CS6504

Mobile Computing

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Mobile IPv4 Micro-mobility

Outline

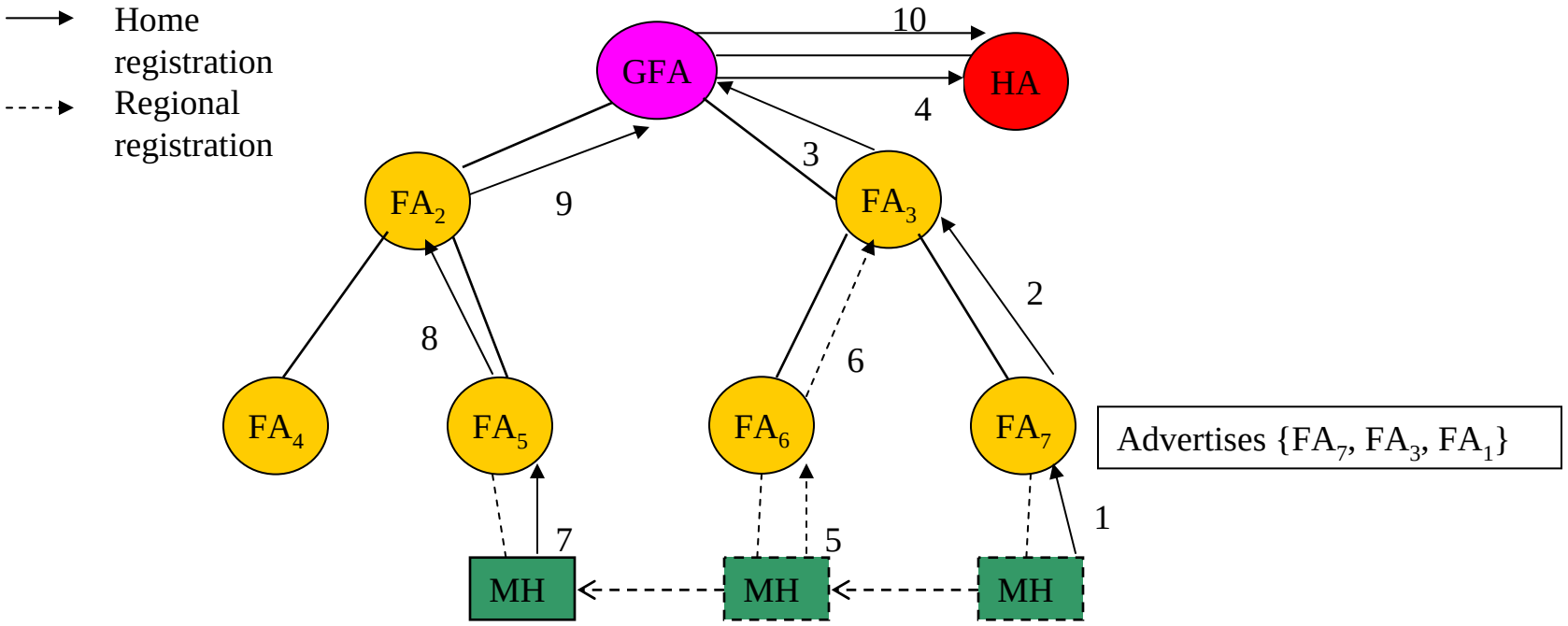
- MIPv4 Micro-mobility solutions

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

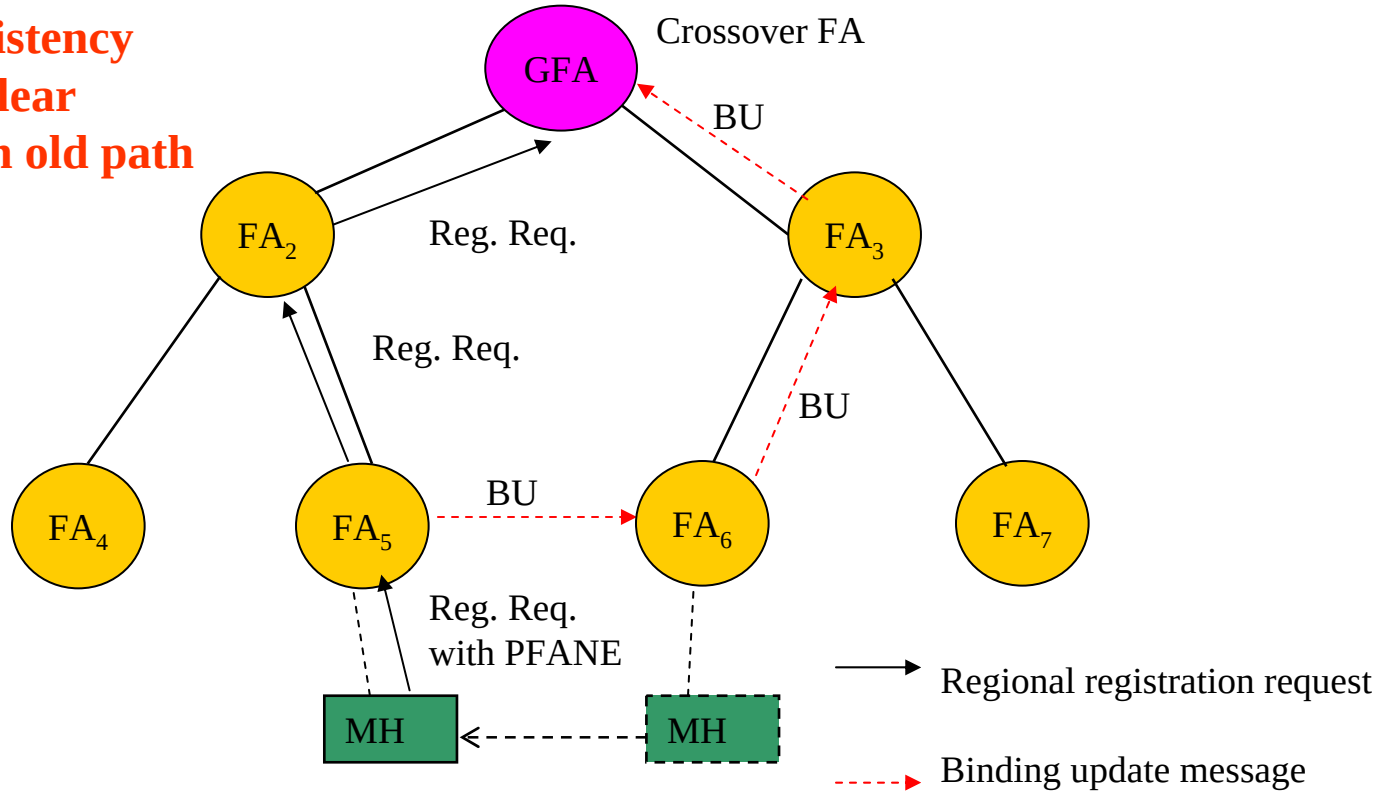
•The old FA relays the BU message, received from the new FA, upwards in the hierarchy (to its father FA) specifying itself as the care-of address of the MH.

•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



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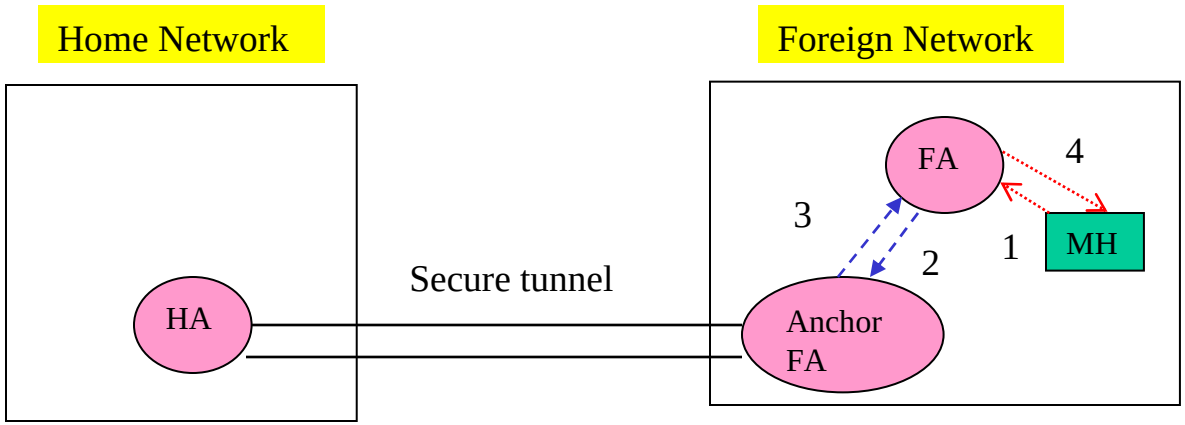
Local and Indirect Registration

