Lab (3)
IPv6 Mobility

Instructor: Prof. Phone Lin
Teacher Assistants: Chia-Peng Lee
Mobile Communications Networking LAB, CSIE, NTU
Date: 2019/04/24

Agenda

- **Introduction to IPv6**
  - **IPv6 Basic**
  - **IPv6 Header**
  - **IPv6 Stateless Auto-Configuration**
- **IP Mobility**
  - **Principles: addressing and routing to mobile users**
  - **Mobile IPv4**
  - **Mobile IPv6**
  - **Proxy Mobile IPv6**

Mobile Communications Networking Lab, NTU

Agenda

- **Introduction to IPv6**
  - **IPv6 Basic**
  - **IPv6 Header**
  - **IPv6 Stateless Auto-Configuration**
- **IP Mobility**
  - **Principles: addressing and routing to mobile users**
  - **Mobile IPv4**
  - **Mobile IPv6**
  - **Proxy Mobile IPv6**

Why a New IP?

- Only compelling reason: more addresses!
  - For billions of new devices,

    e.g., cell phones, PDAs, appliances, cars, etc.
  - For billions of new users,

    e.g., in China, India, etc.
  - For "always-on" access technologies,

    e.g., xDSL, cable, ethernet-to-the-home, PLC/BPL, etc.

Mobile Communications Networking Lab, NTU

But Isn’t There Still Lots of IPv4 Address Space Left?

- Less than 8% of IPv4 addressing space available
  - If size of Internet is doubling each year, does this mean only one year’s worth?
- No, because today we deny unique IPv4 addresses to most new hosts
  - We make them use methods link NAT, PPP, etc. to share addresses
- But new types of applications and new types of access need unique addresses!

Why Are NAT's Not Adequate?

- They won't work for large numbers of "servers", i.e., devices that are "called" by others (e.g., IP phones)
- They inhibit deployment of new applications and services
- They compromise the performance, robustness, security, and manageability of the Internet

Incidental Benefits of Bigger Addresses

- Easy address auto-configuration
- Easier address management/delegation
- Room for more levels of hierarchy, for route aggregation
- Ability to do end-to-end IPsec
  - (because NATs not needed)

Mobile Communications Networking Lab, NTU

Incidental Benefits of New Deployment

- Chance to eliminate some complexity, e.g., in IP header
- Chance to upgrade functionality, e.g., multicast, QoS, mobility
- Chance to include new enabling features, e.g., binding update.

Summary of Main IPv6 Benefits

- Expanded addressing capabilities
- Server-less autoconfiguration (“plug-n-play”) and reconfiguration
- More efficient and robust mobility mechanisms
- Built-in, strong IP-layer encryption and authentication
- Streamlined header format and flow identification
- Improved support for options / extensions

Why Was 128 Bits Chosen as the IPv6 Address Size?

- Some wanted fixed-length, 64-bit addresses
  - Easily good for 10^{12} sites, 10^{15} nodes, at .0001 allocation efficiency
  - Minimize growth of per-packet header overhead
  - Efficient for software processing
- Some wanted variable-length, up to 160 bits
  - Compatible with OSI NSAP addressing plans
  - Big enough for auto configuration using IEEE 802 address
  - Could start with addresses shorter than 64 bits & grow later
- Settled on fixed-length, 128-bit address

What Ever Happened to IPv5?

Version	Protocol	Reason
0-3		unassigned
4	IPv4	todays widespread version of IP
5	ST	The Internet Stream Protocol, RFC 1819, not a new IP
6	IPv6	formerly SIP, SIPP (Simple Internet Protocol Plus)
7	CATNIP	Common Architecture for Next Generation IP, formerly IPv7, IP/IX, RFC 1475, 1707; deprecated
8	PIP	Pip Internet Protocol, RFC 1621, 1622; deprecated
9	TUBA	TCP and UDP with Bigger Address, RFC 1347; deprecated
10-15		unassigned

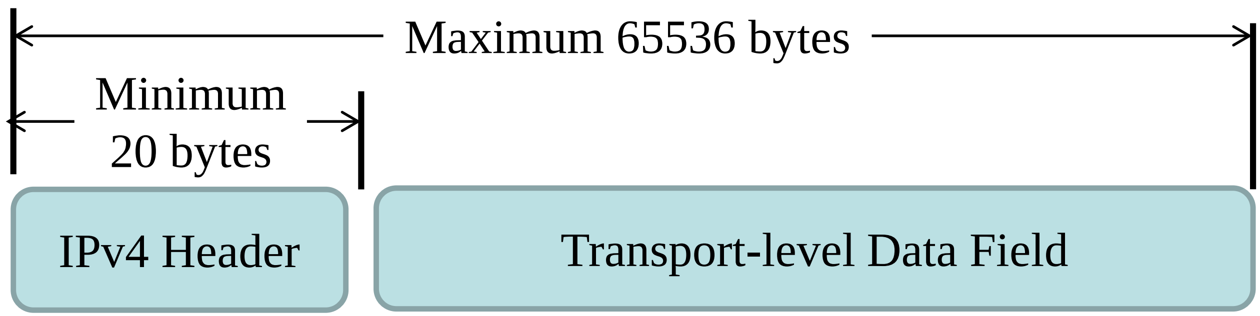
Mobile Communications Networking Lab, NTU

Agenda

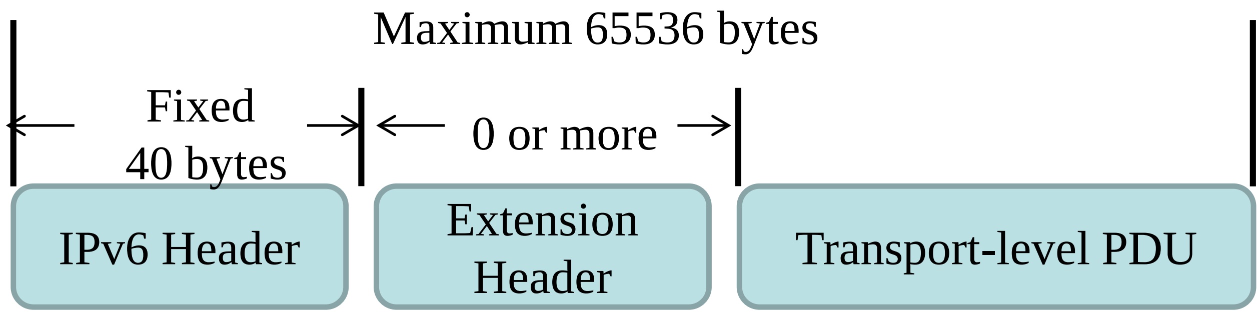
- **Introduction to IPv6**
  - **IPv6 Basic**
  - **IPv6 Header Formats**
  - **IPv6 Stateless Autoconfiguration**
- **IP Mobility**
  - **Mobile IPv4**
  - **Mobile IPv6**
  - **Proxy Mobile IPv6**

