Mobile IP

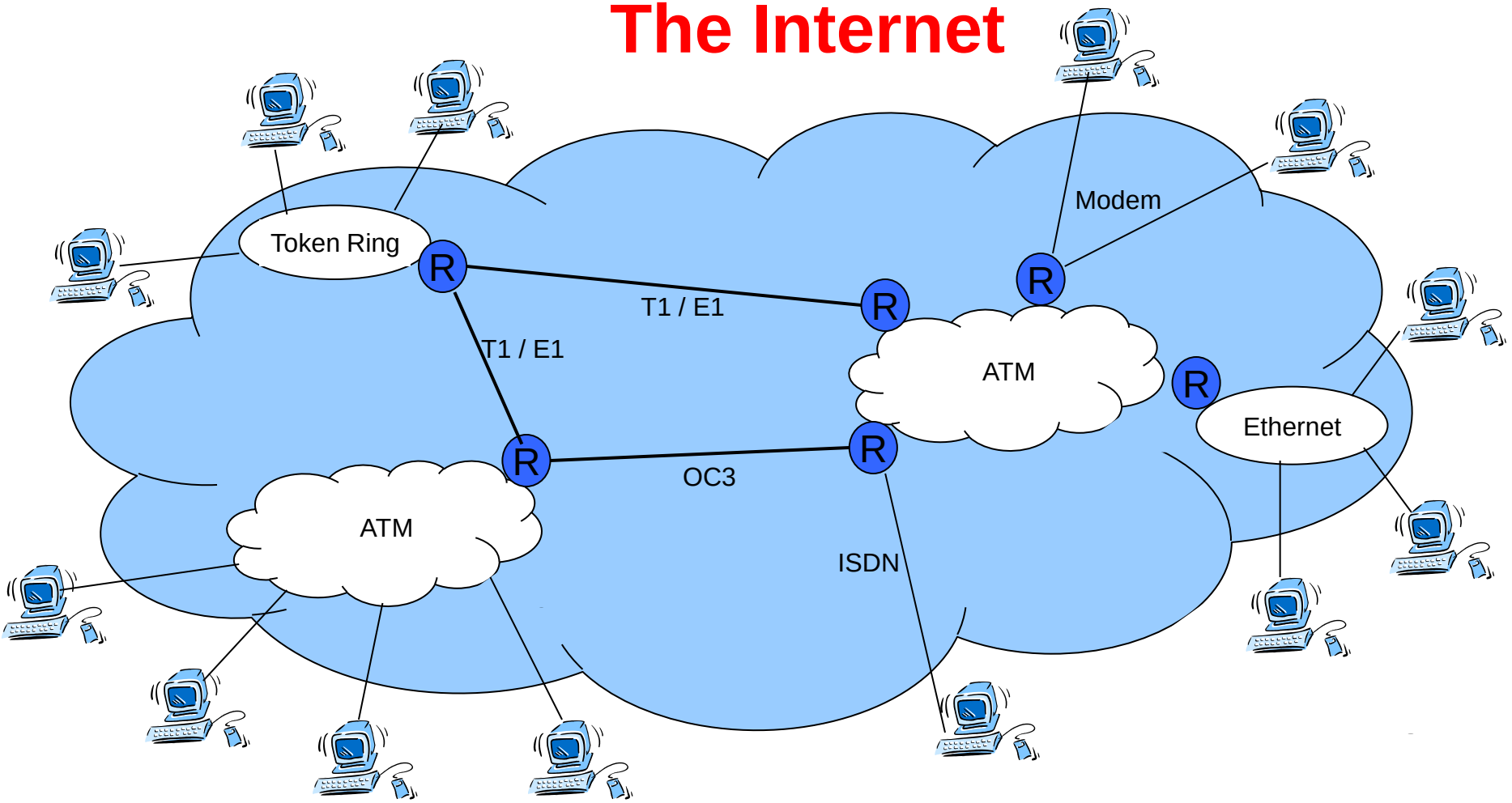
Bheemarjuna Reddy Tamma
IIT Hyderabad

Source: Slides of Charlie Perkins and Geert Heijenk on Mobile IP

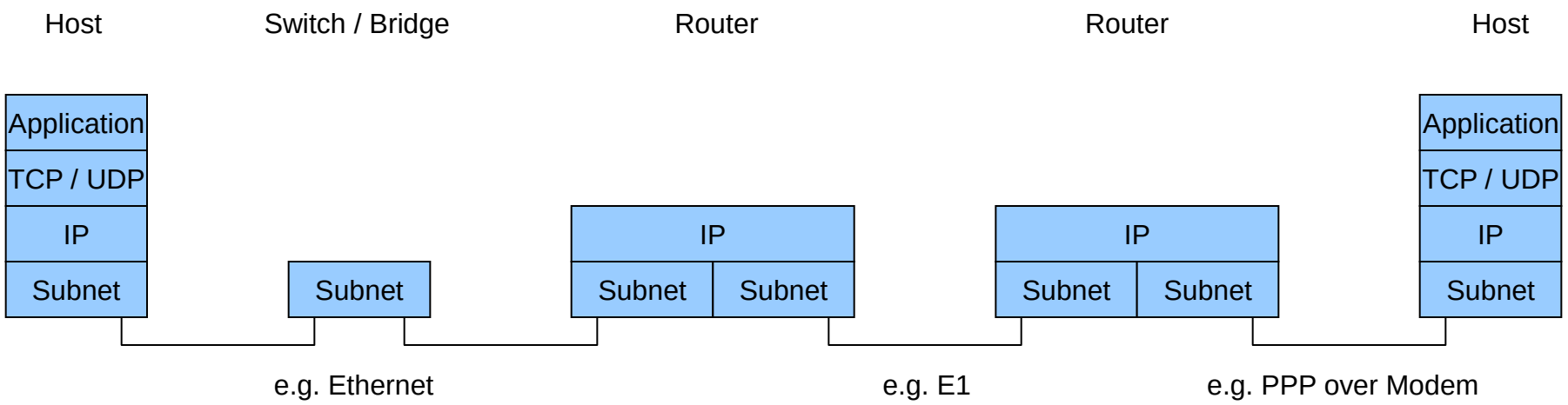
Outline

- IP Refresher
- Mobile IP Basics
- 3 parts of Mobile IP:
  - Advertising Care-of Addresses
  - Registration
  - Tunneling
- Problems/extensions
- Mobility for IPv6
- Conclusion

