# Networking Applications

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Mobility

# Outline

- Mobile Computing
- Mobile IP

# Mobile Computing

*Access to data anywhere, anytime, using any means of connectivity*

- Nomadic access
- Cellular-like access
- Mobile ad hoc networks

# Host Mobility Problem 1/2

An ***IP address*** reflects a host's point of attachment to the network

Example: TCP connection identified by a 4-tuple

***< source IP address, source TCP port,***
***destination IP address, destination TCP port >***

if either host move, and acquire a new IP address, the **TCP connection breaks**

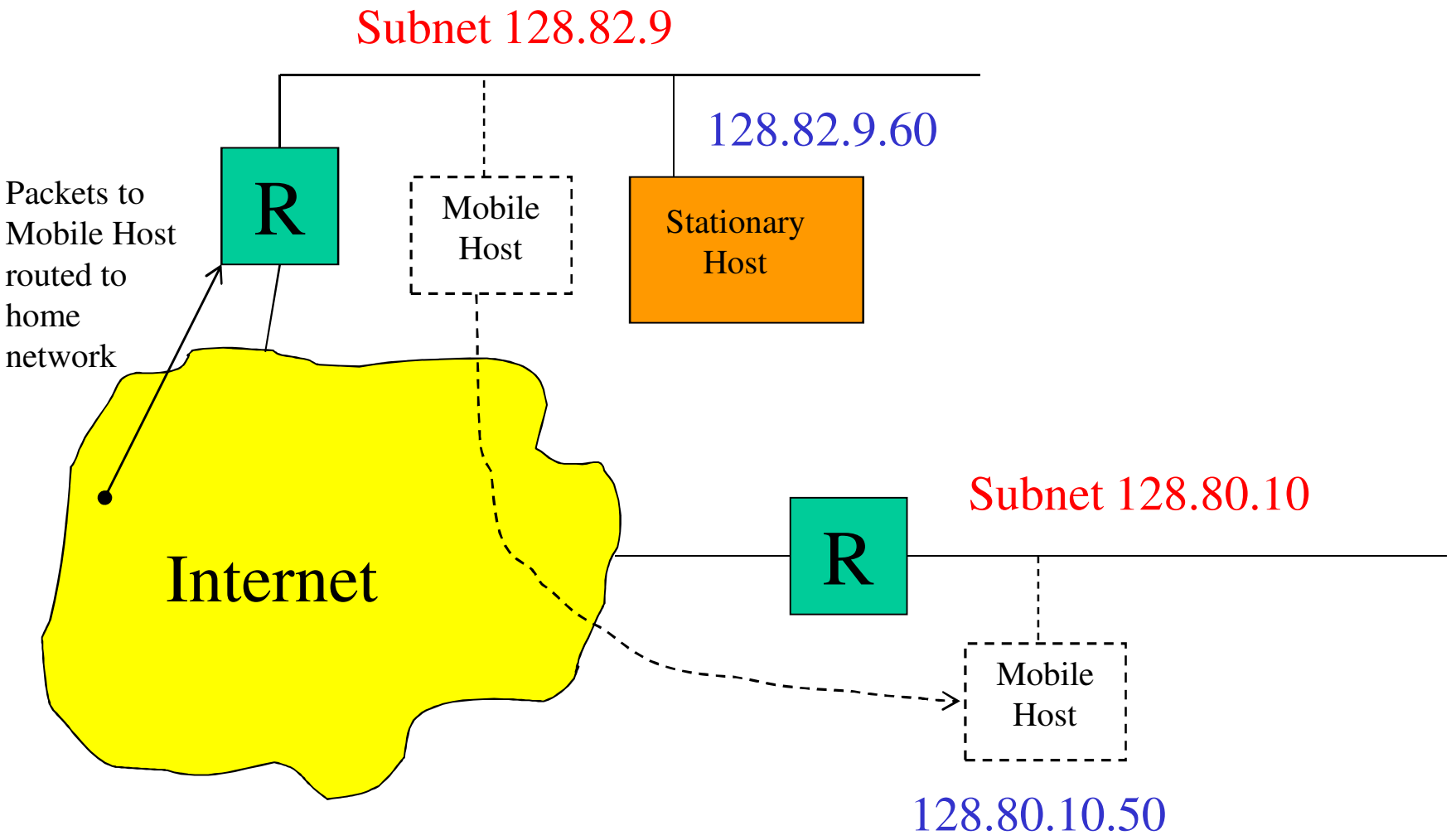
***Fundamental Problem***

**an IP address serves dual purpose**

Transport and application layer perspective: **end-point identifier**

Network Layer: **routing directive**

# Host Mobility Problem 2/2



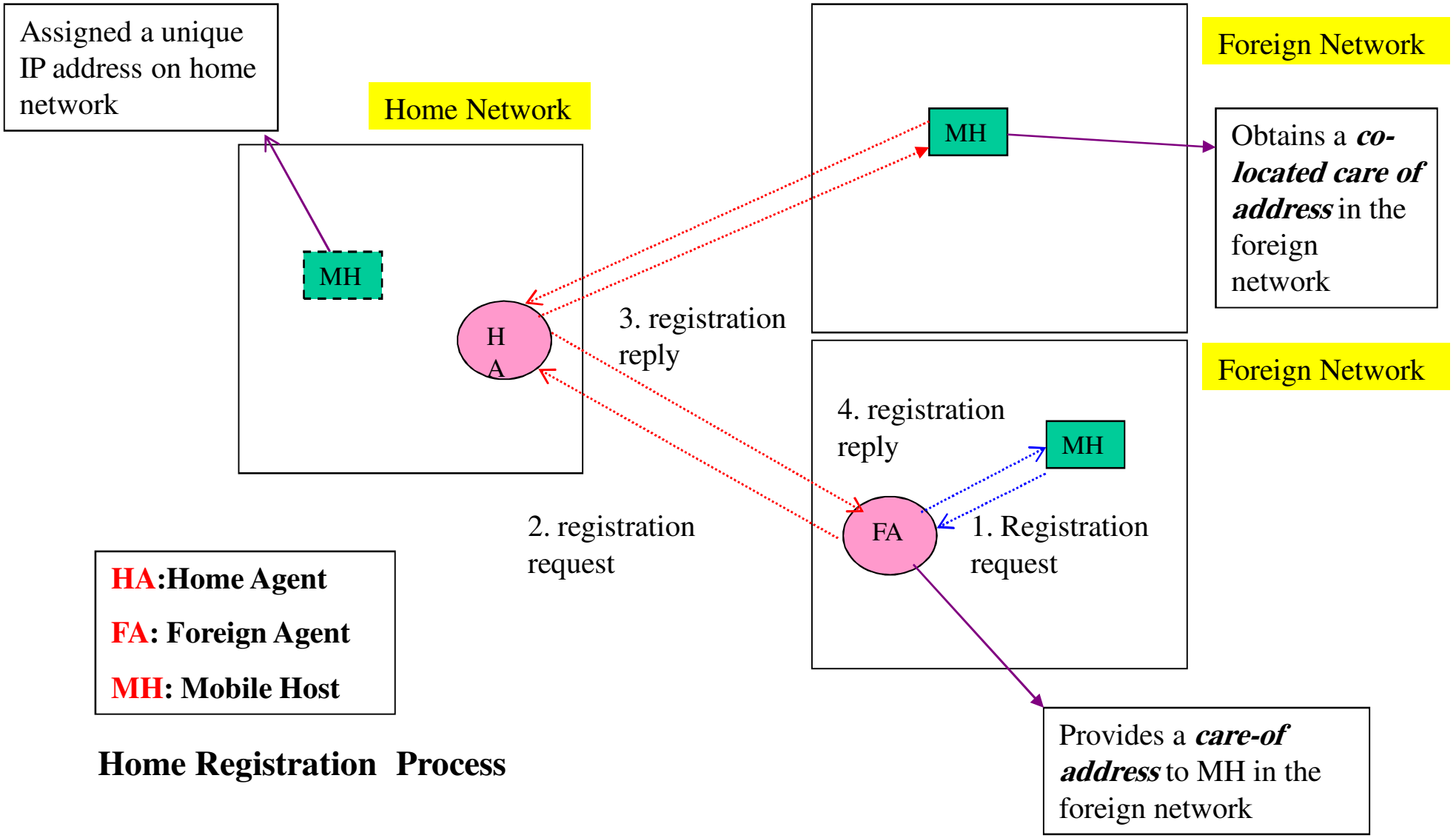
# Host Mobility Problem Solutions

- **Network layer solutions**
