Mobile IP

3/20/2006

Modified based on
http://zoo.cs.yale.edu/classes/cs434/lectures/MobileIP.ppt

Mobile IP

- Incorporation of mobile users in the network.
- Cellular system (e.g., GSM) started with mobility in mind.
- The internet started with no thought of mobile computers.
- IP: a unified networking layer supporting heterogeneous networks.

Outline

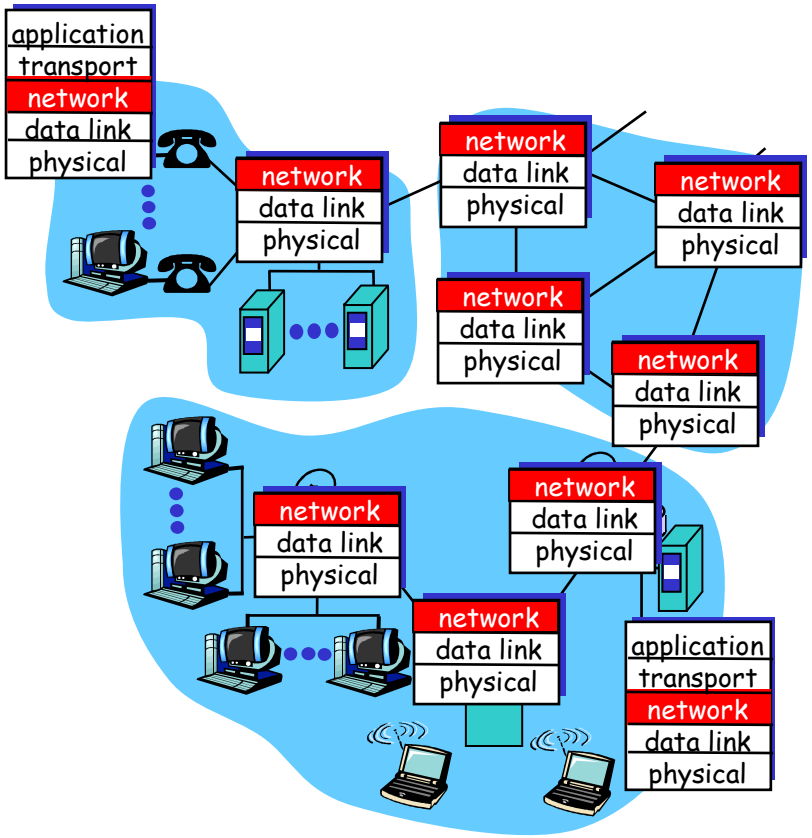
- *Network layer service*
- Mobile IP

Network Layer Service

- Transport packet from source to dest.
- Network layer protocol in *every* host, router

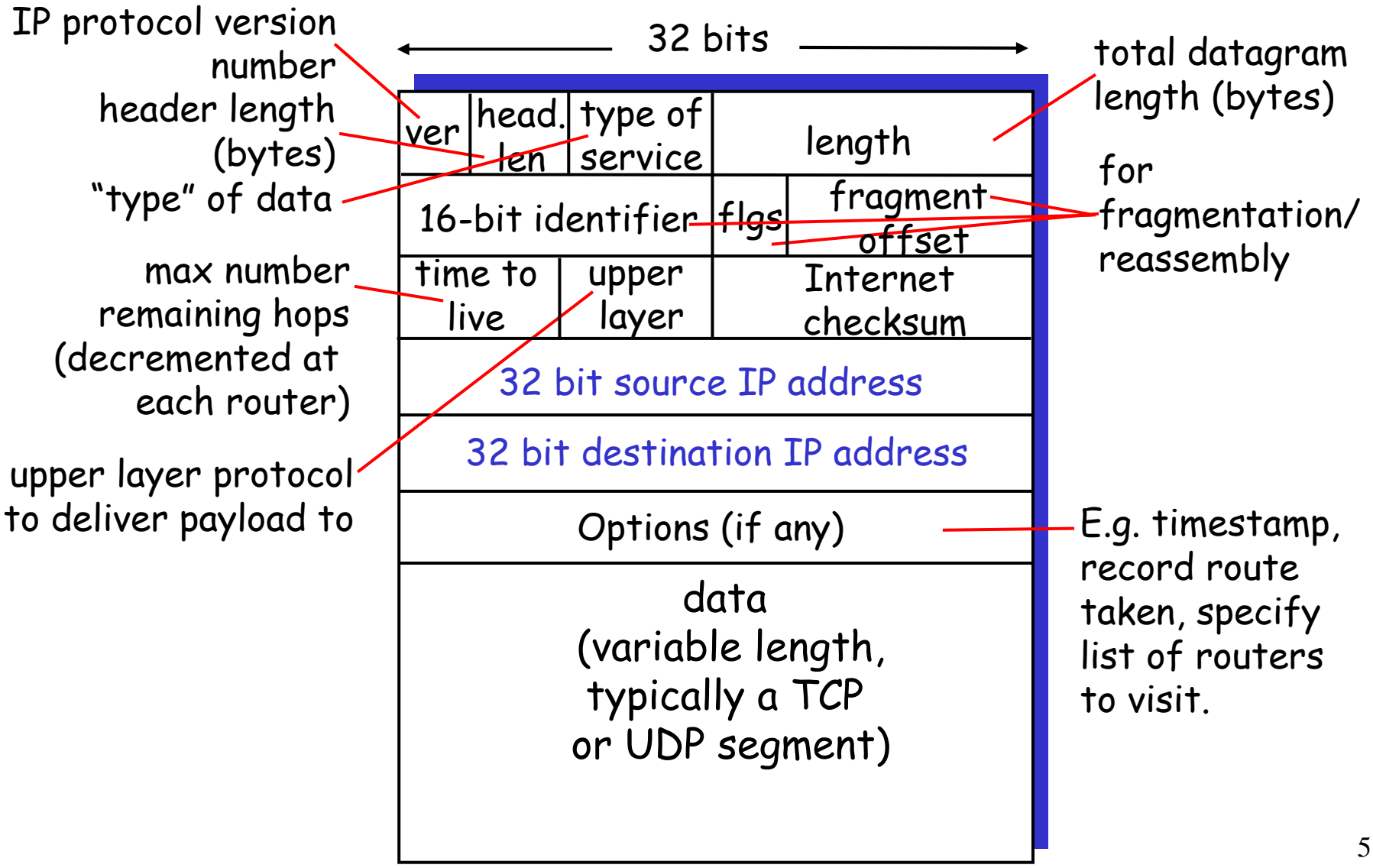
Basic functions:

- *Control path: route determination*
  - route taken by packets from source to destination
- *Data path: forwarding*
  - move packets from router's input to appropriate router output



Question: what are the crucial components to implement the above services?