Mobile Communications Networking Lab, NTU

IPv6 vs. IPv4 Packet Data Unit

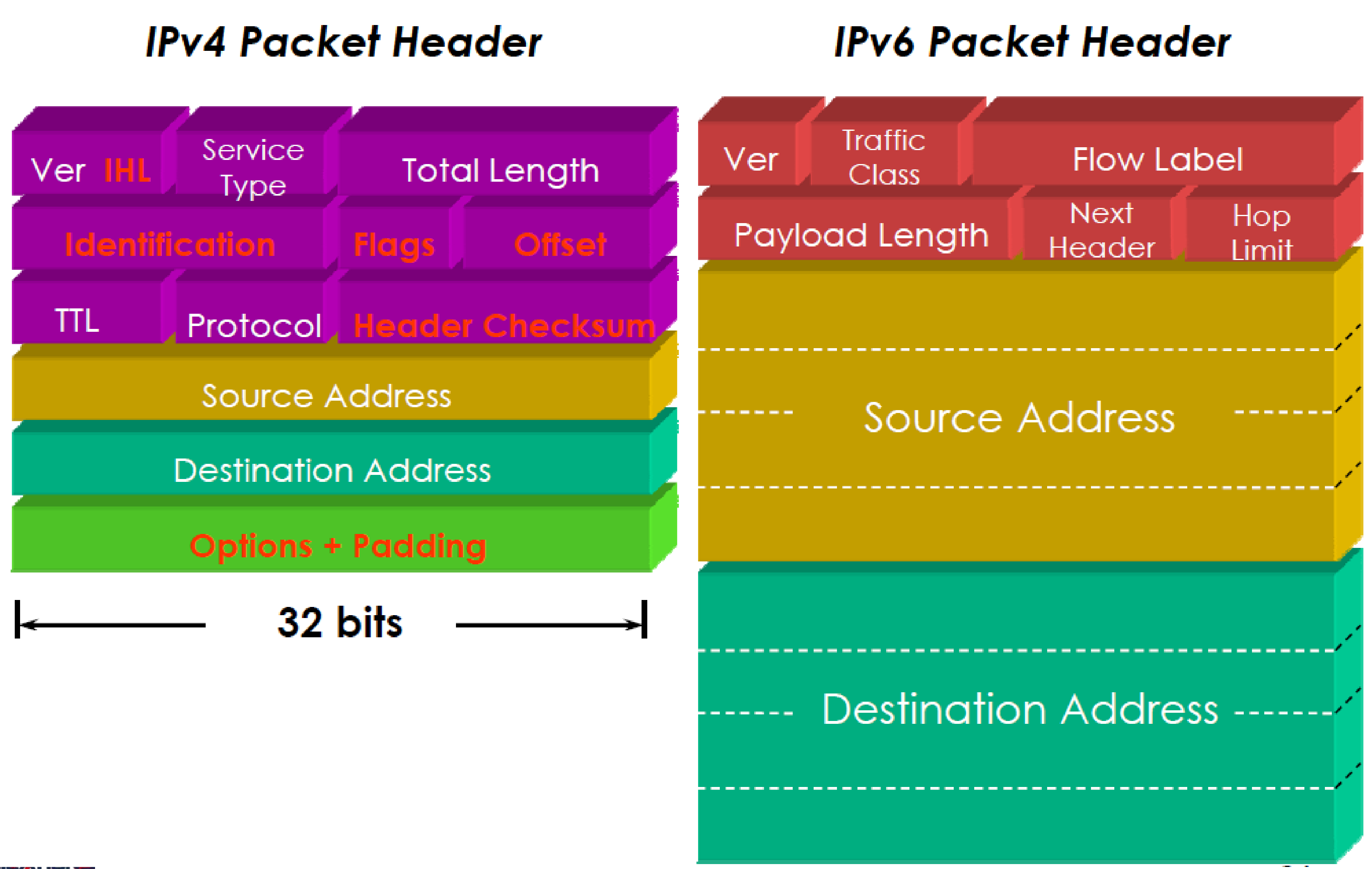


IPv4 PDU



IPv6 PDU

Comparison of IPv4 and IPv6 Headers

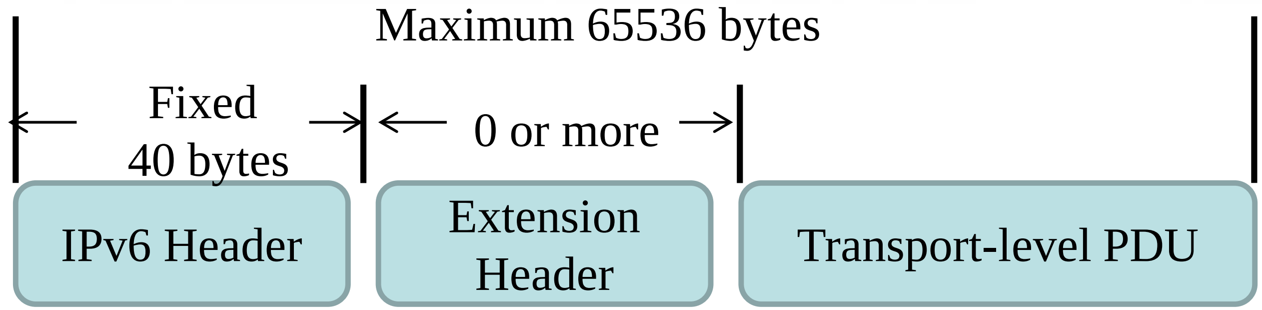


Mobile Communication Networking Lab, NTU

Summary of Header Changes Between IPv4 & IPv6

- Streamlined
  - Fragmentation fields moved out of base header
  - IP options moved out of base header
  - Header Checksum eliminated
  - Header Length field eliminated
  - Length field excludes IPv6 header
- Revised
  - Alignment changed from 32 to 64 bits
  - Time to Live → Hop Limit
  - Protocol → Next Header
  - Precedence & TOS → Traffic Class
  - Addresses increased 32 bits → 128 bits
- Extended
  - Flow Label field added

IPv6 Extension Headers



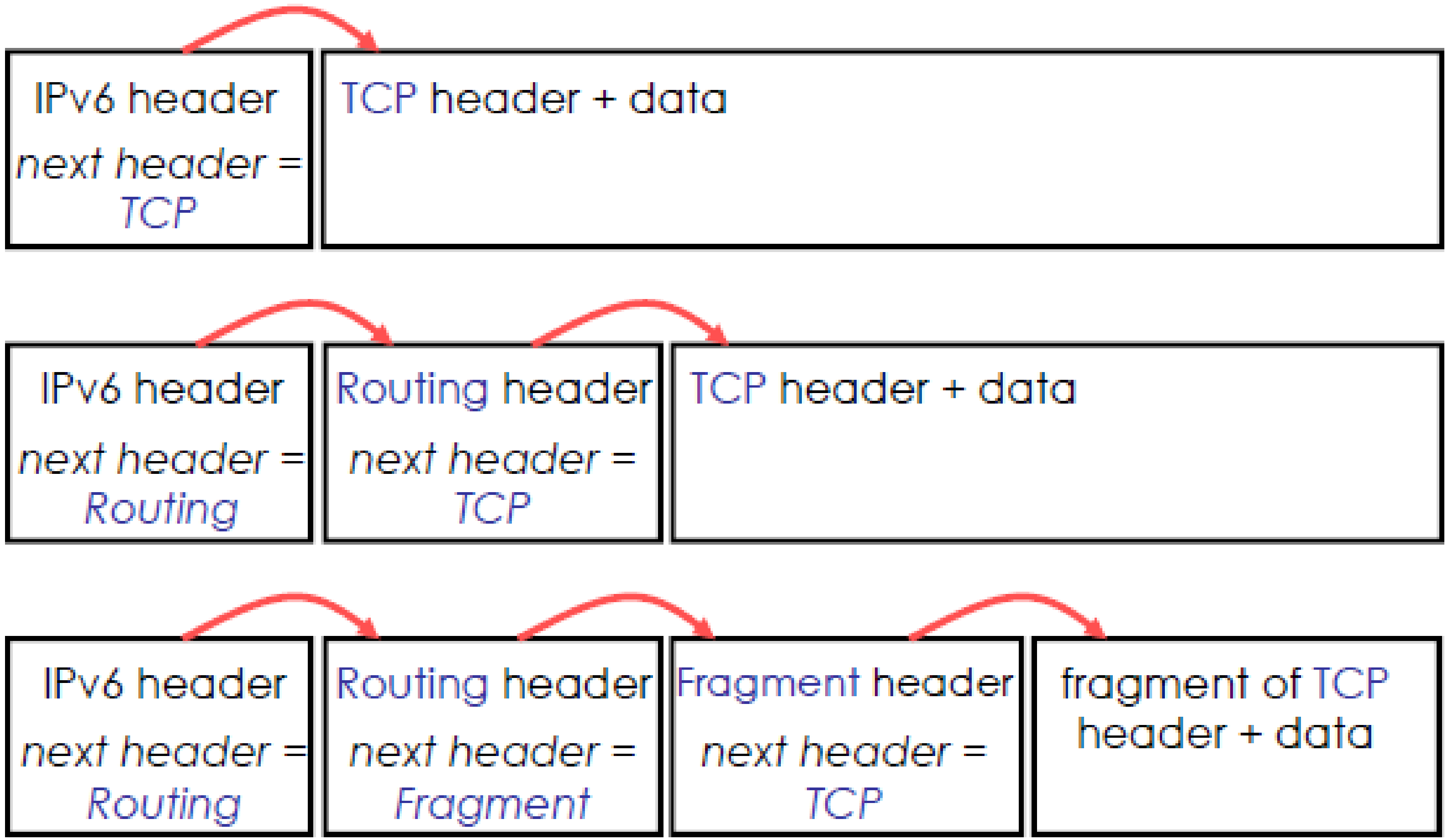
IPv6 PDU

Ordered

- Hop-by-hop options header
- Destination options header
- Routing header
- Fragment header
- Authentication header
- Encapsulating security payload header
- Destination options header

Mobile Communications Networking Lab, NTU

Extension Header Examples



Mobile Communications Networking Lab, NTU

Agenda

- **Introduction to IPv6**
  - **IPv6 Basic**
  - **IPv6 Header Formats**
  - **IPv6 Stateless Auto-Configuration**
- **IP Mobility**
  - **Mobile IPv4**
  - **Mobile IPv6**
  - **Proxy Mobile IPv6**

Mobile Communications Networking Lab, NTU

Stateless Auto-Configuration

- Uses some of Neighbor Discovery ICMPv6 messages
  - Neighbor Discovery message is used to discover the presence and link-layer addresses of other nodes
- On network initialization a node can obtain:
  - IPv6 prefix(es)
  - Default router address(es)
  - Hop limit
  - (link local)MTU
- Only routers have to be manually configured
- Hosts can automatically get an IPv6 address
  - But it isn't automatically registered in the DNS

Mobile Communications Networking Lab, NTU

Stateless Auto-Configuration

- IPv6 Stateless Address Auto-Configuration is described in RFC 4862.
- Hosts are listening for Router Advertisements (RA) messages, periodically transmitted by routers.
- RA messages coming from the router(s) on the link identify the subnet
- Allows a host to create a global IPv6 address from:
  - Its interface identifier (EUI-64 address)
  - Link Prefix (obtained via Router Advertisement)

Global Address = Link Prefix + EUI-64 address

Stateless Auto-Configuration

- Usually, the router sending the RA messages is used, by hosts, as the default router.
- If the RA doesn't carry any prefix
  - The hosts don't configure (automatically) any global IPv6 address (but may configure the default gateway address).
- RA messages contain two flags indicating what type of stateful autoconfiguration (if any) should be performed.
- It's impossible to automatically send DNS server addresses.

Stateless Auto-Configuration Example

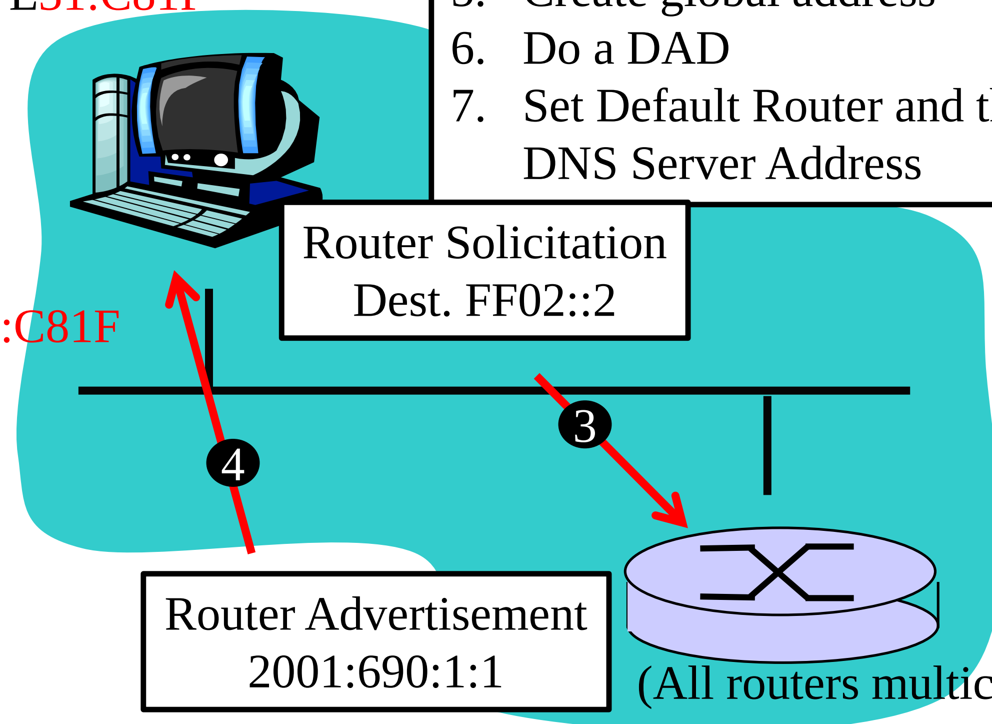
1. Create the link local address
2. Do a Duplicate Address Detection
3. Send Router Solicitation
4. Receive Router Advertisement
5. Create global address
6. Do a DAD
7. Set Default Router and the DNS Server Address