  - -IETF Mobile IP (MIPv4 and MIPv6)
    - •uses "Mobility agents"
    - •hides a change of IP address, when a mobile host is moving between IP networks.
- **Application layer solutions**
  - -Mobility support using "Session Initiation Protocol"
    - •used for real-time mobile communications
    - •problem with TCP connections, suggests using mobile IP for TCP connections
- **End-to-End Host Mobility support**
    - •Relies on DNS secure dynamic updates
    - •TCP option for connection migration (suspend TCP connection and reactivate it from another IP address)

# Network Layer Solutions Model

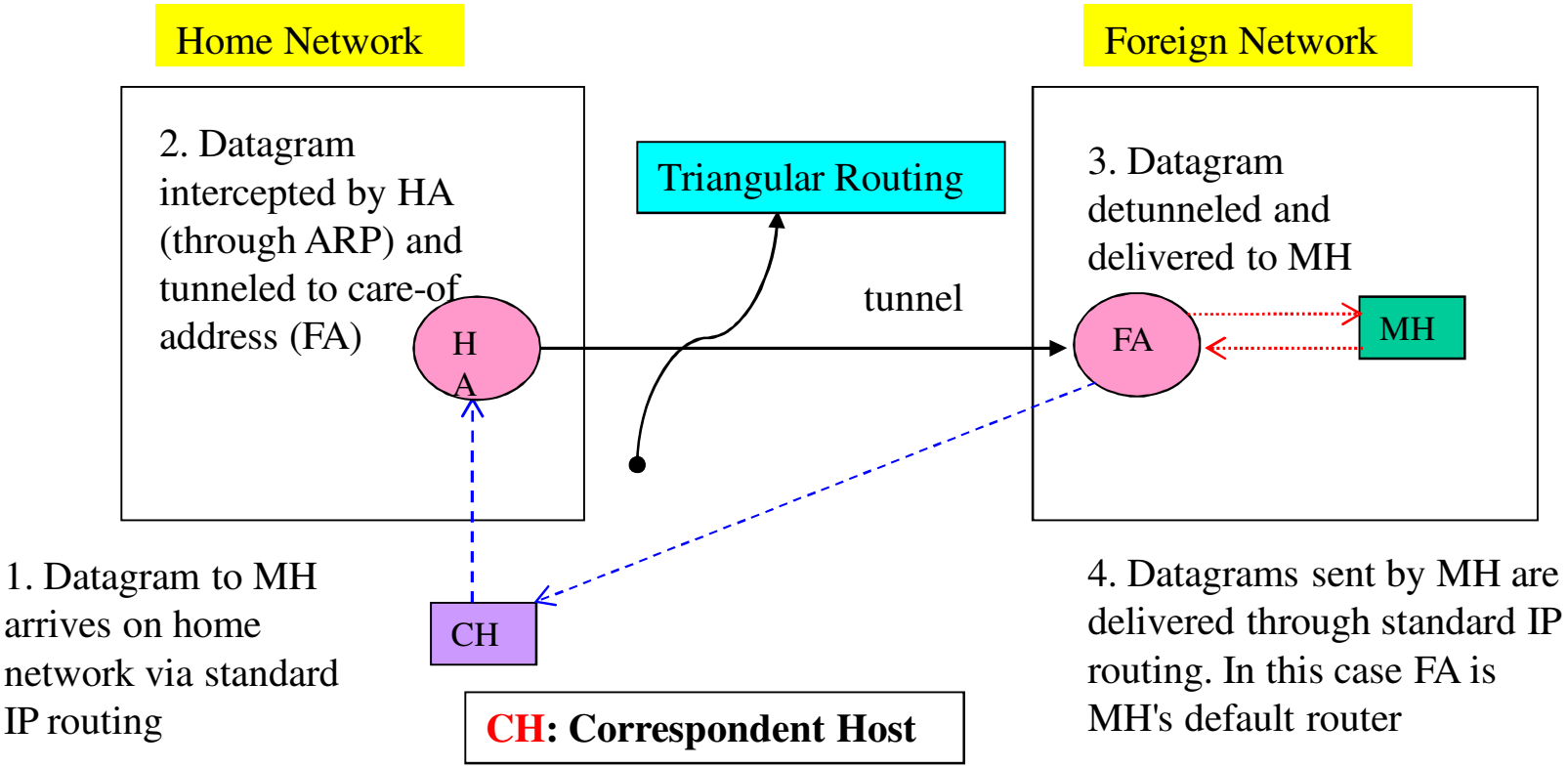
- two-level addressing architecture
  - home address & care-of address
- key mechanisms
  - address translation
    - map home address to care-of address
  - packet forwarding
    - tunnel packets to care-of address
  - location management
    - update mobile host's location