IP Datagram Format



IP Addresses

- The way we assign IP address will affect the efficiency of the routing protocols

- Addressing from daily life:

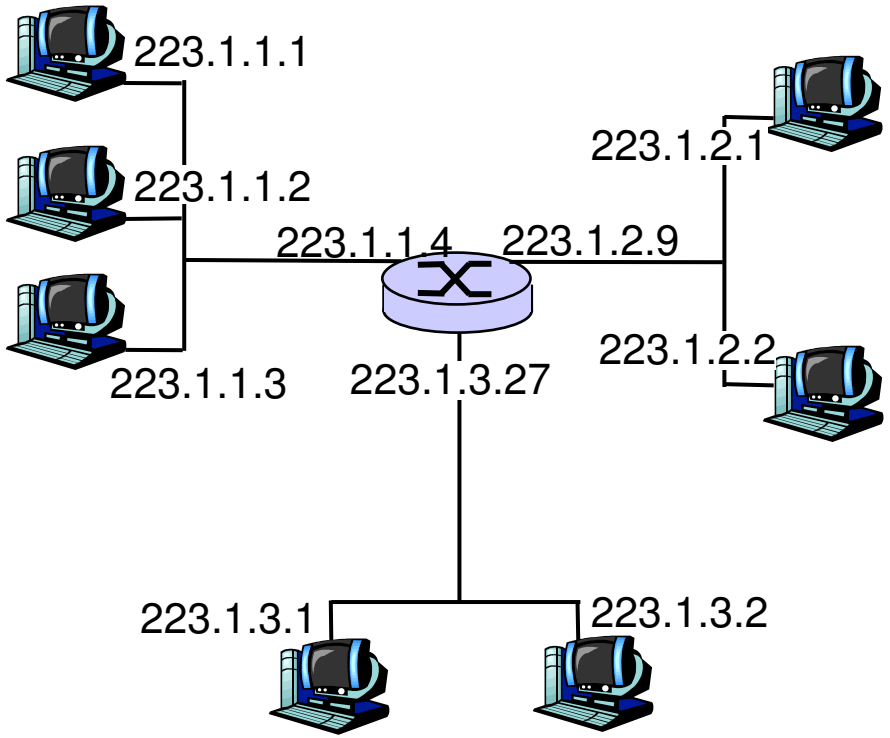
  - Postal address, e.g.,
    150 Main Street
    Stony brook, NY 11790

  - Telephone address, e.g.,
    631-751-0555

IP Address: An IP Address Identifies an Interface

- IP address: 32-bit identifier for host, router *interface*
- *interface:* connection between host, router and physical link
  - routers typically have multiple interfaces
  - host may have multiple interfaces
  - IP addresses associated with interface

  %/sbin/ifconfig -a

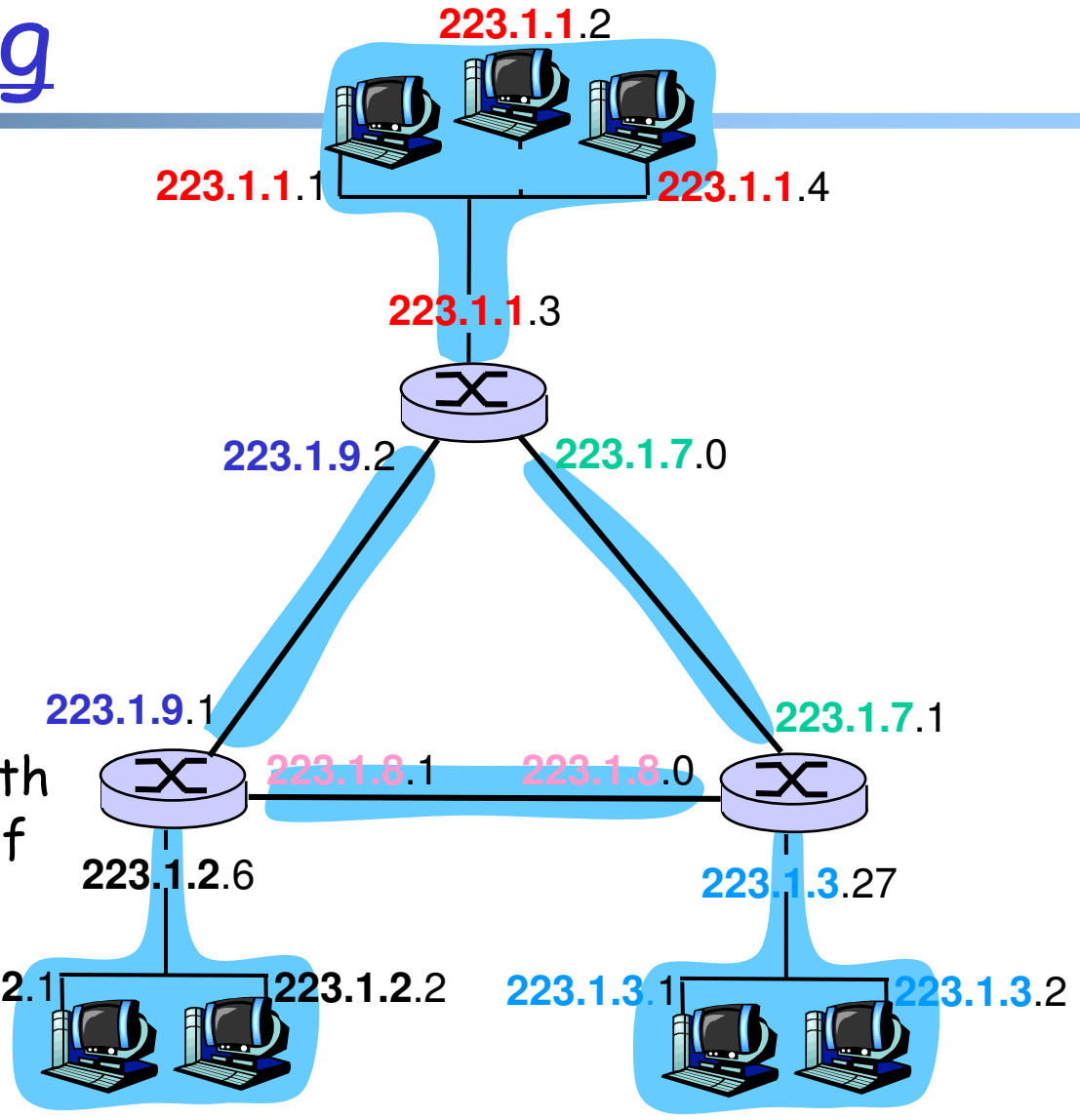


223.1.3.2 = 11011111 00000001 00000011 00000010

223 1 3 2

IP Addressing

- IP address:
  - network part (high order bits)
  - host part (low order bits)
- *What's a network?* (from IP address perspective)
  - device interfaces with same network part of IP address
  - can physically reach each other without intervening router