MAC address is 00:0E:0C:31:C8:1F

EUI-64 address is 20E:0CFF:FE31:C81F

❶
Link-local address:
FE80::20E:0CFF:FE31:C81F

❺
Stateless address:
2001:690:1:1:20E:0CFF:FE31:C81F



(All routers multicast address)
FF02::2

Router Link-local address:
FE80::20F:23FF:FEF0:551A

Agenda

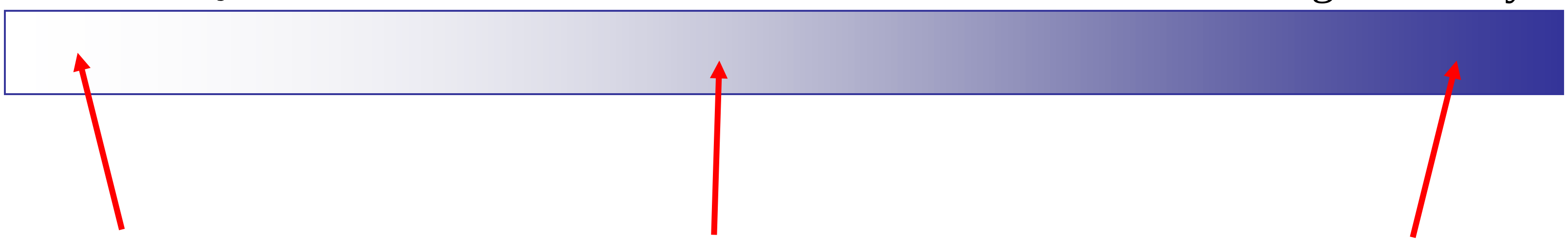
- **Introduction to IPv6**
  - **IPv6 Basic**
  - **IPv6 Header Formats**
  - **IPv6 Stateless Autoconfiguration**
- **IP Mobility**
  - **Principles: addressing and routing to mobile users**
  - **Mobile IPv4**
  - **Mobile IPv6**
  - **Proxy Mobile IPv6**

What is mobility?

- spectrum of mobility, from the *network* perspective:

no mobility

high mobility



mobile wireless user, using same access point

mobile user, connecting/ disconnecting from network using DHCP.

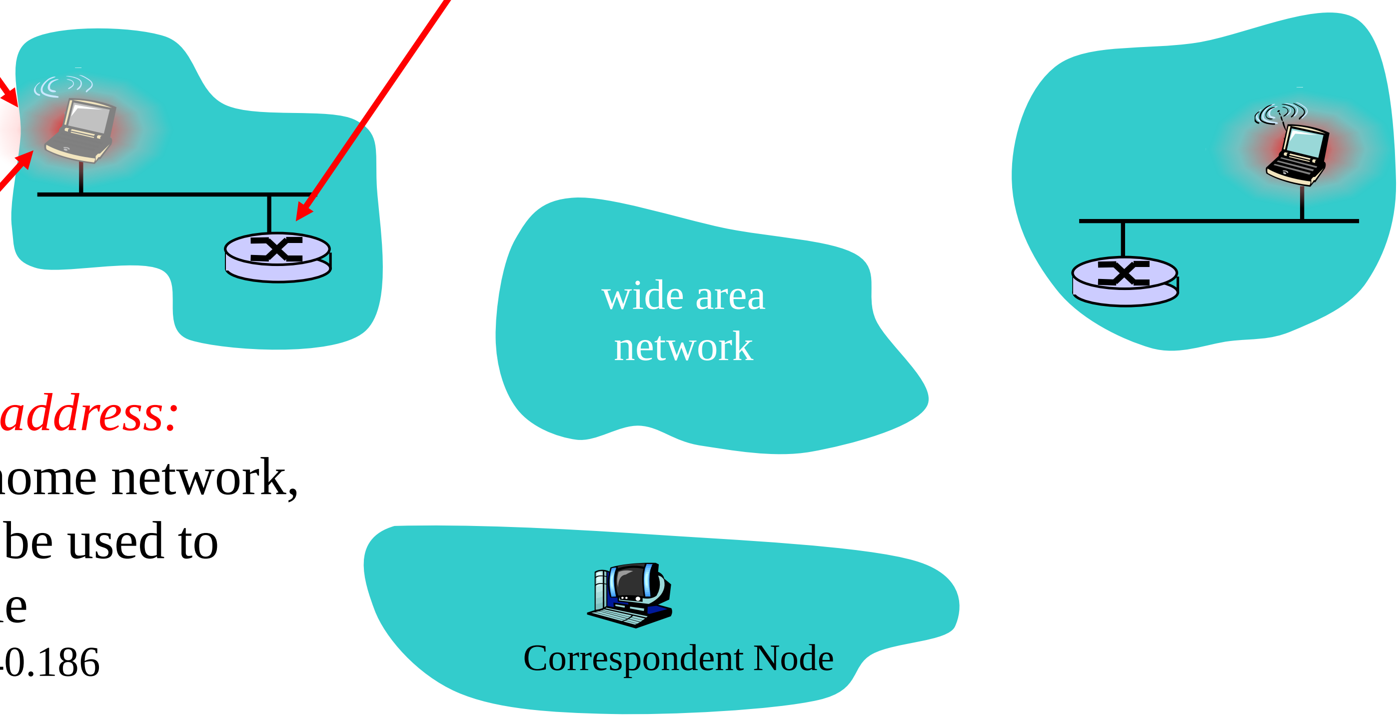
mobile user, passing through multiple access point while maintaining ongoing connections (like cell phone)

Mobile Communications Networking Lab, NTU

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



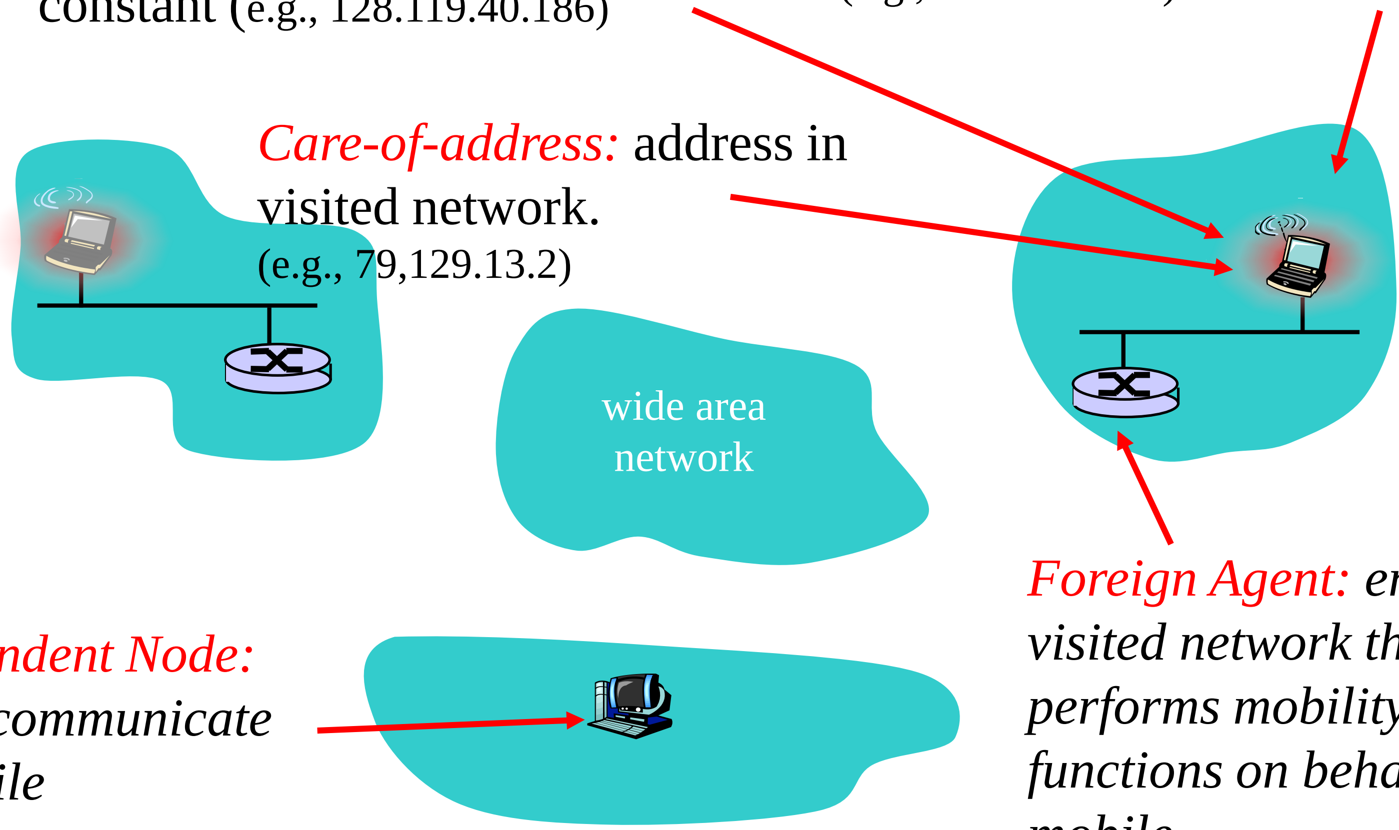
Permanent address:
address in home network, *can always* be used to reach mobile
e.g., 128.119.40.186

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 Node: wants to communicate with mobile

Mobile Communications Networking Lab, NTU

How do *you* contact a mobile friend:

Consider friend frequently changing addresses, how do you find her?