# IETF Mobile IPv4 1/4



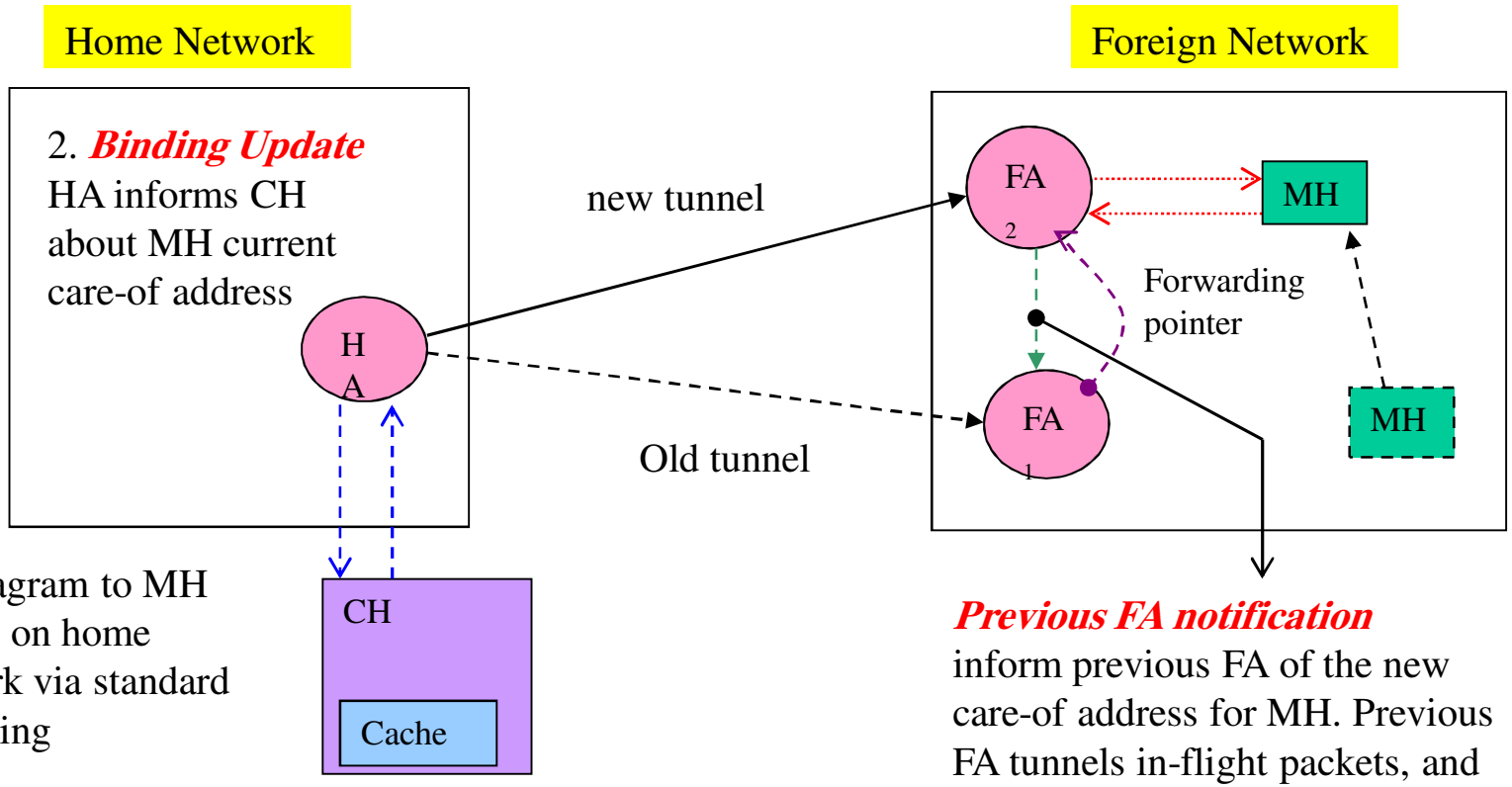

**Home Registration Process**

# IETF Mobile IPv4 2/4




Unicast datagram routing to the MH's care-of address

# IETF Mobile IPv4 3/4




1. Datagram to MH arrives on home network via standard IP routing

3. CH caches MH care-of address and uses it for any subsequent datagrams destined to MH

***Previous FA notification***
inform previous FA of the new care-of address for MH. Previous FA tunnels in-flight packets, and packets from CH with out-of-date location cache entries to new FA. (Handoff)

Route optimization

# IETF Mobile IPv4 4/4

## Problems

- triangular routing (sub-optimal routing)
- tunneling overhead
- use of route optimization solves the triangular routing problem, BUT requires change in the IP stack of CH
- large signaling overhead (registration) , if movement within the same domain (local-area mobility). MH has to inform the HA whenever it changes its point of attachment.