The Internet



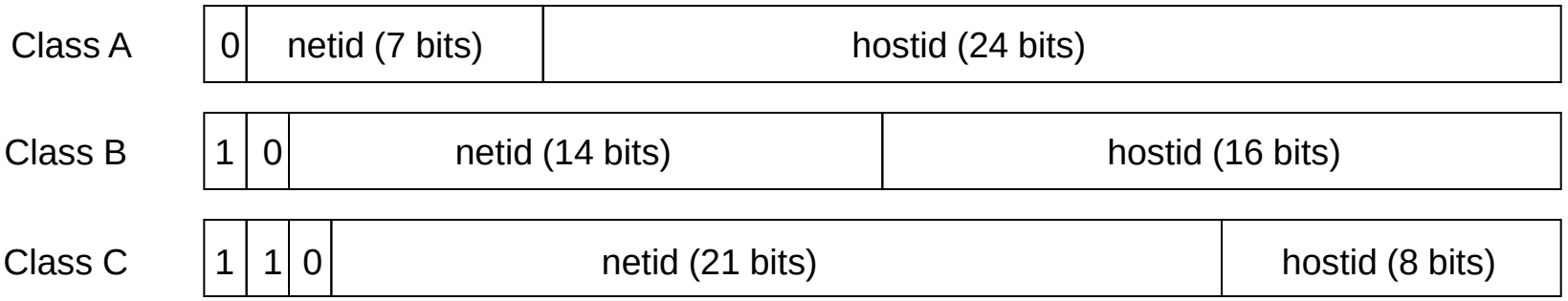
The Internet (2)



IP Addresses

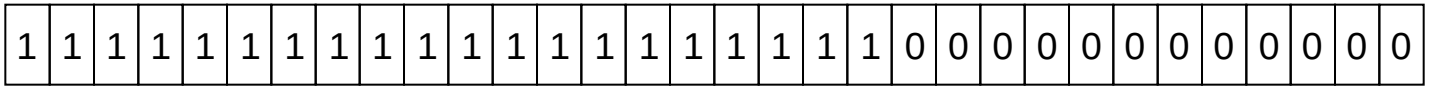
- **4 bytes**
- **Dotted decimal notation, e.g., 130.89.16.82**

Address Classes:



IP Addresses (2)

Subnet Mask



IP Address

Prefix Length

How to obtain an IP Address

- **Manually**
- **Automatically**
  - **PPP (Point-to-Point Protocol) / IPCP (IP Control Protocol)**
  - **BOOTP (Bootstrap Protocol)**
  - **DHCP (Dynamic Host Configuration Protocol)**

Routing Table

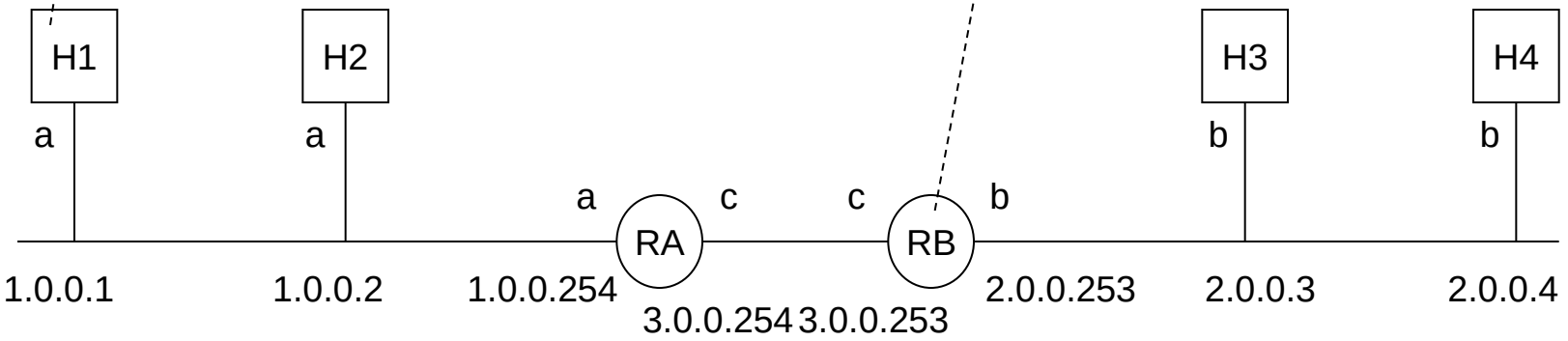
Target	Prefix Length	Next Hop	Interface
7.7.7.99	32	router 1	a
7.7.7.0	24	router 2	a
0.0.0.0	0	router 3	a

Example: Destination Address = 7.7.7.1

Routing Example

Target	Pref.L.	Next Hop	I/f
1.0.0.0	24	"direct"	a
0.0.0.0	0	1.0.0.254	a

Target	Pref.L.	Next Hop	I/f
1.0.0.0	24	3.0.0.254	c
2.0.0.0	24	"direct"	b
3.0.0.0	24	"direct"	c



Levels of addresses in the Internet

Domain name (DNS address)

- a location independent identifier of a host
- utip145.cs.utwente.nl

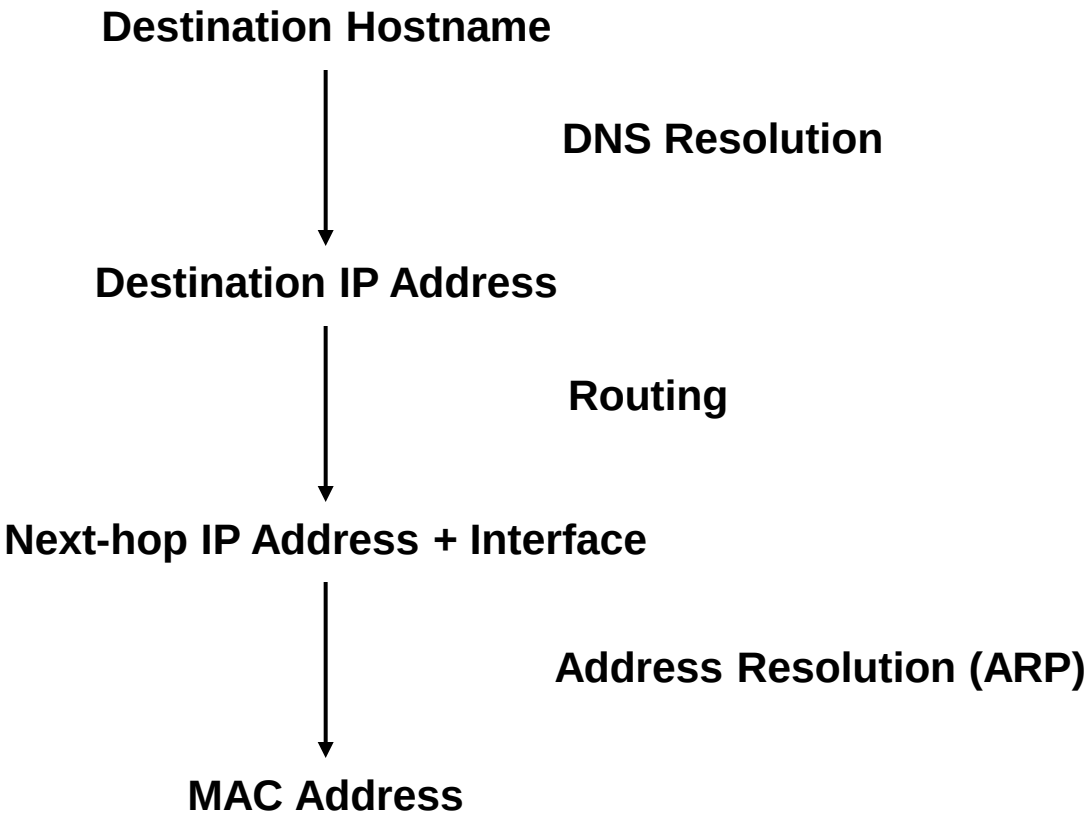
Internet address (IP address)