- **search all phone books?**
- **call her parents?**
- **expect her to let you know where he/she is?**

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

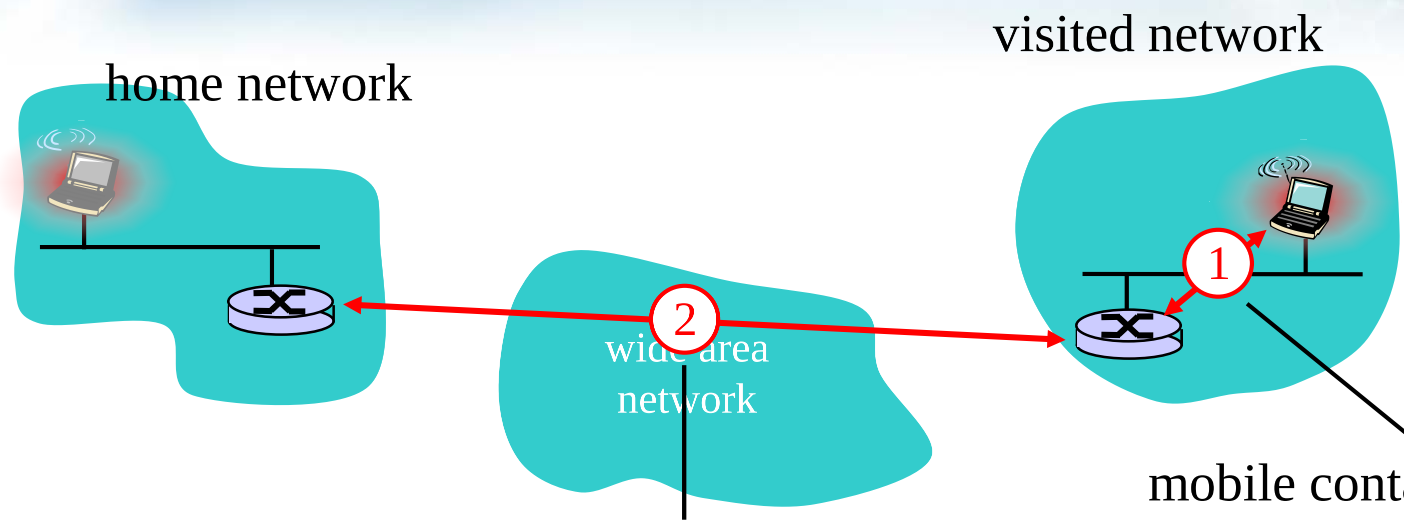
Mobility: approaches

- *Let routing handle it:* ... advertise permanent address of mobile-nodes-in-r... ...sual routing table exchange.
  - routing tables ... each mobile located
  - no changes to e...

not scalable to millions of mobiles

- *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

Mobility: registration



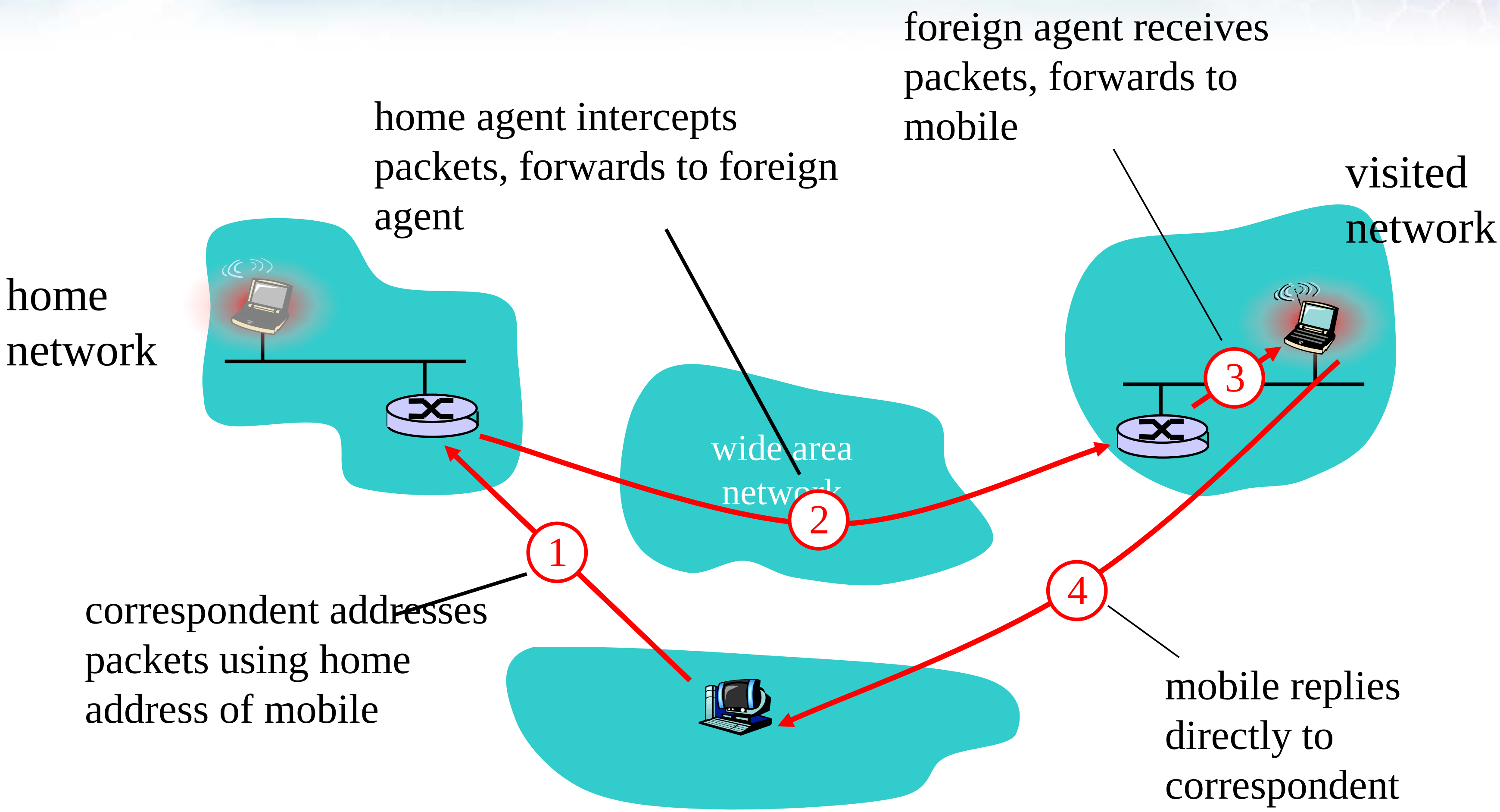
foreign agent contacts home agent home: "this mobile is resident in my network"

mobile contacts foreign agent on entering visited network

End result:

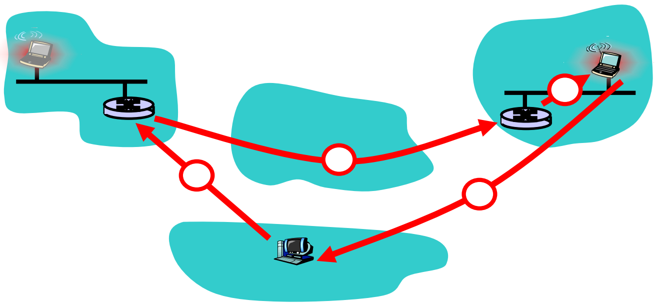
- Foreign agent knows about mobile
- Home agent knows location of mobile

Mobility via Indirect Routing



Indirect Routing: comments

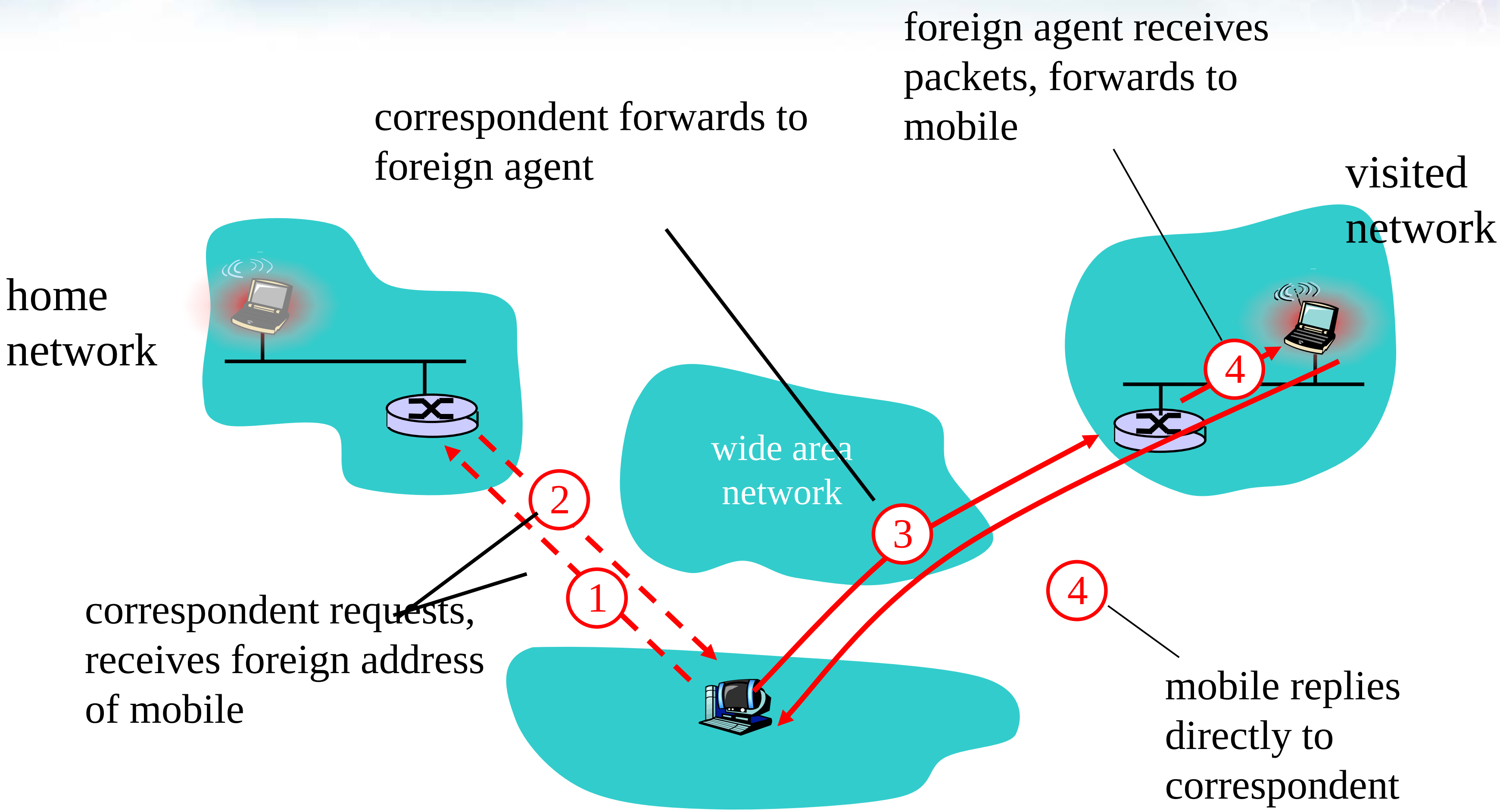
- Mobile uses two addresses:
  - permanent address: used by correspondent (hence mobile location is *transparent* to correspondent)
  - care-of-address: used by home agent to forward datagrams to mobile
- foreign agent functions may be done by mobile itself
- triangle routing: correspondent-home-network-mobile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



