Unit 9

Mobile Communication Systems

1. System Architecture
2. Registration
3. Handoff
4. Roaming

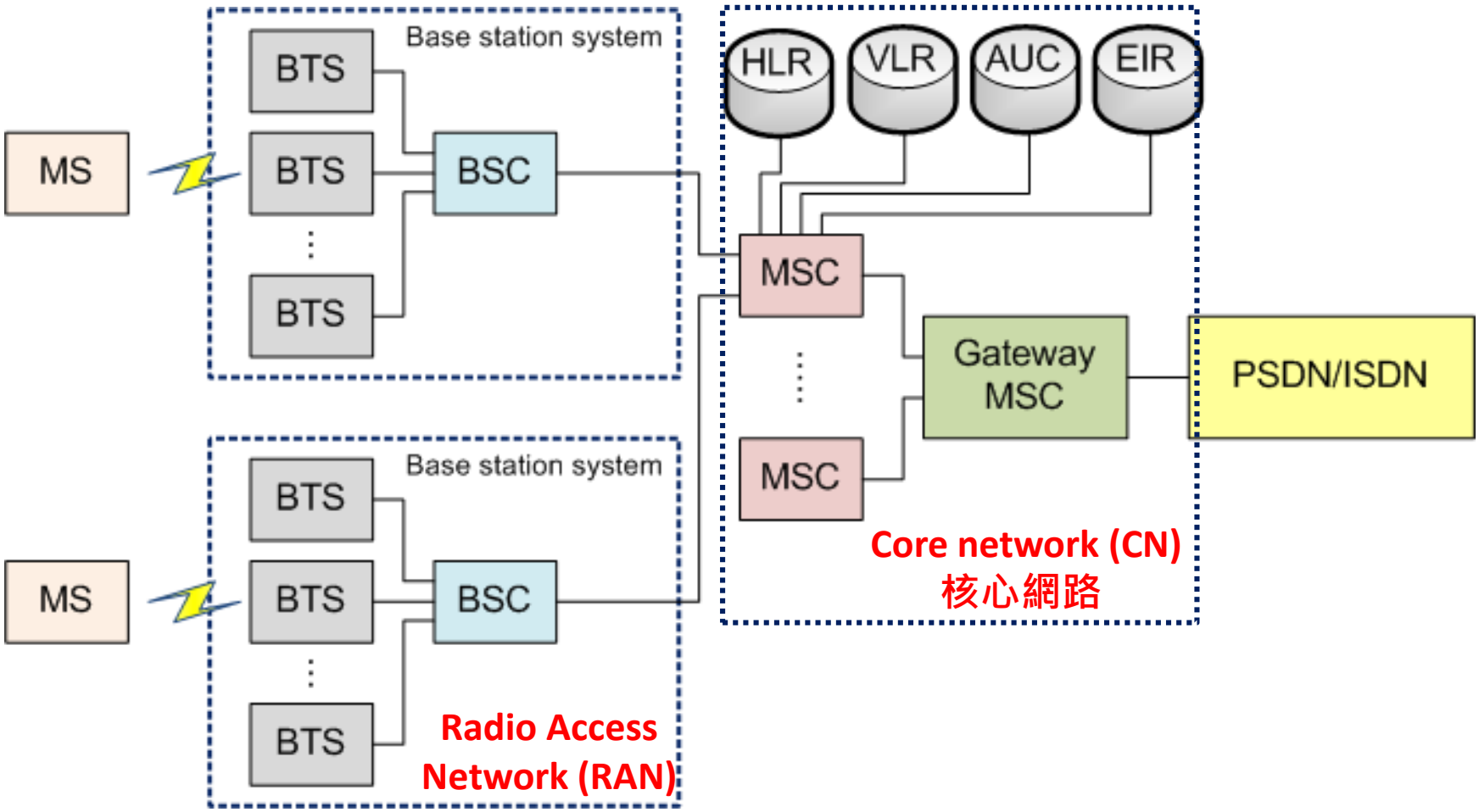
Cellular System Infrastructure (1/4)

- BS=base transceiver system (BTS) + BS controller (BSC)
- BTS: tower + antenna
- BSC: electronics
- Authentication center (AUC)
  - Authentication and encryption to verify users' identities
  - Cell confidentiality
- Equipment identity register (EIR): database containing information about the identity of mobile equipment
- AUC +EIR or AUC/EIR

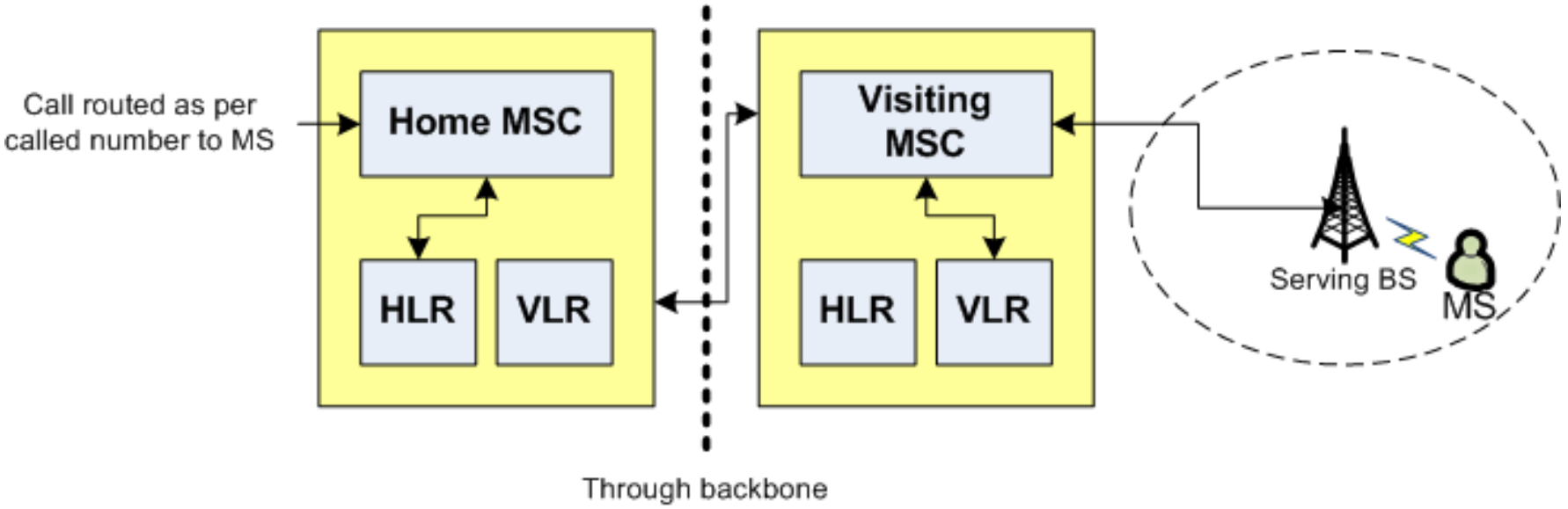
Cellular System Infrastructure (2/4)

- Home location register (HLR) & Visitor location register (VLR): two sets of pointers to support mobility and enable the use of the same phone number over a wide range
  - HLR: at the MSC where the mobile is initially registered and is the initial home location for billing and access information
  - VLR: contains information about all MSs visiting that particular MSC and points to the HLR of the visiting MSs for exchanging related information

Cellular System Infrastructure (3/4)