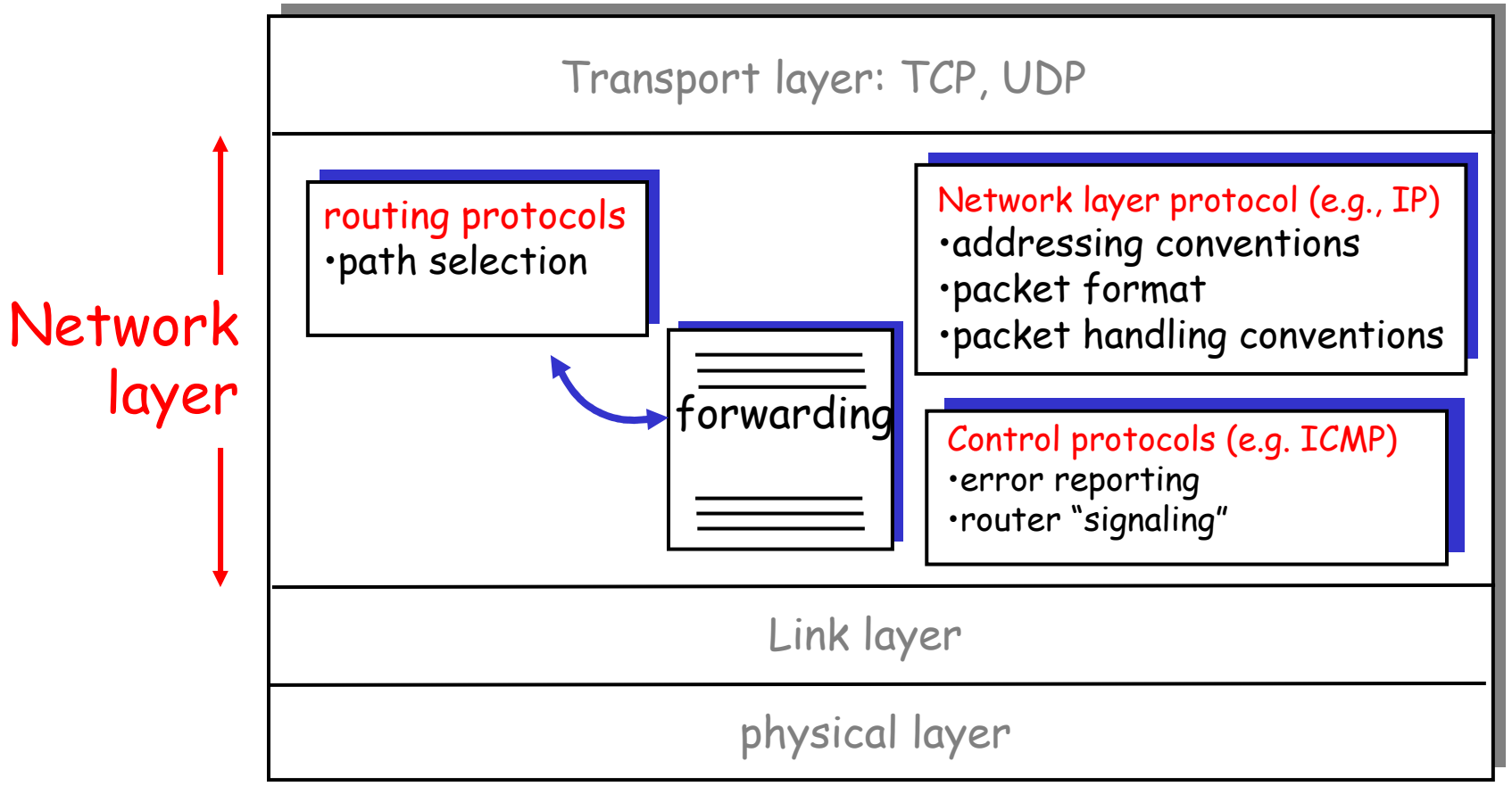


IP hierarchy

- The hierarchical nature of IP addresses enables compression at routers.
- In routing tables, only prefixes are stored.
- This also allows the smooth integration of heterogeneous networks into the Internet.
  - Inside each network different architectures can be adopted.
  - In-between networks a unifying networking layer allow their cooperation.

Network Layer in Internet: Big Picture

Host, router network layer functions:



Outline

- Network layer services
  - *Mobile IP*

Discussion

- IP works fine for the Internet
  - it has problems; but during vast majority of the time it gets its job done efficiently—moving a packet from a src. to a dest.
- What problem can mobility cause?
- How do you solve the problem?

Mobile IP

- Routing
  - based on IP destination address, network prefix (e.g. 129.13.42) determines physical subnet
  - change of physical subnet implies change of IP address to have a topological correct address (standard IP) or needs special entries in the routing tables

Mobile IP

- Specific routes to end-systems?
  - change of all routing table entries to forward packets to the right destination
  - does not scale with the number of mobile hosts and frequent changes in the location
  - IP hierarchies can not be used.

Mobile IP

- Changing the IP-address?
  - adjust the host IP address depending on the current location
  - DHCP (dynamic host configuration protocol): re-assign a new IP address.
  - almost impossible to find a mobile system, DNS updates take to long time
  - Limited in local use.
  - TCP connections break, security problems

Mobile IP

- Transparency
  - mobile end-systems keep their IP address
  - continuation of communication after interruption of link possible
  - point of connection to the fixed network can be changed
- Compatibility
  - support of the same layer 2 protocols as IP
  - no changes to current end-systems and routers required
  - mobile end-systems can communicate with fixed systems

