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

Outline

- MIPv4 Micro-mobility solutions

Regional Registration Framework (MIP_RR) 1/3

1. Home registration when the MH first enters the foreign domain.
2. Regional registration with a local handoff from FA_2 to FA_3.
3. Home registration involving a local handoff from FA_2 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

Cellular IP 1/2

Cellular IP and Mobile IP

Global Internet with Mobile IP

Wireless access network

Local handoffs

Global mobility

Local handoffs

Wireless access network model
**Cellular IP**

- MH sends paging update packets (routed hop-by-hop towards the GW).
- MH responds with a route-update packet which configures routing caches along the way to the GW.

**HAWAII**

- 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
- 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 updates during power up and after handoffs

**Multicast and Mobility**

- 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

• 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

Spring 2007

Outline

• A cooperating FA hierarchies local-area mobility support framework

Cooperating Foreign Agents Hierarchies

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

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

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

Regional Registrations Framework

- Regional Registration messages (Request/Reply)
- Route Optimization messages (BU/Binding ack.)
**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.

<table>
<thead>
<tr>
<th>Type</th>
<th>Reserved</th>
<th>MH Home Address</th>
<th>New MH Identification</th>
<th>Identification</th>
<th>Extensions</th>
</tr>
</thead>
</table>

**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 2/3**

What lifetime is used for the BU?

\[
BU\text{ lifetime} = \max\{\text{home reg. latency}, \alpha \times \text{remaining reg. lifetime}\}
\]

Where \(0 < \alpha \leq 1\) (we use \(\alpha = 0.5\))

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*.

BU with estimated lifetime, along with new FA IP address information.

Old FA can tunnel buffered or future packets to new FA.
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

- The crossover FA switches the MH tunneling path to the new path before receiving a home registration reply.
- 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](image)

- LD: Link delay
- 1.5 Mbps Link rate
- 10 Mbps Link rate
- 100 Mbps Link rate
- Foreign domain

Performance Evaluation 2/4

![UDP Traffic](image)

- Using the KOPA approach
- Average lost packets per handoff
- Average encapsulated packets per HR-LH
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

- 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 5/8

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 4/8

Foreign Domain

Routing Zone 1

Routing Zone 2

The MH movement between FA hierarchies

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

MH Regional FA in GFA hierarchy GFA i GFA j (MH’s HRGFA)

Home-regional registration request
Registration reply
If the HRGFA accepted the regional registration request, the GFA 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

MH Regional FA in GFA hierarchy GFA i GFA j (The MH’s HRGFA) HA

Home-regional registration request
Registration reply
Home registration reply
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

LD: Link Delay

Performance Evaluation 2/3

UDP Traffic
Performance Evaluation 3/3

TCP Traffic

![Graph 1: TCP Throughput vs. GFA-HA link delay](image1)

- NC-GFAs: 
- C-GFAs: 

![Graph 2: Retransmission Ratio vs. GFA-HA link delay](image2)

- NC-GFAs:
- C-GFAs: