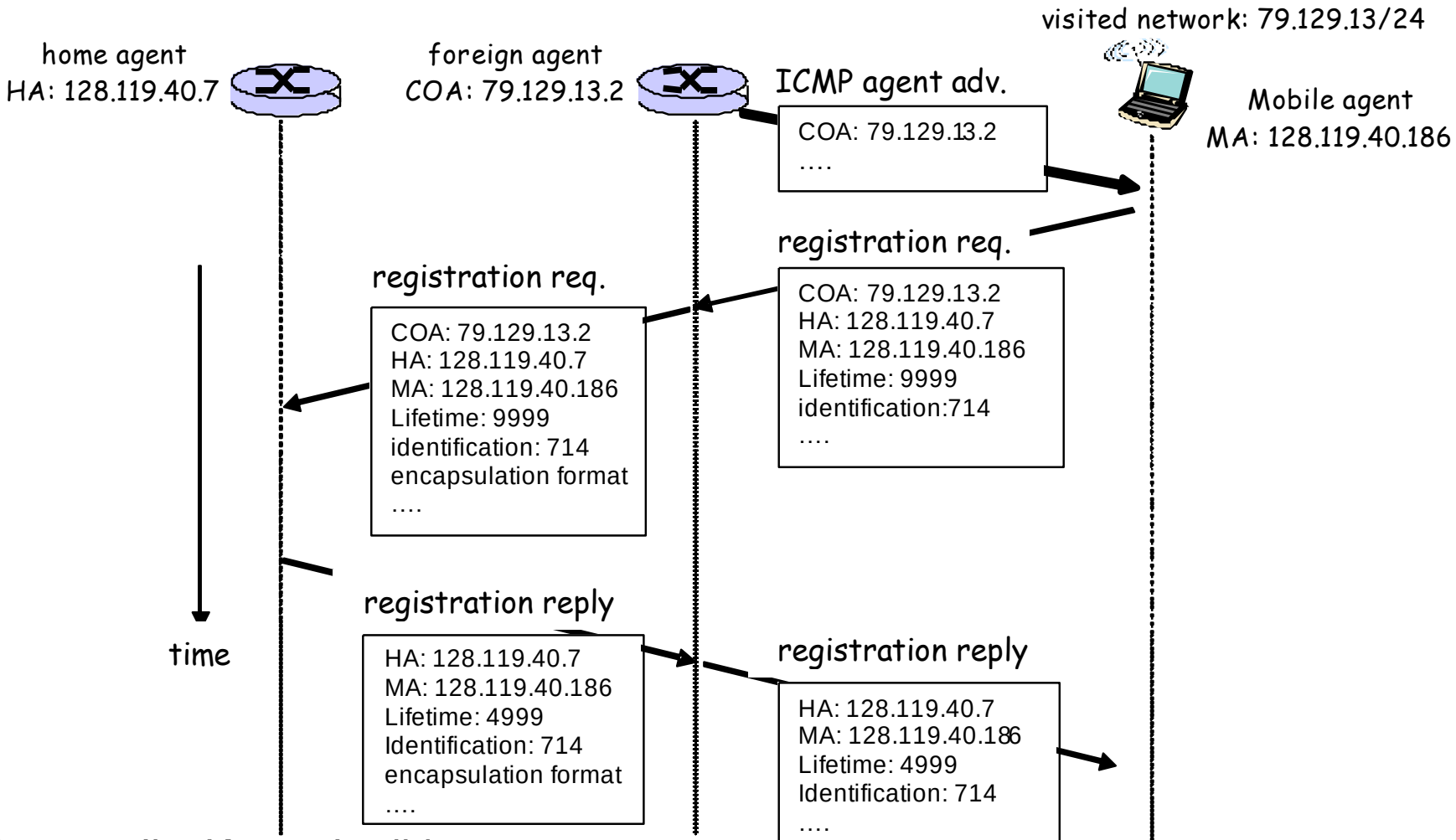


Source: Jim Kurose's slides

Agent Advertisement

- HA/FA periodically send advertisement messages into their physical subnets
- MN listens to these messages and detects, if it is in home/foreign network
- MN reads a COA from the FA advertisement messages

Mobile IP: registration example



Source: Jim Kurose's slides

MN Registration

- MN signals COA to the HA via the FA
- HA acknowledges via FA to MN
- limited lifetime, need to be secured by authentication

ICMP messages from the tunnel

Encapsulator may receive ICMP messages from any intermediate router in the tunnel other than exit

- Network unreachable:
  - Return dest unreachable message to org sender
- Host unreachable:
  - Return host unreachable message
- Datagram too big:
  - Relay ICMP datagram too big to org sender