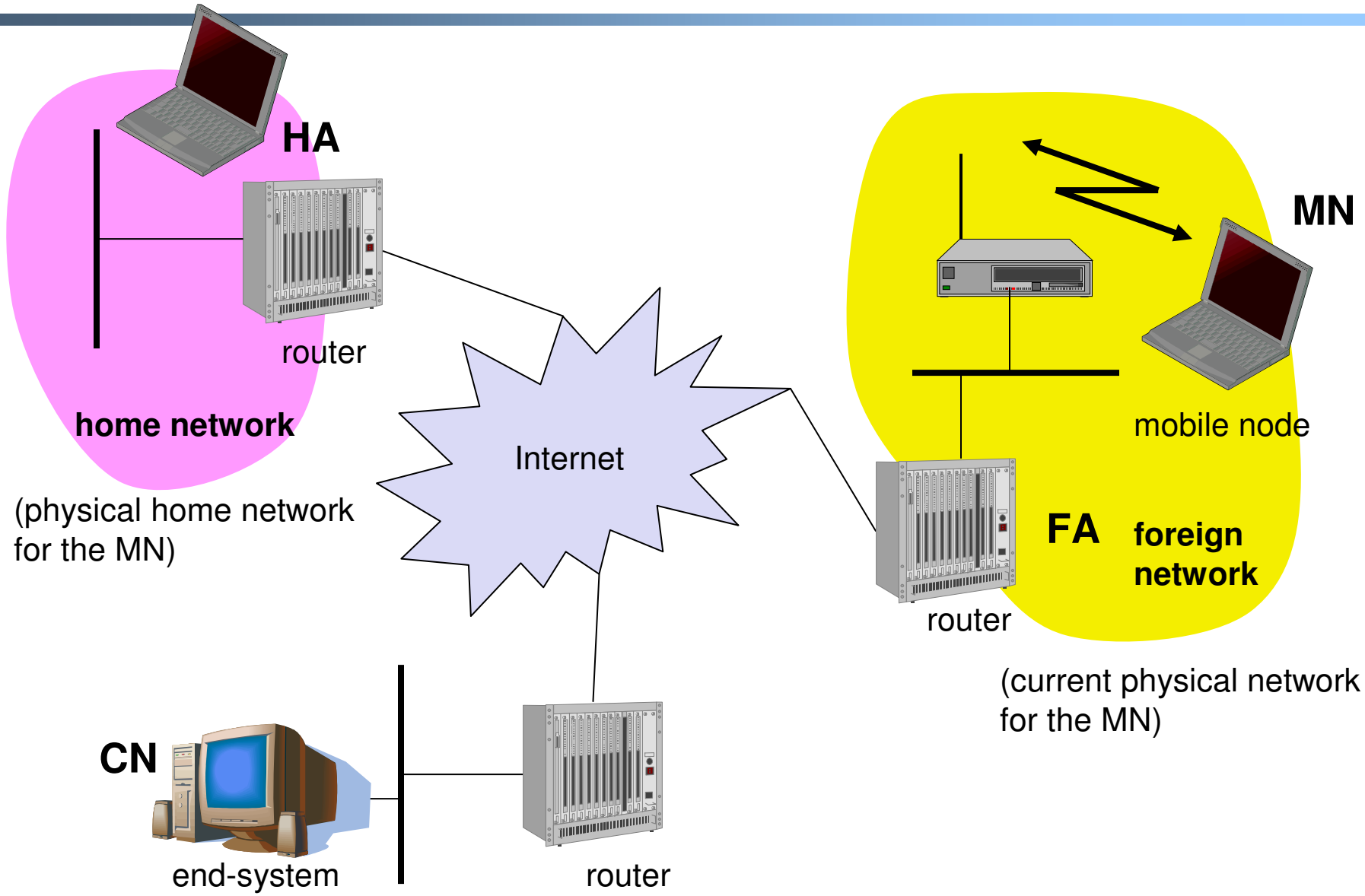
Mobile IP

- Security
  - authentication of all registration messages
- Efficiency and scalability
  - only little additional messages to the mobile system required (connection typically via a low bandwidth radio link)
  - world-wide support of a large number of mobile systems in the whole Internet

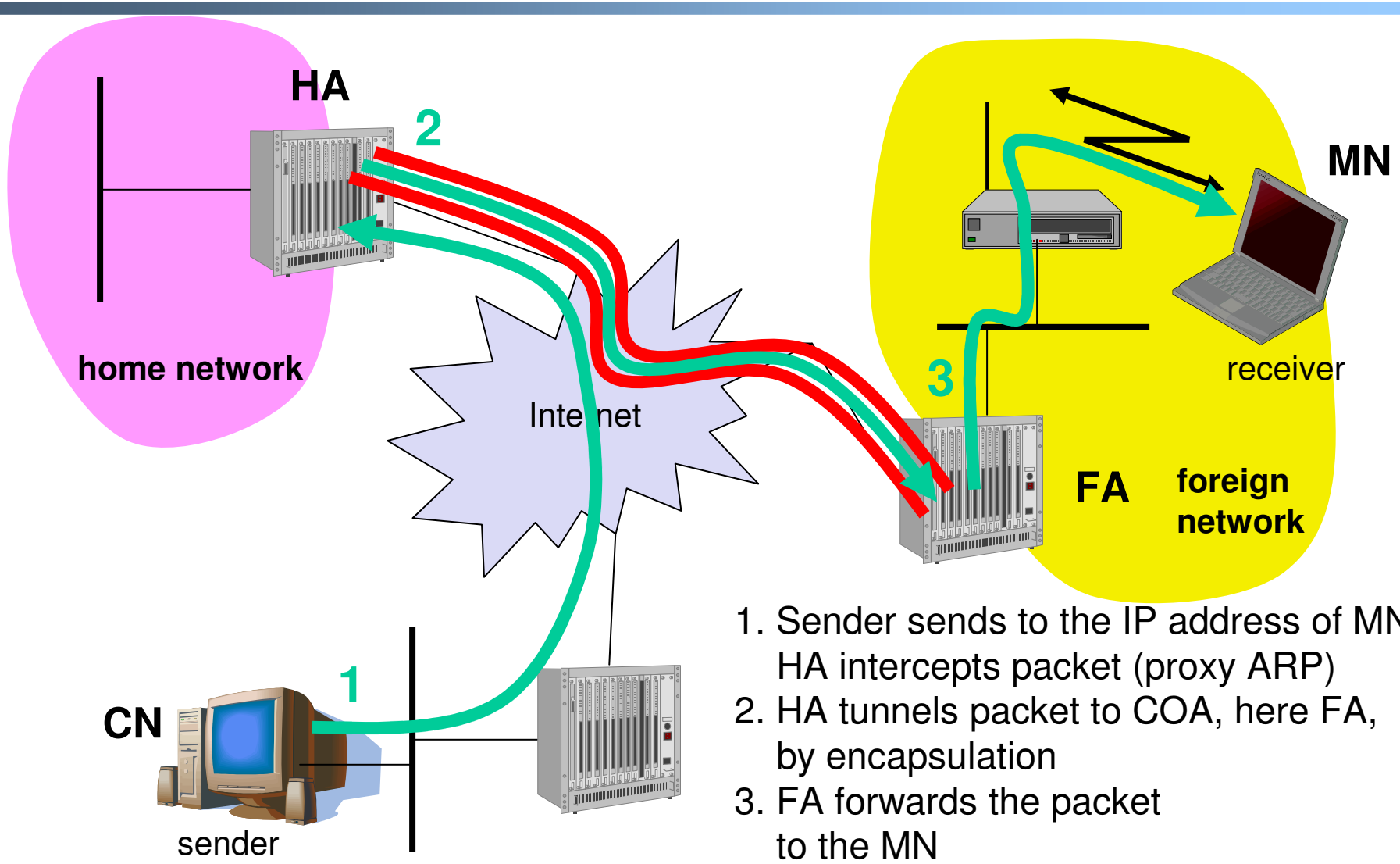
Mobile IP: Terminology

- Mobile Node (MN)
  - the node under consideration
- Home Agent (HA)
  - a stationary network node (e.g., a router) at the home network
- Foreign Agent (FA)
  - A network node (e.g. a router) in the foreign network
- Care-of Address (COA)
  - The address in the foreign network
- Correspondent Node (CN)
  - communication partner