# Outline

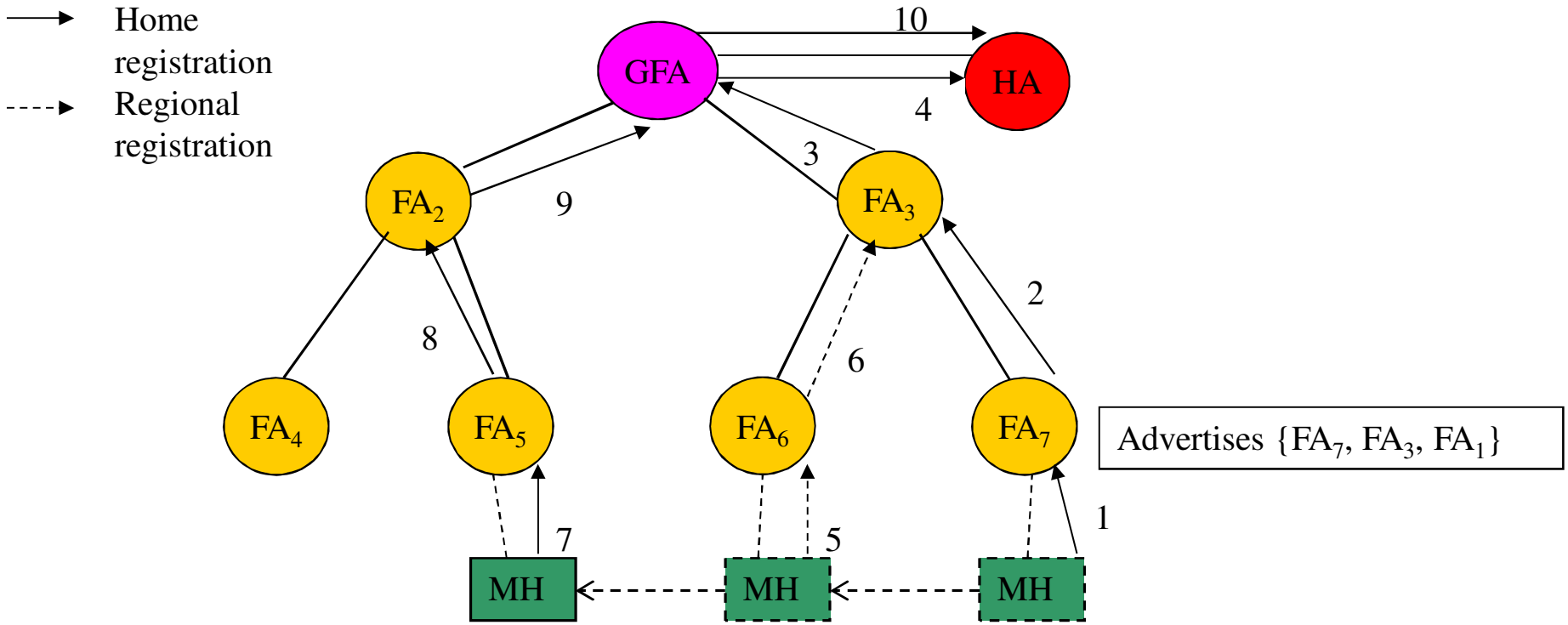
- MIPv4 Micro-mobility solutions

# Local-area Mobility Solutions

- Within the Mobile IP framework
  - Regional Registration Framework (MIP_RR)
  - Local and Indirect Registration
- Host-based forwarding schemes
  - Cellular IP (Columbia University)
  - HAWAII (Bell Labs)
- Multicast-based schemes

  Assign MH a scoped multicast address within the foreign domain

# Regional Registration Framework (MIP_RR) 1/3




{1, 2, 3, and 4}: Home registration when the MH first enters the foreign domain.

{5, 6}: Regional registration with a local handoff from $FA_7$ to $FA_6$.

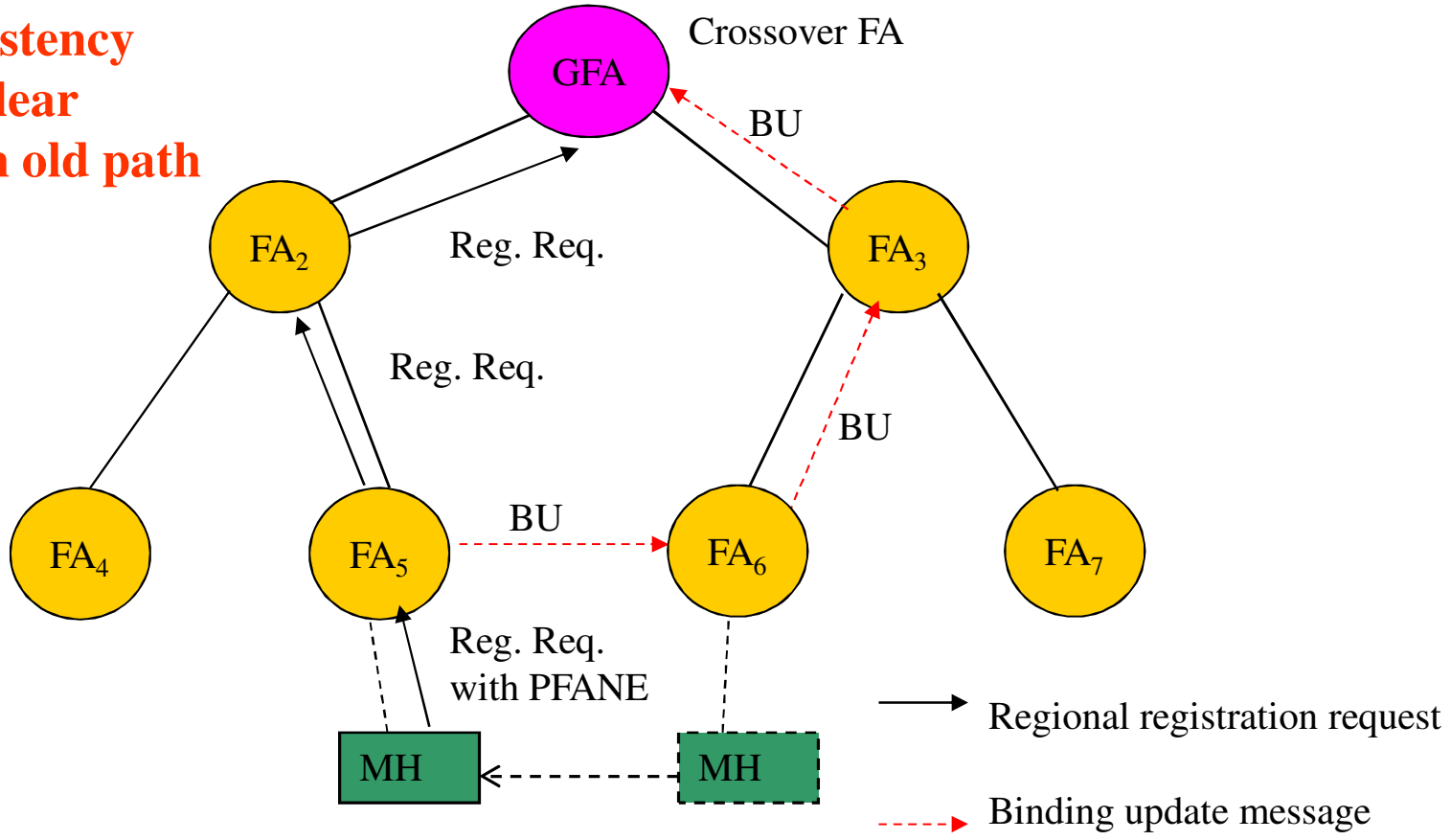
{7, 8, 9, and 10}: Home registration involving a local handoff from $FA_6$ to $FA_5$.