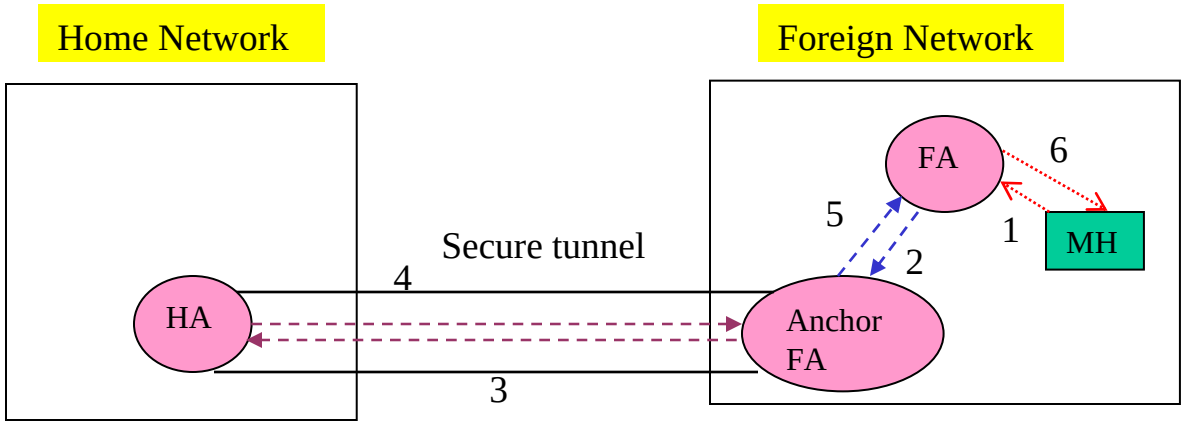
HA:Home Agent

FA: Foreign Agent

Local Registration



Indirect Registration



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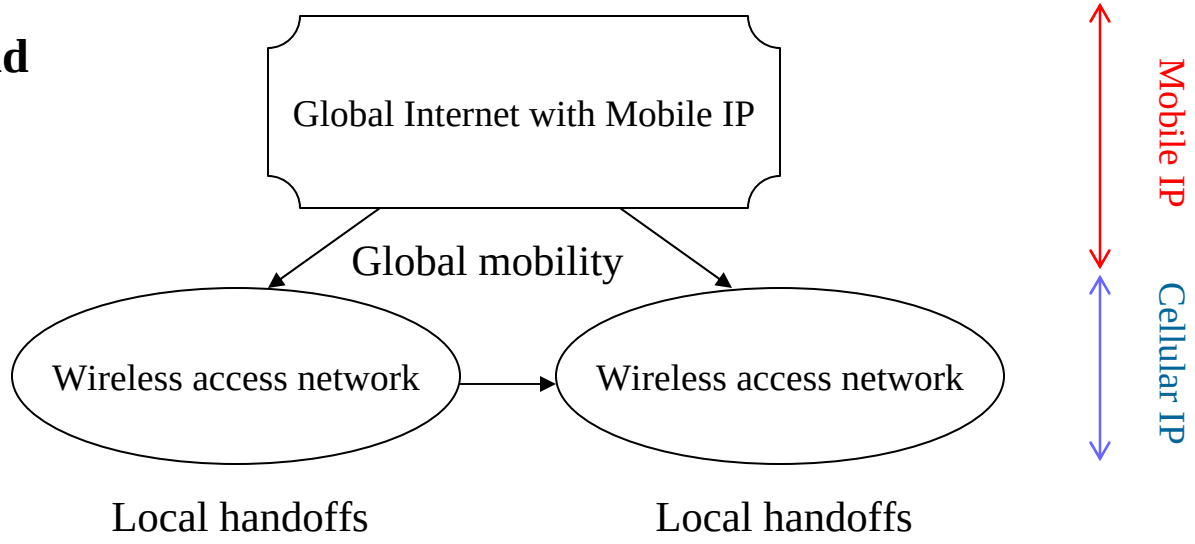
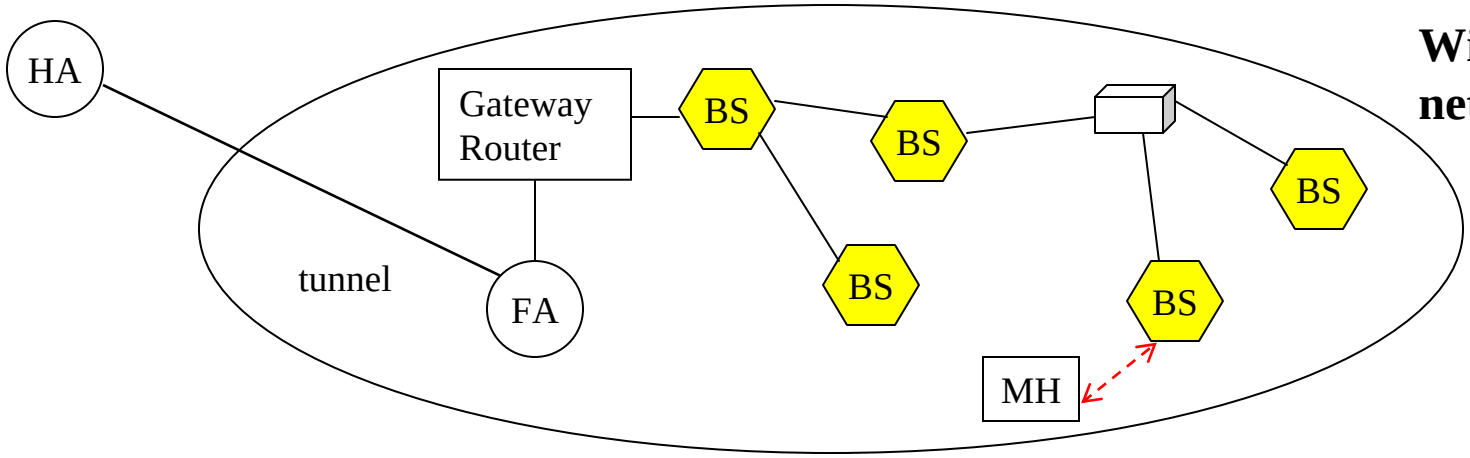
Cellular IP 1/2

Cellular IP and Mobile IP



Wireless access network model



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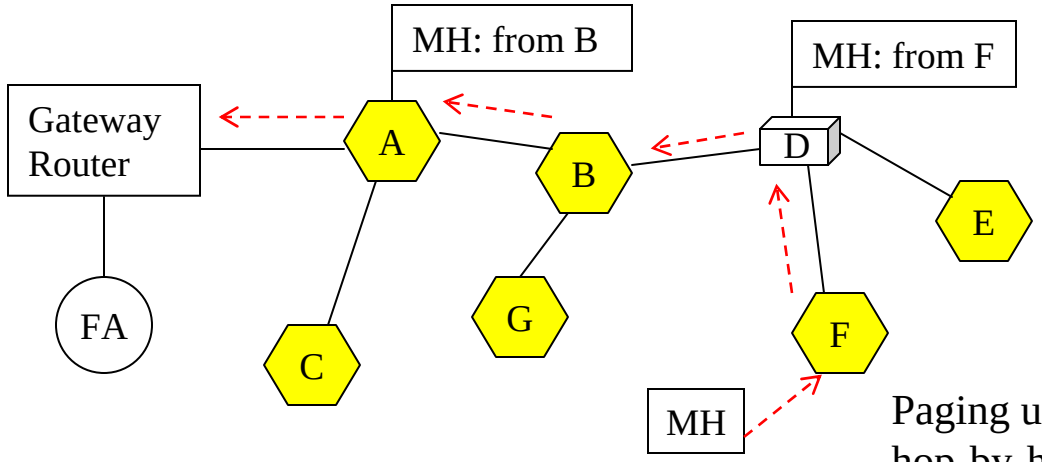
Cellular IP 2/2

paging update packets



A, D have paging caches

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

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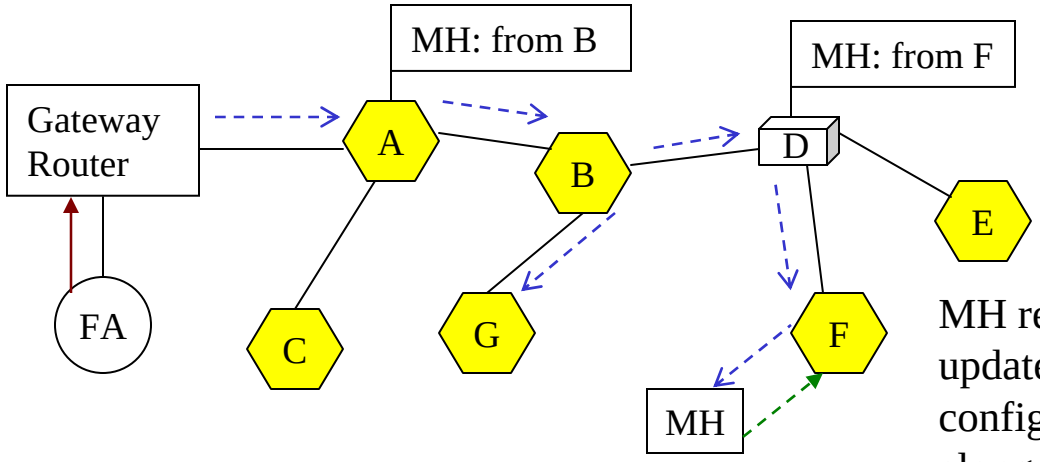
paging packet routed to MH using paging caches



Data packets for MH

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

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HAWAII 1/2

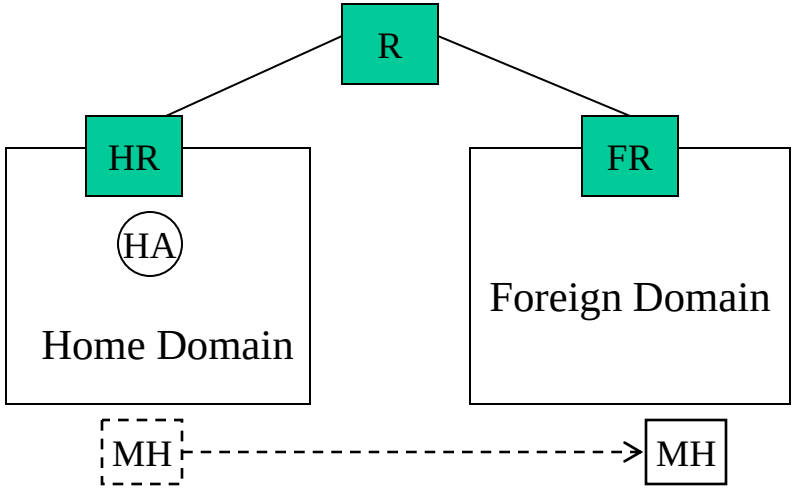
•Handoff-Aware Wireless Access Internet Infrastructure

•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



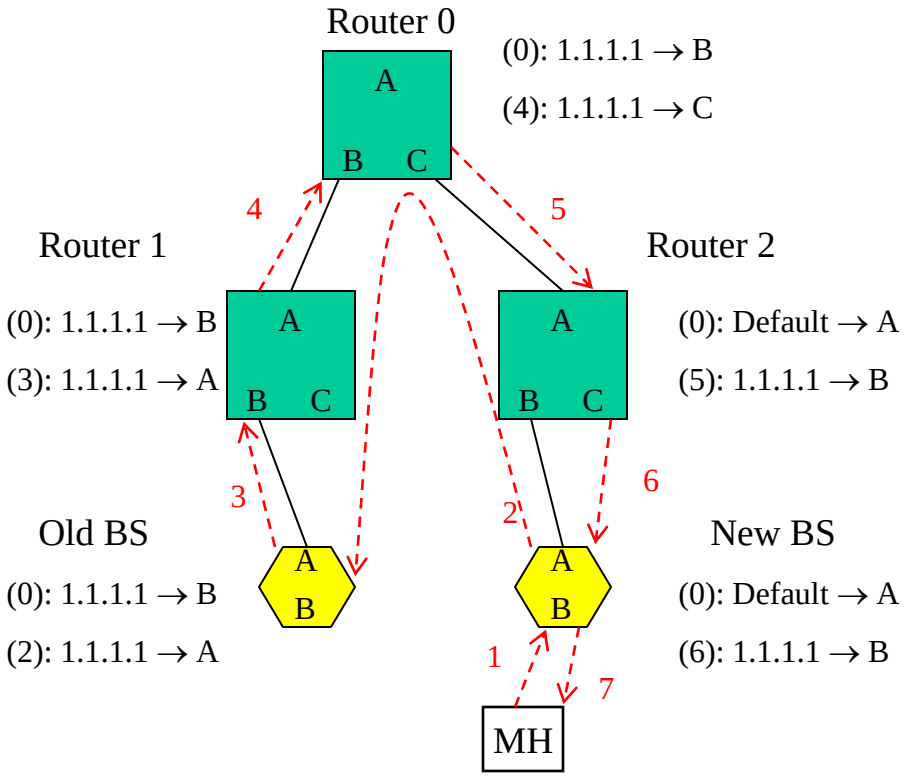
HA notified of co-located care of address