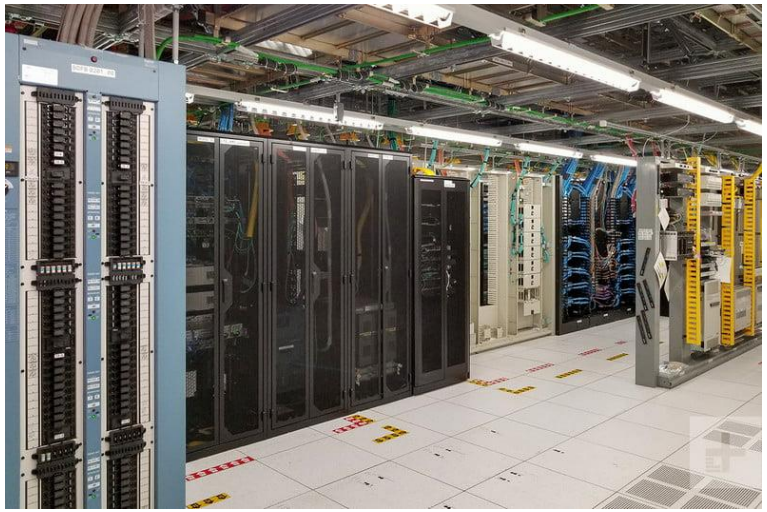


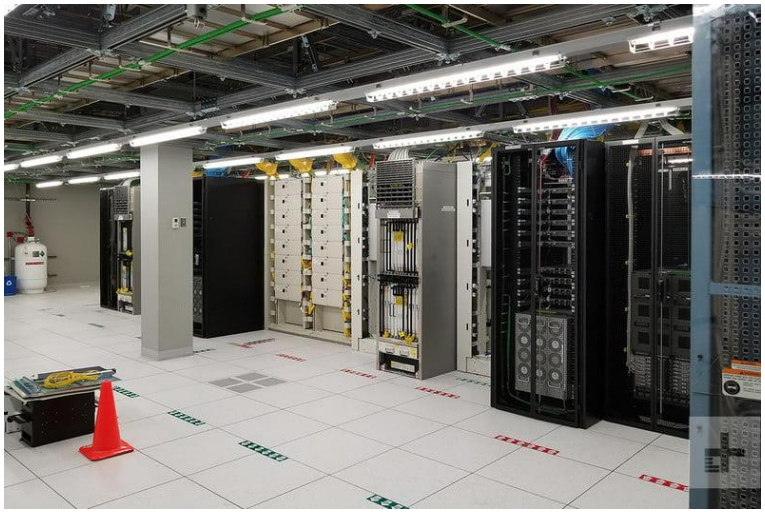
Cellular System Infrastructure (4/4)

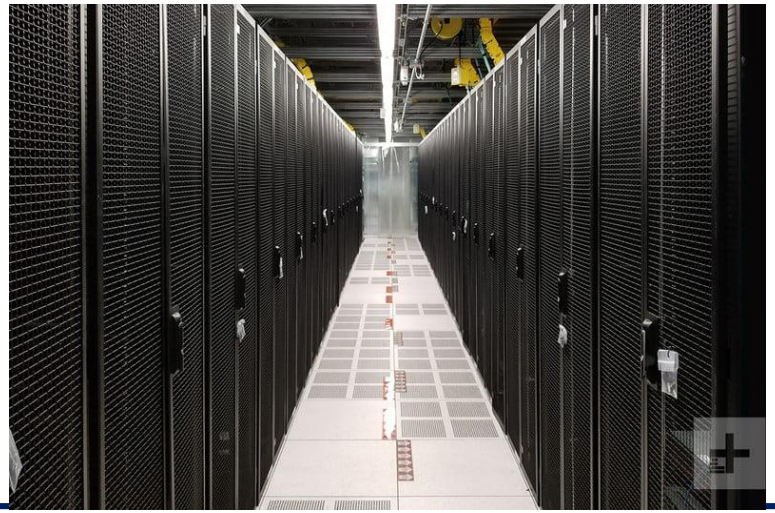


MS跟serving BS註冊，BS將MS登錄在visiting MSC的VLR，MSC再登錄在home MSC的HLR

Verizon Mobile Switching Center (MSC)



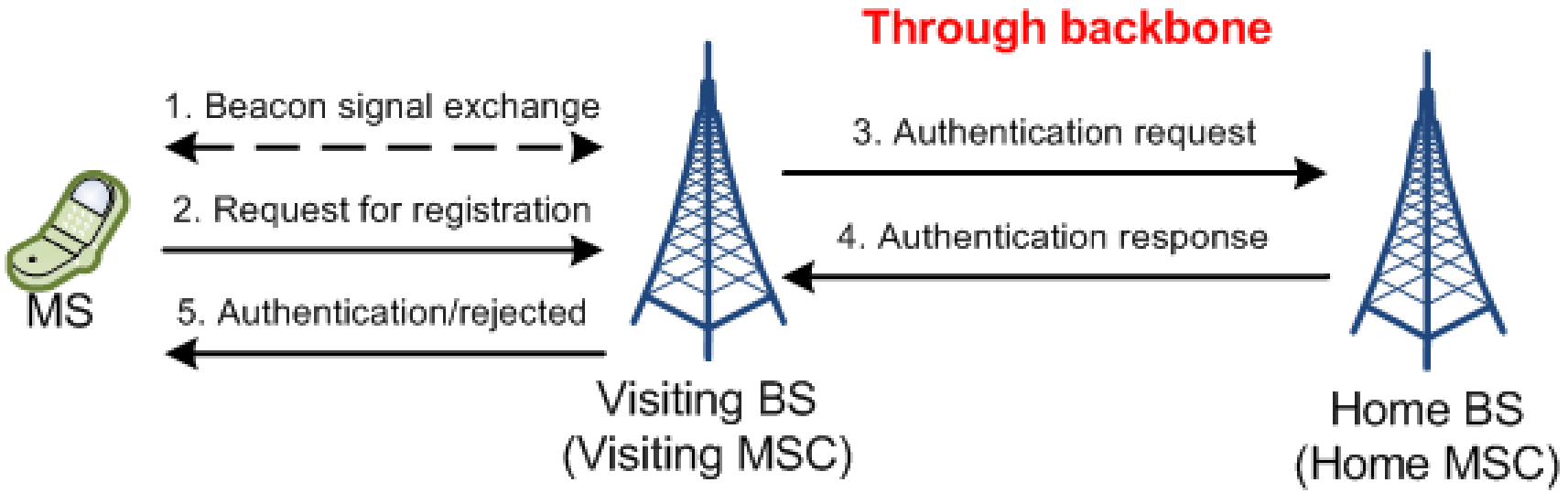




Registration (1/2)

- Where?
  - Between MSs and MSCs
- How?
  - Through beacon signals
  - Update active beacon kernel table
  - Information carried in beacons: cellular network identifier, timestamp, gateway address, ID of the paging area (PA), etc
- Details
  - A MS listens for new beacons. Kernel modulation initiates the handoff process if needed
  - MS locates the nearest BS (strongest signal)
  - Authentication response from the home site; update HLR-VLR
  - The visiting BS approves or disapproves user access

Registration (2/2)



Handoff (1/6)

- Initiated either by BS or MS, due to
  - Radio link (MS mobility)
  - Network management (imbalance)
  - Service issues (QoS)
- Factors to define right time for handoff
  - Signal strength
  - Bit error rate
  - Distance
  - etc

Handoff (2/6)