# Regional Registration Framework (MIP_RR) 2/3

- The old FA relays the BU message, received from the new FA, upwards in the hierarchy (to its father FA) specifying itself as the care-of address of the MH.
- The father FA performs the following steps
  - delete its MH's visitor entry,
  - create a binding cache entry for the MH with care-of address the child FA that sent the BU message,
  - relay the BU message upwards in the hierarchy, and
  - send back a binding acknowledge message to its child FA

# Regional Registration Framework (MIP_RR) 3/3

**Tunneling consistency mechanism to clear visitor entries in old path**

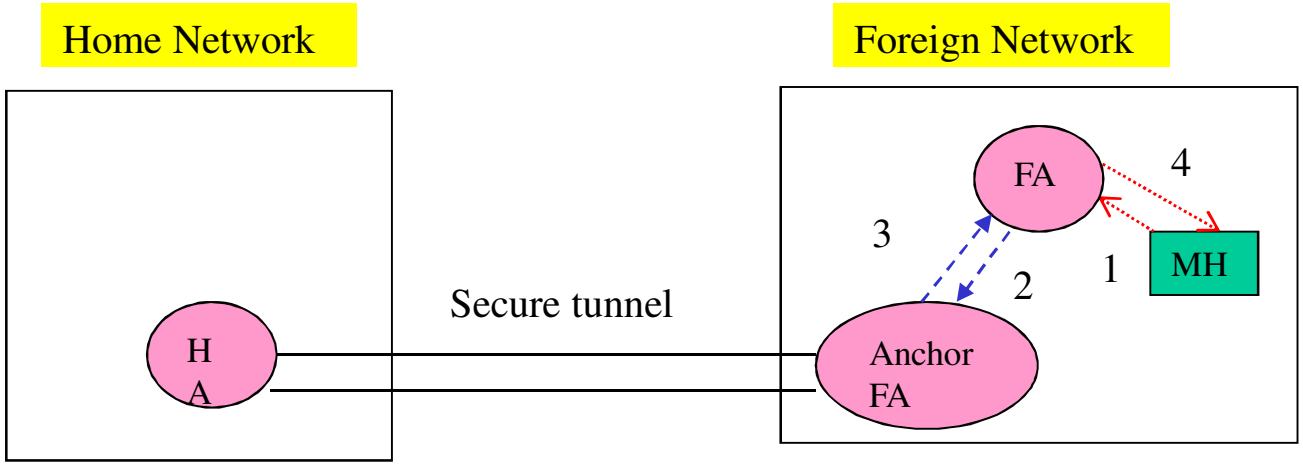