HR: Home Domain Root Router

FR: Foreign Domain Root Router

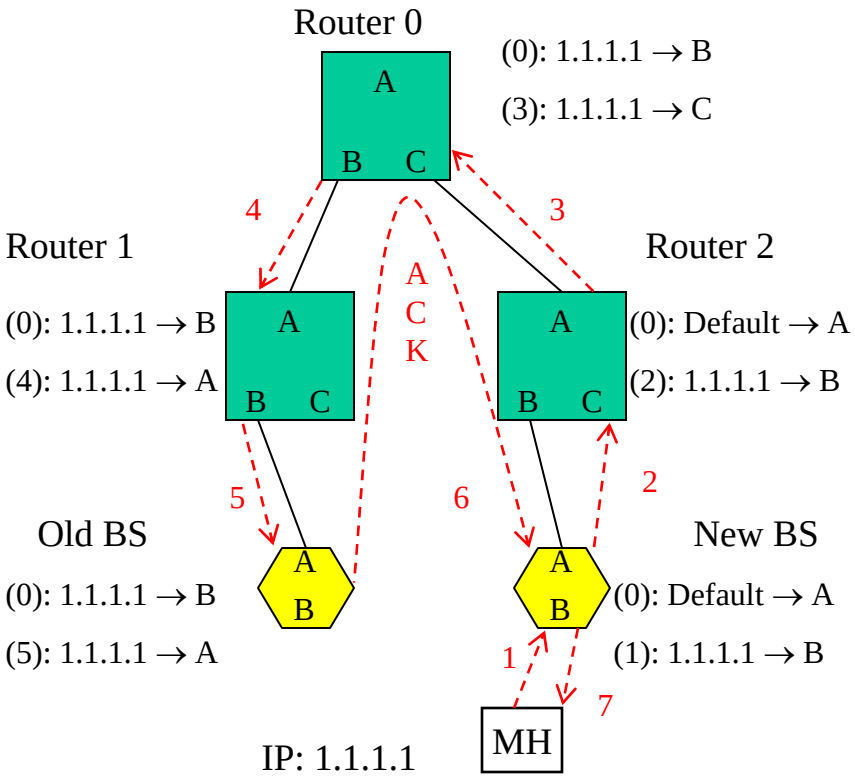
domain model within HAWAII

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

Outline

- A cooperating FA hierarchies local-area mobility support framework

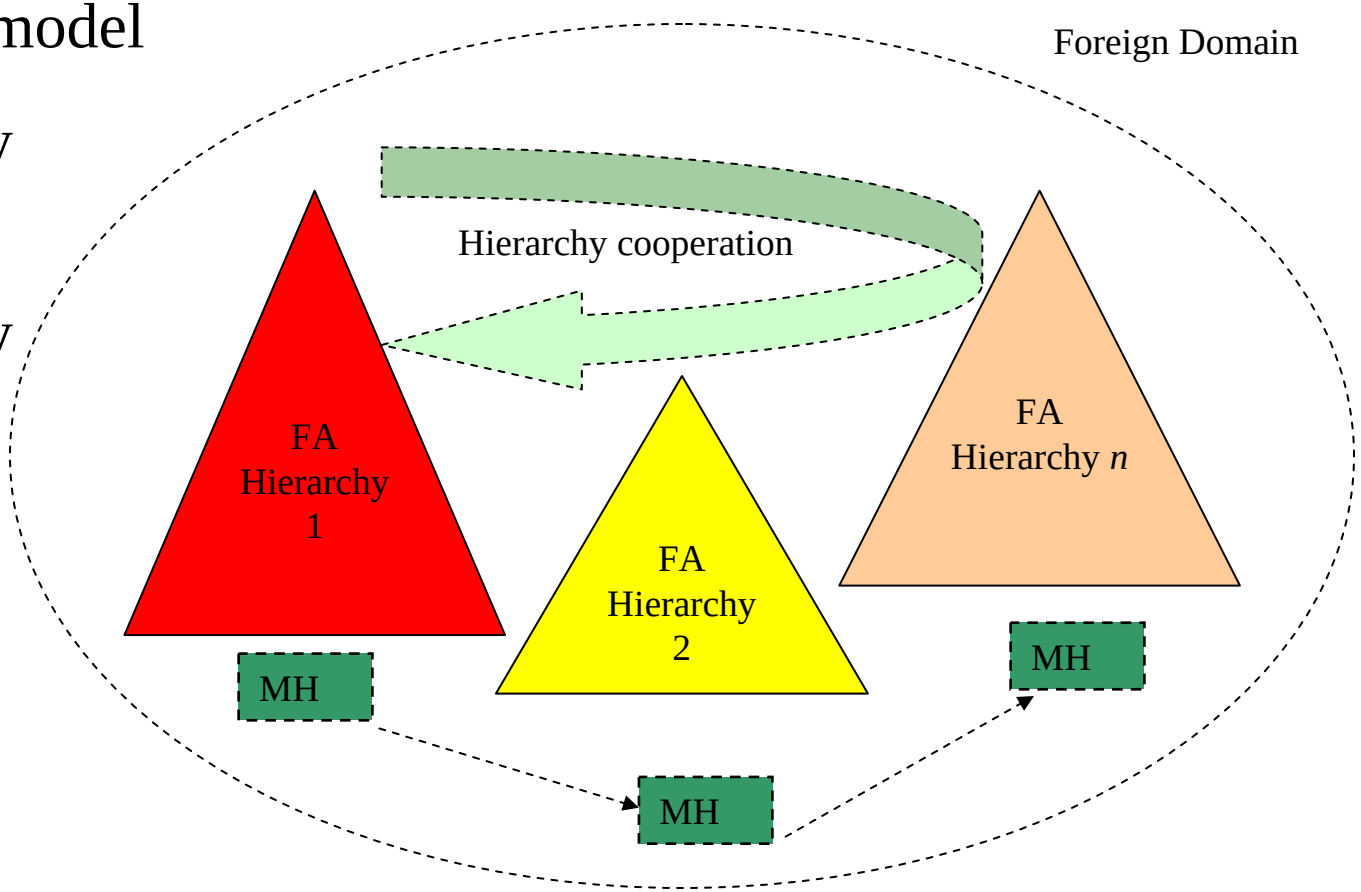
Cooperating Foreign Agents Hierarchies 1/2

A local-area mobility support framework

- Efficiently handle local-area movement scenarios within a foreign domain through cooperation between FA hierarchies
- Provide authentication and replay protection for all protocol messages
- Not specific to any access technology
- Explore the hierarchy structure to enhance registration processing

Cooperating Foreign Agents Hierarchies 2/2

- FA hierarchy model
- Intra-hierarchy handoffs
- Inter-hierarchy handoffs



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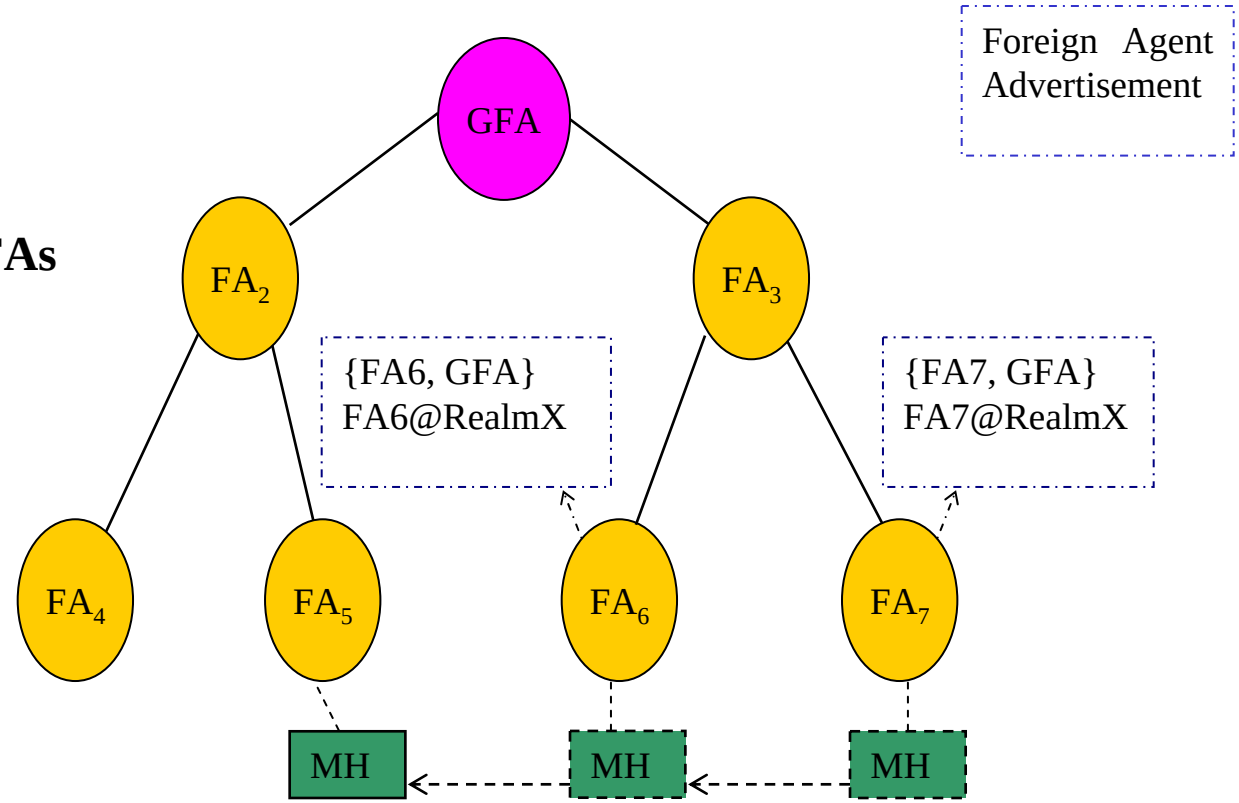
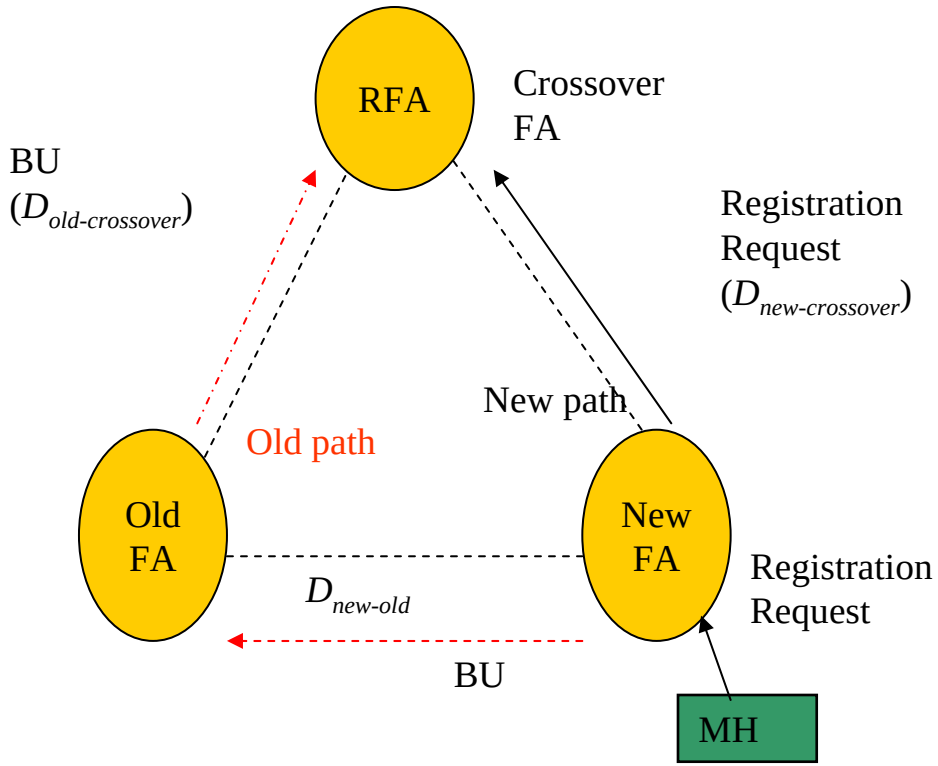
FA Hierarchy Model



- **Advertise the FA IP address (if not private) for legacy MHs**
- **Hide the hierarchy structure**

Critique of MIP_RR's tunneling consistency

- **Requires smooth handoff mechanism**
- **Potential race condition if BU from old path reaches crossover FA before the registration request from new path**