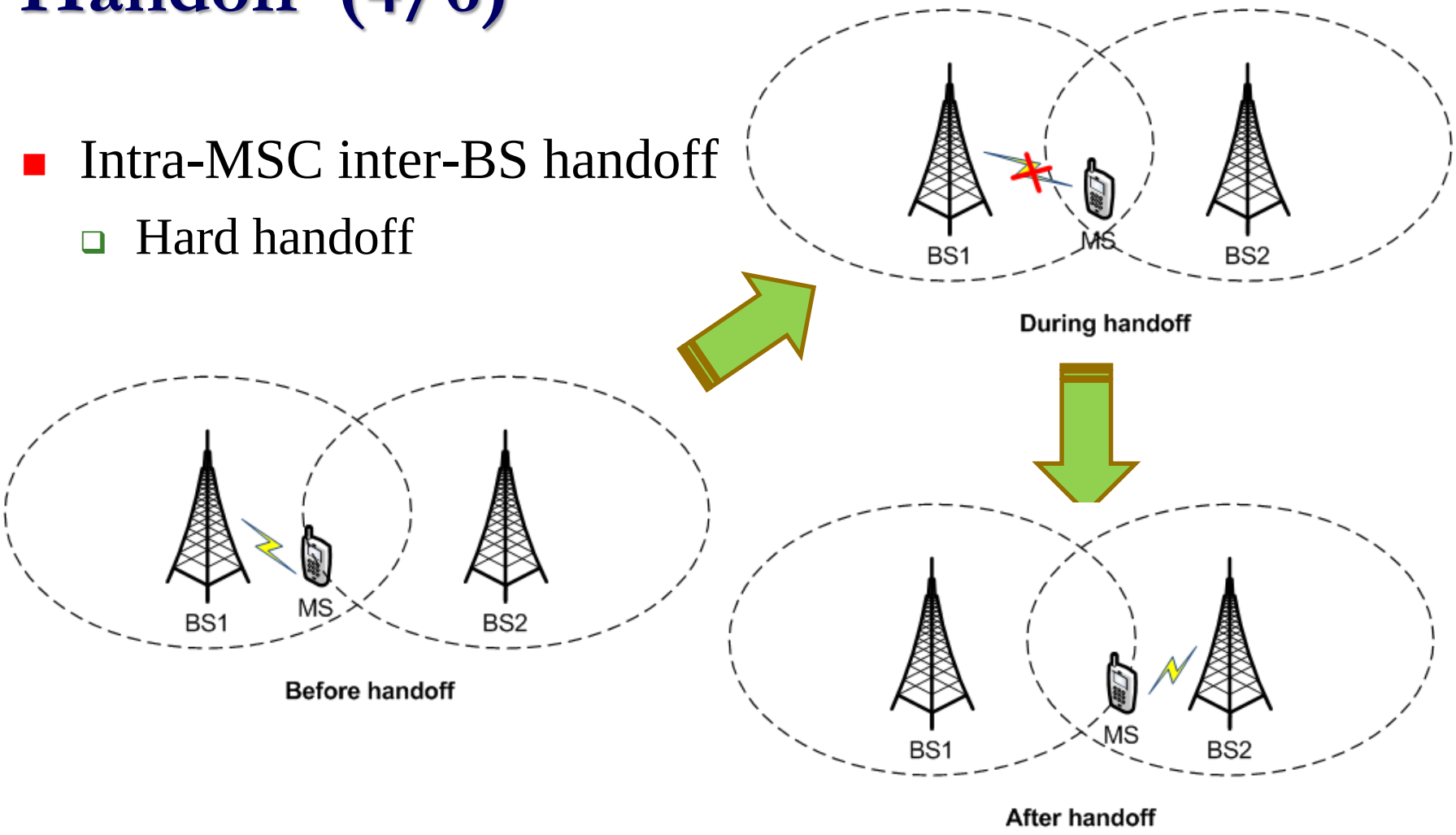
- The need for handoff is determined in two different ways
  - Signal strength
  - Carrier-to-interference ratio (CIR)
- Units involved in setting up a handoff call
  - Base station controller (BSC)
  - Mobile station (MS)
  - Mobile switching center (MSC)

Handoff (3/6)

- Types of handoff
  - Hard: break before make (FDMA & TDMA employ hard handoff)
  - Soft: simultaneously communicate with both BSs (CDMA employs soft handoff)

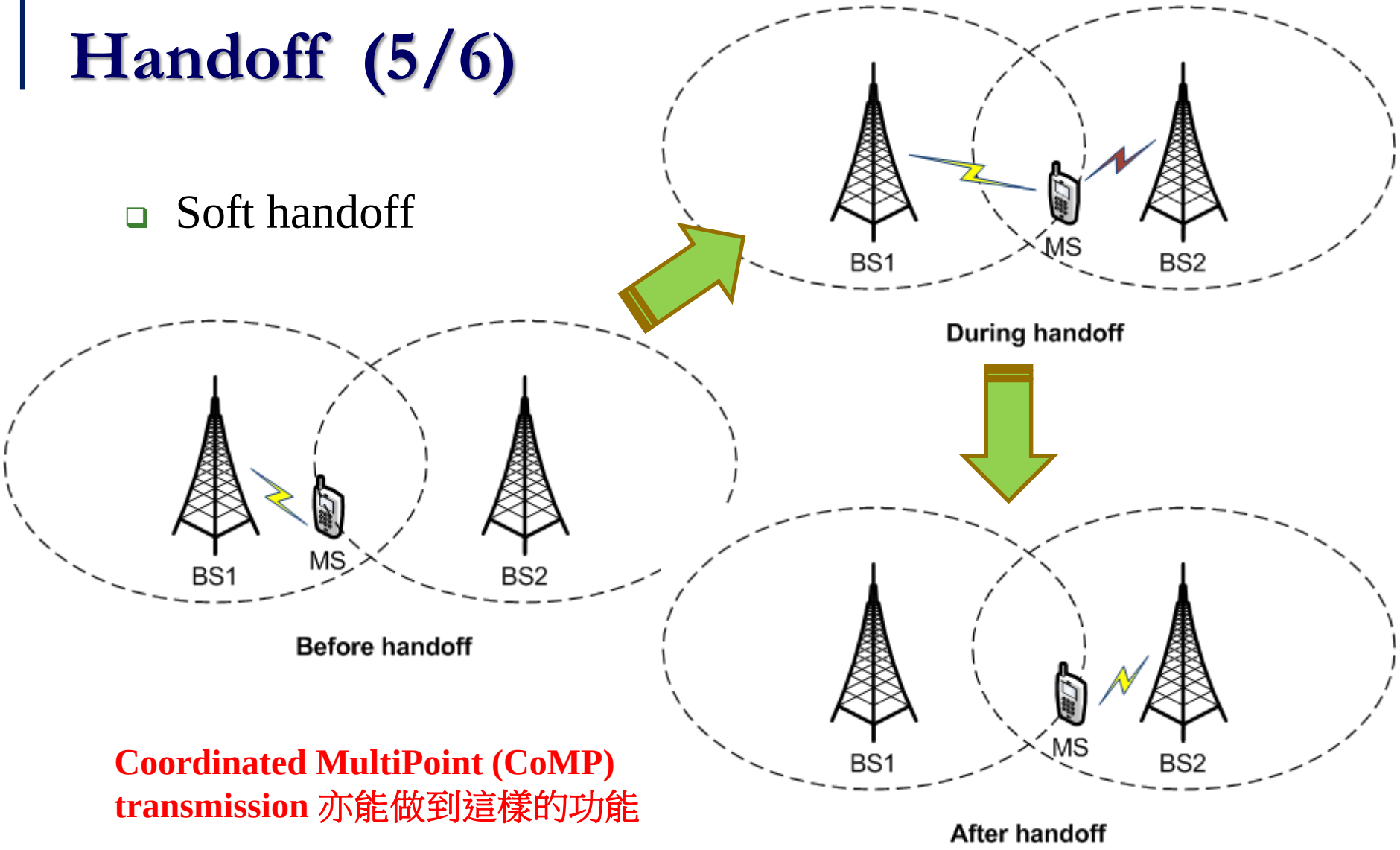
Handoff (4/6)

- Intra-MSC inter-BS handoff
  - Hard handoff



Handoff (5/6)