# Local and Indirect Registration

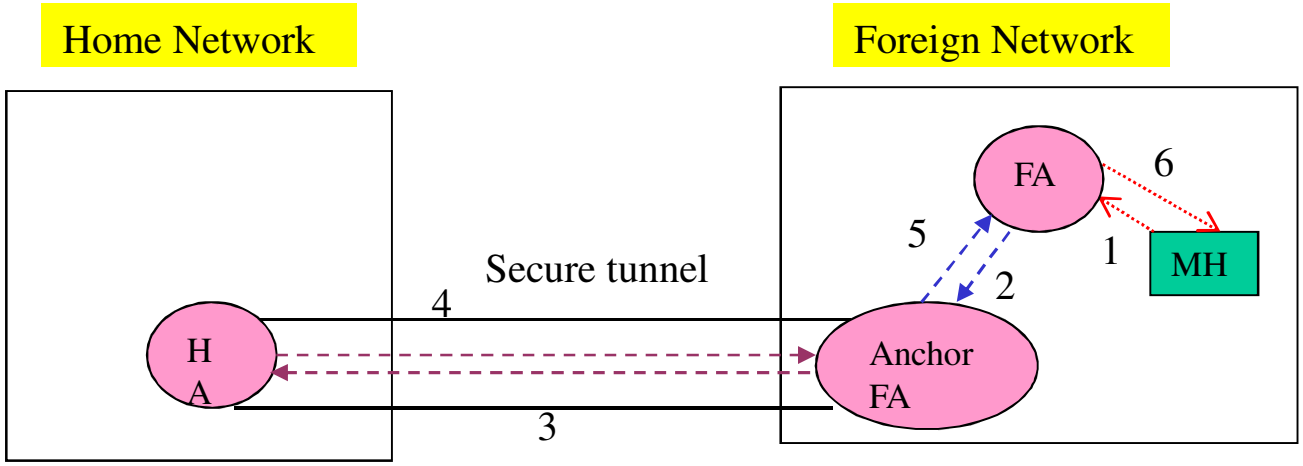
**HA:Home Agent**

**FA: Foreign Agent**

**Local Registration**

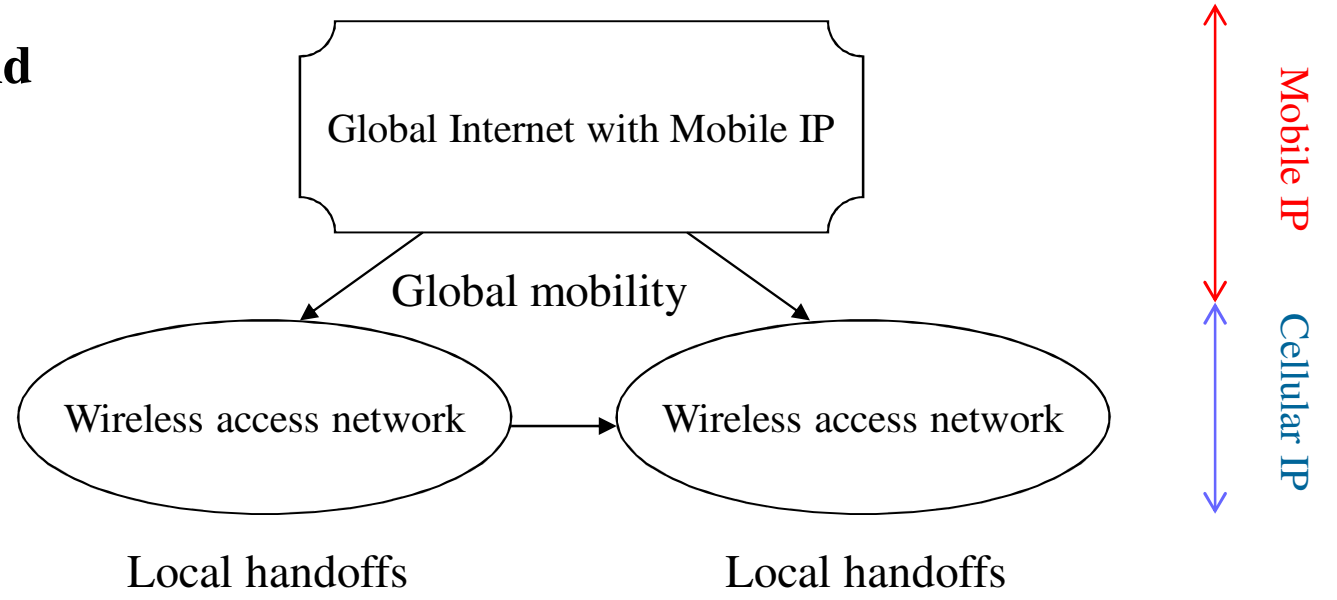



**Indirect Registration**

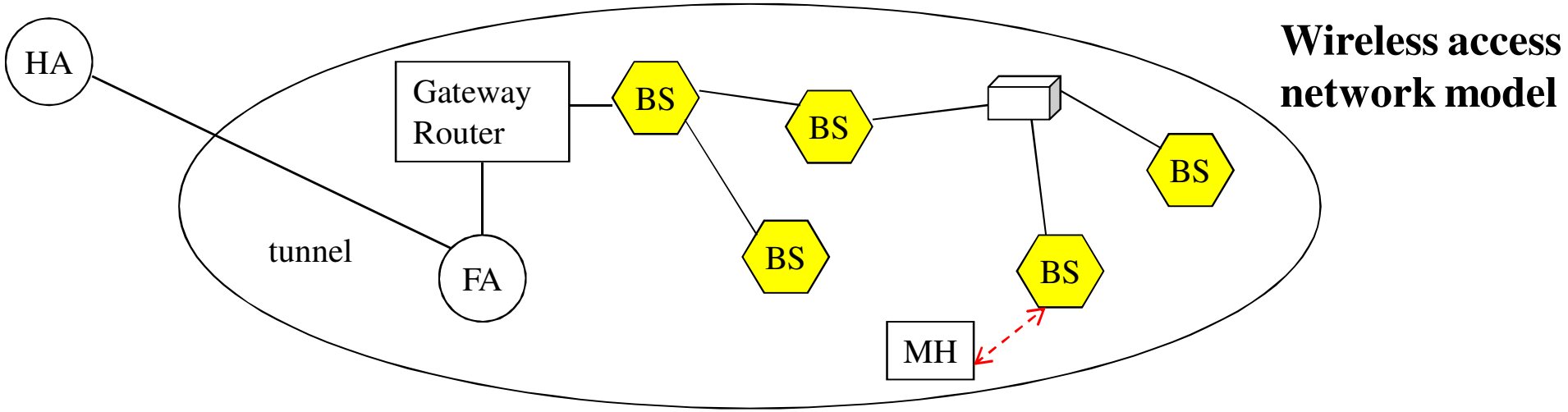


# Cellular IP 1/2

**Cellular IP and Mobile IP**

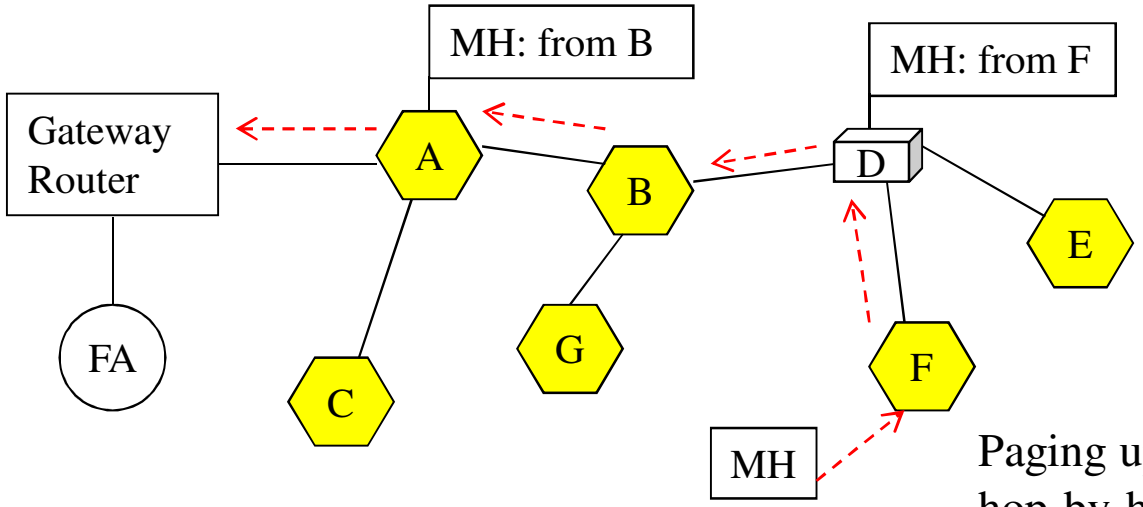



**Wireless access network model**



# Cellular IP 2/2

**paging update packets**




A, D have paging caches

Paging update packet (routed hop-by-hop towards the GW)