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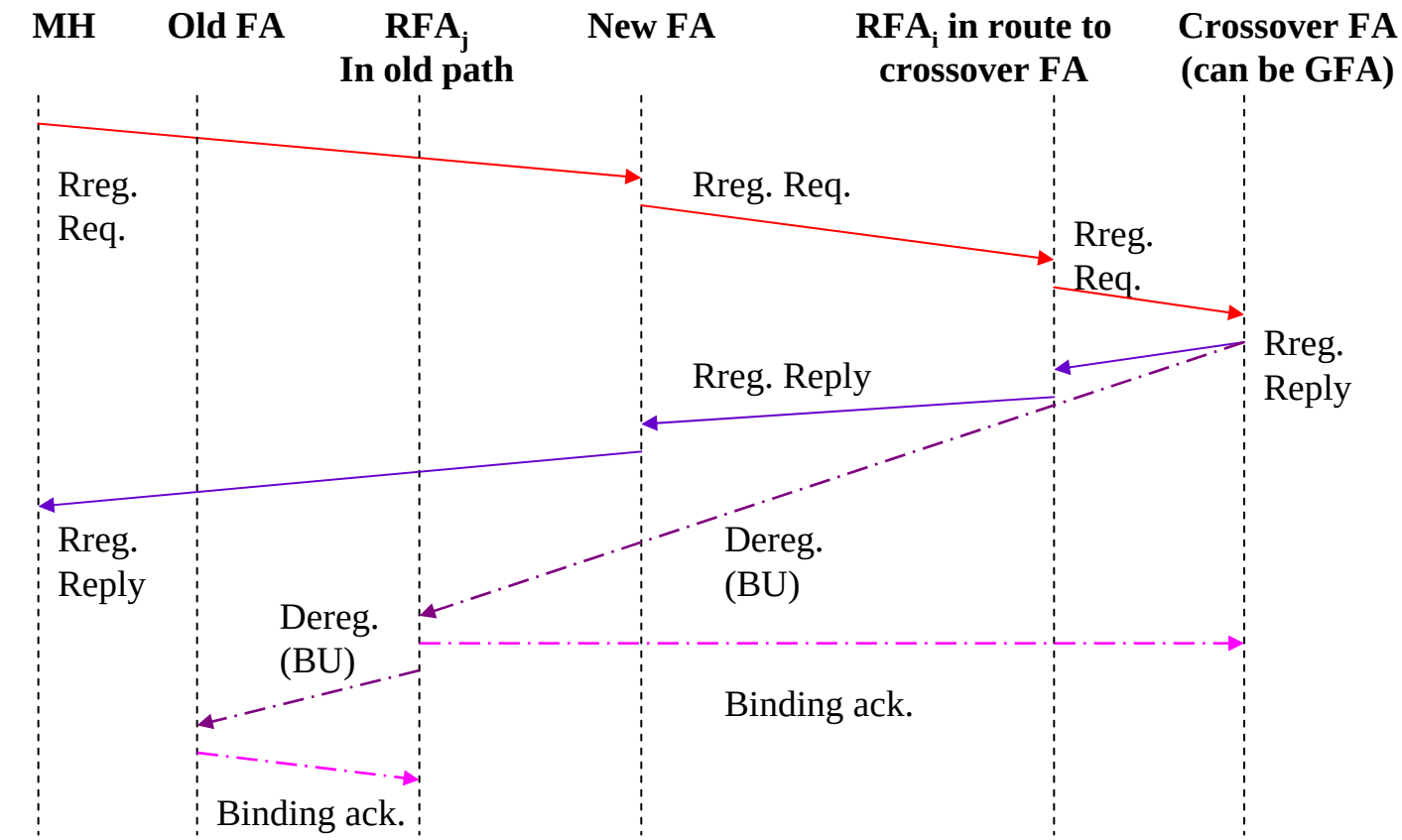
Regional Registrations Framework 1/2



Regional Registration messages (Request/Reply)

Route Optimization messages (BU/Binding ack.)

Rreg.:Regional Registration
Req.:Request
Ack.:Acknowledgement
Dereg.:Deregistartion

Regional Registrations Framework 2/2

Replay Protection

•Crossover FA propagates upwards in the hierarchy towards the GFA a *replay protection update message* to ensure future successful processing of registrations by upper RFAs in the path

•This message propagates the new identification value assigned to the MH by the crossover FA

•Used for nonce replay protection and timestamp replay protection

Type	Reserved
MH Home Address	
New MH Identification	
Identification	
Extensions …	

Home Registrations Framework

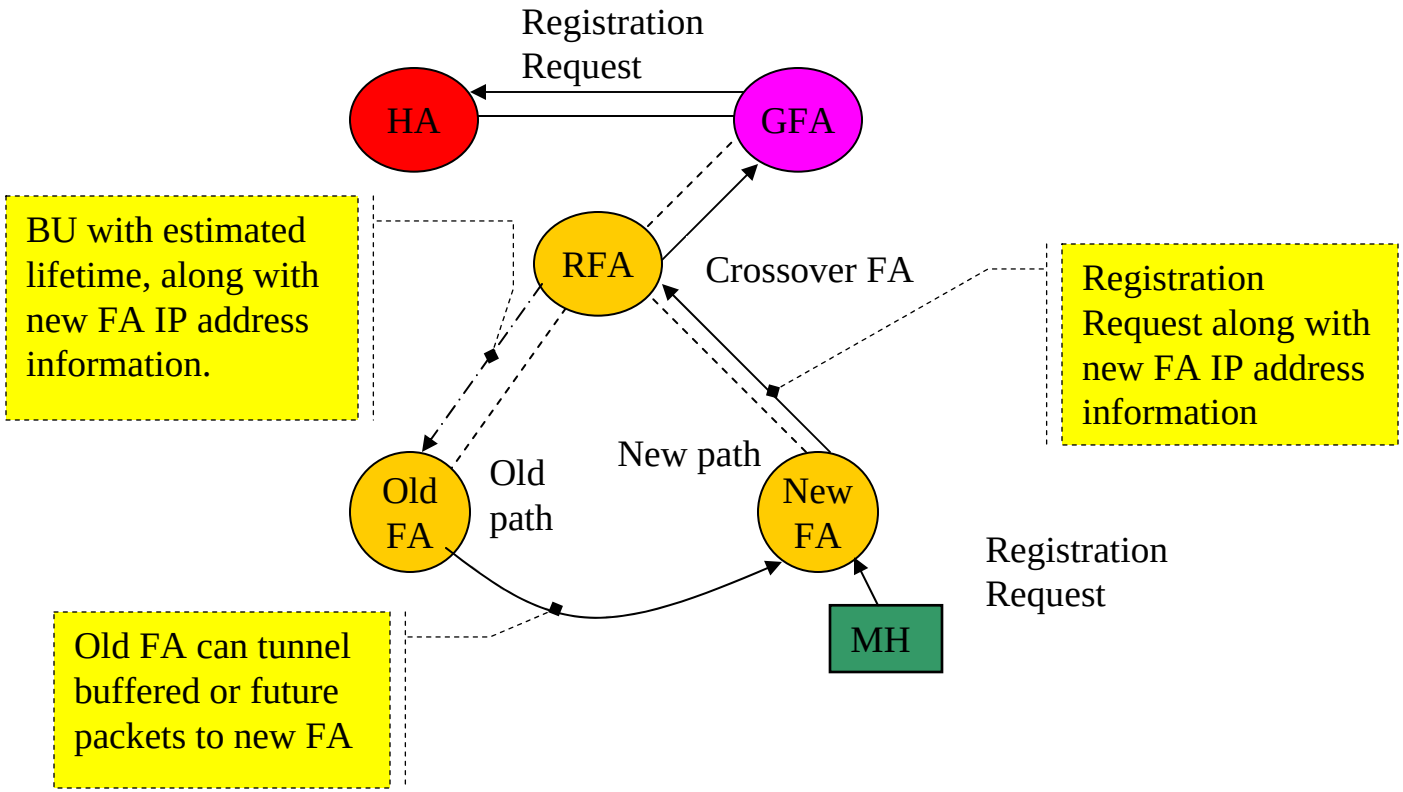
Home Registrations involving local handoffs

- A home registration is forwarded to the HA to renew the MH's mobility binding
- How about the old path?
  - A deregistration mechanism similar to the regional registration framework would clear the old path, but increases packet loss while waiting for the reply from the HA
  - The need to clear the visitor entries on the old path

Our solutions

- KOPA approach (Keep Old Path Alive)
- SINP approach (Switch Immediately to New Path)

Intra-Hierarchy Handoffs: The KOPA Approach 1/3



Intra-Hierarchy Handoffs: The KOPA Approach 2/3

What lifetime is used for the BU?

BU lifetime = Max {*home reg. latency*, α * *remaining reg. lifetime*}
Where 0 < α <= *1* *(we use α = 0.5)*

Maintain observed home registration latency at each RFA

How the new FA information is propagated without the smooth handoff mechanism?

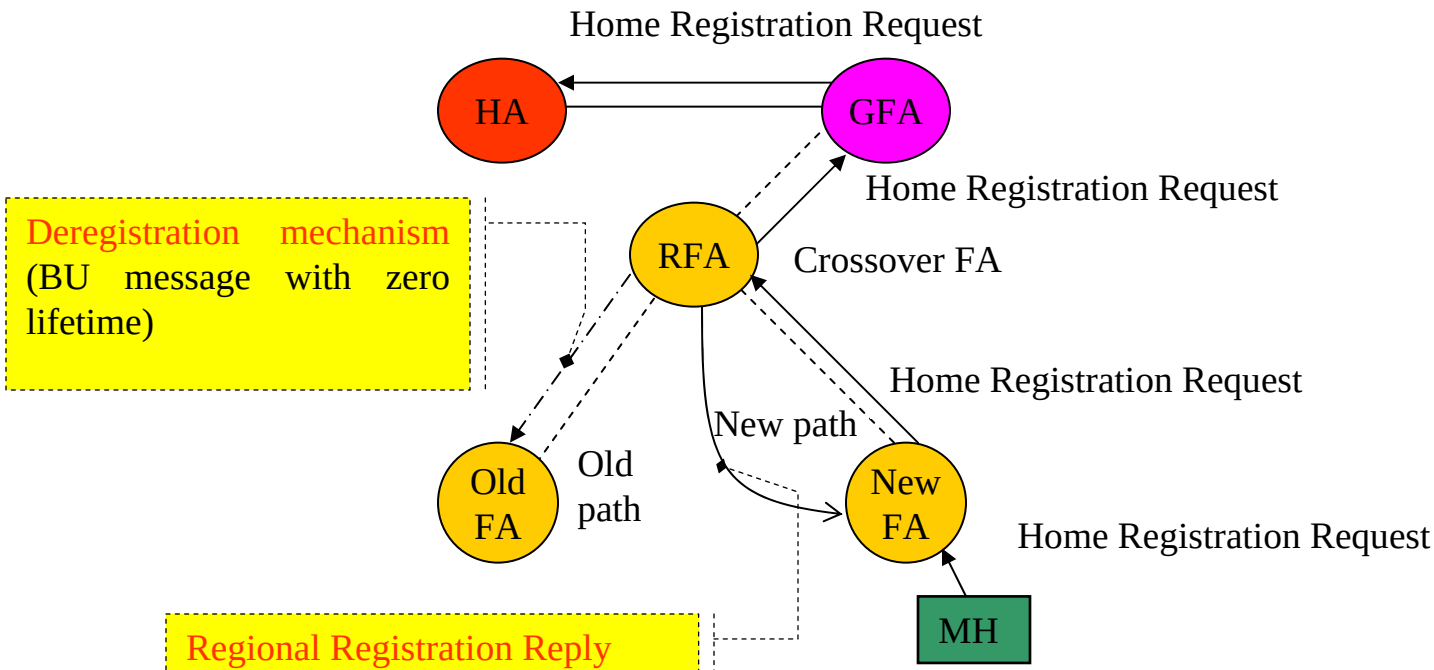
- Benefit from the existence of a hierarchy, an old and new path
- Propagate new FA information along new path to crossover FA, then along old path to old FA through a *local care-of address extension*