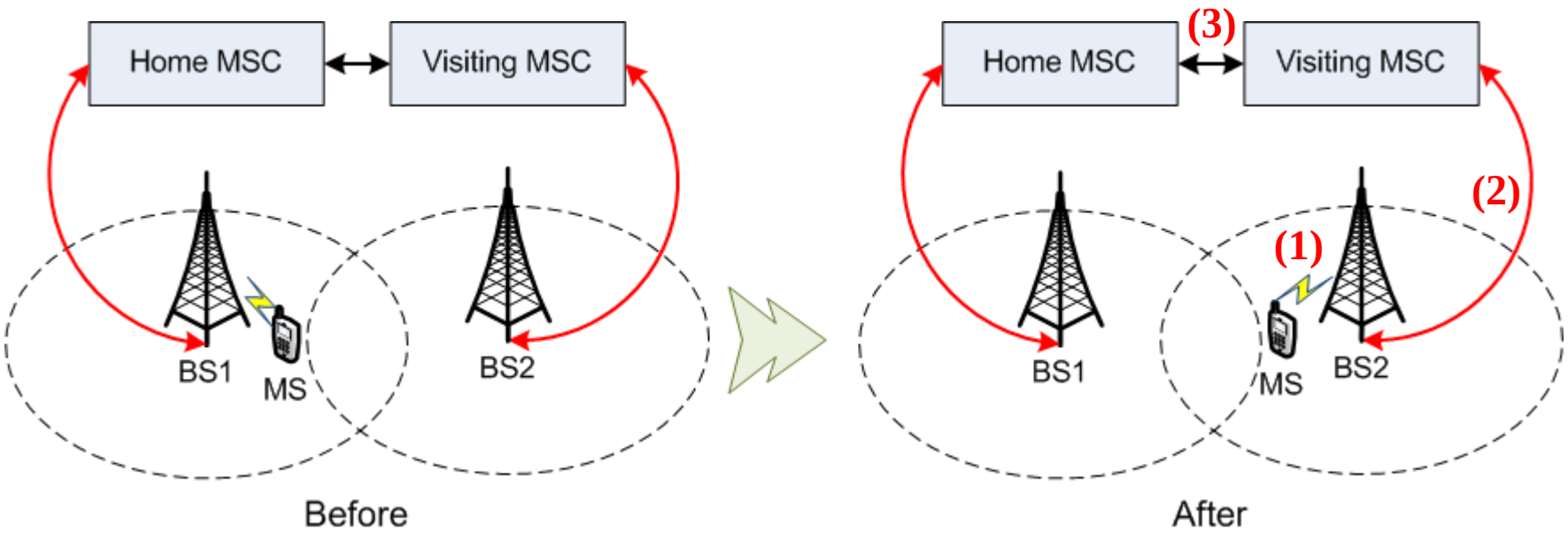
- Soft handoff



Coordinated MultiPoint (CoMP) transmission 亦能做到這樣的功能

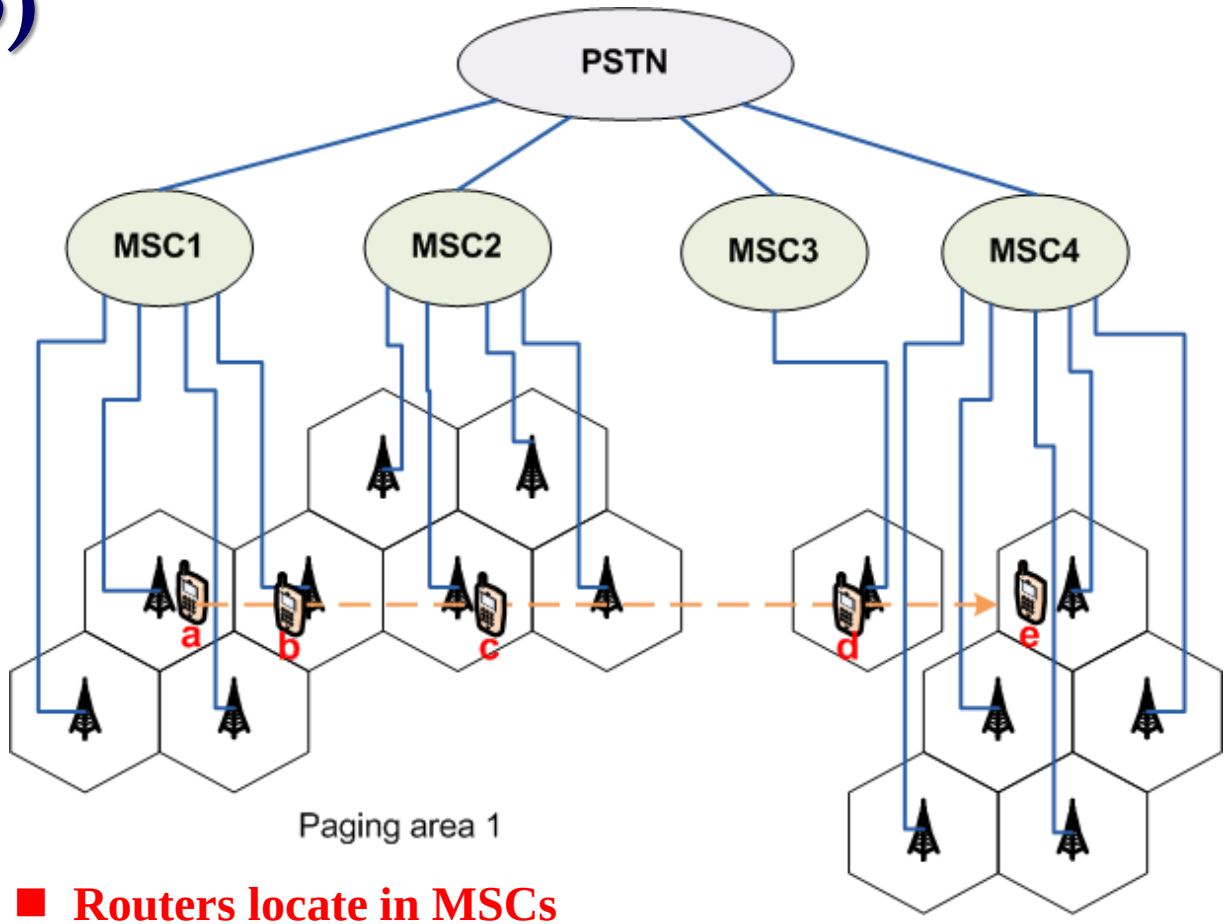
Handoff (6/6)