- the logical location of a host (interface)
- I.e., (sub)network id followed by host id
- 130.89.16.82

Physical address (MAC address)

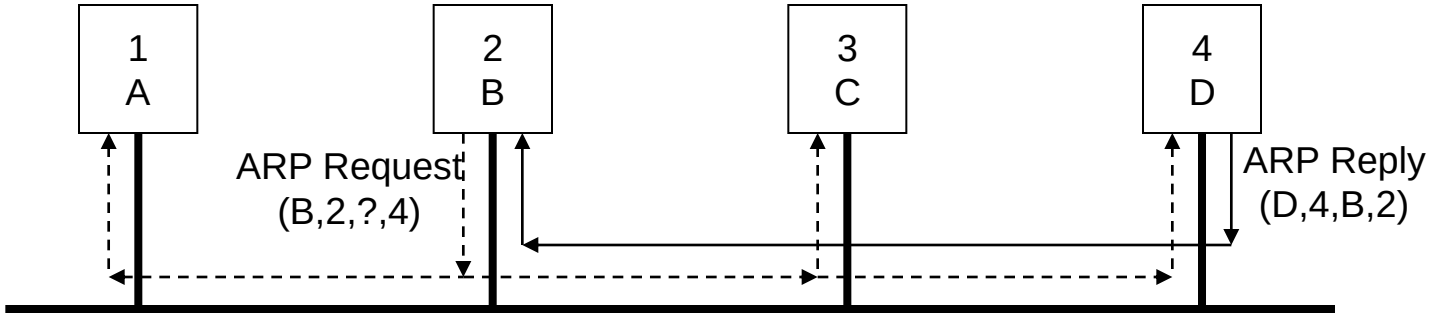
- the hardware address of an interface card
- 00 a4 24 4a 82 07

Address Resolution

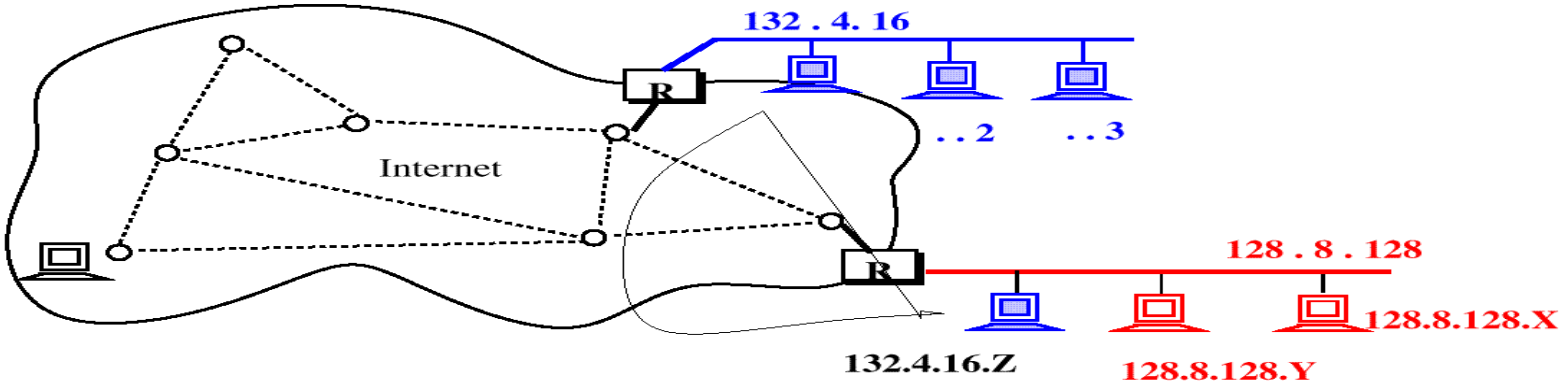


ARP

- **ARP: Address Resolution Protocol**
- **Used to find (Physical) MAC address if IP address is known**
- **ARP Request is a broadcast**
- **ARP Reply is returned to requester**



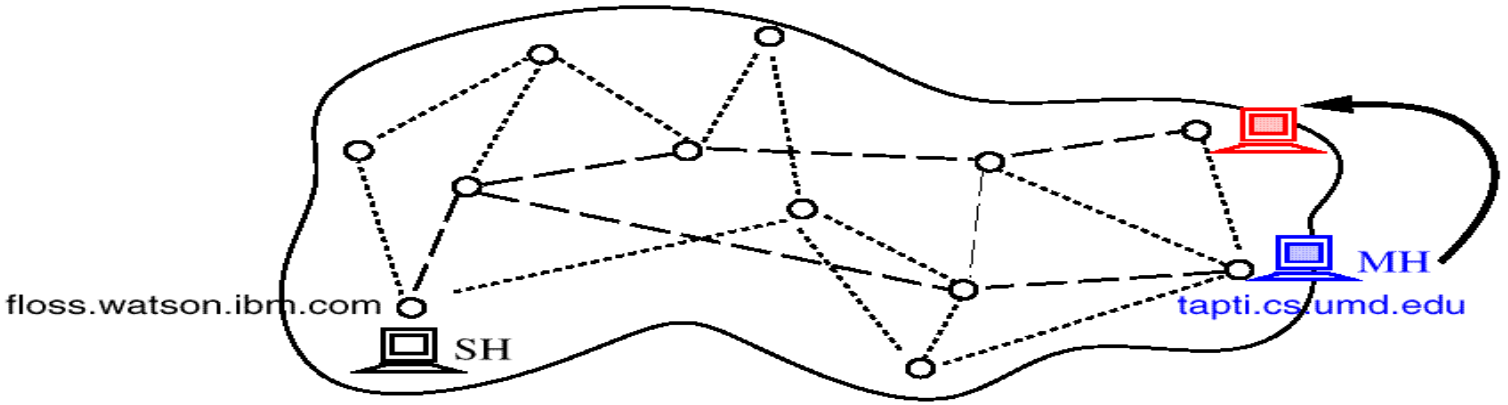
Routing in the Internet



- **Packets flow from link (subnetwork) to link via routers**
- **Packets are routed individually, based on their IP addresses**
  (not on DNS name)
- **Routing is based on the (sub)network prefix of the IP address**