Illustration

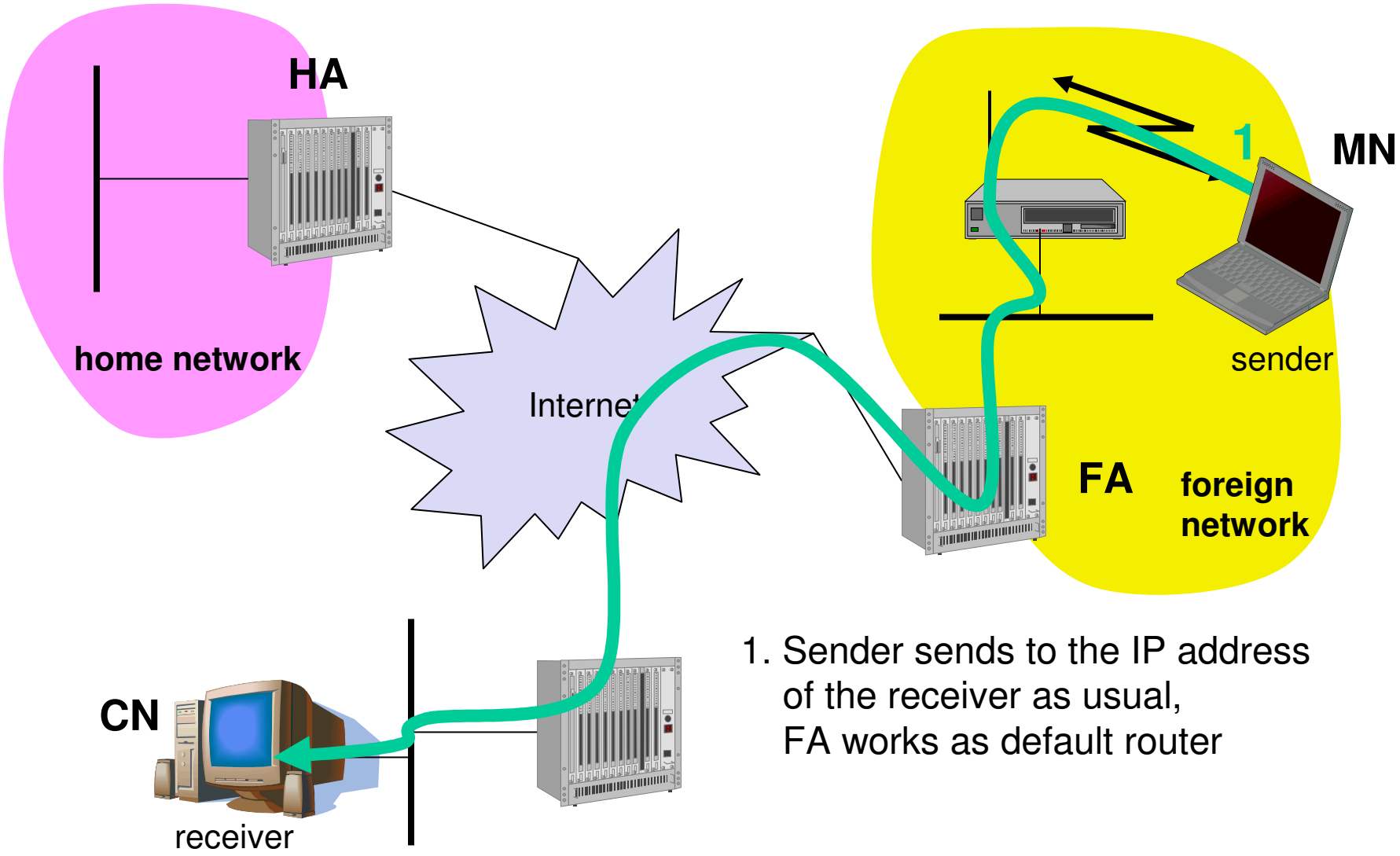


Data transfer



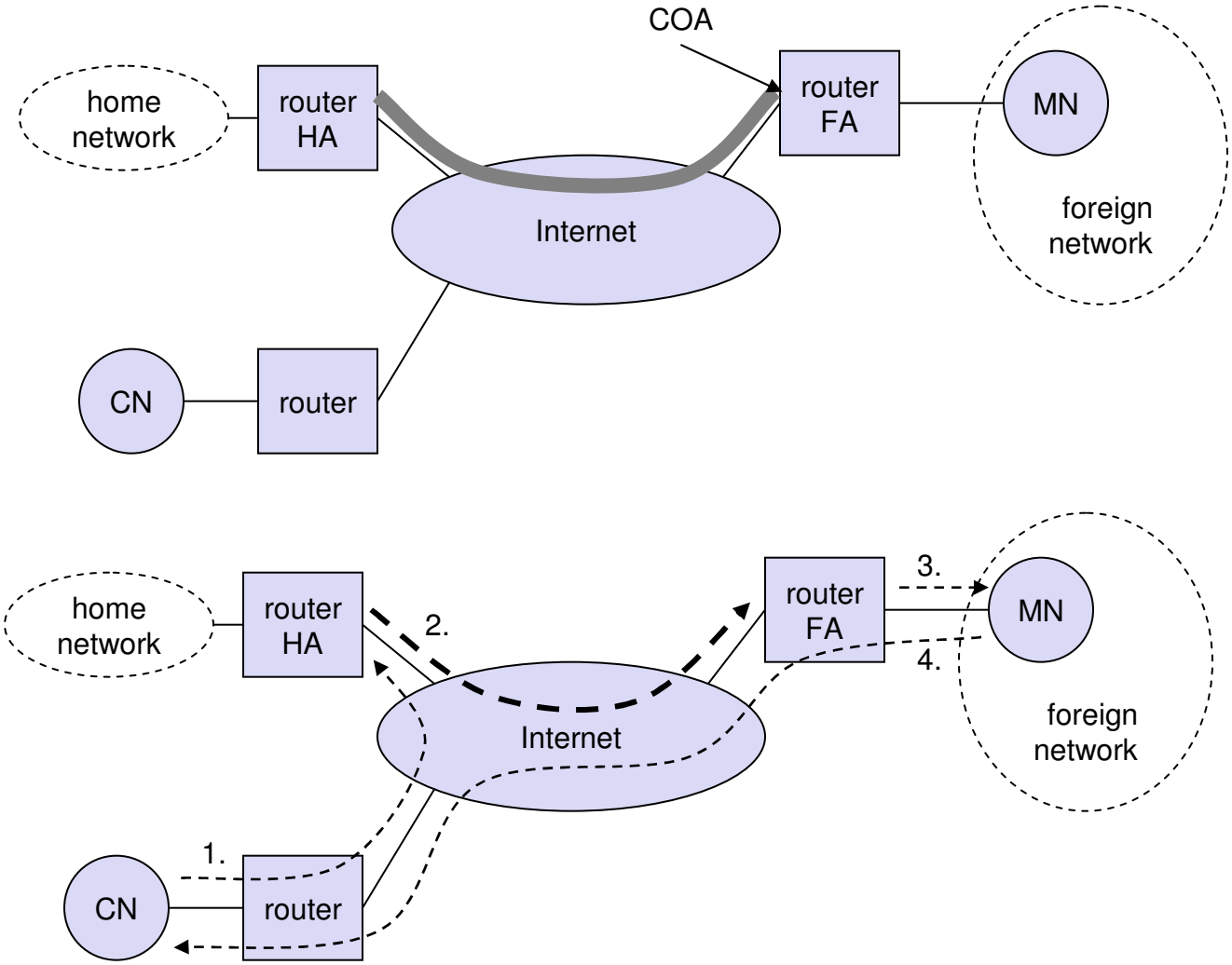
1. Sender sends to the IP address of MN, HA intercepts packet (proxy ARP)
2. HA tunnels packet to COA, here FA, by encapsulation
3. FA forwards the packet to the MN