- Inter-MSC handoff



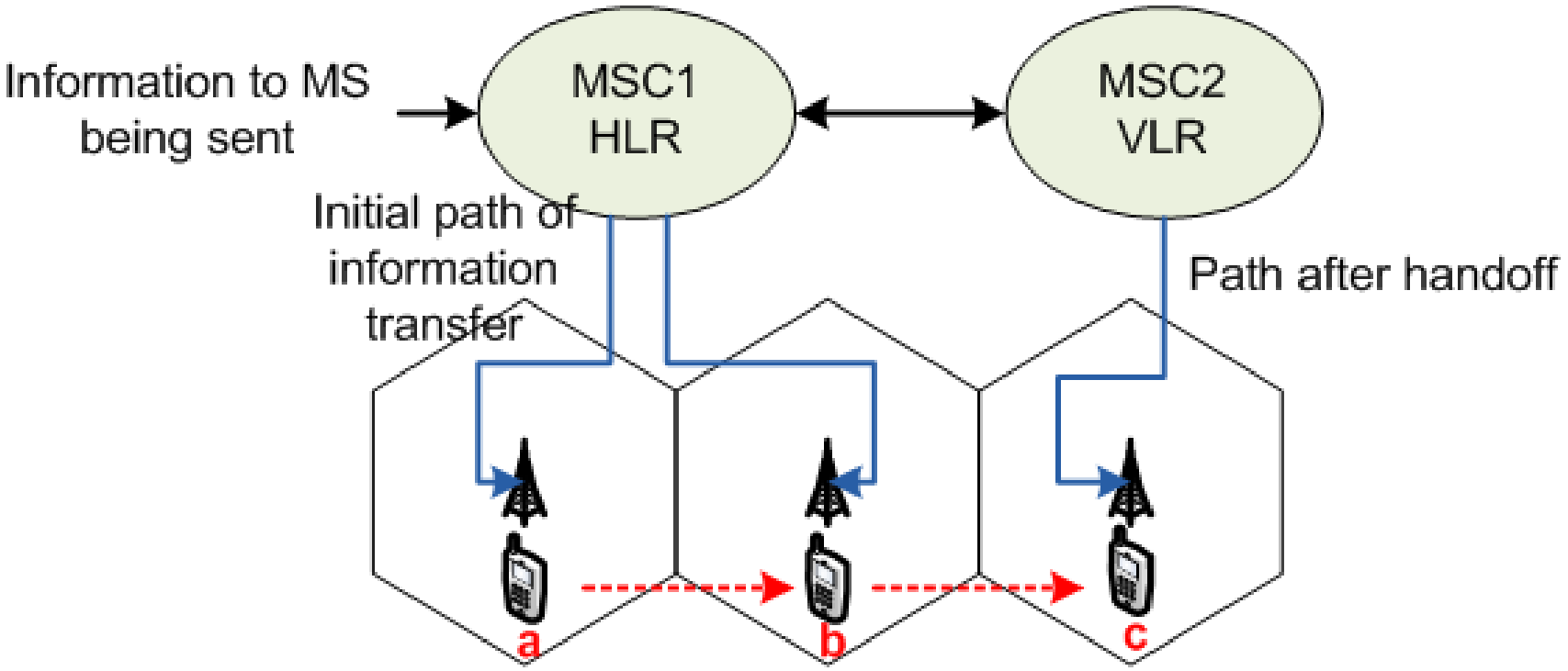
Roaming (1/3)

- Path selection (routers involved)
  - Shortest path
  - Current location to the MS

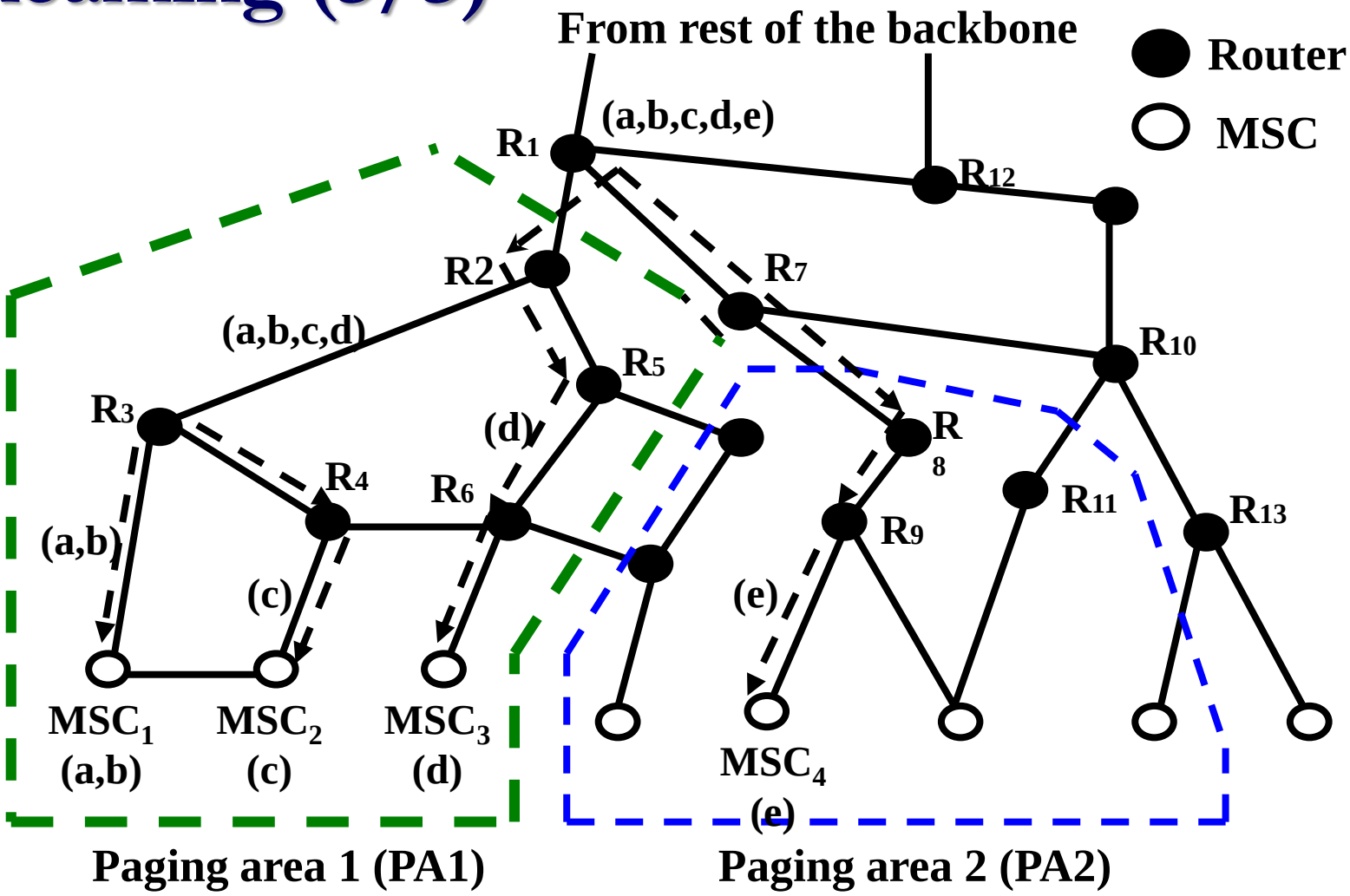


- **Routers locate in MSCs**
- **As MS moving from location a to location e, the routers on the shortest path change**

Roaming (2/3)


Information to MS being sent
MSC1
HLR
MSC2
VLR
Initial path of information transfer
Path after handoff
a
b
c

Roaming (3/3)


From rest of the backbone
Router
MSC
(a,b,c,d,e)
R1
R12
R2
R7
(a,b,c,d)
R10
R5
R3
(d)
R8
R4
R6
R11
R13
(a,b)
R9
(c)
(e)
MSC1
(a,b)
MSC2
(c)
MSC3
(d)
MSC4
(e)
Paging area 1 (PA1)
Paging area 2 (PA2)

Backbone Network

- Routing done according to the topology and connectivity of the backbone network
- The dotted lines show the possible paths for a call headed for different MS locations
- One option is to find a router along the original path, from where a new path needs to start to reach the MSC along the shortest path → eventually this approach would result in inefficient paths

Mobile IP (1/6)

- Two important software modules are associated with routers, home agent (HA) and foreign agent (FA)
- MS is registered with a router, mostly a router closest to the home MSC can be used to maintain its HA
- A router other than closest one could also serve as an HA
- Once a MS moves from the home network, a software module in the new network FA assists MS by forwarding packets for the MS
- This functionality is somewhat similar to HLR-VLR

Home MSC	MSC1	MSC2	MSC3	MSC4
Selected router for maintaining its home agent	R3	R4	R6	R9