» **A mobile host must be assigned a new address when it moves**

Connections between Internet computers

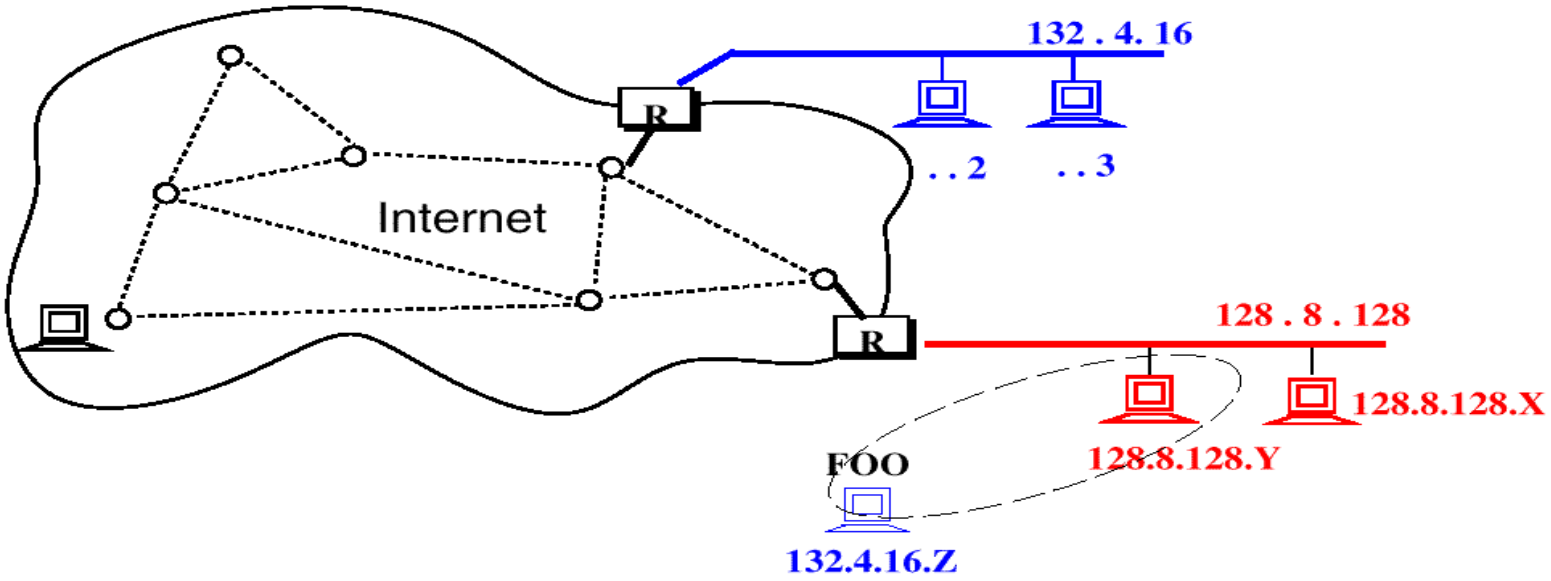


Connection := <129.34.16.43, sh_port #, 128.8.128.45, mh_port #>

- **TCP connections are defined by source and destination IP addresses and port numbers**
- **Change of host address would cause the connection to break**

» **Host address must be preserved regardless of a hosts location**

The Mobile IP problem



A mobile host must be assigned a new address when it moves

«»

Host address must be preserved regardless of a hosts location

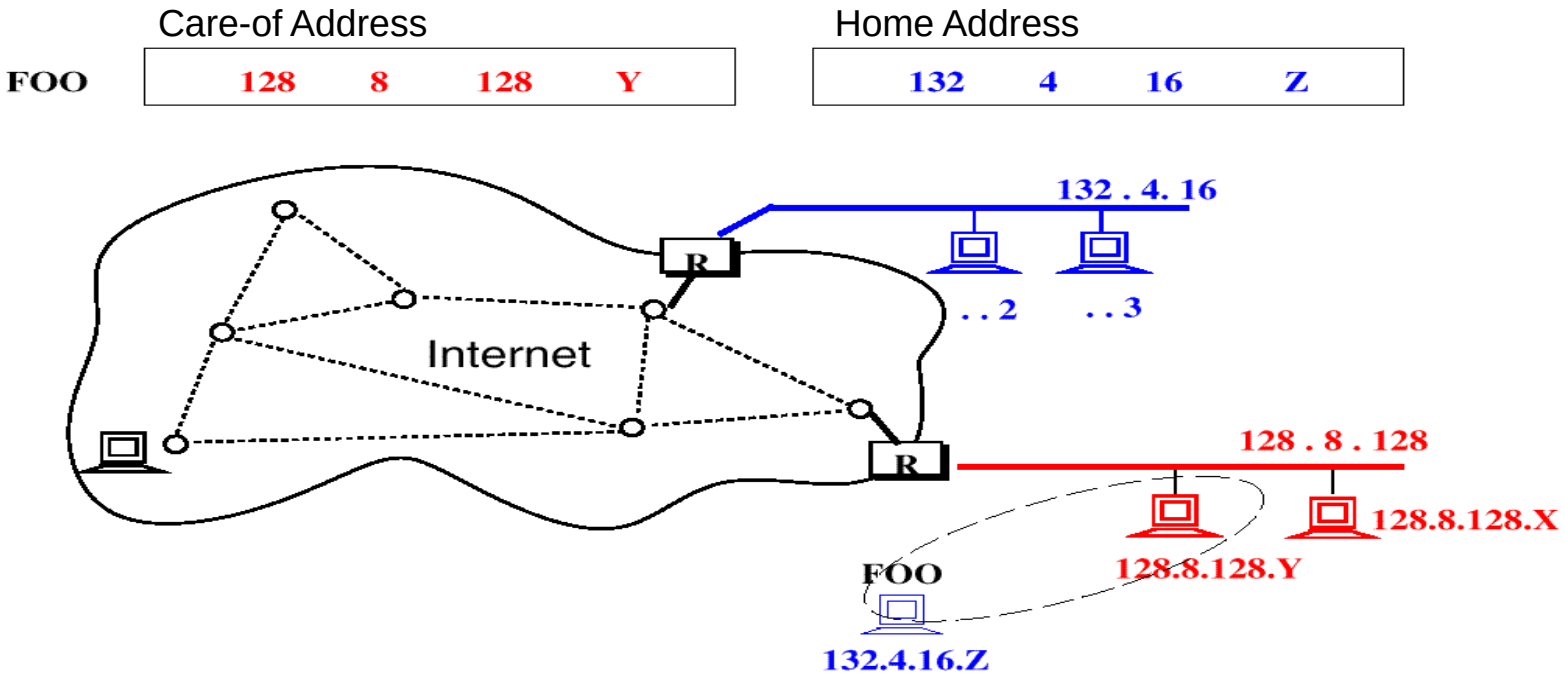
Why Mobility at the Network (IP) Layer?