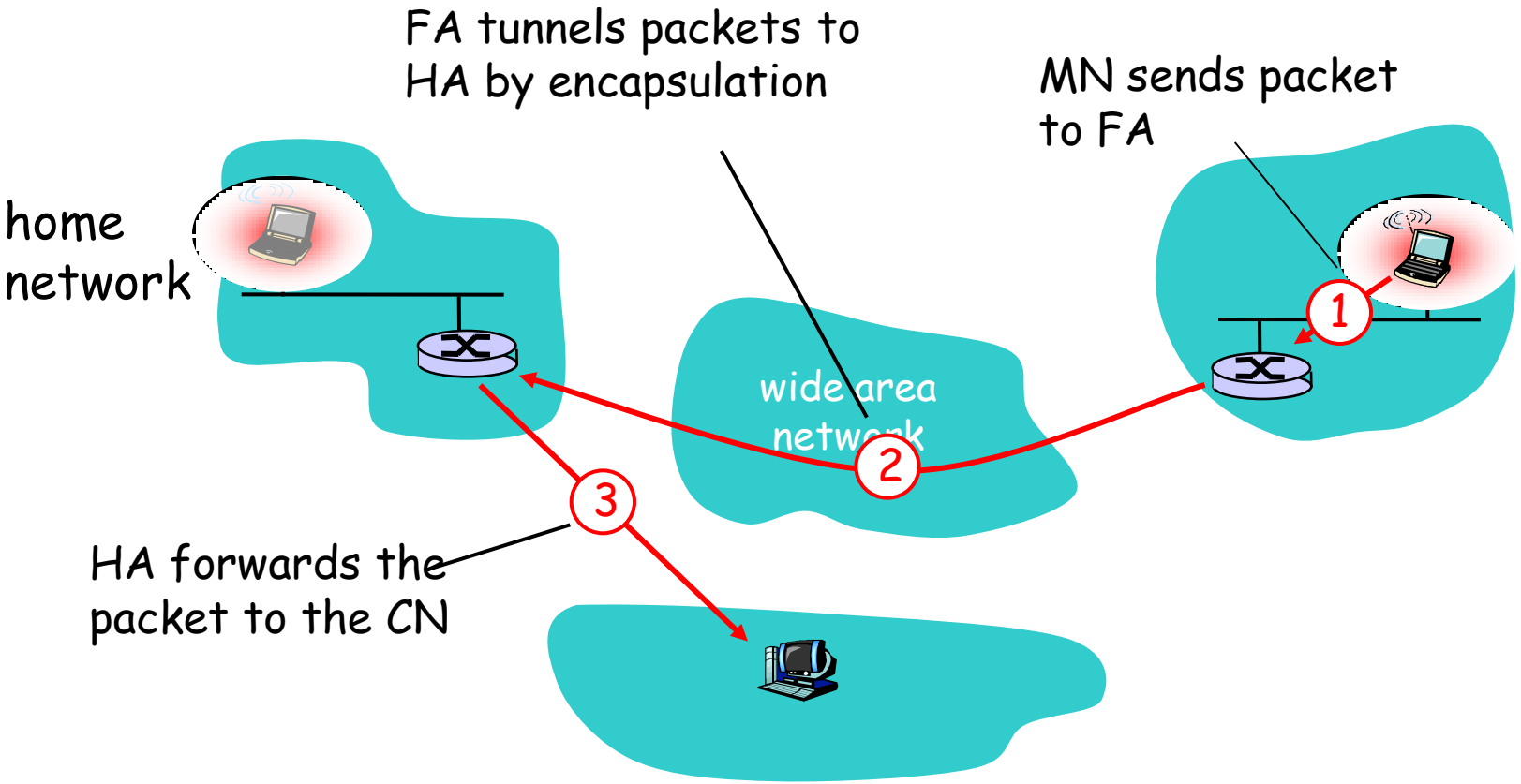
ICMP error messages (contd.)

- Source route failed:
  - Handled by encapsulator itself and MUST NOT relay message to orginal sender
- Source quench:
  - SHOULD NOT relay message to original sender , SHOULD activate congestion control mechanism
- Time exceeded:
  - MUST be reported to original sender as host unreachable message

Mobile IP: Other Issues

- Reverse Tunneling
  - firewalls permit only “topological correct“ addresses
- Optimizations
  - Triangular Routing: HA informs sender the current location of MN
  - Change of FA: new FA informs old FA to avoid packet loss

Reverse tunneling (RFC 3024)



Adapted from Kurose's slide

Mobile IP: Reverse tunneling

- Router accept often only “topological correct“ addresses (firewall!)
  - a packet from the MN encapsulated by the FA is now topologically correct

Reverse tunneling

- Reverse tunneling does not solve
  - problems with *firewalls*, the reverse tunnel can be abused to circumvent security mechanisms (tunnel hijacking)
  - optimization of data paths, i.e. packets will be forwarded through the tunnel via the HA to a sender (double triangular routing)

Optimization of forwarding

- Triangular Routing
  - sender sends all packets via HA to MN
  - higher latency and network load
- “Solutions”
  - sender learns the current location of MN
  - direct tunneling to this location
  - HA informs a sender about the location of MN

Binding

- Registration: When node acquires a new care-of address
- Intimation: Node must intimate to
  - HA
  - Correspondent node
- Binding Ack: Node may expect an Ack
- Life-time: Node should know its likely time of association.