Intra-Hierarchy Handoffs: The KOPA Approach 3/3

Authentication and replay protection

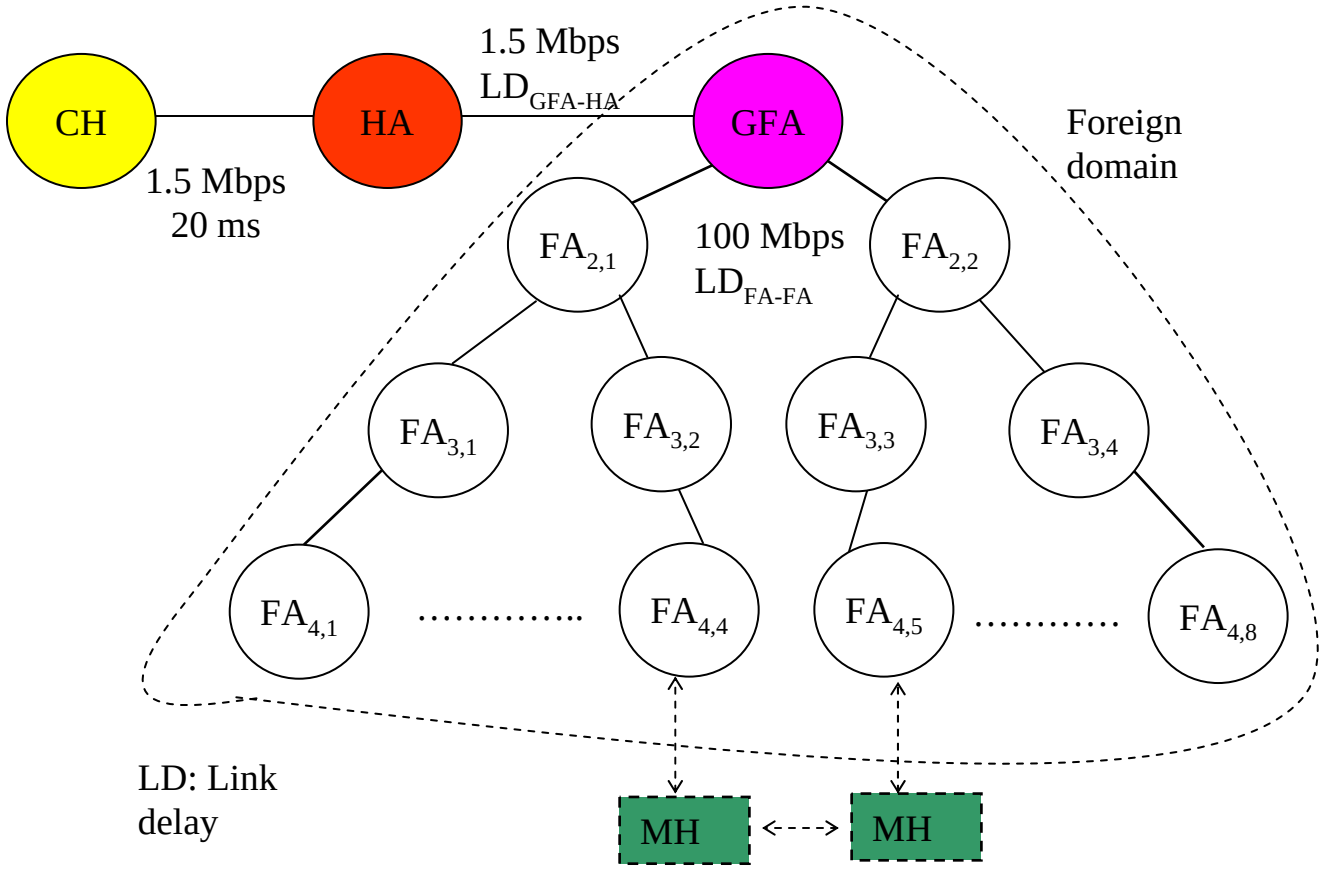
- A home registration request would only include home authentication and identification information
- How can the crossover FA authenticate the request to initiate KOPA?
  - MH includes a *local replay protection extension*, such that the crossover FA is capable of ensuring the freshness of its request
  - MH authenticates its request using a MH-GFA authentication extension
  - Crossover FA authenticates the request before initiating the tunneling consistency mechanism on the new path

Intra-Hierarchy Handoffs: The SINP Approach



- View such registrations as a truly combined home and regional registrations
- The local handoff completion does not have to wait for a reply from the HA