- **Network layer is present in all Internet nodes**
- **Network layer is responsible for routing packets to the proper location**
- **Mobility across the entire Internet, even changing physical medium is possible**
- **Application transparent**
- **Universal solution for all applications**

Design constraints for Mobile IP

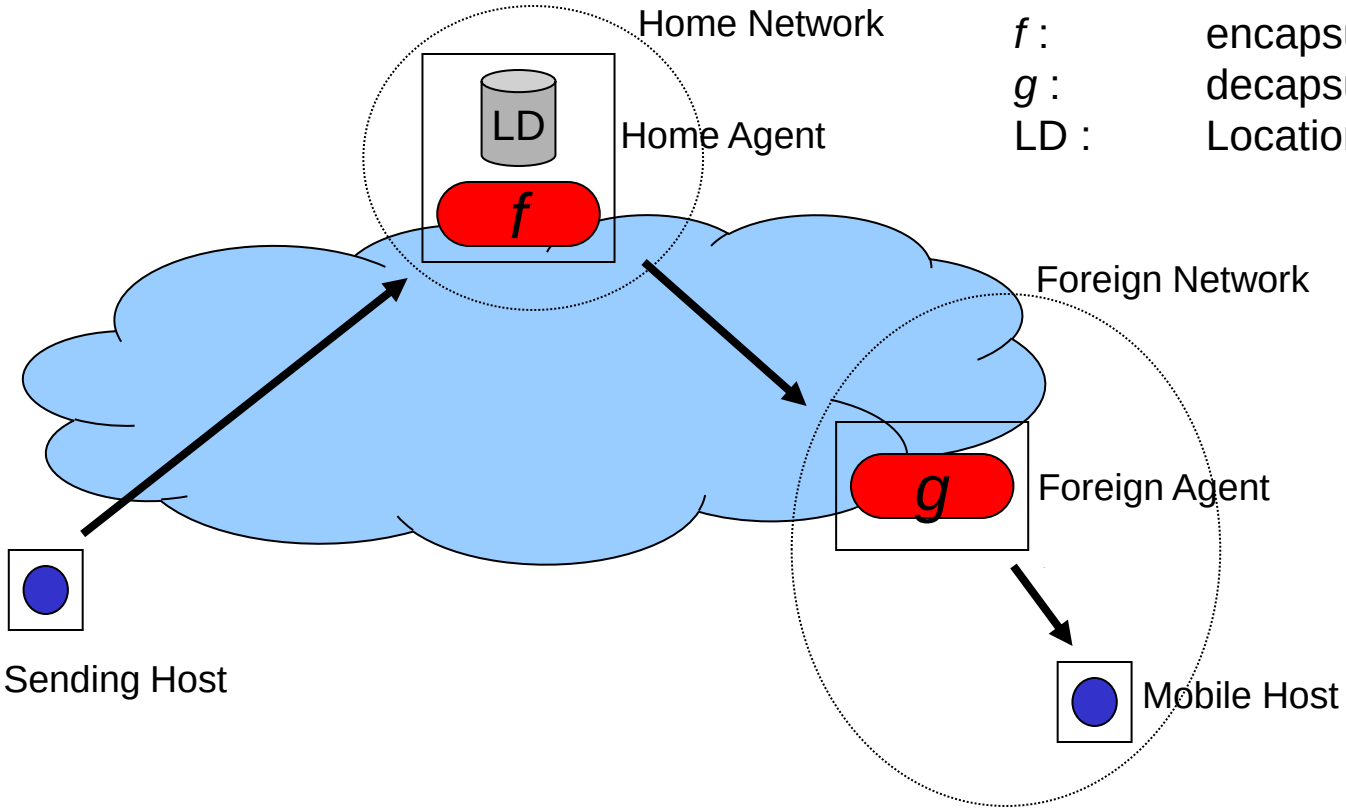
- **Interoperability with the TCP/IP protocol suite**
- **Existing networking applications should run unmodified on mobile hosts**
- **System should provide Internet wide mobility**
- **No modifications to existing routing infrastructure required**
- **No modifications to existing protocols required**
- **Independence of wireless hardware technology**
- **Good scaling properties**

Mobile IP: Basics



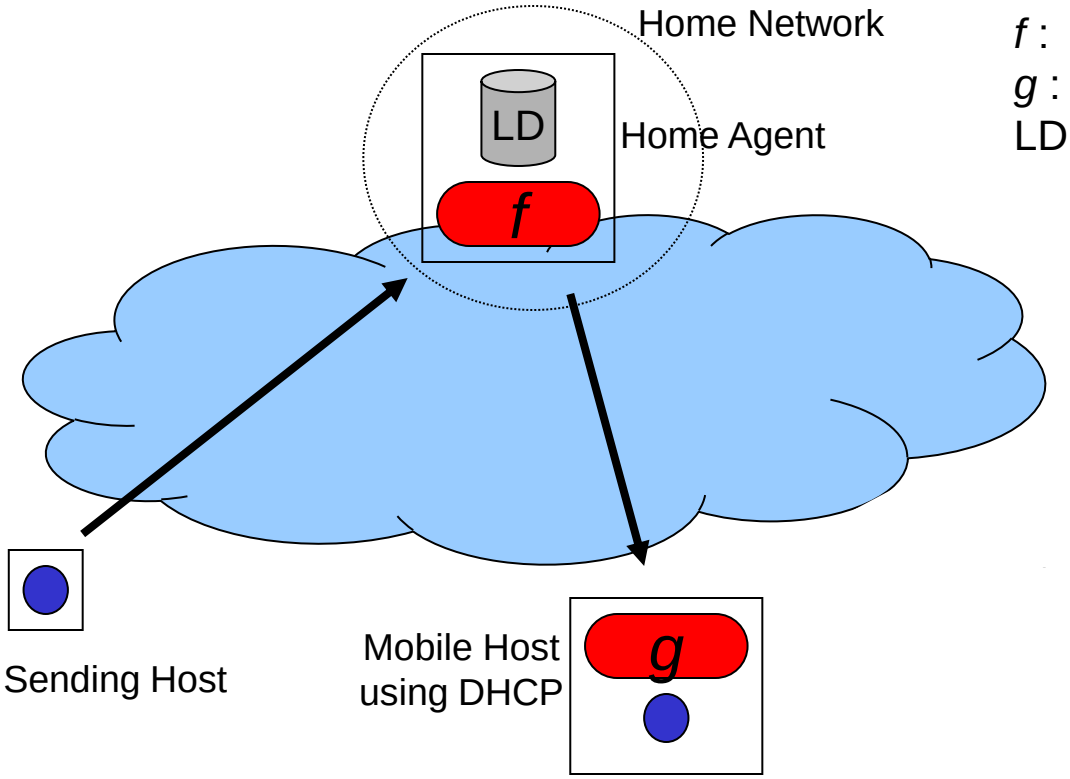
- **A mobile host keeps its *home address*, but on a foreign network, it borrows a *care-of address***
- **Mobile IP takes care of all issue related to the mapping of the care-of address to the home address**

Mobility Model



f : encapsulation and re-addressing
g : decapsulation and forwarding
LD : Location Directory