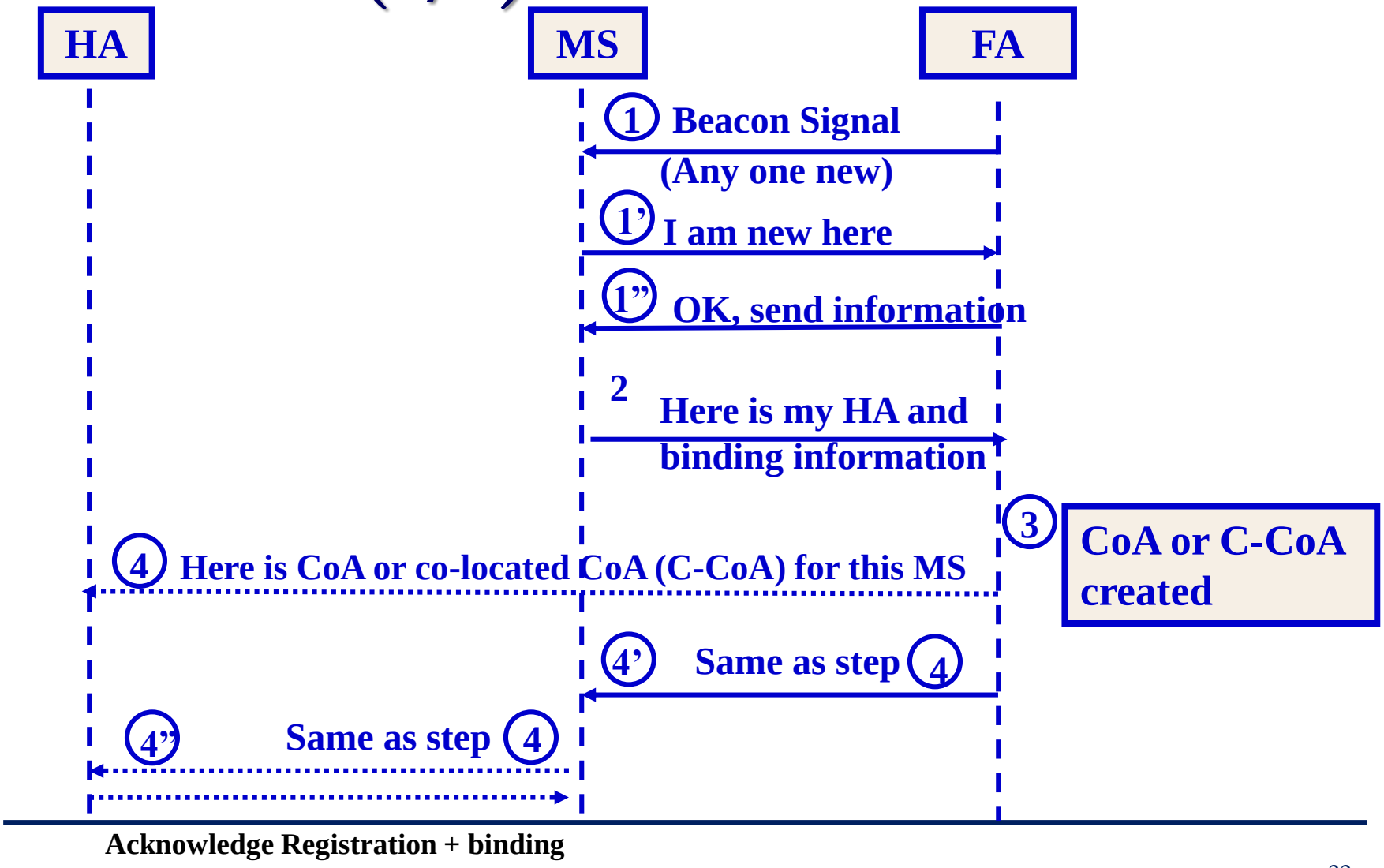
Mobile IP (2/6)

- FA detection
  - Through FA periodic beacon signals
  - MS sends agent solicitation messages
- After detection, FA allocates a care-of-address (CoA) to the MS
  - This CoA address could be the address of the FA itself, or
  - A DHCP new address (called colocated CoA (CCoA))
- The MS (or the FA) registers this CoA with its HA and valid time limit
- Binding between the HA and FA has been established
- In the following, forwarding encapsulated packet to the MS or the FA

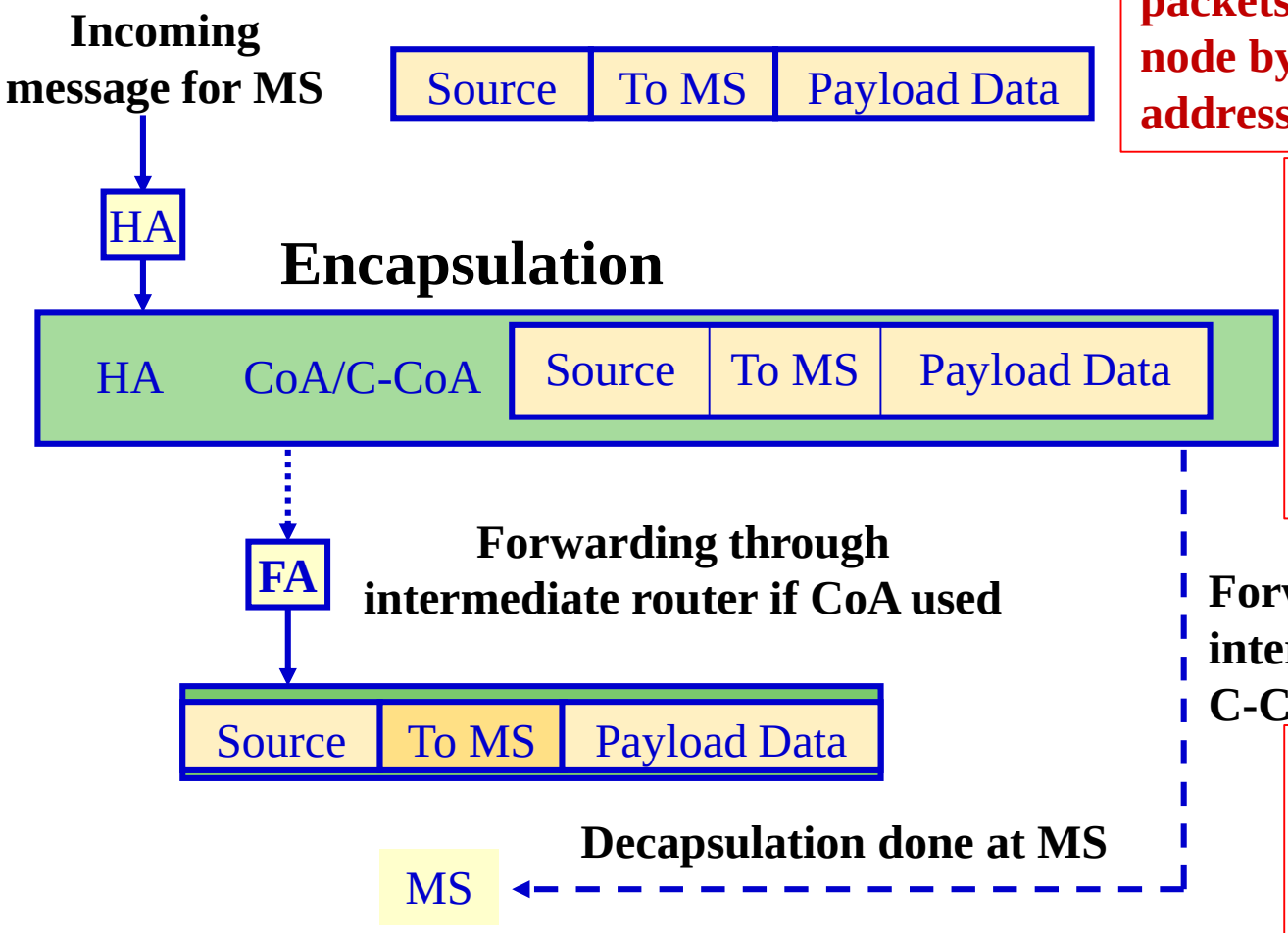
Mobile IP (3/6)

- When binding expires, and the MS still wants to have packets forwarded through HA, it renews its registration request
- When the MS returns to its home network, it sends a registration request to its HA
- The HA will not forward any packets to the FA
- If the MS moves to another foreign network, it have to go through another registration process