Data transfer



1. Sender sends to the IP address of the receiver as usual, FA works as default router

Overview


COA
home network
router HA
router FA
MN
Internet
foreign network
CN
router
home network
router HA
2.
router FA
3.
MN
4.
Internet
foreign network
1.
CN
router

Mobile IP Operations

- Basic idea of Mobile IP: a MN acquires a COA in a foreign network from a foreign agent and registers to the home agent; all messages sent to its home address is forwarded by its home agent to its COA
- Three steps
  - discovering home/foreign agents and the care-of address (COA)
  - registering the care-of address
  - data transfer using the care-of address

Discovering the Agents and Care-of Address

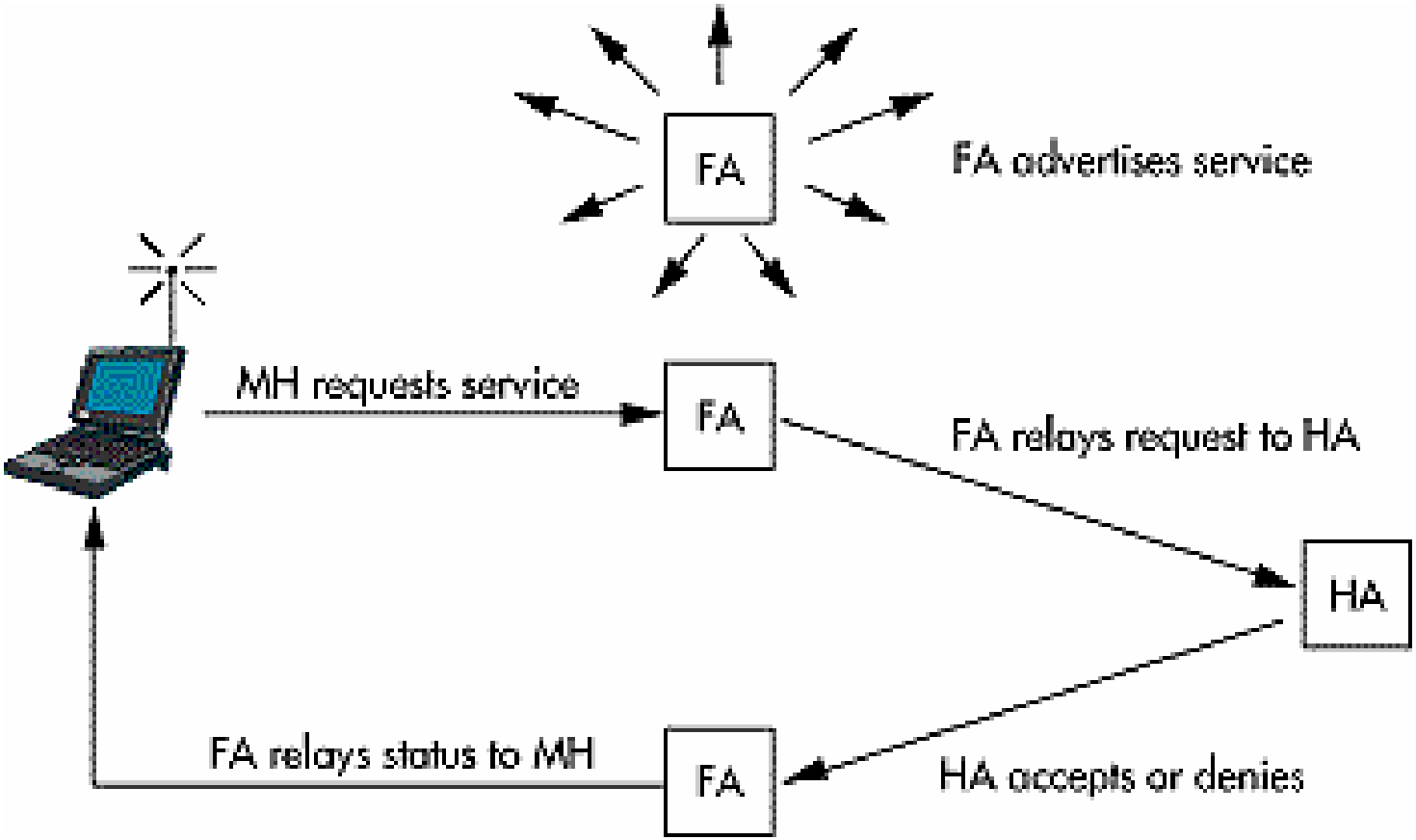
- Mobile IP discovery process
  - (home or foreign) agent broadcasts advertisements at regular intervals
    - announce the network
    - list one or more available care-of addresses
  - mobile node takes a care-of address
  - mobile node can also send solicitation to start the process

Registering the Care-of Address

- Once a mobile node has a care-of address, its home agent must find out about it

- Registration process
  - mobile node sends a registration request to its home agent with the care-of address information
  - home agent approves/disapproves the request
  - home agent adds the necessary information to its routing table
  - home agent sends a registration reply back to the mobile node

Registration Operations in Mobile IP



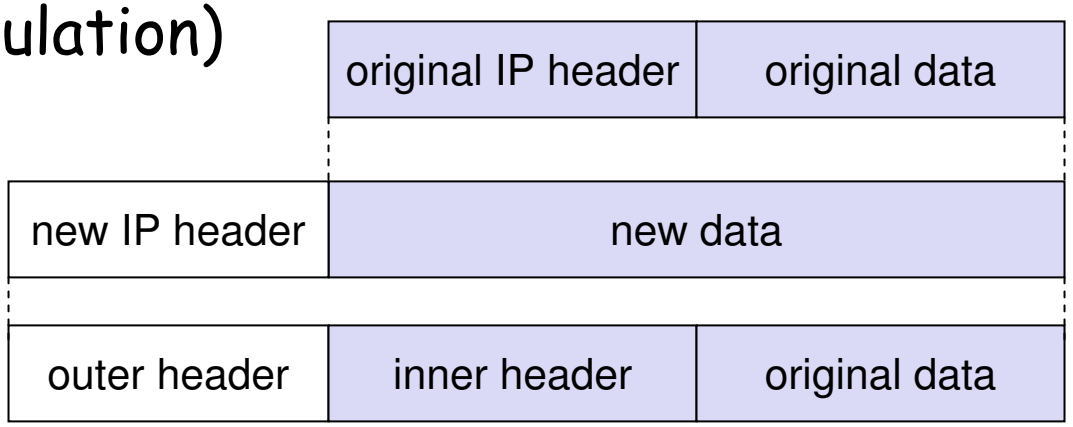
- MH = Mobile Host
- FA = Foreign Agent

HA = Home Agent

Discussion: what is the major challenge of the registration process?