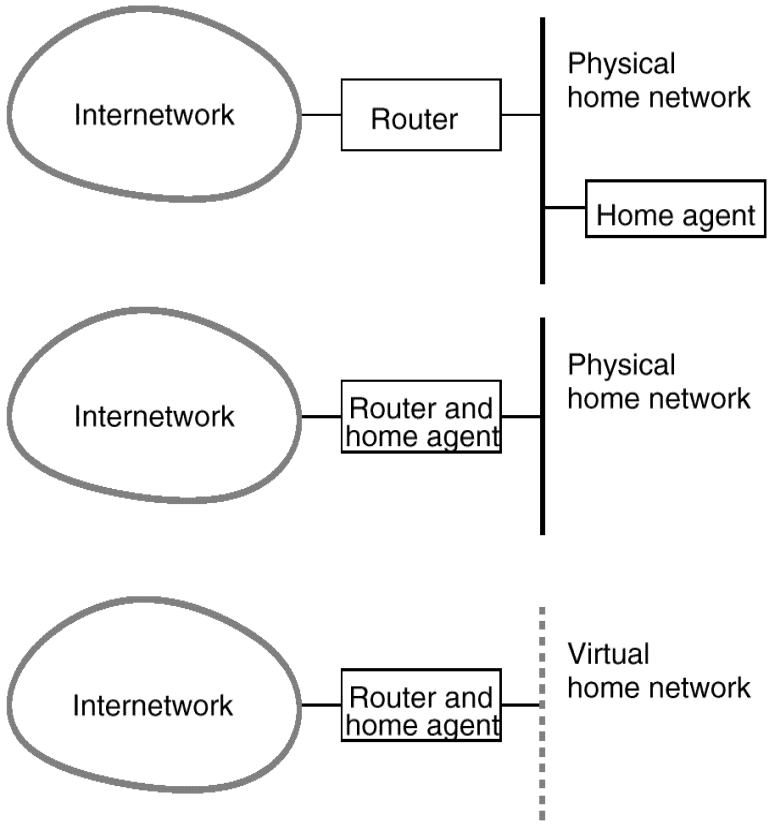
Mobility Model



f : encapsulation and re-addressing
g : decapsulation and forwarding
LD : Location Directory

Types of Home Networks

- **Home agent as a separate system on the home network**
- **Home agent integrated with a router on the home network**
- **A virtual home network**



3 Parts of Mobile IP

- **Advertising Care-of Addresses**
- **Registration**
- **Tunneling**

Advertising Care-of Addresses

A *mobility agent* is either a foreign agent or a home agent or both

- Mobility agents broadcast agent advertisements (ICMP messages with TTL=1)
- Mobile hosts can solicit for an advertisement
- Advertisements contain:
  - mobility agent address
  - care-of addresses
  - lifetime
  - flags

Home Network & Move Detection

Home Network is detected if:

- **Network Prefix IP Source Address advertisement = Network Prefix Home Address**

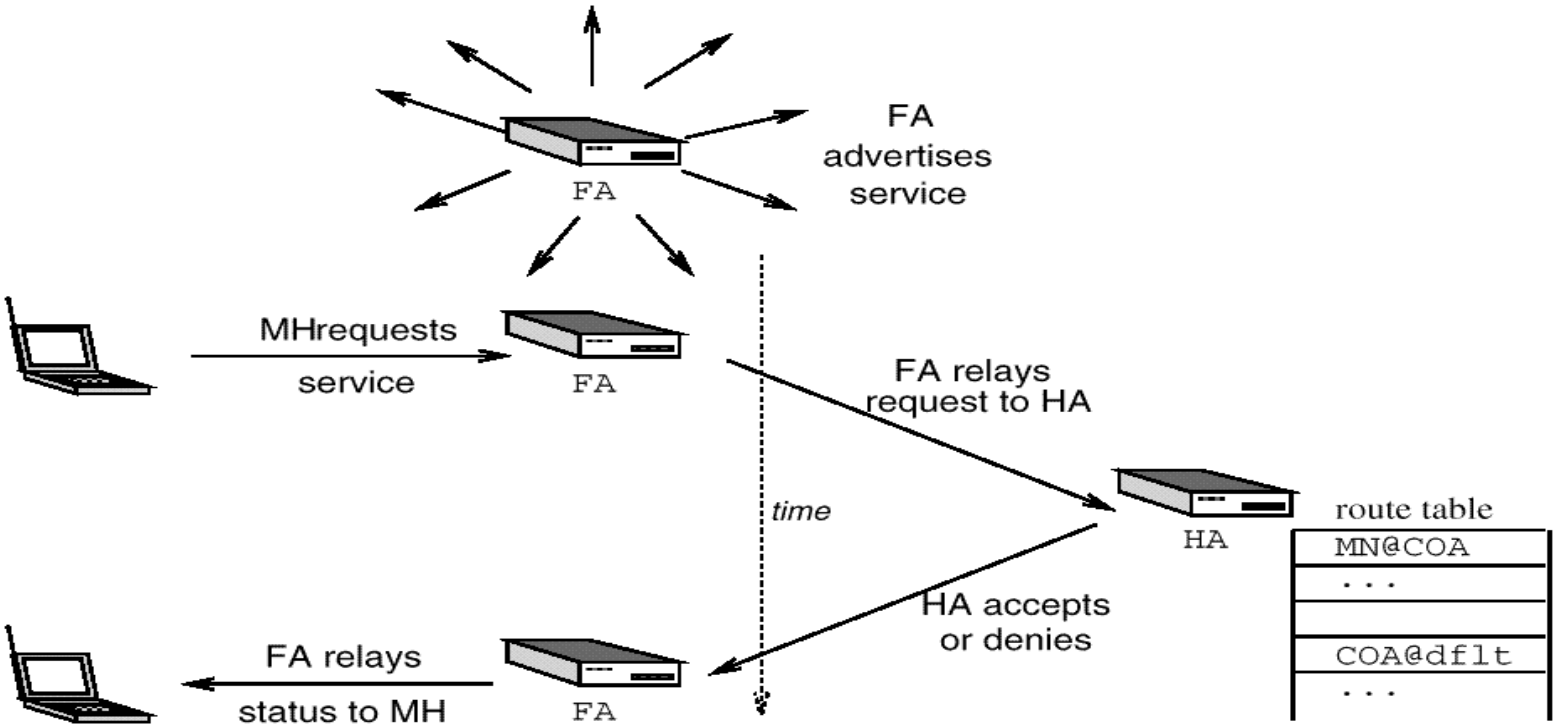
Move is detected if:

- **No advertisement has been received within Lifetime**
- **Network Prefixes have changed**

3 Parts of Mobile IP

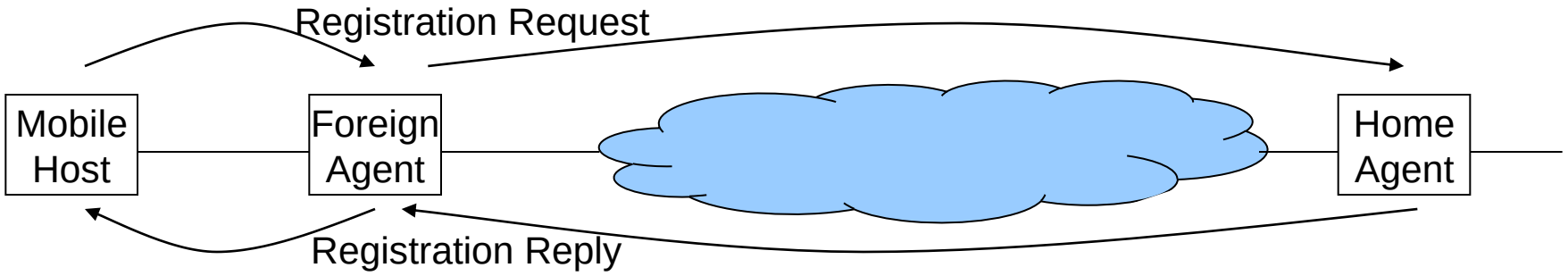
- Advertising Care-of Addresses
- **Registration**
- Tunneling