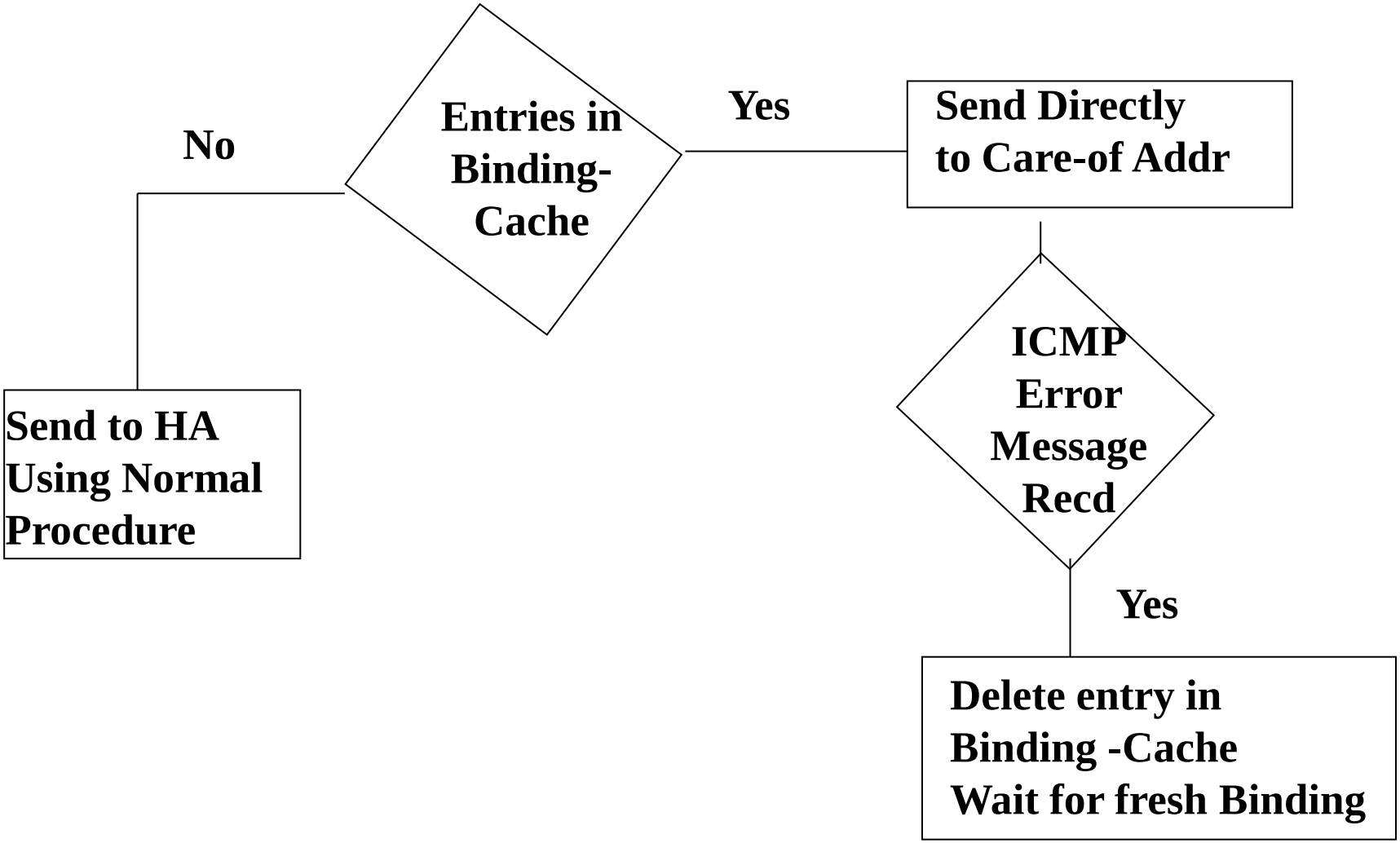
Mobile Node Operation

- IP decapsulation
- Send Binding updates
- Receive Binding Ack
- Keep track of Nodes (because of Life-time)
- Send Binding Updates using Routing Header