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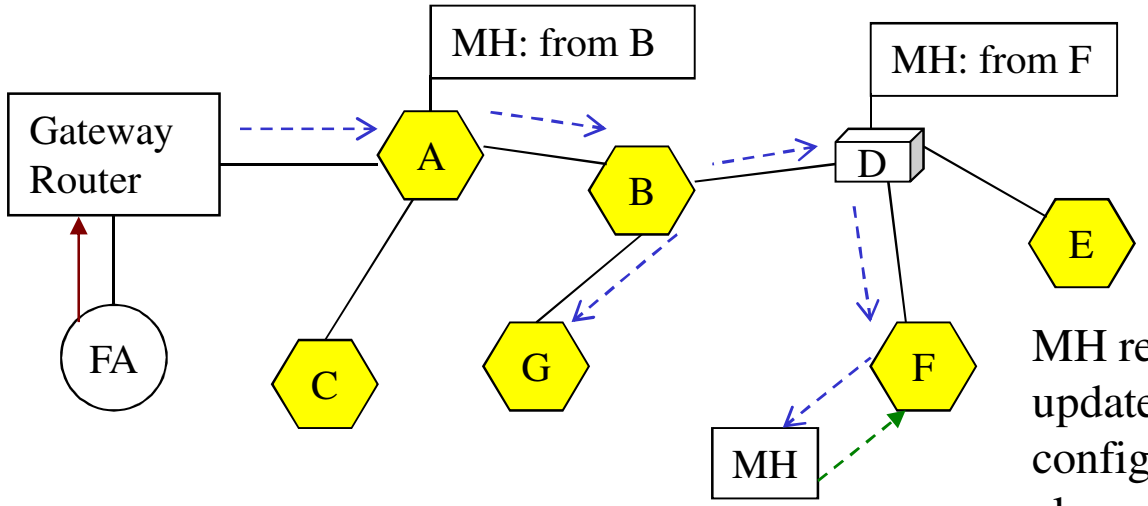
**paging packet routed to MH using paging caches**




Data packets for MH

MH responds with a route-update packet which configures routing caches along the way to the GW

# HAWAII 1/2

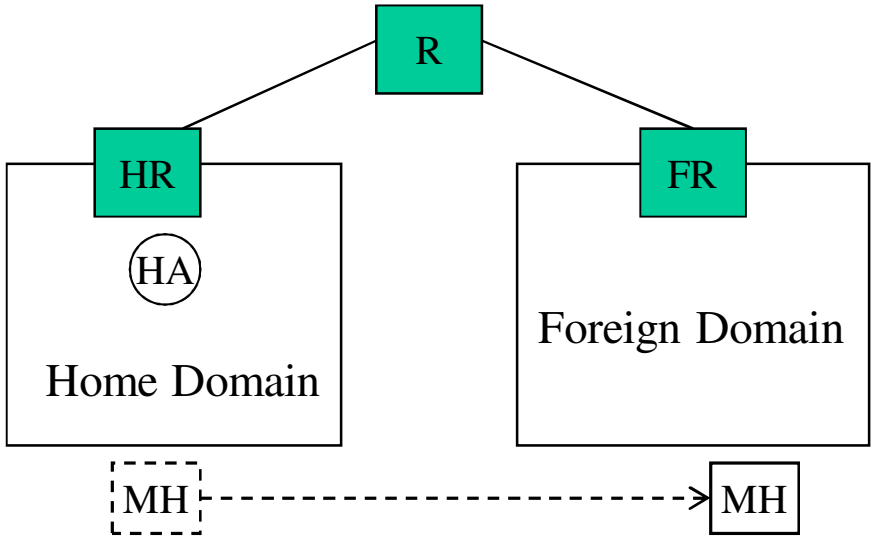
•Handoff-Aware Wireless Access Internet Infrastructure

•Uses specialized path setup schemes which install host-based forwarding entries in **specific routers** to handle intra-domain micro-mobility

•defaults to using mobile IP for inter-domain macro-mobility

•requires that MH obtains a **co-located care of address** within a domain, nevertheless MH is required to register with a BS within the domain to be able to better handle handoffs