Encapsulation

- Tunneling
- Encapsulation of one packet into another as payload
  - e.g. IPv6 in IPv4 (6Bone), Multicast in Unicast (Mbone)
  - here: e.g. IP-in-IP-encapsulation, minimal encapsulation or GRE (Generic Record Encapsulation)



Encapsulation I

- IP-in-IP-encapsulation (mandatory, RFC 2003)
  - tunnel between HA and COA

ver.	IHL	DS (TOS)	length
IP identification		flags	fragment offset
TTL		*IP-in-IP*	IP checksum
IP address of HA			
Care-of address COA			
ver.	IHL	DS (TOS)	length
IP identification		flags	fragment offset
TTL		lay. 4 prot.	IP checksum
IP address of CN			
IP address of MN			
TCP/UDP/ ... payload			

Encapsulation I

- Minimal encapsulation (optional)
  - avoids repetition of identical fields
  - e.g. TTL, IHL, version, DS (RFC 2474, old: TOS)
  - only applicable for unfragmented packets, no space left for fragment identification

ver.	IHL	DS (TOS)	length	
IP identification			flags	fragment offset
TTL		*min. encap.*	IP checksum	
IP address of HA				
care-of address COA				
lay. 4 protoc.	S	reserved	IP checksum	
IP address of MN				
original sender IP address (if S=1)				
TCP/UDP/ ... payload				

Discussion

- Any problems of the Mobile IP approach?

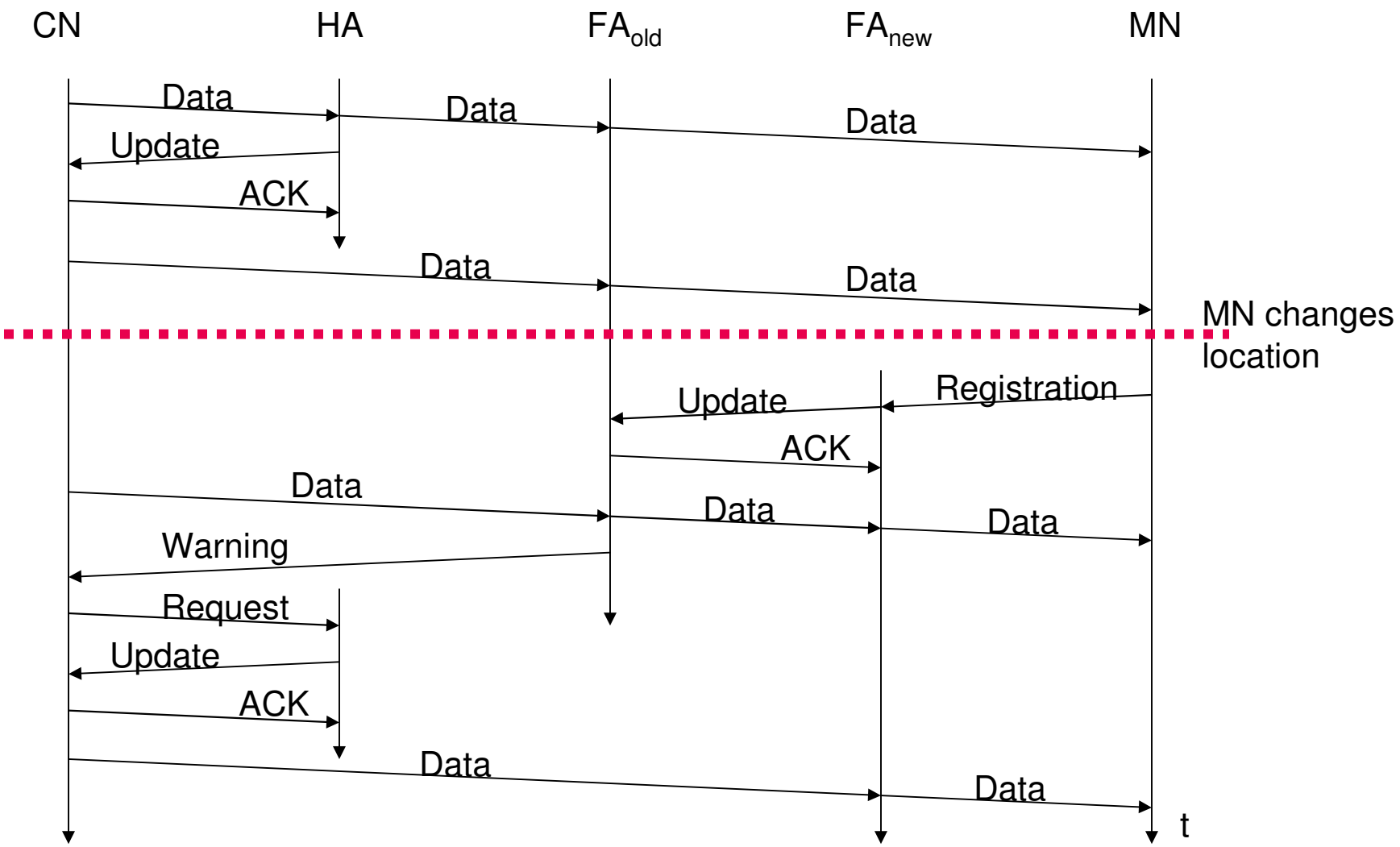
Triangular Routing

- Triangular Routing
  - CN sends all packets via HA to MN
  - higher latency and network load
- "Solution"
  - CN learns the current location of MN
  - direct tunneling to this location
  - HA or MN informs a CN about the location of MN
- Problem of the solution
  - big security problems!