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!*

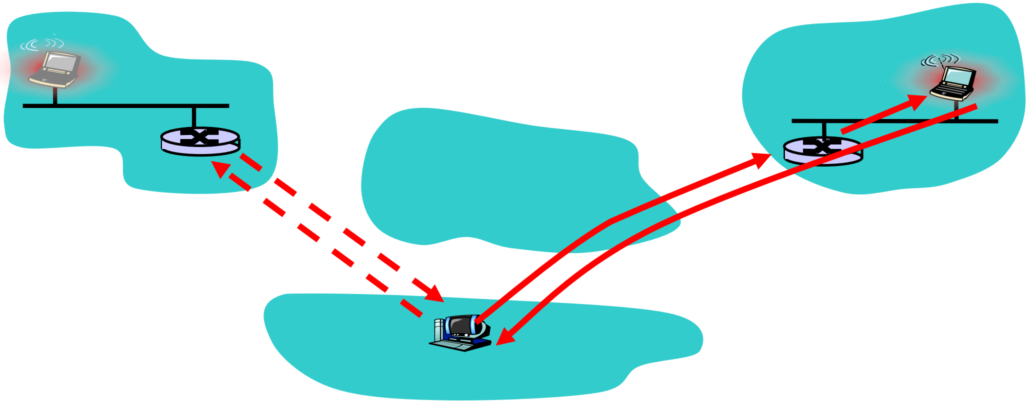
Mobility via Direct Routing



Mobile Communications Networking Lab, NTU

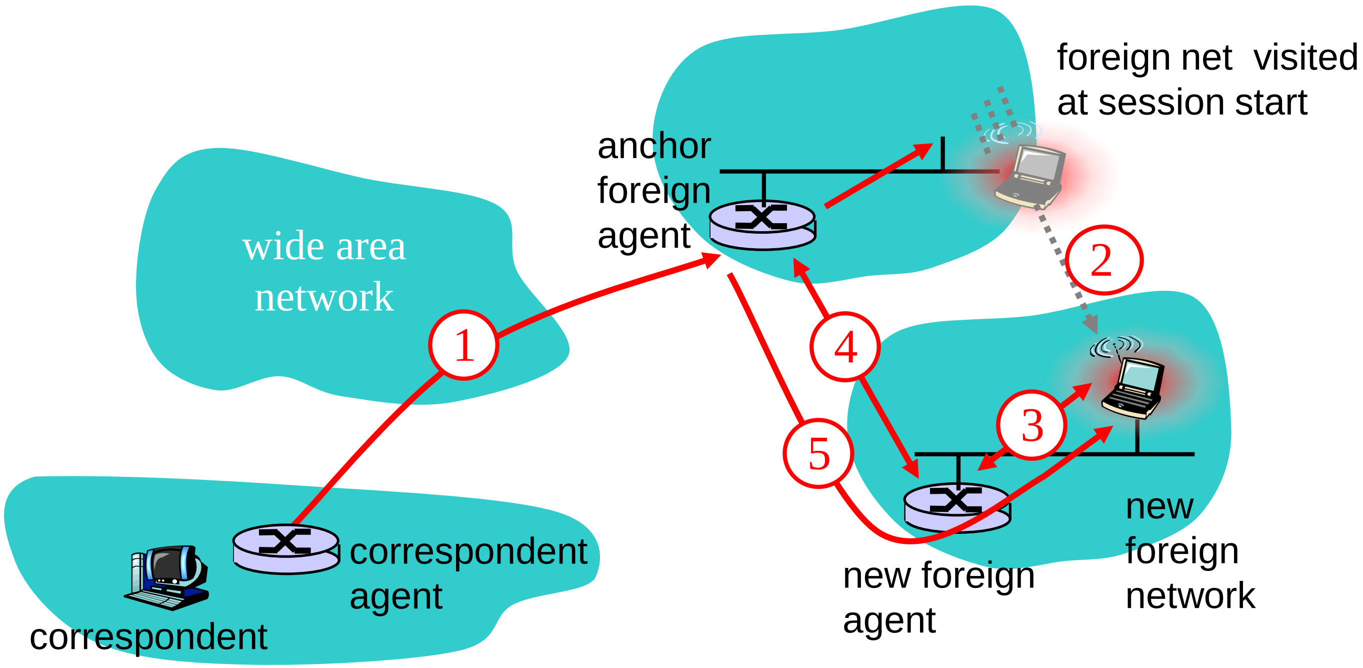
Mobility via Direct Routing: comments

- overcome triangle routing problem
- non-transparent to correspondent: correspondent must get care-of-address from home agent
  - what if mobile changes visited network?



Accommodating mobility with direct routing

- anchor foreign agent: FA in first visited network
- data always routed first to anchor FA
- when mobile moves: new FA arranges to have data forwarded from old FA (chaining)



Agenda

- **Introduction to IPv6**
  - **IPv6 Basic**
  - **IPv6 Header Formats**
  - **IPv6 Stateless Autoconfiguration**
- **IP Mobility**
  - **Principles: addressing and routing to mobile users**
  - **Mobile IPv4**
  - **Mobile IPv6**
  - **Proxy Mobile IPv6**

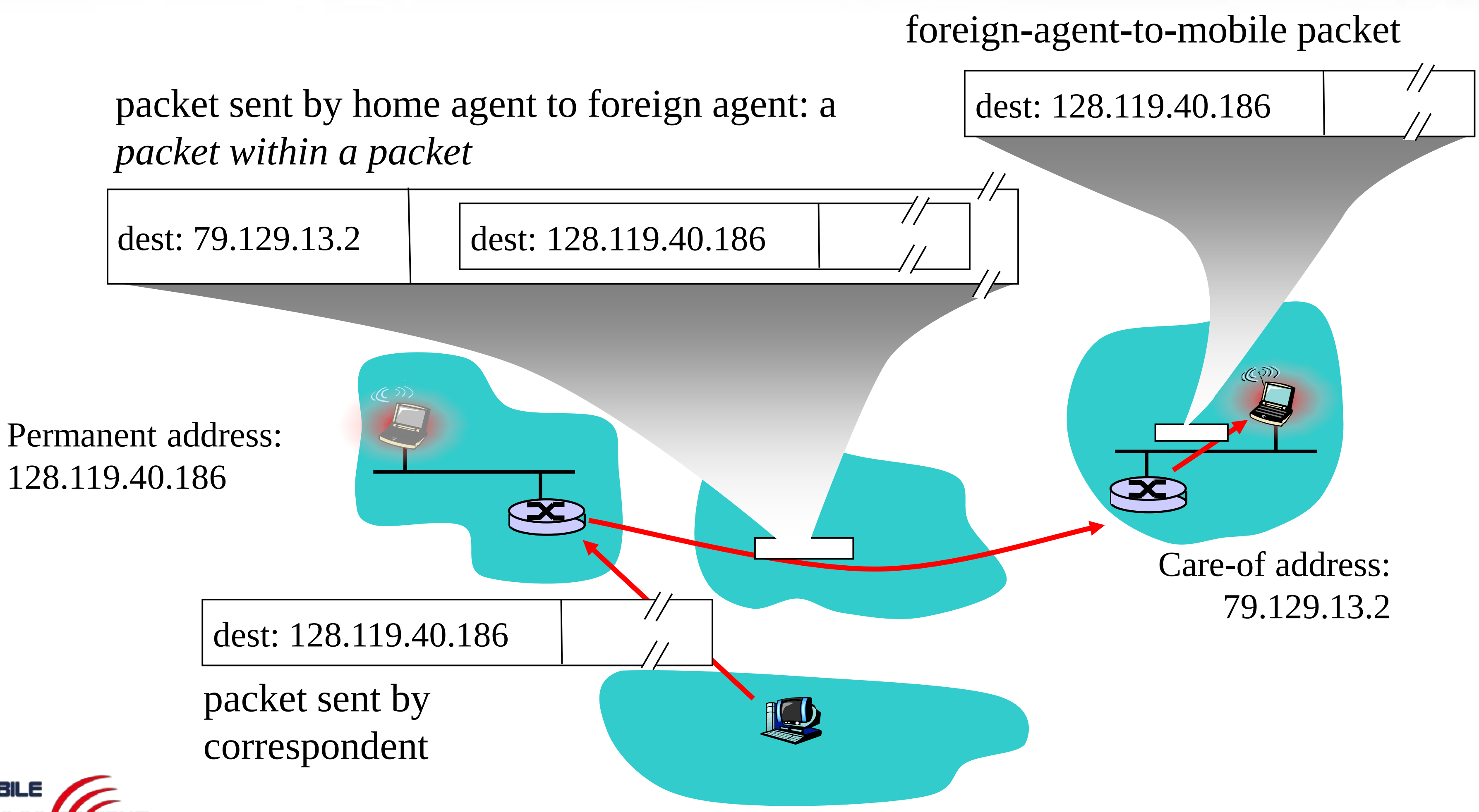
Mobile Communications Networking Lab, NTU

Mobile IPv4

- RFC 5944 (November 2010)
- 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:
  - indirect routing of datagrams
  - agent discovery
  - registration with home agent

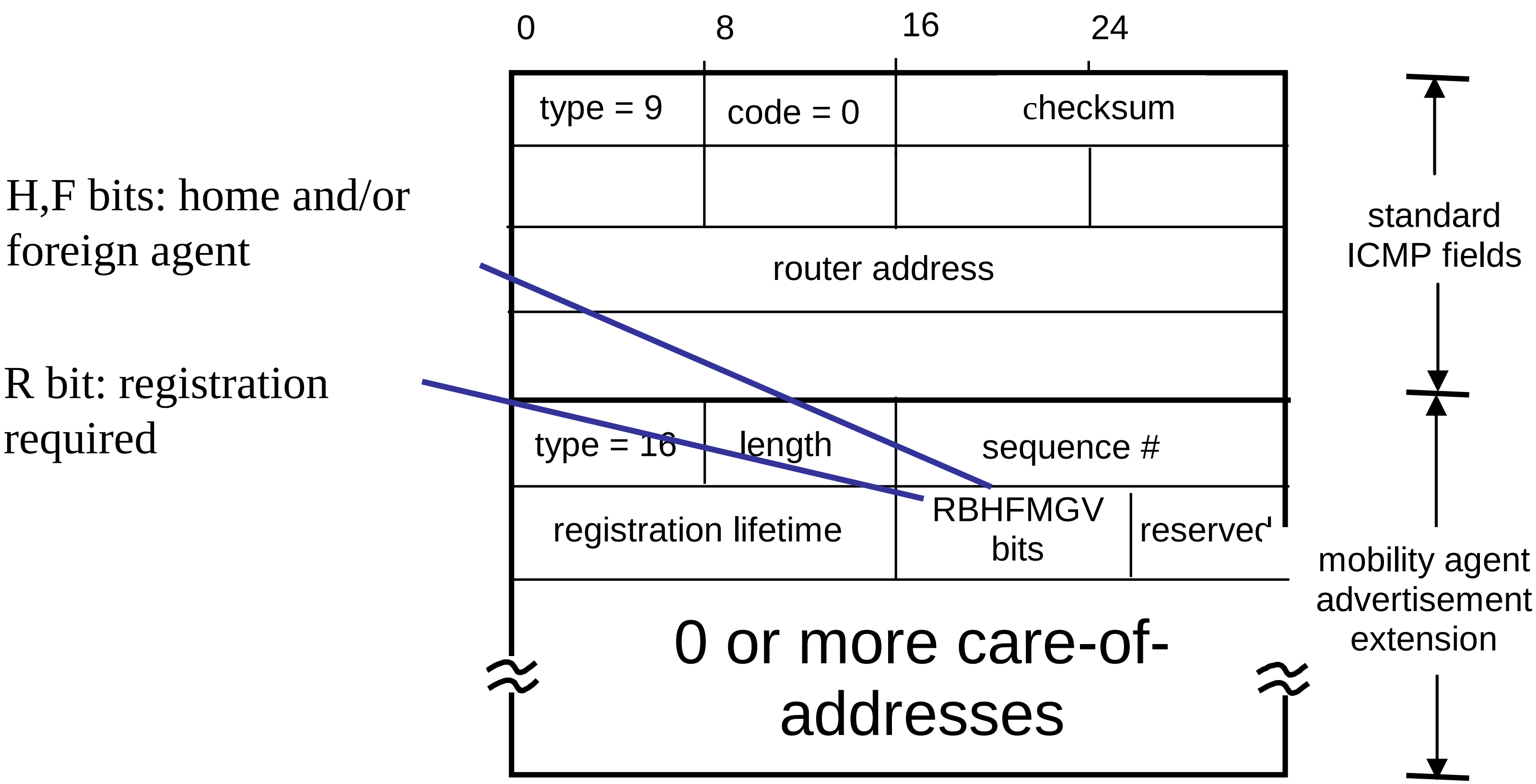
Mobile Communications Networking Lab, NTU