•MH sends **path setup update** messages during power up and after handoffs



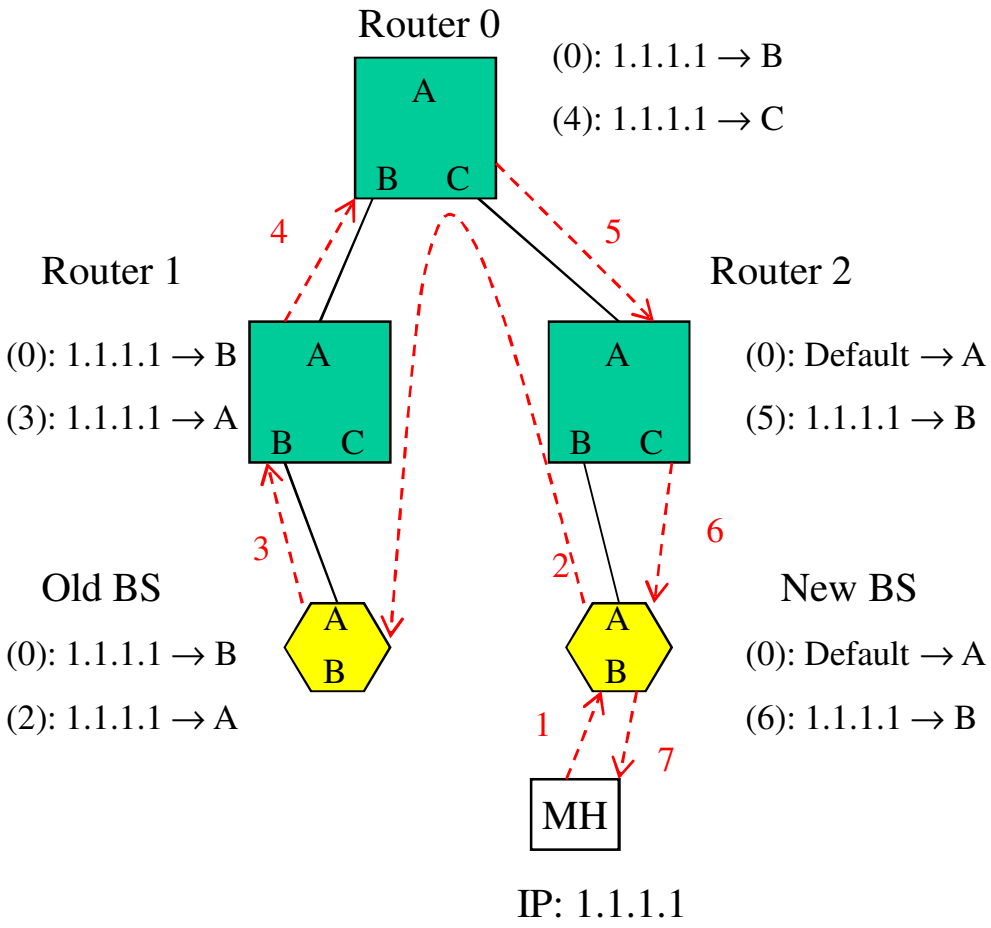

HA notified of co-located care of address

**HR**: Home Domain Root Router

**FR**: Foreign Domain Root Router

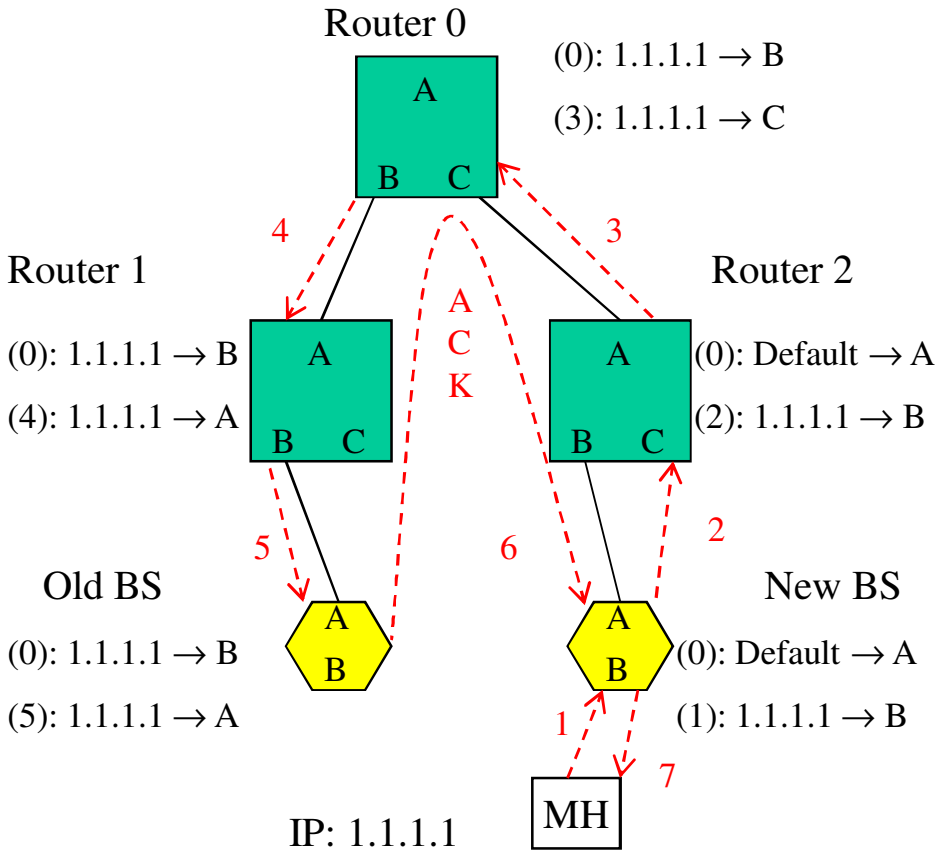
**domain model within HAWAII**

# HAWAII 2/2




**Forwarding path setup scheme**

(MH can listen/transmit to only one BS)




**Non-Forwarding path setup scheme**

(MH can listen/transmit to multiple BS)

# Multicast and Mobility 1/3

- **The Deadalus Approach (Berkeley, 1995)**
  - –maintains the HA concept of Mobile IP
  - –MH pre-assigned a multicast address by HA
  - –HA encapsulates any packets destined to MH and forwards them over the pre-assigned multicast group
  - –MH informs nearby Base Stations about multicast group and controls forwarding/buffering of packets at BSs through a control protocol

# Multicast and Mobility 2/3

- **A Multicasting-based Mobility Solution (1997)**
  - –multicast sole mechanism to provide addressing and routing services to MHs
  - –each MH is assigned a unique multicast IP address (globally unique)
  - –approach affects a number of existing protocols such as TCP, ICMP, ARP, IGMP

# Multicast and Mobility 3/3

- **Fast Handoffs for Wireless Networks (1999)**
  - –foreign domain arranged as a two level hierarchy with a domain FA at the root and base stations as leafs.
  - –MH assigned a multicast address within the foreign domain by the domain FA (centralized server)
  - –domain FA becomes forwarding agent for all MHs (single point of failure, bottleneck)
  - –does not discuss details of multicast address allocation or effects on multicast routing