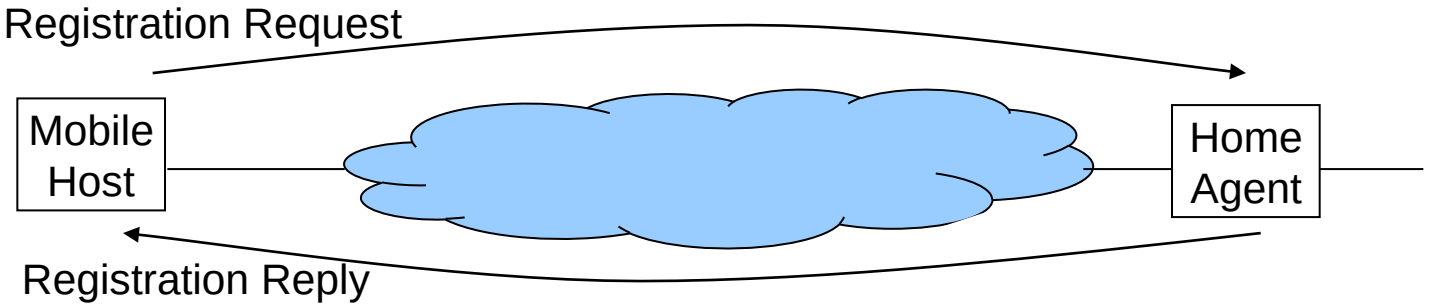
Registration



- ***binding*** **: (home address, care-of address, lifetime)**
- **registration is needed to update the binding**
- **registration requires authentication**
- **registration uses UDP**

Registration Scenarios





Simultaneous Bindings

- **A Mobile Node may register multiple bindings simultaneously**
- **The Home Agent makes multiple copies of packets destined for the mobile host, and tunnels a copy to each care-of address**
- **Simultaneous bindings may be used to**
  - **facilitate seamless hand-off**
  - **avoid too frequent registrations**

Home Agent Address Discovery

- **Mobile Node sends Registration Request as home network directed broadcast (network-prefix.11111…1)**
- **Home Agents reply with a negative Registration Reply (registration denied)**
- **Mobile Node learns Home Agent address from the reply, and initiates a registration**

3 Parts of Mobile IP

- Advertising Care-of Addresses
- Registration
- **Tunneling**

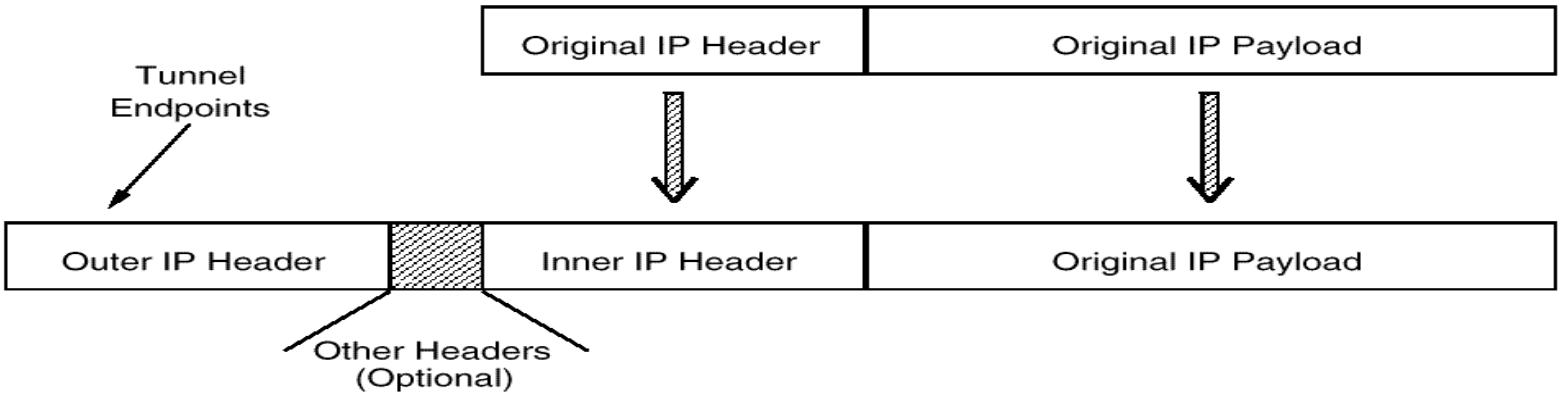
Tunneling

- **Packet destined to the mobile node are routed to the home network (normal IP operation)**
- **Home Agent intercepts packets on the home network**
- **Home Agent encapsulates packets, and tunnels them to the care-of address**
- **At the care-of address (either Foreign Agent or co-located, the packet is decapsulated, and delivered to the mobile node**

Tunneling

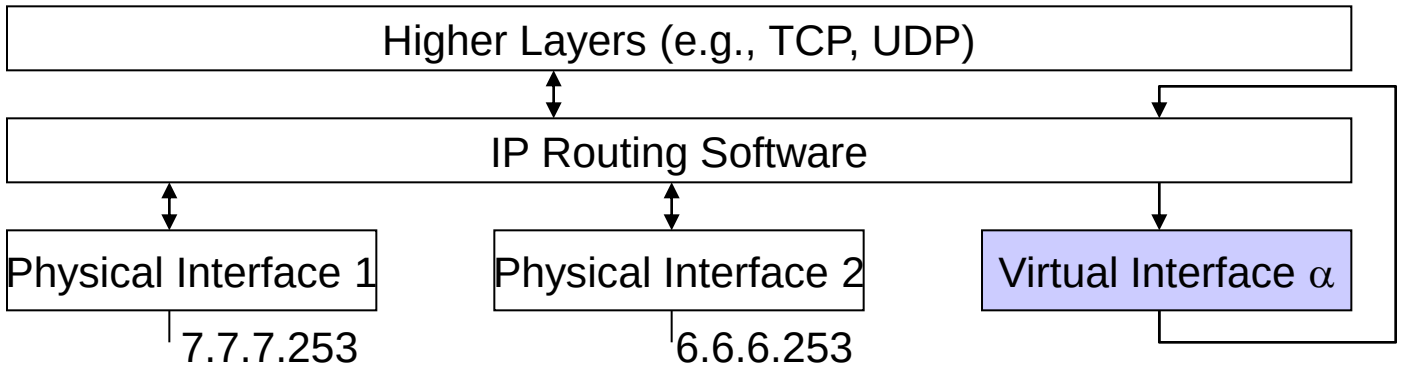
- **Home agent tunnels (encapsulates) packets to care-of address**
- **Tunnel source is the home agent's address**
- **Tunnel destination is the care-of address**