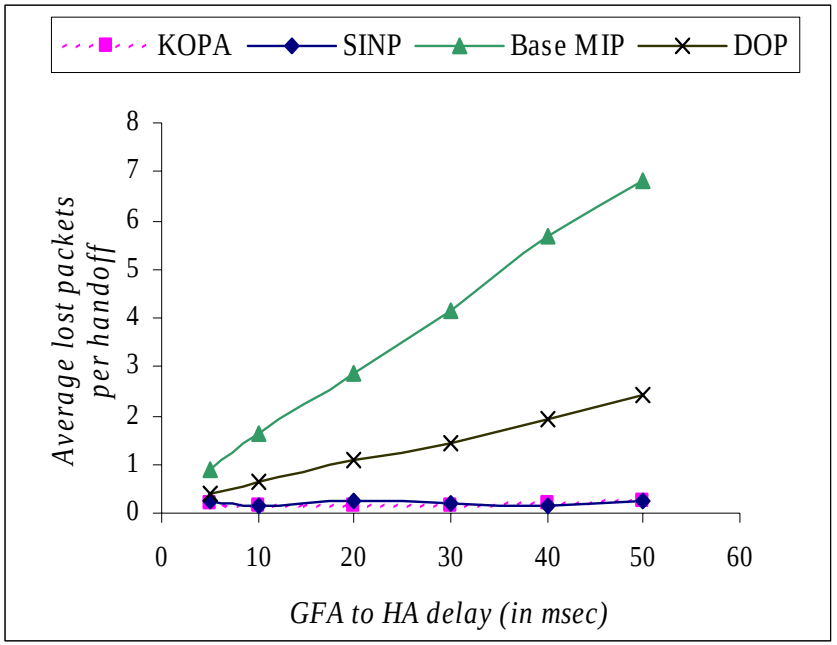
Performance Evaluation 1/4

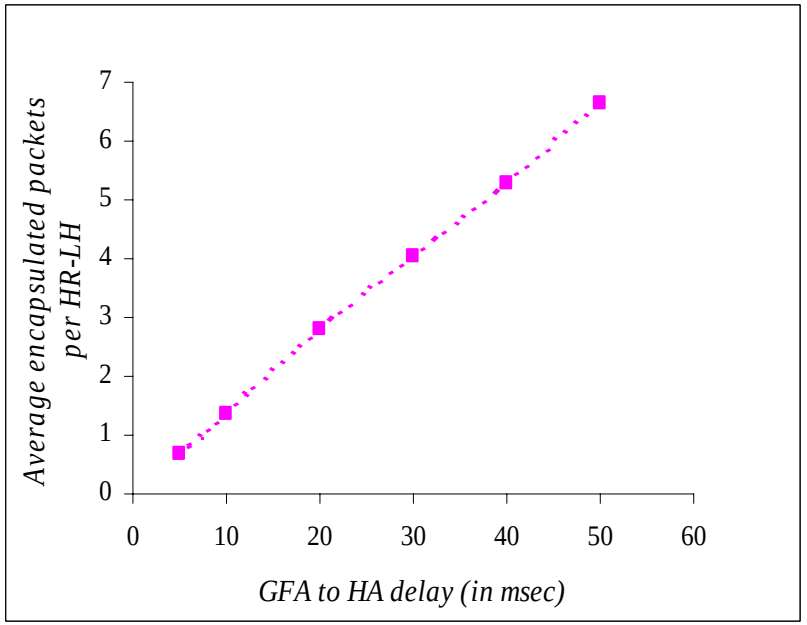


Simulated Network Topology

Performance Evaluation 2/4

UDP Traffic

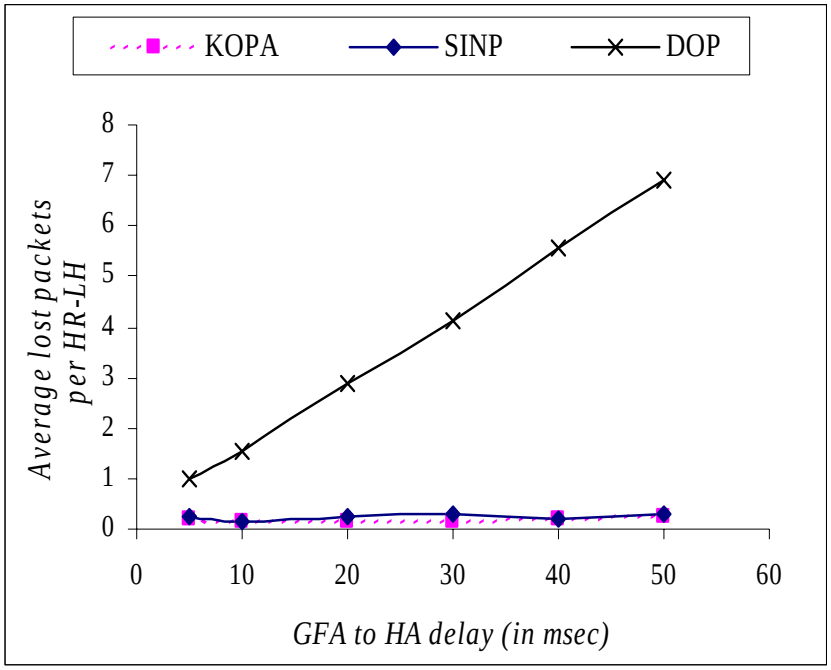


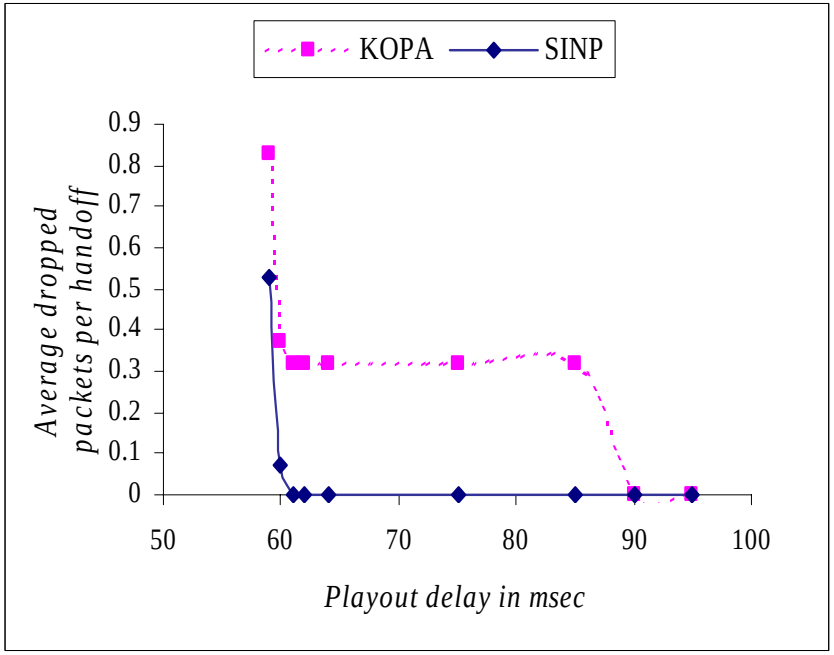


Using the KOPA approach

Performance Evaluation 3/4

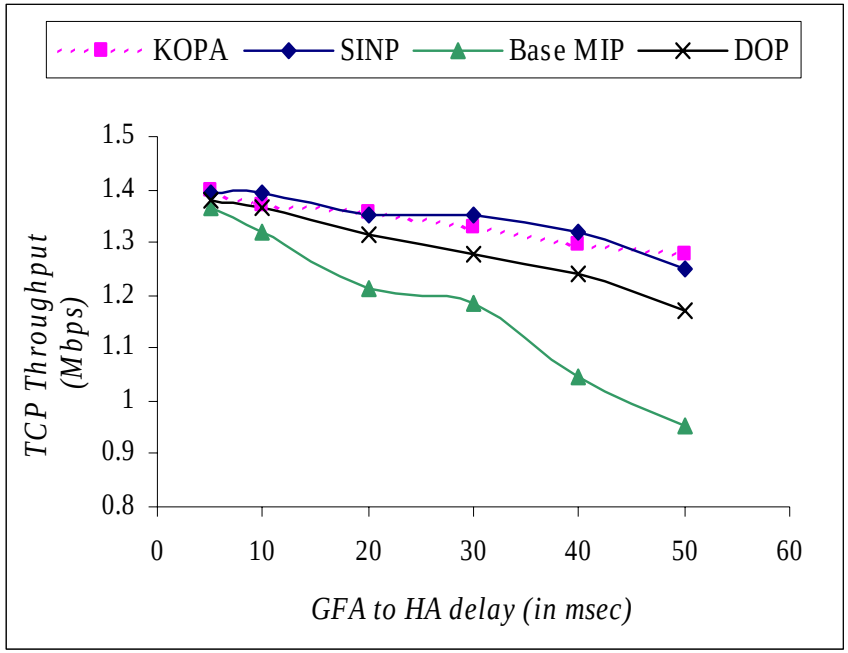
UDP Traffic

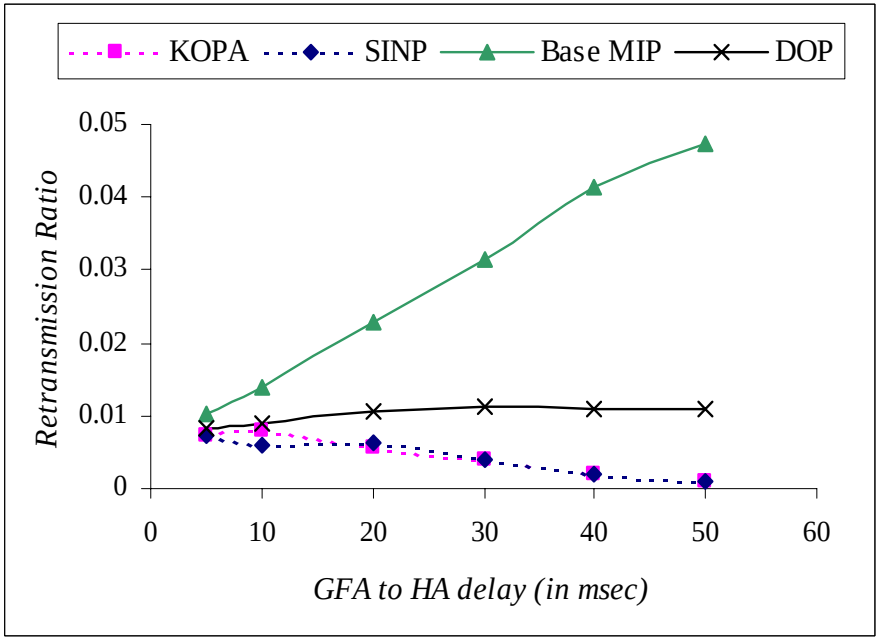




Performance Evaluation 4/4

TCP Traffic





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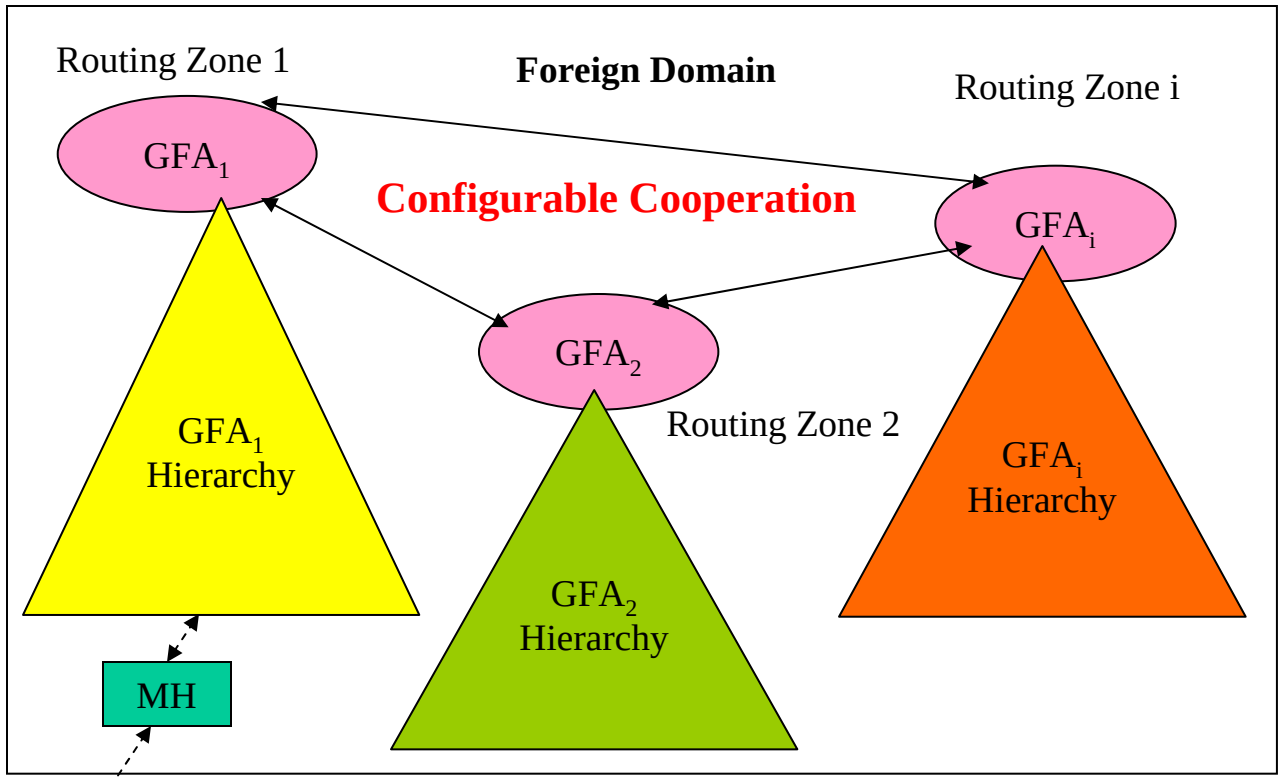
Inter-Hierarchy Handoffs 1/8

- One FA hierarchy in foreign domain is a burden on the GFA. (single point of failure, maintain routing entries for all MHs)
- If multiple FA hierarchies are deployed, no configurable scalable cooperation is envisioned between hierarchies
- Reduce the number of required security associations between FAs in different hierarchies
- Shield the HA from the MH's movement within the foreign domain

Inter-Hierarchy Handoffs 2/8



MH registers GFA_1 as its care-of address.

GFA_1 is termed the MH's HRGFA (Home-registered GFA).

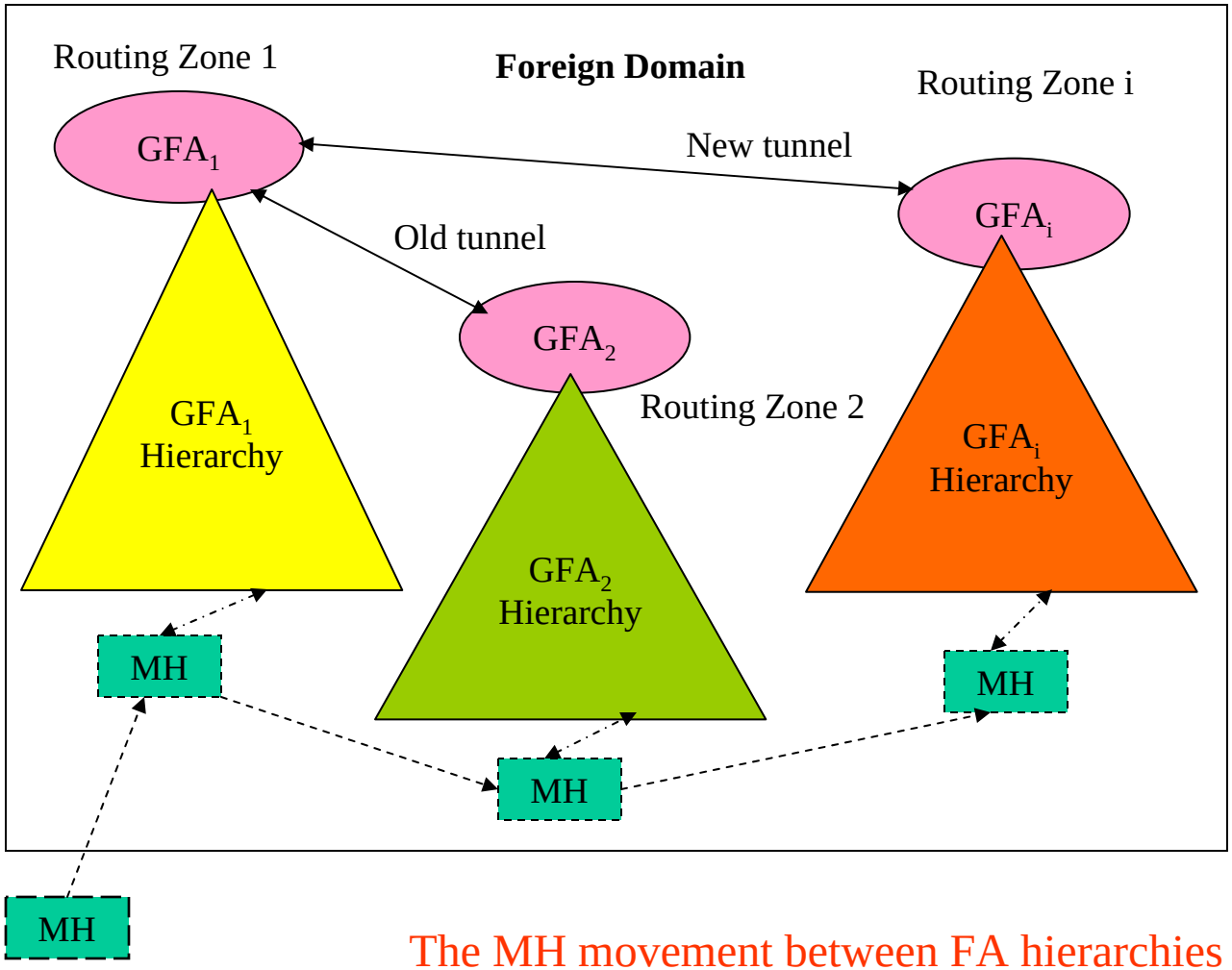
- Partition foreign domain into routing zones
- Each routing zone is an independent FA hierarchy
- FAs advertise their own IP address and the GFA address

Inter-Hierarchy Handoffs 3/8

Configurable Cooperation

- Cooperation is only allowed between the roots of the FA hierarchies (*2 security associations between each pair of GFAs*)
- The FAs advertise two new options in their mobility agent advertisements
  - will this GFA accept cooperation requests from other GFAs?
  - will this GFA send cooperation requests on behalf of the MH?