Mobile IPv4: indirect routing

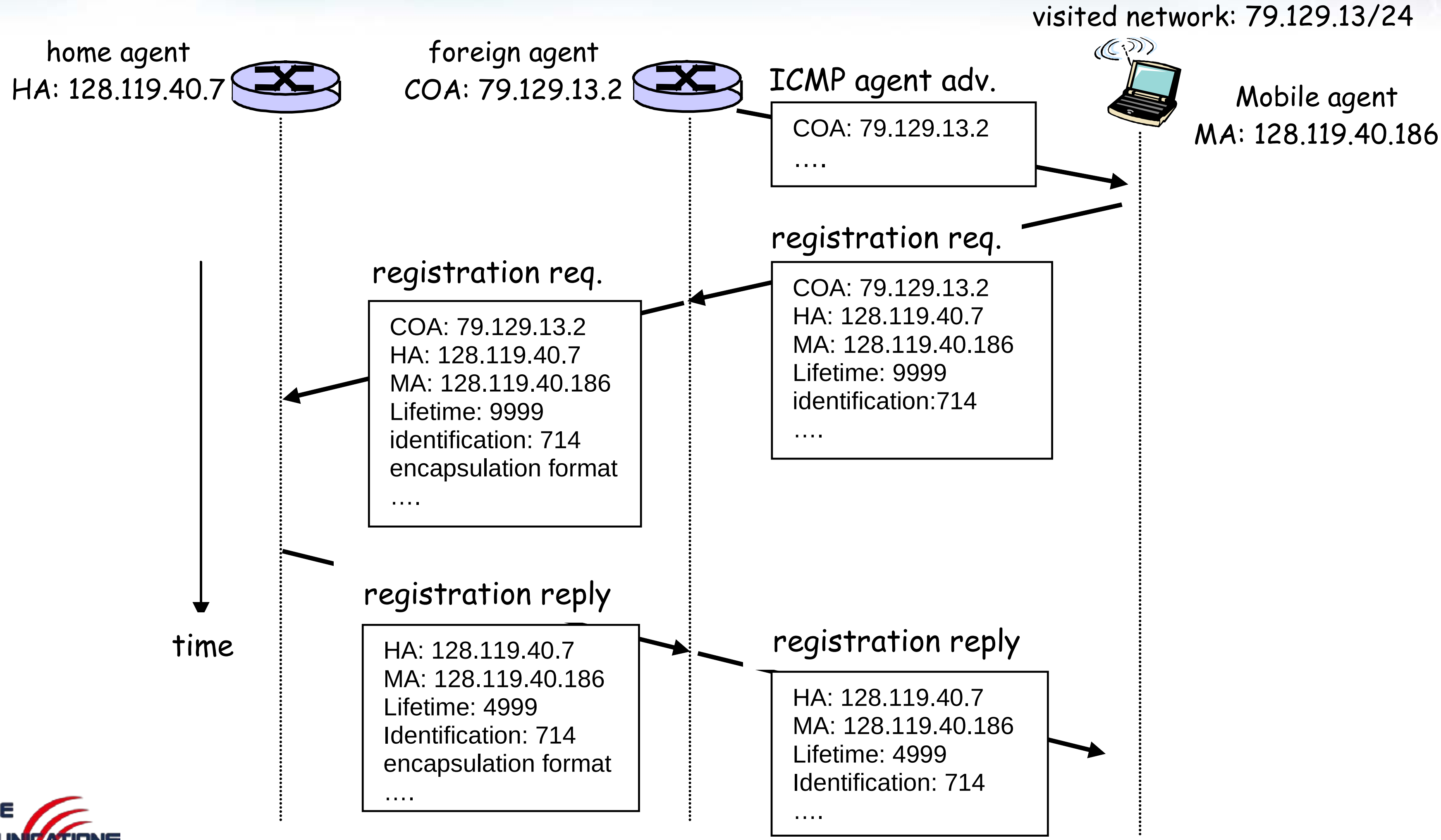


Mobile IPv4: agent discovery

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



Mobile IPv4: registration example



Mobile Communications Networking Lab, NTU

Agenda

- **Introduction to IPv6**
  - **IPv6 Basic**
  - **IPv6 Header Formats**
  - **IPv6 Stateless Autoconfiguration**
- **IP Mobility**
  - **Principles: addressing and routing to mobile users**
  - **Mobile IPv4**
  - **Mobile IPv6**
  - **Proxy Mobile IPv6**

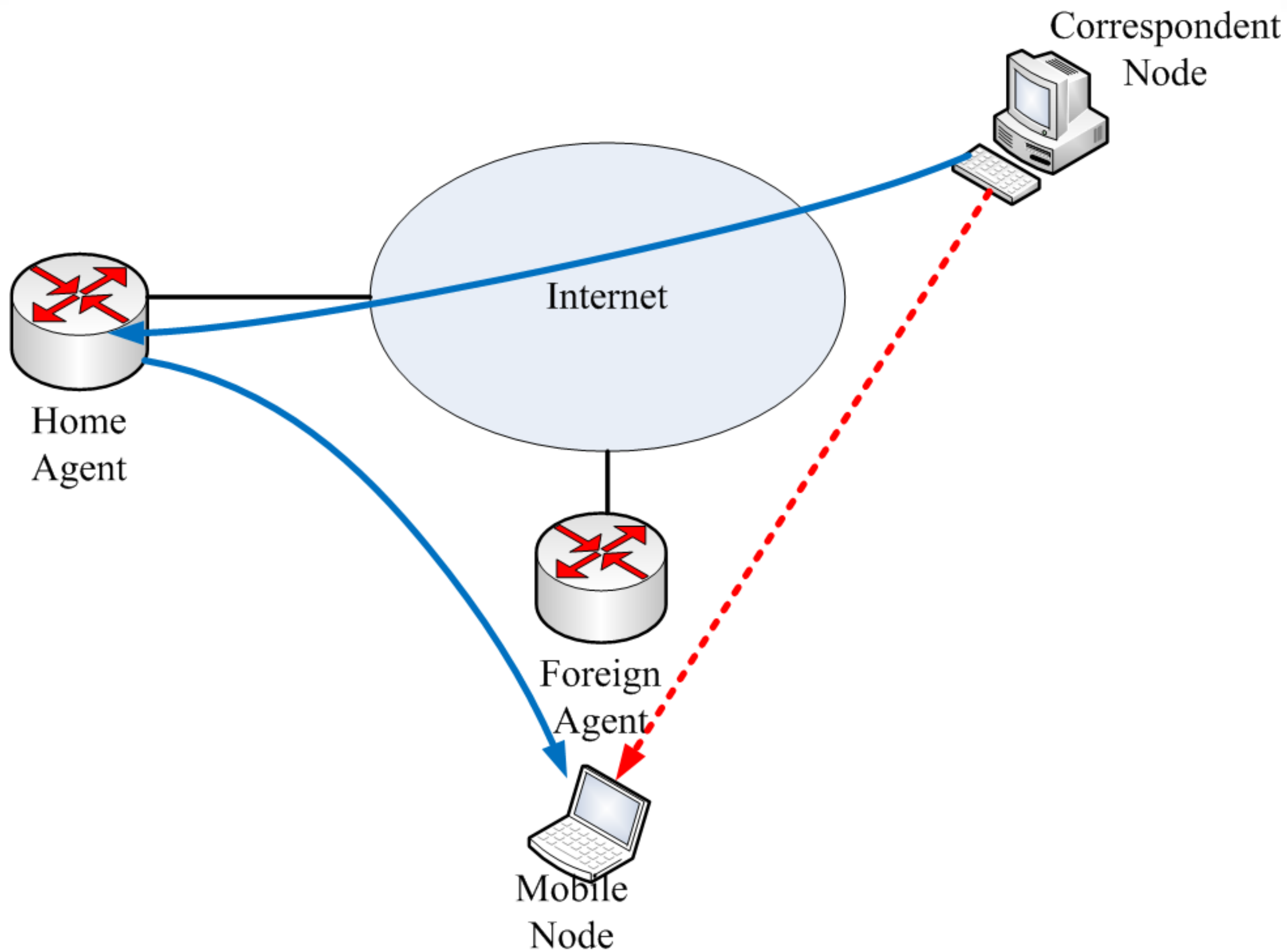
Mobile Communications Networking Lab, NTU

Mobile IPv6

- RFC 6275 (July 2011)
- MIPv6 = MIPv4 + IPv6
- Major Difference from IPv4
  - FA in MN
    - No FA for MIPv6
  - CoA: IP address of MN
    - By DHCPv6 or IPv6 Stateless Auto-Configuration
  - Route Optimization
    - To solve the “Triangular Routing” Problem
    - MN ⇔ CN