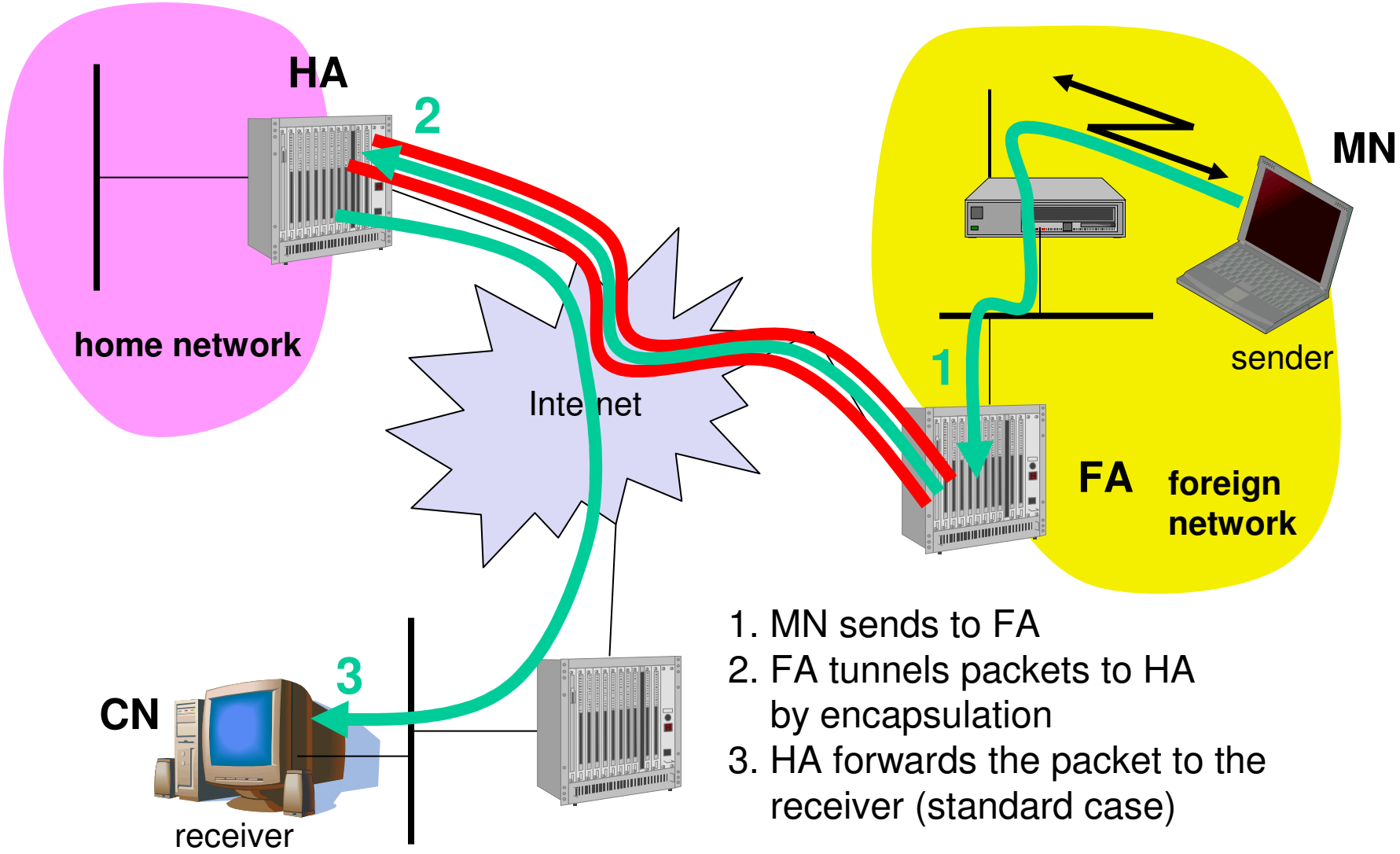
Handoff

- Change of FA (COA)
  - packets on-the-fly during the change can be lost
- "Solution"
  - new FA informs old FA to avoid packet loss, old FA buffers and then forwards remaining packets to new FA
  - this information also enables the old FA to release resources for the MN

Change of Foreign Agent



Reverse tunneling



1. MN sends to FA
2. FA tunnels packets to HA by encapsulation
3. HA forwards the packet to the receiver (standard case)

Reverse tunneling

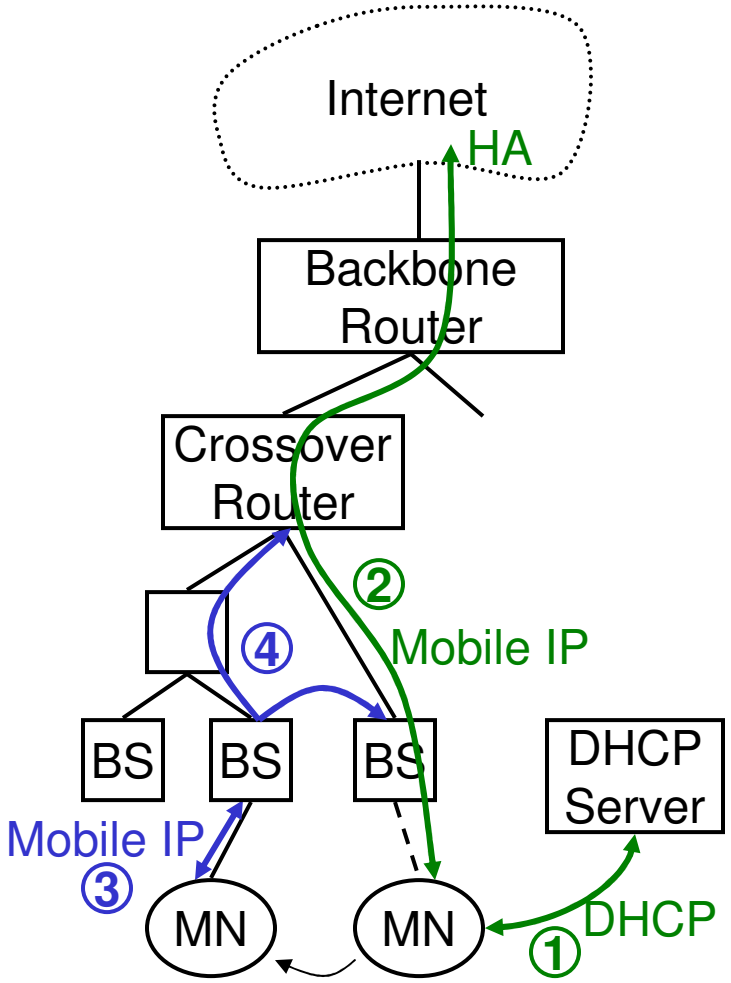
- Router accept often only "topological correct" addresses (firewall!)
  - a packet from the MN encapsulated by the FA is now topological correct
  - furthermore multicast and TTL problems solved (TTL in the home network correct, but MN is to far away from the receiver)
- Reverse tunneling does not solve
  - 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)

Micro Mobility

- A very typical scenario of Mobile IP is that a MN visits a company or university
  - the MN may change foreign networks multiple times in the foreign network, generating much control traffic
  - Efficient local handover inside a foreign domain without involving a home agent
  - Reduces control traffic on backbone
  - Especially needed in case of route optimization

Handoff Aware Wireless Access Internet Infrastructure (HAWAII)

- Operation:
  - MN obtains co-located COA ①
    and registers with HA②
  - Handover: MN keeps COA, ③
    new BS answers Reg. Request
    and updates routers ④
  - MN views BS as foreign agent



Summary

- Mobile IP
- Design focus: compatibility, transparency.
- Big problem: security.

- Next class: what problems will mobility create in transport layer (TCP)?