Inter-Hierarchy Handoffs 4/8



The MH movement between FA hierarchies

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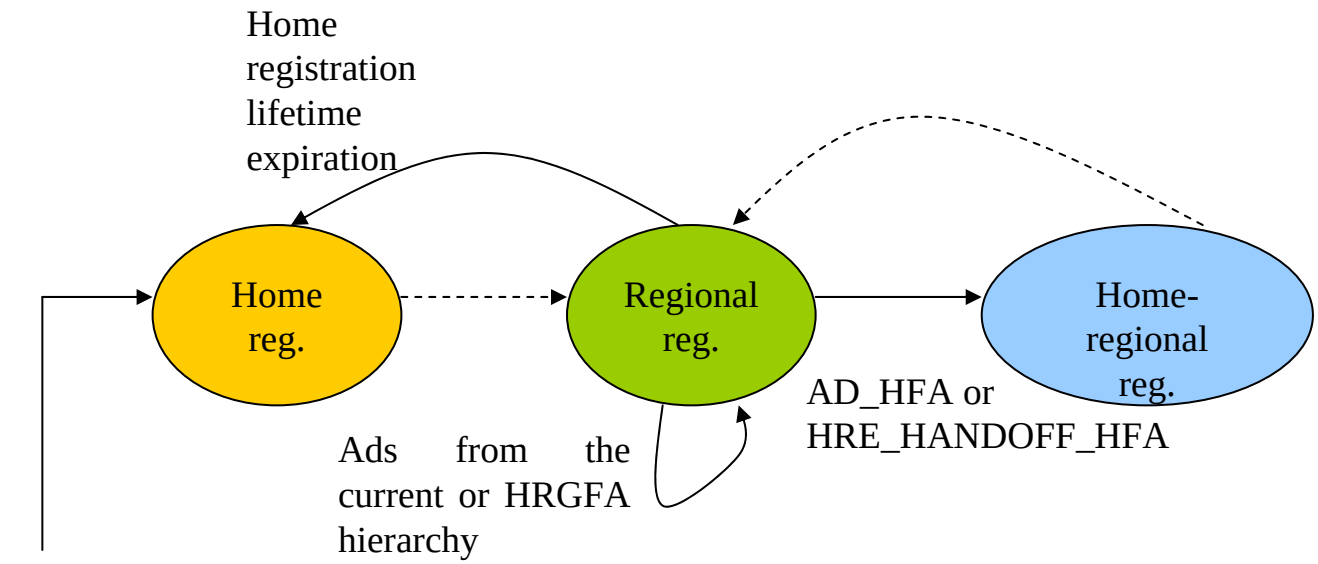
Inter-Hierarchy Handoffs 5/8



reg.: registration

Ads: FA advertisements

AD_HFA: Ads from another FA hierarchy

HRE_HANDOFF_HFA: Home registration lifetime expiration while moving to another hierarchy

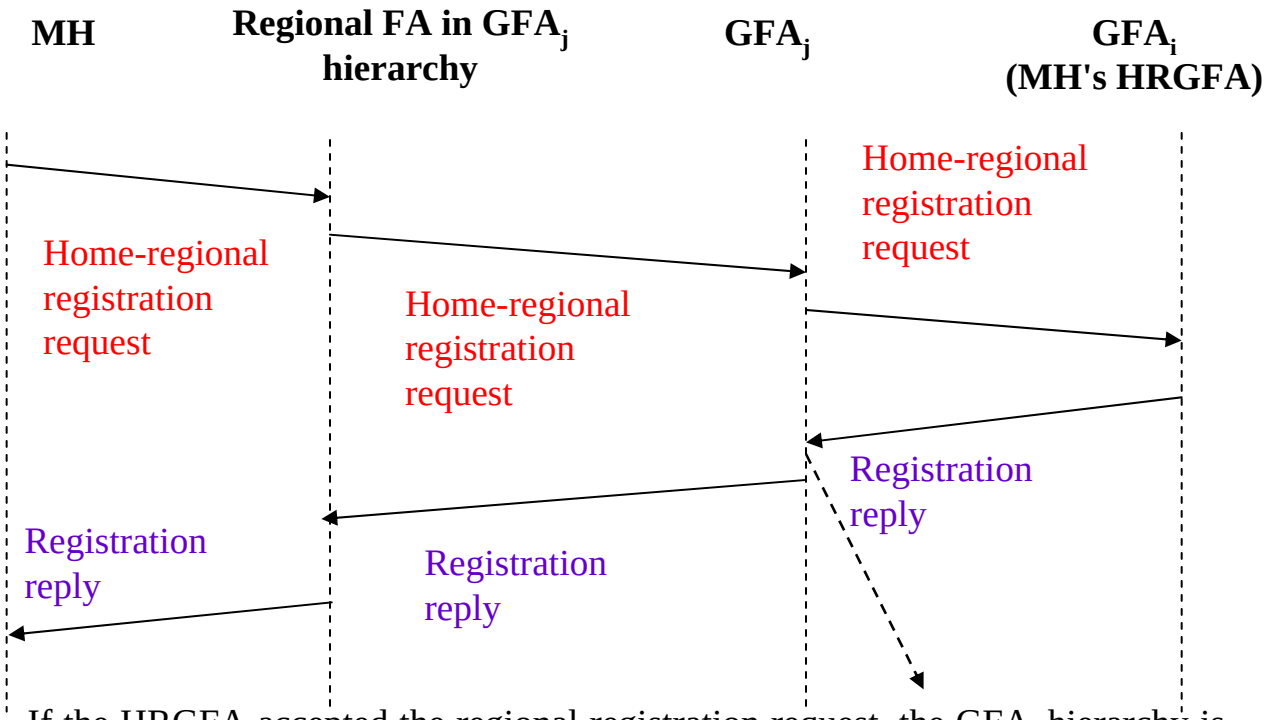
Registration State Diagram

Inter-Hierarchy Handoffs 6/8

Home-regional Registration

- A home registration with a regional data extension
- The current GFA attempts to contact the HRGFA using the information in the regional extension
- If success, the current GFA receives tunneled packets for the MH from the HRGFA
- If the HRGFA does not respond, use the MH's home credentials to perform a home registration on behalf of the MH

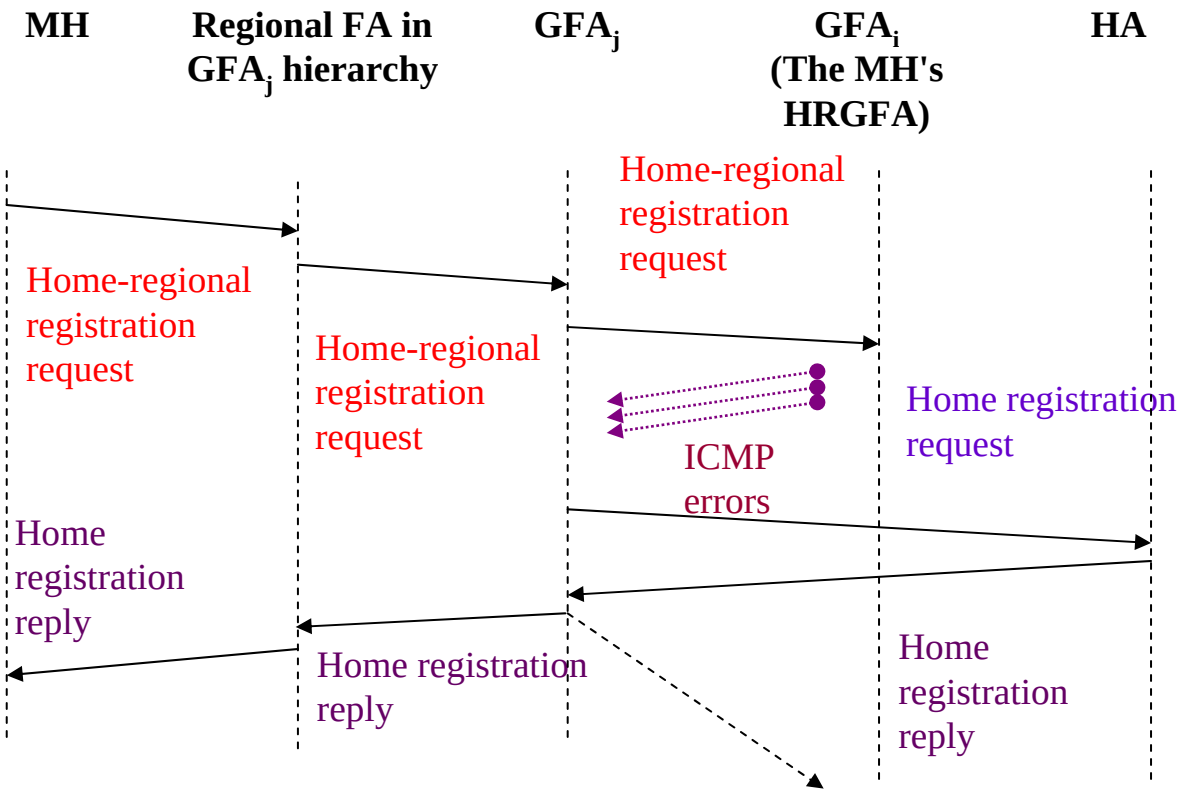
Inter-Hierarchy Handoffs 7/8



If the HRGFA accepted the regional registration request, the GFA$_j$ hierarchy is now able to authenticate any future registration requests by the MH.

The home-regional registration process, in case the HRGFA is reachable.