Mobile Communications Networking Lab, NTU

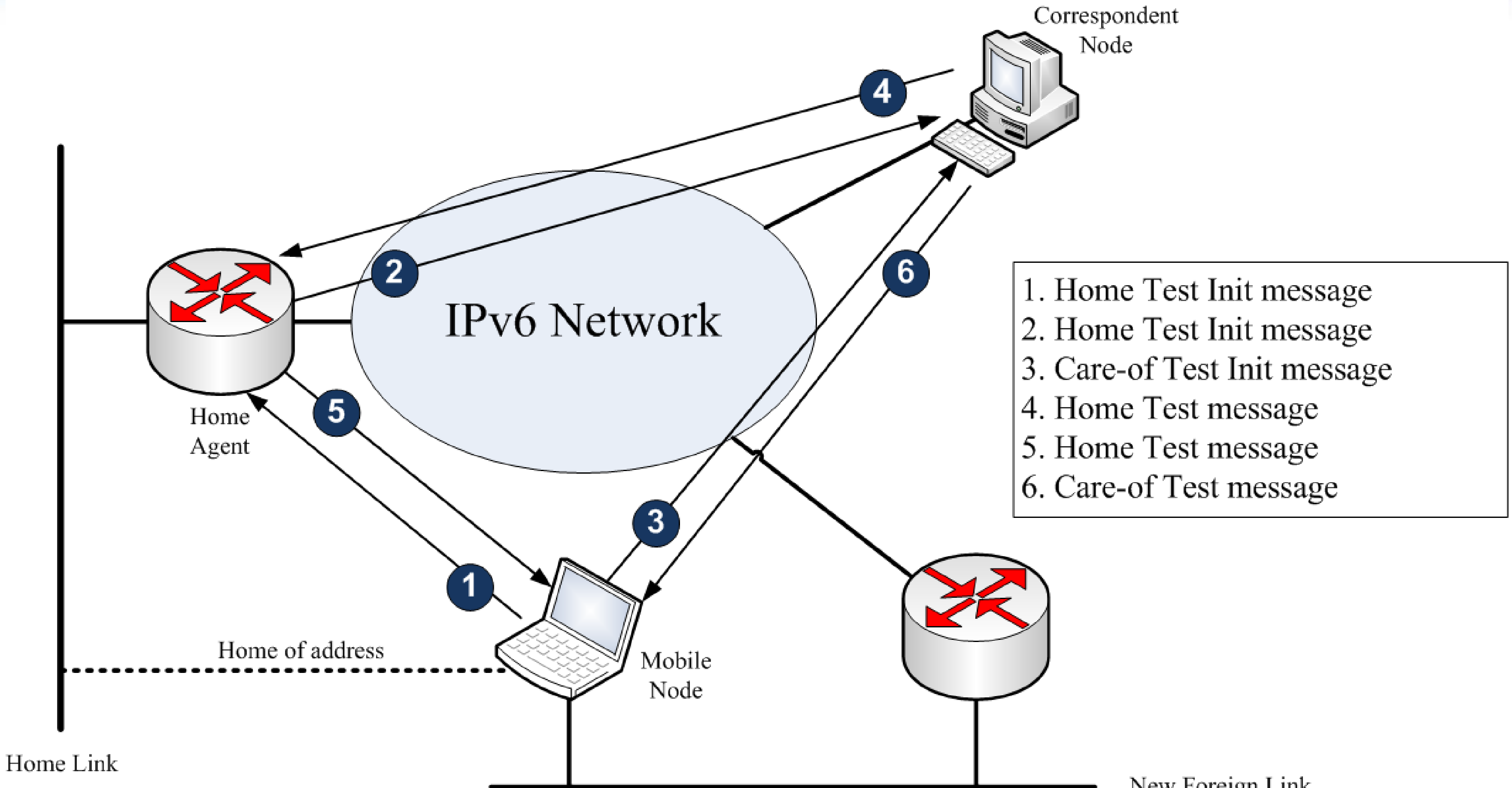
MIPv4: Triangular Routing Problem



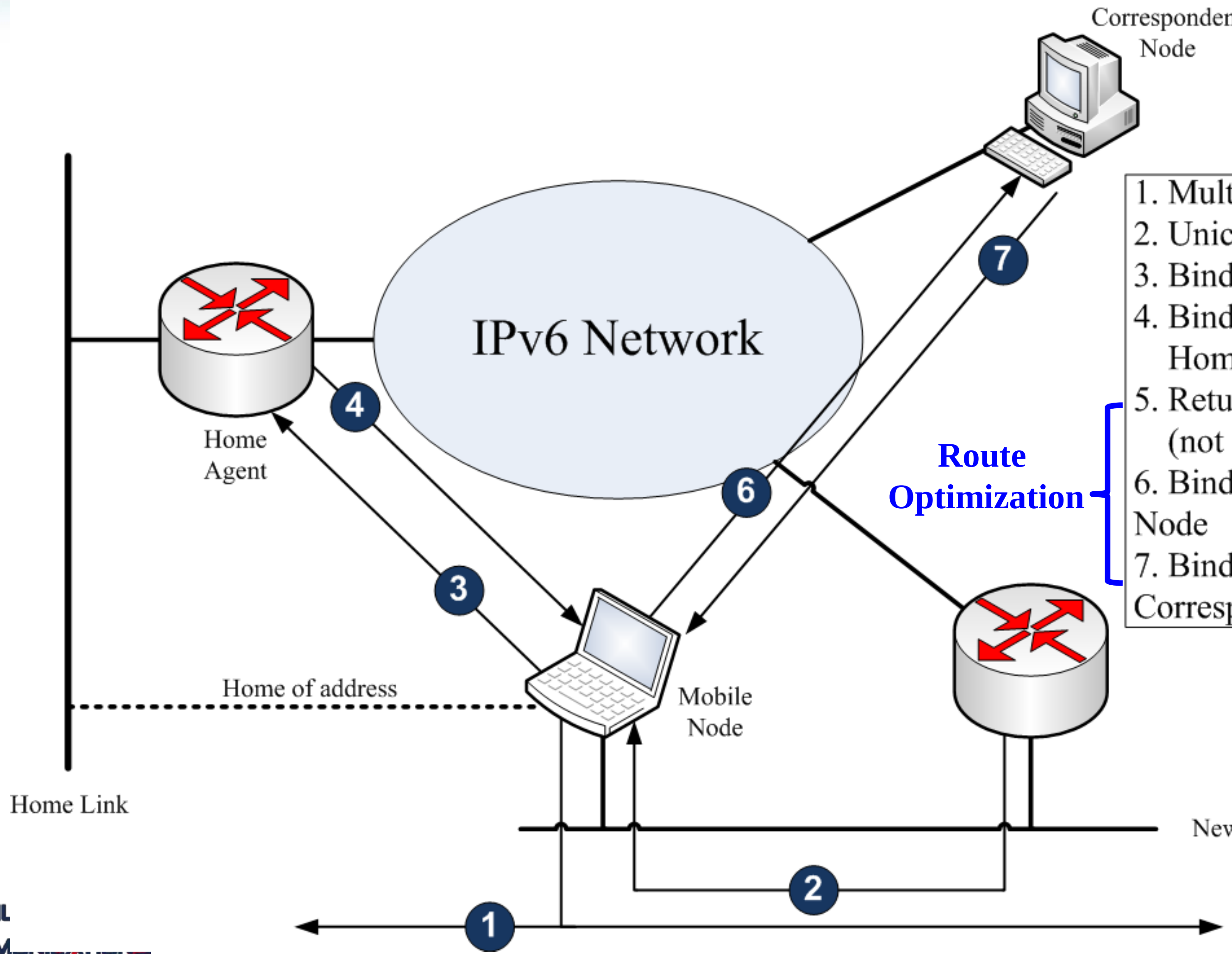
MIPv6: Return Routability Procedure

- Purpose: Enables the correspondent node to obtain some reasonable assurance that the mobile node is in fact addressable at its claimed care-of address as well as at its home address.
- Only with this assurance is the correspondent node able to accept Binding Updates from the mobile node.

MIPv6: Return Routability Procedure



Mobile IPv6: handover example



1. Multicast Router Solicitation
2. Unicast Router Advertisement
3. Binding Update to Home Agent
4. Binding Acknowlegement from Home Agent
5. Return Routability Procedure (not shown)
6. Binding Update to Correspondent Node
7. Binding Acknowledgement from Correspondent Node

Agenda

- **Introduction to IPv6**
  - IPv6 Basic
  - IPv6 Header Formats
  - IPv6 Stateless Autoconfiguration
- **IP Mobility**
  - Principles: addressing and routing to mobile users
  - Mobile IPv4
  - Mobile IPv6
  - **Proxy Mobile IPv6**

Mobile Communications Networking Lab, NTU

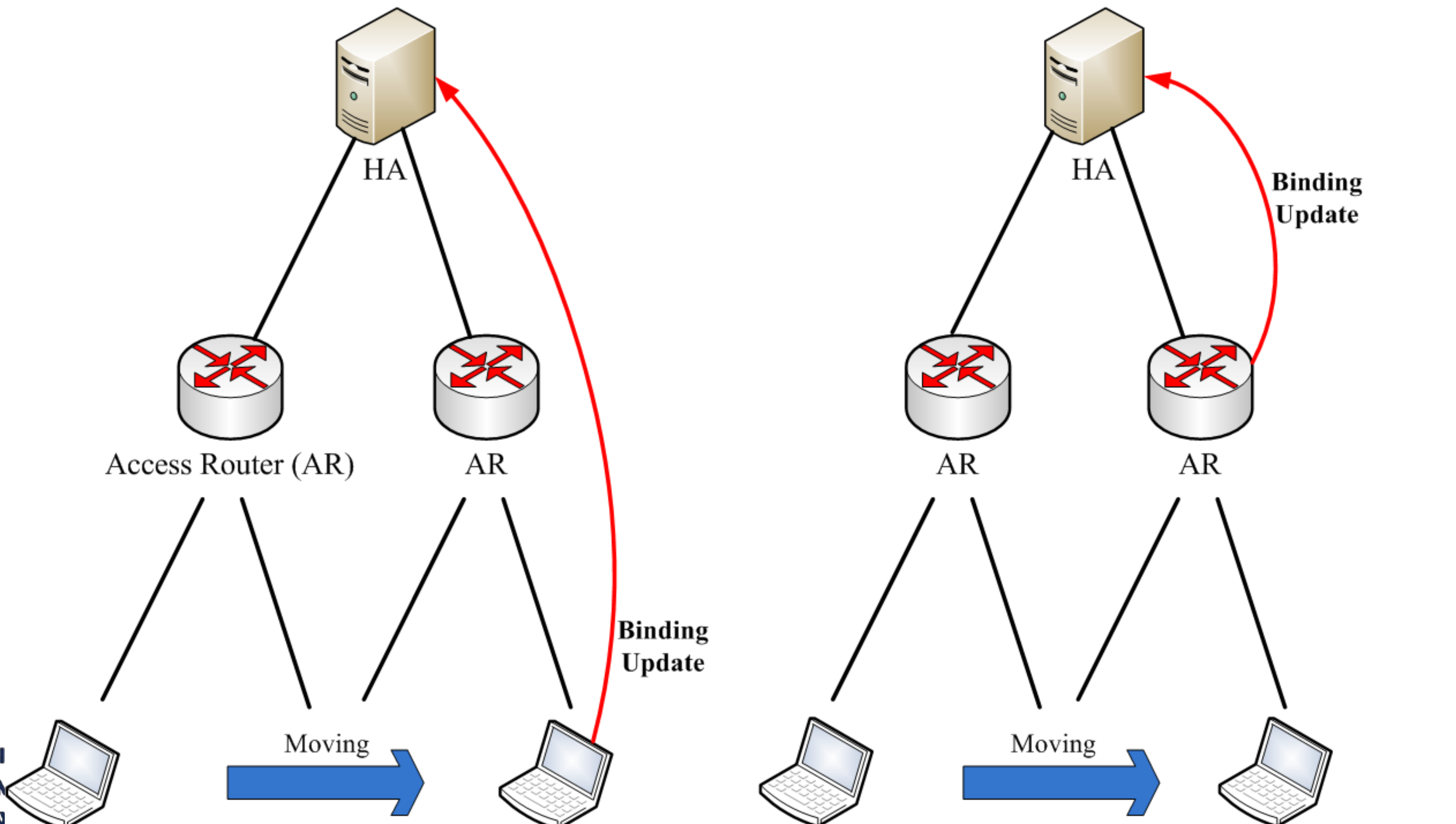
Proxy Mobile IPv6

- RFC 5213 (August 2008)
- Network-based Mobility Management
- Goal
  - This protocol is for providing mobility support to any IPv6 host within a restricted and topologically localized portion of the network and without requiring the host to participate in any mobility related signaling.