- **IP within IP (other ways exist):**



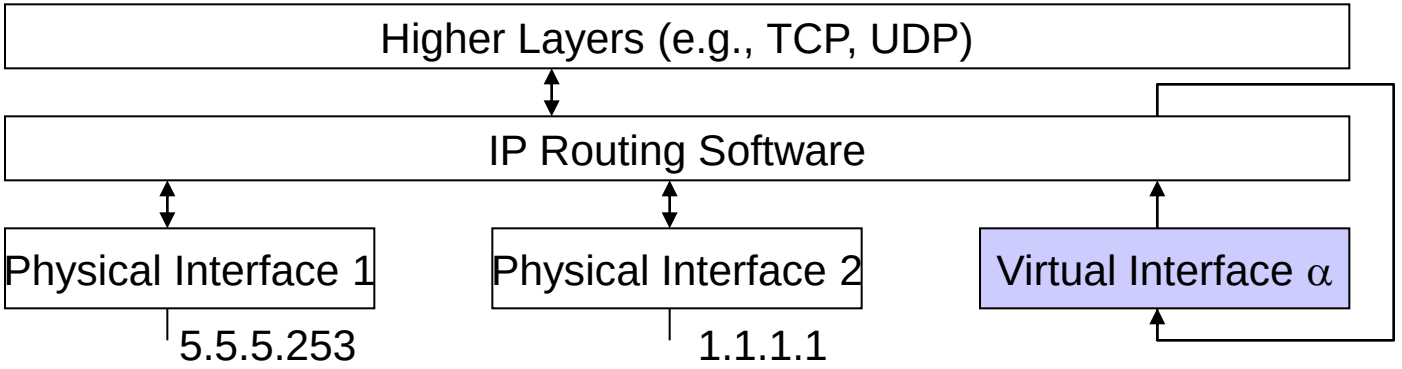
Encapsulation Implementation (HA)

Target	Prefix Length	Next Hop	Interface
7.7.7.0	24	“Direct”	1
default	0	6.6.6.254	2
7.7.7.1 (MN Home Address)	32	1.1.1.1 (MN Care-of Address)	α

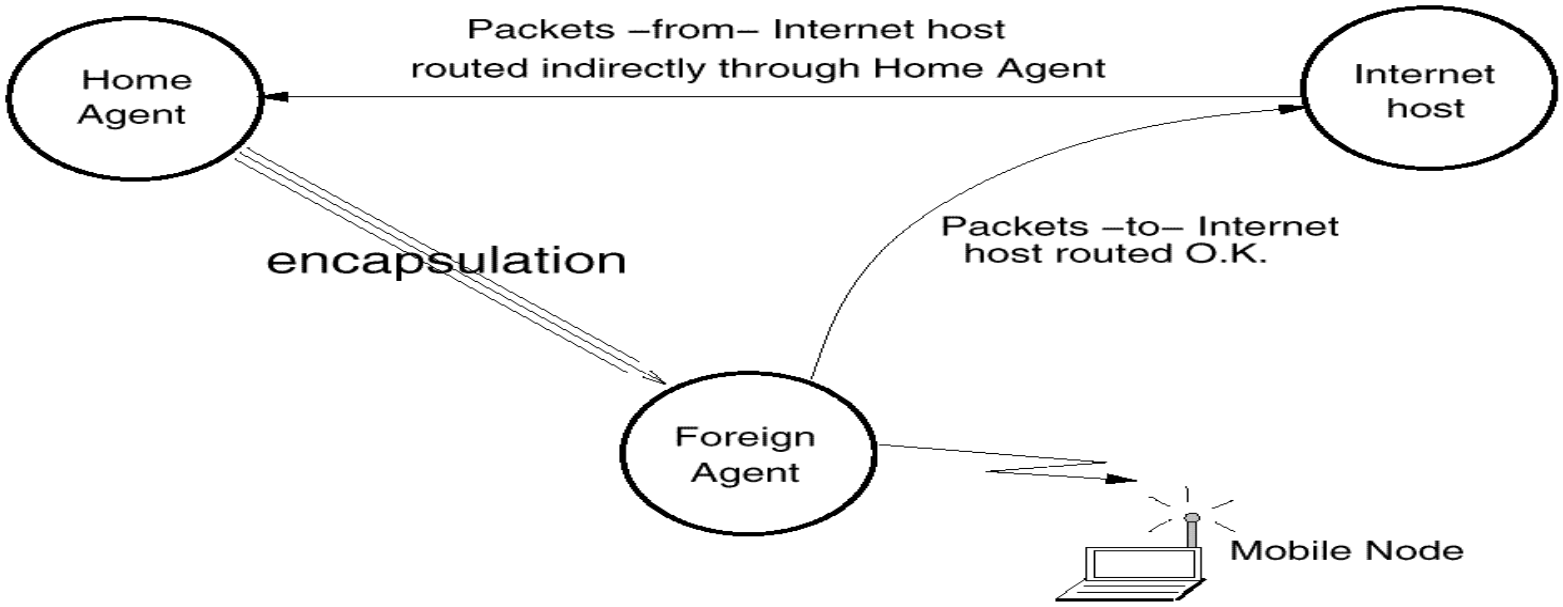


Decapsulation Implementation (FA)

Target	Prefix Length	Next Hop	Interface
5.5.5.0	24	“Direct”	1
1.1.1.0	24	1.1.1.254	2
7.7.7.1 (MN Home Address)	32	“Direct”	1



Triangle Routing



Triangle routing is undesirable because

- **home agent is the bottleneck**
- **more network load, and sensitivity to network partition**

In case of reverse tunneling, the situation is even worse

⇒ Route optimization: Get binding to the correspondent host

(Smooth) Handoff

- **Mobile host moves along subnetworks, from FA to FA.**
- **Packets already in flight to old FA are lost after handoff to new FA**
- **Route optimization allows old FA to forward packets to new care-of address**

Route Optimization (1)

Get binding to relevant correspondent hosts for optimal routing:

- **binding warning (mobility agent → correspondent host)**
- **binding request (correspondent host → home agent)**
- **binding update (home agent → correspondent host)**
- **binding acknowledge (optional)**

security association between correspondent host and home agent is needed for authentication

Route Optimization (2)

Get binding to old Foreign Agent for smooth handoff:

- **previous foreign agent notification extension (mobile host → new FA)**
- **binding update (new FA → old FA)**
- **binding acknowledge (old FA → mobile host)**

mobile host and foreign agent need to exchange registration key for authentication

last resort: special tunnel (old FA tunnels packet back to the HA)

Mobility for IPv6

- All nodes can handle bindings
  - No triangular routing
- Binding updates are carried in Destination Option
  - Small overhead for distributing bindings
- Mobile host can create its own care-of address using link-local address and automatic address configuration (combine advertised subnet prefix with own hardware address)
  - No need for foreign agent

Conclusion

- **Mobile IP consists of 3 parts:**
  - **Advertising Care-of Addresses**
  - **Registration**
  - **Tunneling**
- **Mobility will be an important feature of the next generation Internet (Mobile Internet)**
- **Other solutions exist:**
  - **cellular solution (HLR / VLR)**
  - **application specific solutions (e.g., SIP)**

  but Mobile IP provides global, application independent Internet mobility

Further reading

- **“Mobile Networking Through Mobile IP”**
  Tutorial by Charlie Perkins:
  http://computer.org/internet/v2n1/perkins.htM
- **“Mobile IP, Design Principles and Practices”**
  Book by Charles E. Perkins
- **“Mobile IP, The Internet Unplugged”**
  Book by James D. Solomon
- **IETF Mobile IP WG:**
  http://www.ietf.org/html.charters/mobileip-charter.html