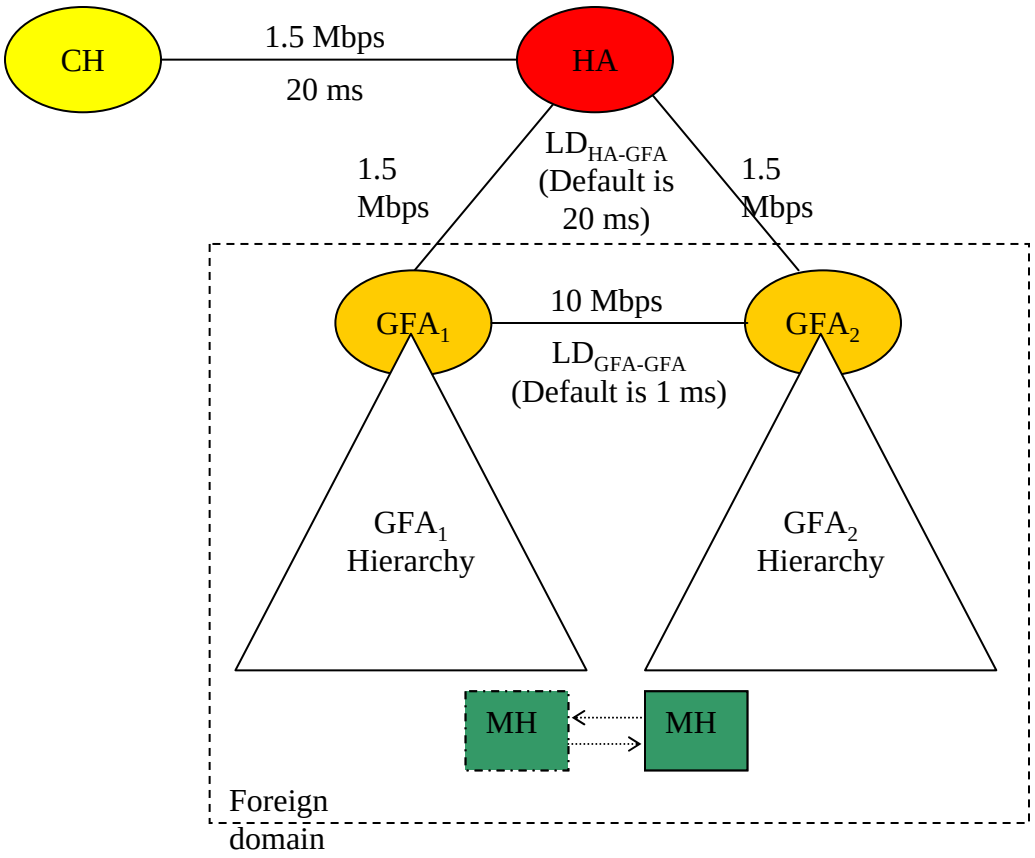
Inter-Hierarchy Handoffs 8/8

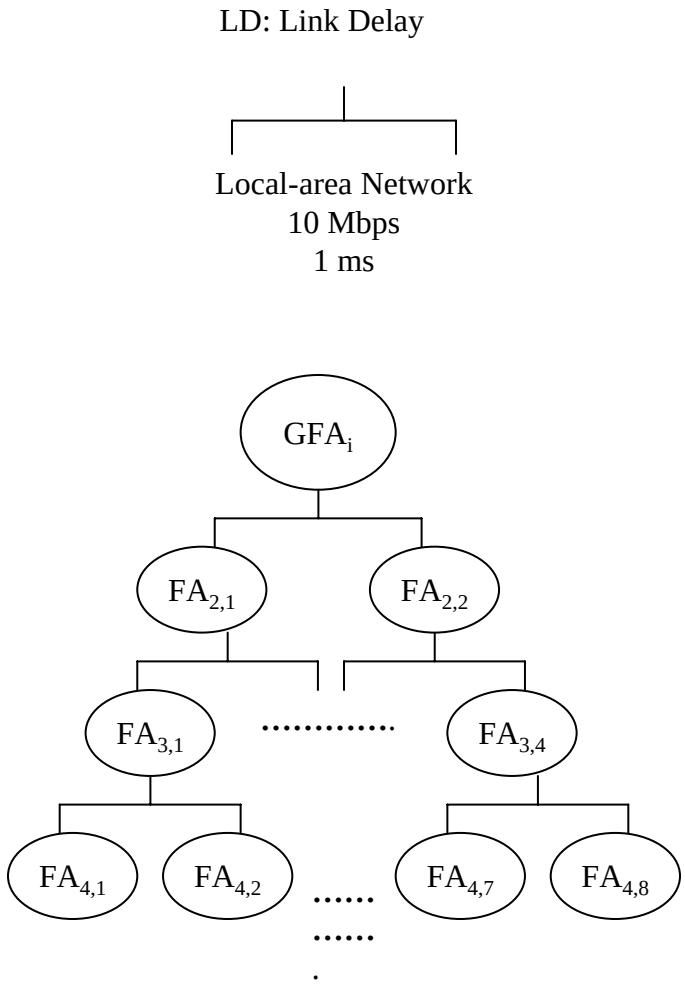


Upon successful registration, the MH's HRGFA is changed within the foreign domain.

The home-regional registration process, in case the HRGFA is not reachable.

Performance Evaluation 1/3

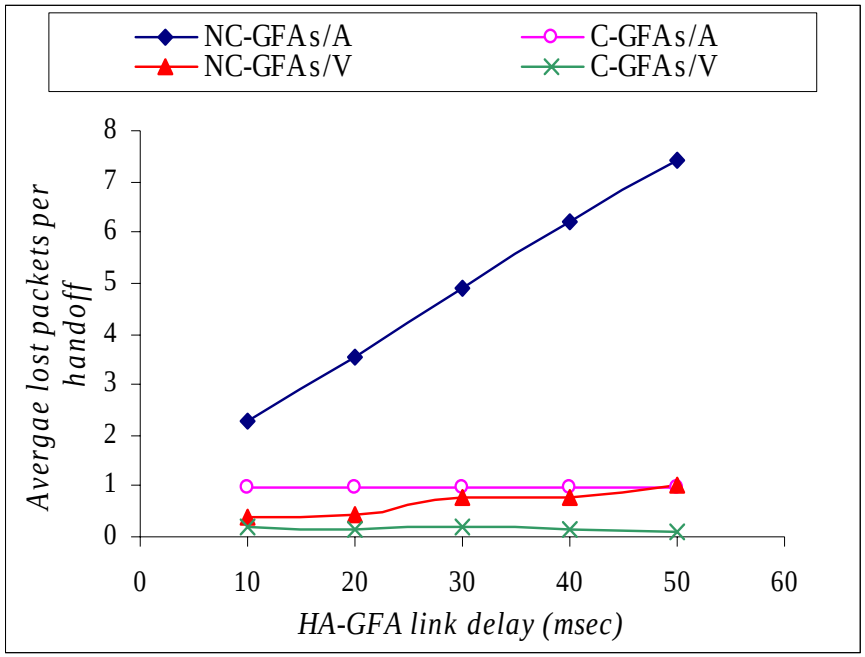


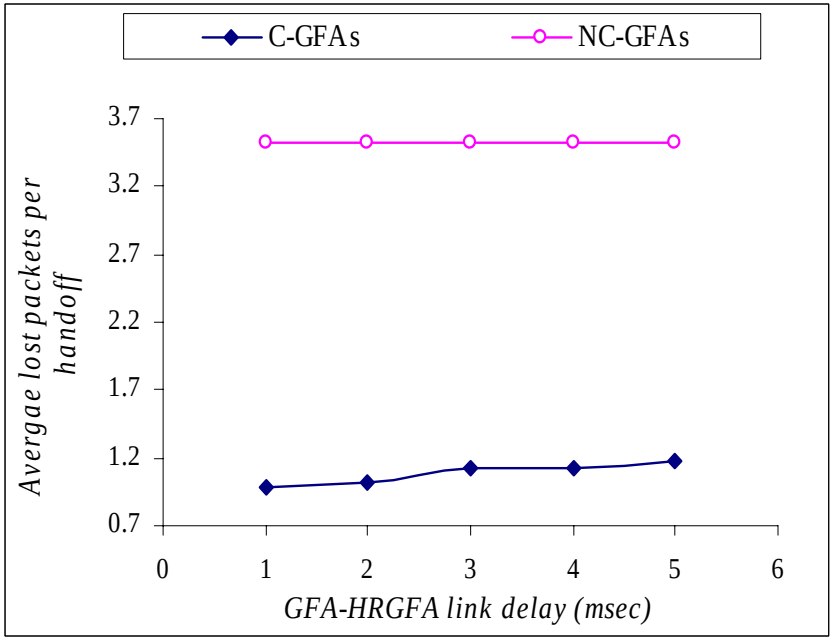


Simulated Network Topology

Performance Evaluation 2/3

UDP Traffic





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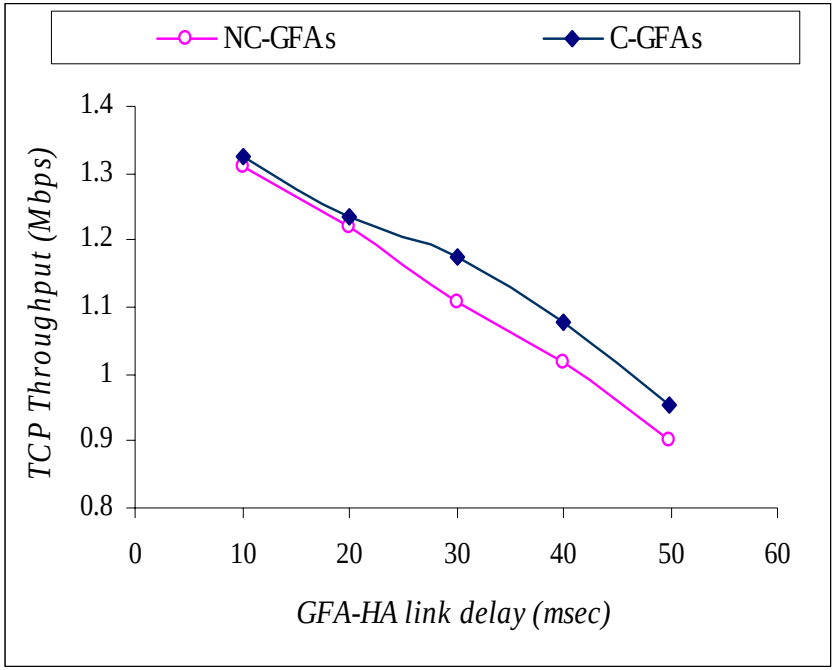
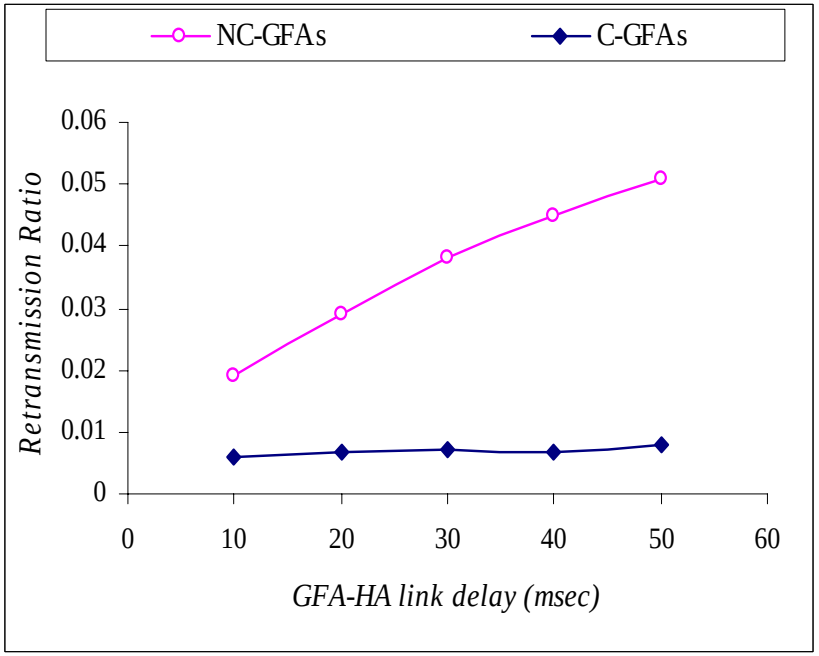
Performance Evaluation 3/3

TCP Traffic





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