Mobile Communications Networking Lab, NTU

Technical Background

Host-based vs. Network-based Mobility

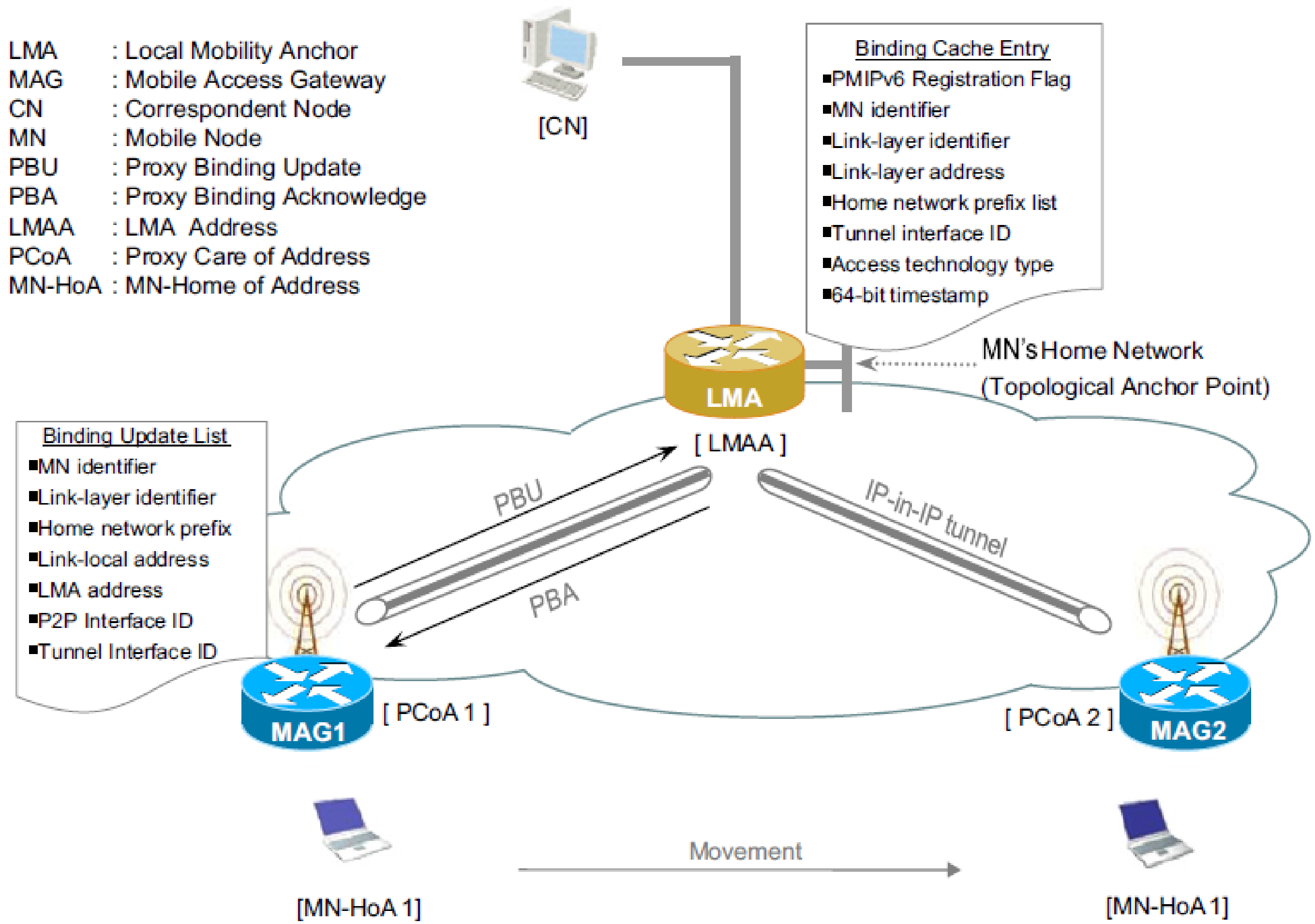


Mobi Comm Netw Lab, NTU

Proxy MIPv6 Overview

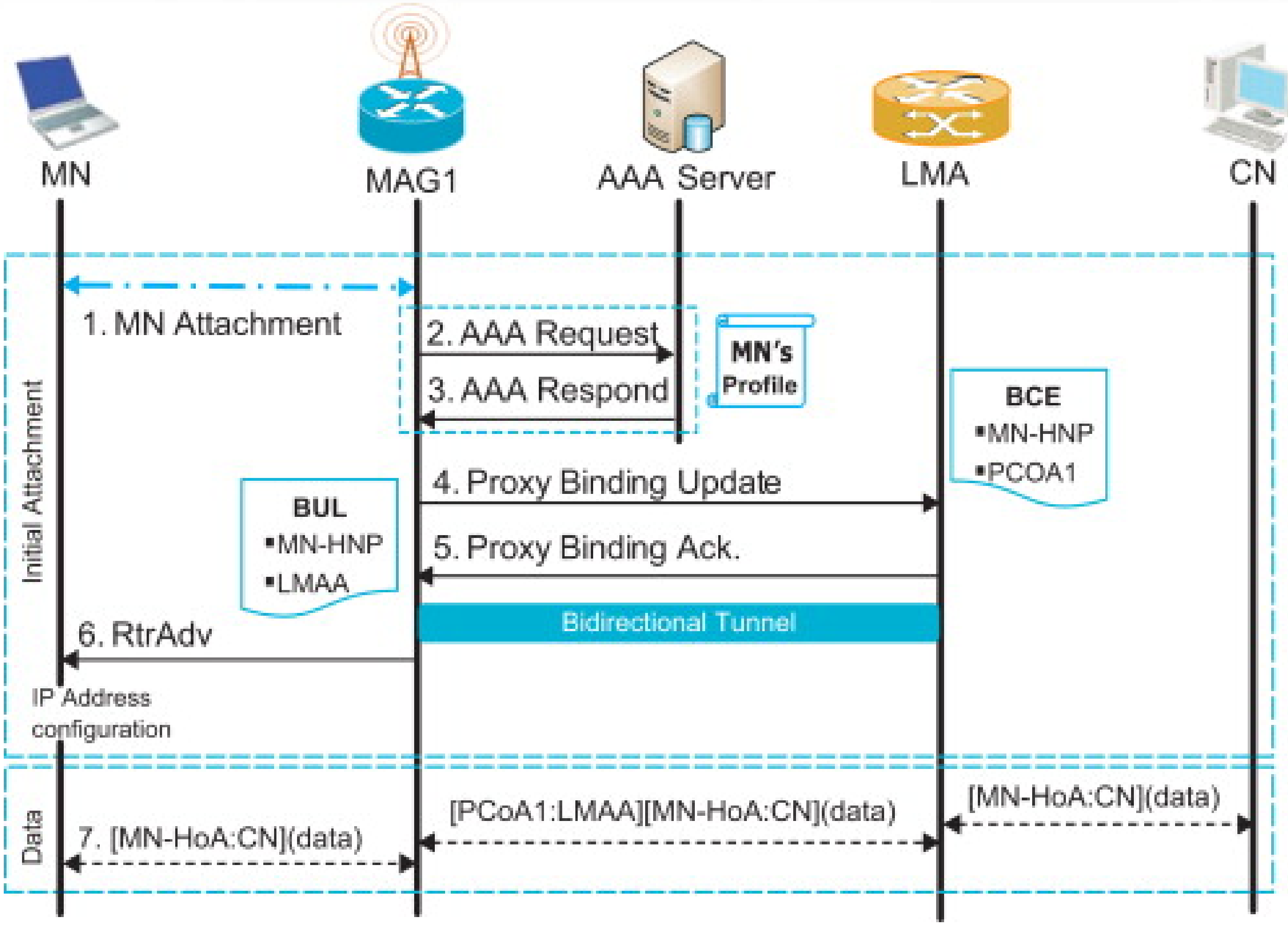
- No host stack change for IP mobility
- Avoiding tunneling overhead over the air
- Re-use of Mobile IPv6
  - PMIPv6 is based on Mobile IPv6.
- Only supports Per-MN-Prefix model
  - Unique home network prefix assigned for each MN.
  - The prefix follows the MN.

Proxy Mobile IPv6



Mobile Communication Networking Lab, NTU

Proxy Mobile IPv6: registration example



MOBILE COMMUNICATIONS NETWORKING Lab, NTU

Proxy Mobile IPv6: registration example

- Procedures
  1. MN moves and attaches to an access router.
  2. After authentication, MAG (access router) identifies MN.
  3. MAG obtains MN's profile containing the Home Address.
  4. MAG sends the Proxy Binding Update to LMA on behalf of MN.
  5. MAG receives the Proxy Binding Ack. from LMA.
  6. MAG sends Router Advertisements containing MN's home network prefix (MN-HNP).

Mobile Communications Networking Lab, NTU

Reference

1. Joseph Davies, “Understanding IPv6, Second Edition, ” January 19, 2008.
2. Ibrahim Al-Surmi, Mohamed Othman, and Borhanuddin Mohd Ali. “Mobility management for IP-based next generation mobile networks: Review, challenge and perspective.” Journal of Network and Computer Applications, September 2011.
3. http://www.6deploy.org/tutorials2/080-6deploy_ipv6_autoconfiguration_mechs_20120207_v2_0.pdf

Thanks for your attention!

Mobile Communications Networking Lab, NTU