Mobile IP (4/6)


HA
MS
FA
1 Beacon Signal
(Any one new)
1' I am new here
1" OK, send information
2 Here is my HA and
binding information
3
CoA or C-CoA
created
4 Here is CoA or co-located CoA (C-CoA) for this MS
4' Same as step 4
4" Same as step 4
Acknowledge Registration + binding

Mobile IP (5/6)



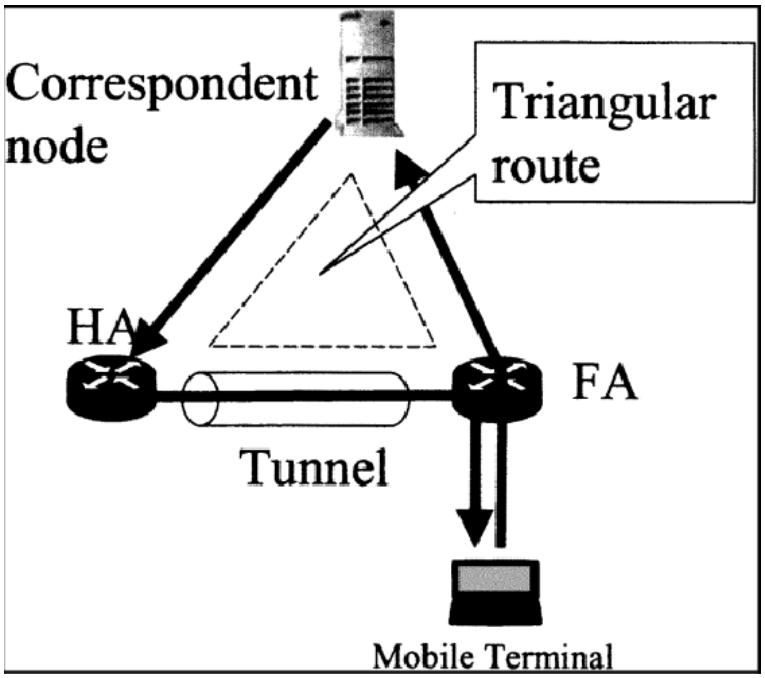
Triangular routing (route optimization): MS directly sends packets to the corresponding node by using its home IP address as the source address

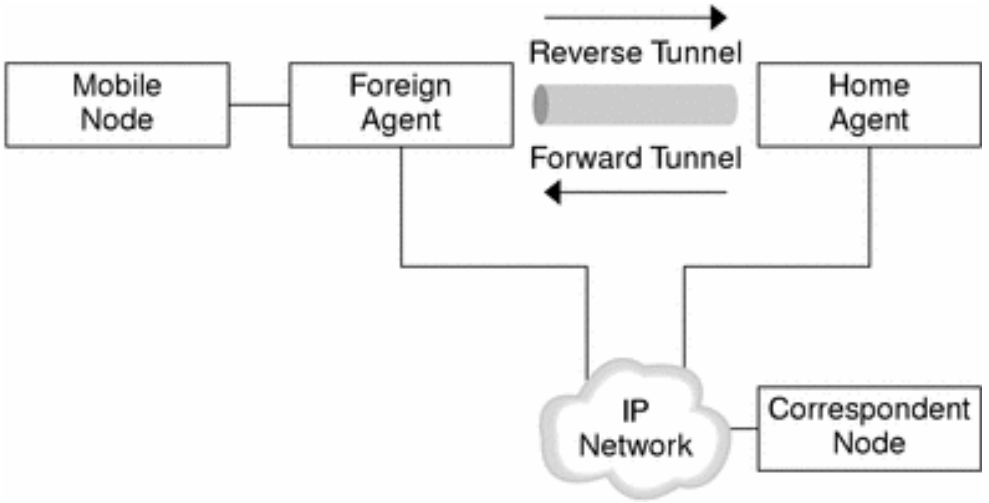
Reverse tunneling: tunneling the MS's packets to the home agent, which in turn forwards them to the corresponding node

Default setting in Mobile IP v6: reverse tunneling; triangular routing is optional

Mobile IP (6/6)

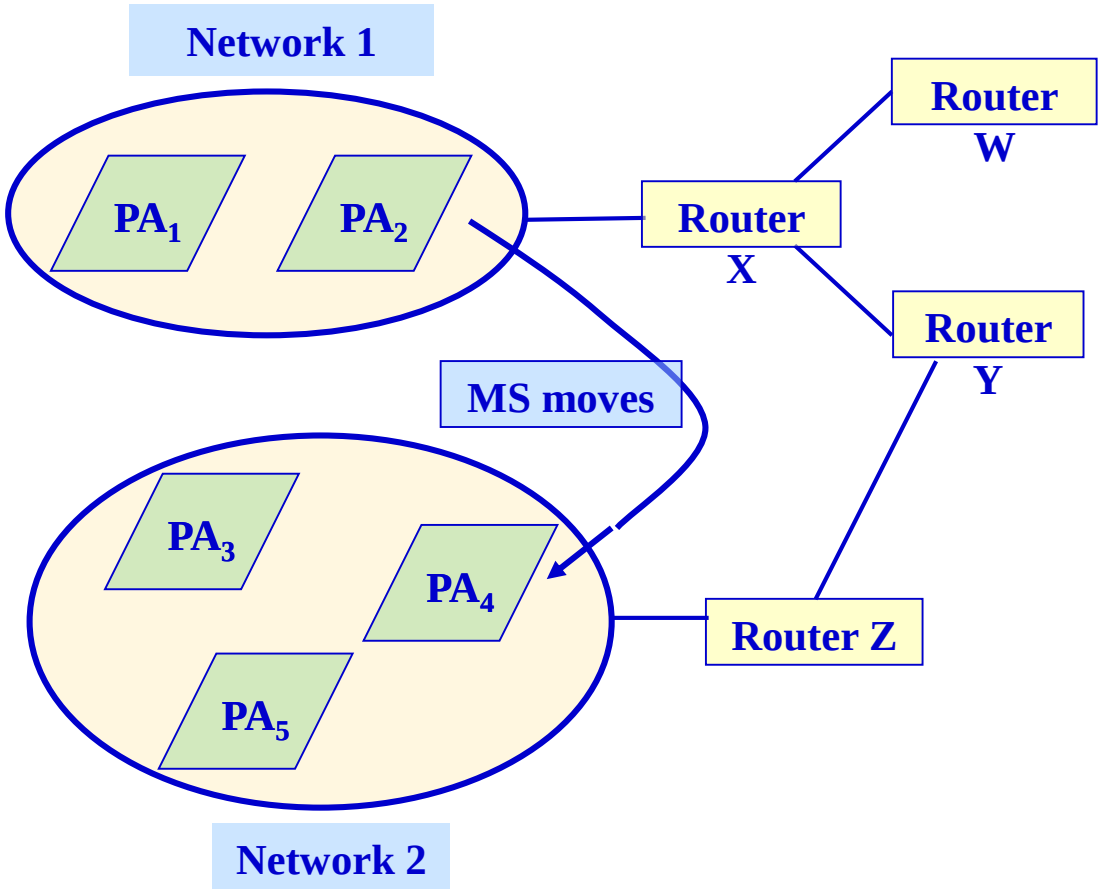
- **Triangular routing problem**
- **Reverse tunneling**





Rerouting in Backbone Routers (1/2)

- How does the FA locate the HA?
  - Each router maintains a global table
  - The global table construction/maintenance is through distributed routing schemes



A paging area consists of multiple BSs

Rerouting in Backbone Routers (2/2)

Table at router W		Table at router X		Table at router Y		Table at router Z	
Route to PA	Next hop	Route to PA	Next hop	Route to PA	Next hop	Route to PA	Next hop
1	X	1	-	1	X	1	Y
2	X	2	-	2	X	2	Y
3	X	3	Y	3	Z	3	-
4	X	4	Y	4	Z	4	-
5	X	5	Y	5	Z	5	-