Correspondent Node Operations

- Process received Binding Updates
- Send Binding-Ack
- Maintain Binding-Cache
- Maintain Security Association

Packet Delivery at CN



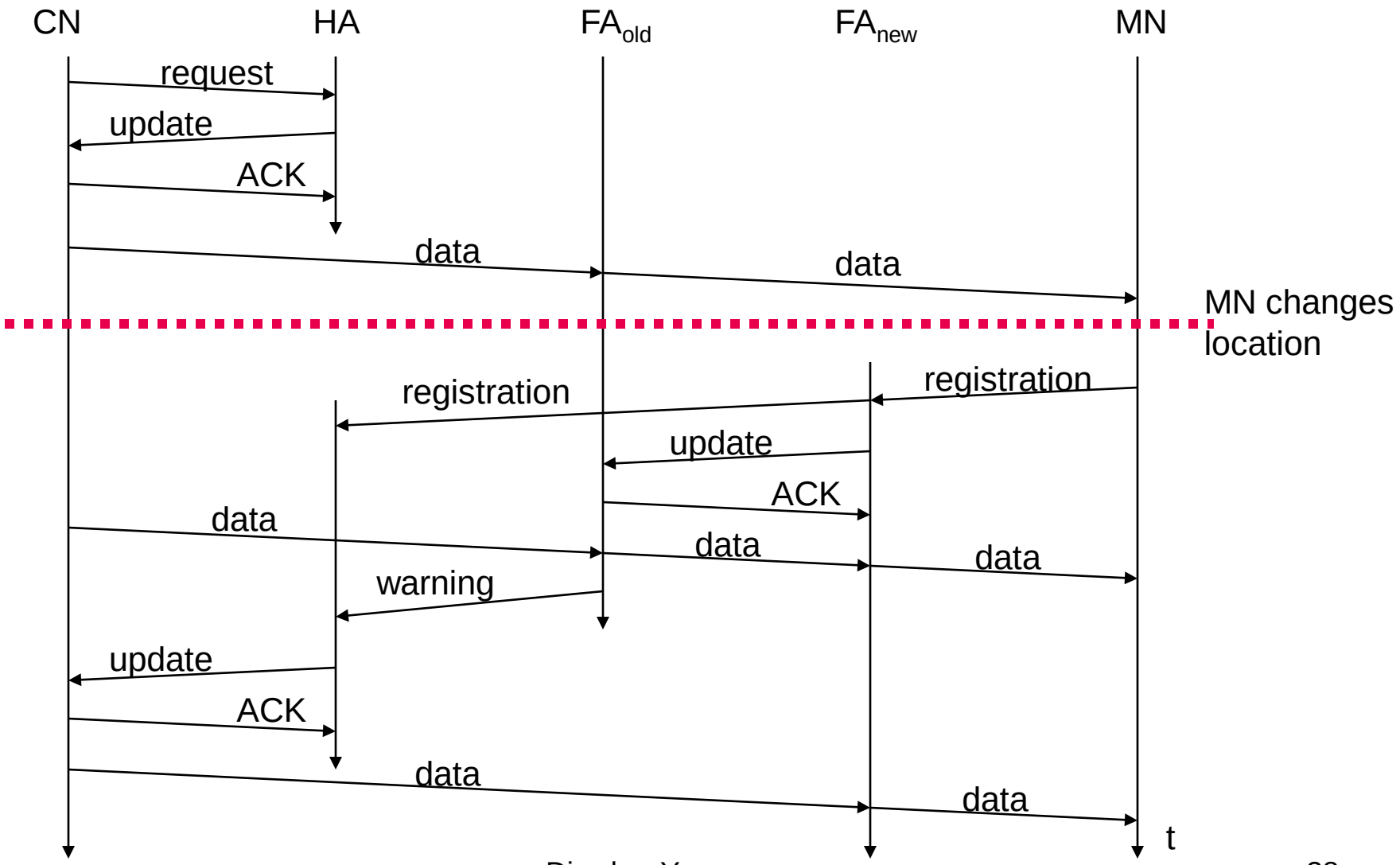
Home Agent Operations

- Send Binding-Ack to Binding Updates
- Encapsulate Packets for tunneling
- Home Agent Discovery
- Handle returned ICMP errors

Change of FA

- packets on-the-fly during the change can be lost
- new FA informs old FA to avoid packet loss, old FA now forwards remaining packets to new FA
- this information also enables the old FA to release resources for the MN

Change of foreign agent



Mobile IP Summary

- Mobile node moves to new location
- Agent Advertisement by foreign agent
- Registration of mobile node with home agent
- Proxying by home agent for mobile node
- Encapsulation of packets
- Tunneling by home agent to mobile node via foreign agent