Multicasting (1/6)

- One source to multiple recipients by using a group address
- Multicasting routing protocols can be classified into two categories
  - Source-based tree
  - Core-based tree (share tree)
- Due to dynamic membership, to make the constructed routing path be efficient, two functions are inherently provided
  - Grafting: enable pruned branches periodically
  - Pruning: temporarily remove no-member branches
- Two methods proposed by IETF for providing multicast over Mobile IP
  - Bidirectional tunneling (BT)
  - Remote subscription

Multicasting (2/6)

- Bidirectional Tunneling
  - A tunnel from HA to FA per MS
  - (-) packet duplication when multiple MSs move to the same FA
  - (+) no data disruption

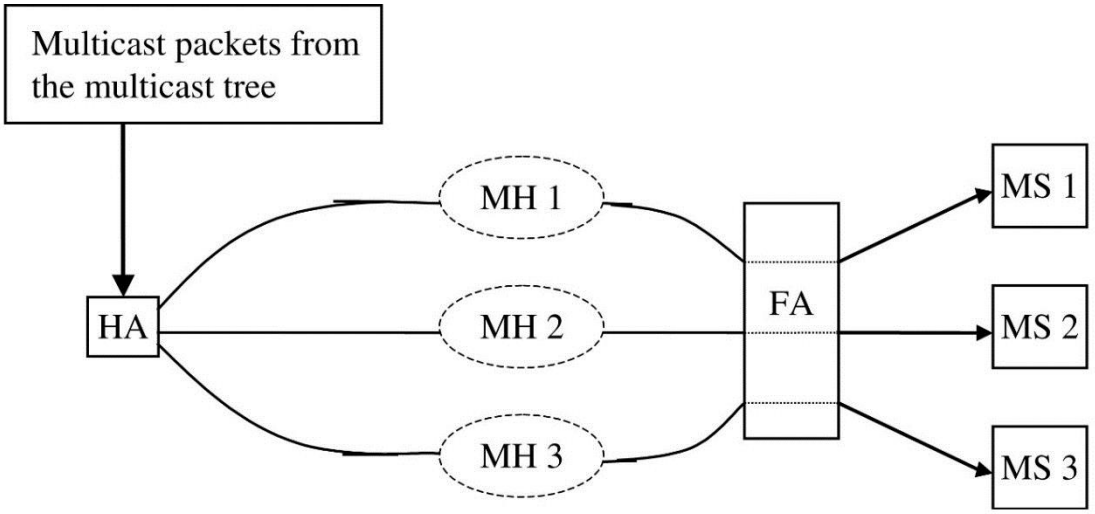


Figure 9.14 Packet duplication in BT approach [9.10].*Courtesy*: Siddesh Kamat, "Handling Source Movement over Mobile-IP and Reducing the control overhead for a secure, scalable Multicast Framework" M.S. Thesis, University of Cincinnati, October 2002.

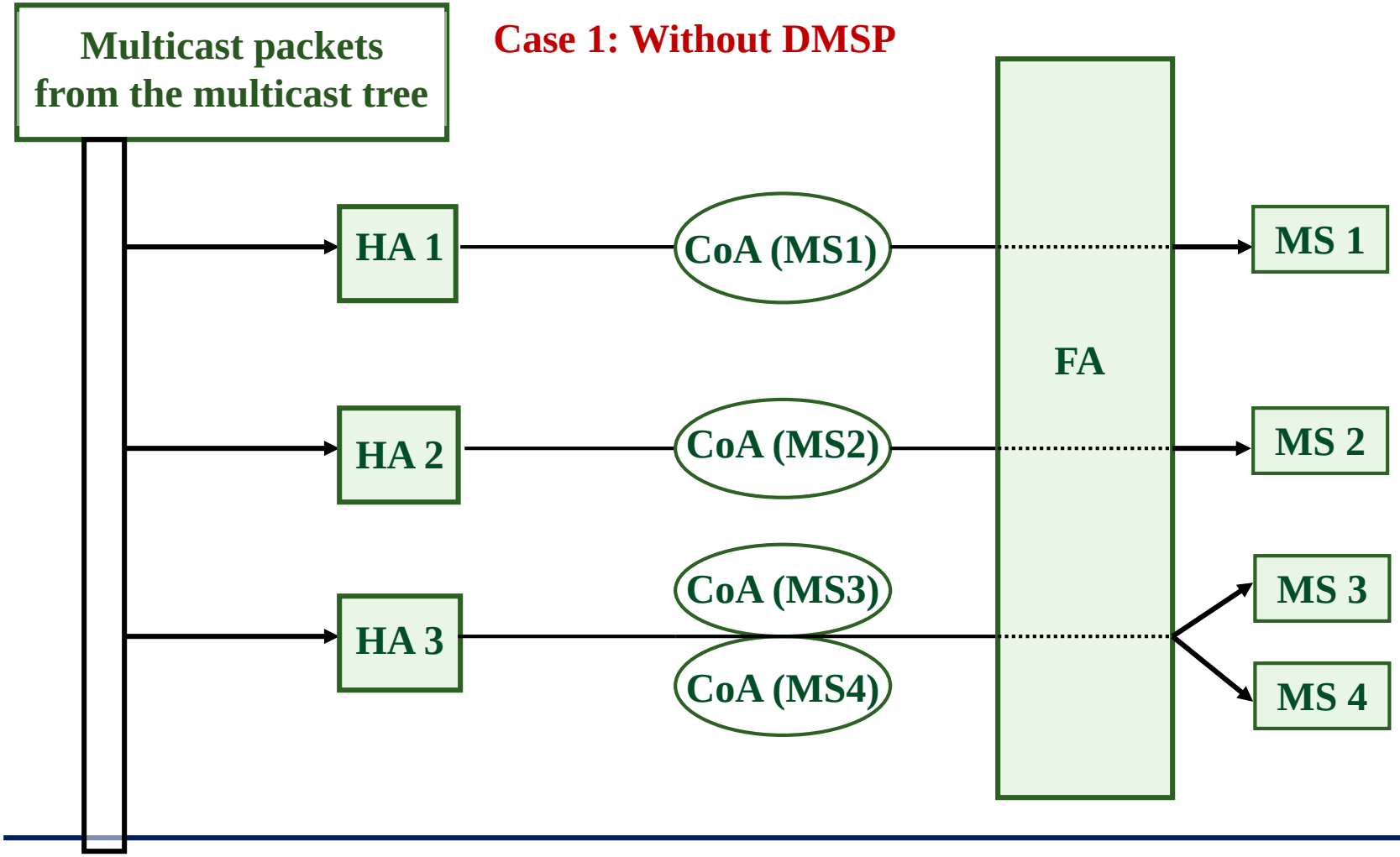
Multicasting (3/6)

- Remote subscription
  - Instead of HA forwarding data, FA itself joins the delivery tree
  - (-) data disruption (before FA is on tree, MSs cannot receive pkts)
  - (+) prevent data duplication (one copy only in the previous figure)
  - (+) prevent non-optimal path delivery (routing path is from source node to FA directly)
- Tunnel convergence problem
  - MSs under different HAs move into the same foreign domain
  - The FA would receive duplicate packets from the HAs for their MSs
  - Mobile Multicast (MoM) protocol tries to address this issue

Multicasting (4/6)

- MoM
  - FA selects a designated multicast service provider (DMSP) for each group among the given set of HAs
  - Only the DMSP is responsible for forwarding a multicast packet to the FA for that group
  - If the MS of the serving DMSP moves out, the FA re-selects a new DMSP
  - Data disruption occurs when re-selecting DMSP
  - To handle this issue, MoM employs more than one DMSP for a particular group, and thus may result in data duplication

Multicasting (5/6)



Multicasting (6/6)