Mobility Management for Networks in Motion

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Handoffs in terrestrial and satellite networks.
Mobile IP
SIGMA
Network in Motion – NEMO
SINEMO – SIgma for NEMO
Handoffs in LEO Satellite Constellations
Handoffs in satellite IP networks

- **Link Layer Handoff**
  - Inter-satellite handoff
  - Link handoff
  - Spotbeam handoff

- **Network Layer Handoff**
  - Satellite as a router
  - Satellite as a mobile host

*A Globalstar design, with 48 active satellites in 8 planes of 6.*
Network Layer Handoff
Case 1: satellite as a router

- Satellites act as IP routing devices.
  - No on-board device generating or consuming data
- Satellites are allocated with different IP prefix.
- FH/MH need to maintain continuous connection with Remote Computer.
Case 2: satellite as a mobile host

- Satellite onboard equipments act as the endpoint of the communication.
- Ground stations are allocated with different IP prefix.
- Satellite need to maintain continuous connection with remote computer.
- When Mobile Host moves to a new domain, a location update is sent to Home Agent.
- Packets from CN to Mobile Host are encapsulated and forwarded to MH’s current care-of address.
- Packets are decapsulated and delivered to upper layer protocol.
Main Drawbacks of base Mobile IP

- Need modification to Internet infrastructure.
- High handoff latency and packet loss rate.
- Inefficient routing path.
- Conflict with network security solutions such as Ingress Filtering and Firewalls.
- Home Agent must reside in MH’s home network, making it hard to duplicate HA to various locations to increase survivability and manageability.
SIGMA: Seamless IP-diversity based Generalized Mobility Architecture
Several NASA projects considering IP in space and Mobile IP

- Global Precipitations Measurement (GPM)
- Operating Missions as Nodes on the Internet (OMNI)
- Communication and Navigation Demonstration on Shuttle (CANDOS)
- NASA currently working with Cisco on developing a Mobile router

Mobile IP may play a major role in various space related NASA projects

- Advanced Aeronautics Transportation Technology (AATT)
- Weather Information Communication (WINCOMM)
- Small Aircraft Transportation Systems (SATS)

Develop an efficient, secure and seamless handoff scheme which would be applicable to both the satellite and wireless/cellular environment.
SIGMA: Objectives

- No need for install new hardware or software component in Internet infrastructure.

- Low handoff latency and packet loss rate.

- Efficient data path
  - Avoid triangular routing.

- Cooperate with existing network security mechanisms.

- Increased survivability, scalability and manageability.

- Suitable for satellite IP handoffs.
SIGMA: Basic concepts

- Decouple location management from handoff
- Carry out location management and handoff in parallel to data transmission
- Allow the layer whose performance is to be optimized to take responsibility of the handoff

Implementation:
- Multihoming to achieve simultaneous communication with multiple access points.
- Stream Control Transmission Protocol (RFC 2960).
Mobile IP assumes the upper layer protocol use only one IP address to identify a logical connection. Some buffering or re-routing should be done at the router for seamless handover.

SCTP support multiple IP addresses at transport layer naturally via multi-homing feature. When mobile host moving between cells, it can set up a new path to communicate with the remote computer while still maintaining the old path.

Advantages of SIGMA:
- Reduced packet loss and handover latency
- Increased throughput
- No special requirement on Router and Access networks.
Signaling
1. Satellite obtain a new IP address in new domain.

2. Satellite notify remote computer about the new IP address.

3. Satellite let remote computer set primary address to new IP address.

4. Update Location Manager.

5. Delete or deactivate old IP address.
SIGMA: Data Transfer Path

Satellite

Ground Station A

Ground Station B

IP Router A

IP Router B

Internet

Location Manager

CN

Packets sent to old path

New/Retransmitted Packs
Vertical Handoff
Different access network technologies are integrating with each other to give mobile user a transparent view of Internet.

Handover is no longer only limited to between two subnets in WLAN or between two cells in cellular network (horizontal handover).

Mobile users are expecting seamless handover between different access networks (vertical handover).

The mobility based on SCTP multi-homing is a feasible approach to meet the requirement of vertical handover.
Results
SIGMA: Preliminary Results

SCTP Handover Throughput

Throughput (Byte)

Time (Second)
Network Mobility
Why NEMO?

- Moving vehicles and satellites may contain several IP enabled devices
  - Ex: computers, data collecting equipments, PDAs, observing equipment
- Each mobile device can individually manage its mobility using MIPv6
  - Requires lot of signaling messages over the precious wireless link
- Could this mobility be managed in an aggregated way?
NEtwork MObility (NEMO)

Mobile network: A group of nodes moving together as a unit under a particular network.

Mobile router (MR) provides gateway to the mobile network.

Three types of nodes in the network:
1. Local Fixed Node (LFN)
2. Visiting Mobile Node (VMN)
3. Personal Area Network (PAN)
Home agent (HA_MR) keeps track of the mobile network.

At home network (access point 1), MR registers with HA_MR to get home addresses and some delegated prefixes to advertise in the mobile network.

At access point 2 the MR registers a new Care of Address (CoA).

MR sends a binding update with the CoA to the HA_MR.
   - HA_MR knows the location of the MR.

Same registration procedure has to be completed by the VMN and MR1 with their respective home agents when they move into the mobile network.
When a host sends a packet to a LFN, HA Intercepts it

- HA tunnels the packet to the MR
- MR delivers the packet to the LFN
- Packets from LFN to CN follow the same path reversed
NEMO: Routing for Visiting Mobile Node

- VMN registers its CoA (address of MR) with its own home agent (HA_VMN) when it enters the Mobile network.
- Fixed host sends a packet to the VMN which is intercepted by the HA_VMN.
- HA_VMN tunnels the packet to the address of the MR which in turn is intercepted by the HA_MR.
- HA_MR tunnels the packet to the MR.
- MR delivers the packet to the VMN.
- Routing for the hosts in the PAN is also done in the same way.
Limitations of NEMO BSP

- Inefficient routing specially in case of nesting and visiting mobile nodes
- Header overhead due to tunneling encapsulation
- Other drawbacks of MIPv6 are inherited by NEMO BSP
SINEMO - Sigma for NEMO
- **Seamless IP-diversity based NEtwork MObility.**
  - Uses IP-diversity to hand over between subnets.

- **SINEMO is an extension of SIGMA (Seamless IP-diversity based Generalized Mobility Architecture).**
  - Underlying transport protocol has to support IP diversity.
- MR acts as a gateway, acquires IP prefix from the access points.
- Each host inside the MN has both public and private IP addresses. MR keeps a mapping between public and private IPs.
- Network Address Translation (NAT) at MR.
- Hierarchical Location Manager is used.
MR only updates the Central DNS when subnet is changed.

**CN** queries **Central DNS** to get the IP address of **MH**.

Central DNS redirects the query to **Local DNS** and local DNS replies with the IP address of **MH**.
## Comparison between NEMO BSP and SINEMO

<table>
<thead>
<tr>
<th>Features</th>
<th>NEMO BSP</th>
<th>SINEMO</th>
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</thead>
<tbody>
<tr>
<td>Signaling</td>
<td>Low</td>
<td>Slightly higher than NEMO BSP</td>
</tr>
<tr>
<td>Routing</td>
<td>Not very efficient</td>
<td>Efficient</td>
</tr>
<tr>
<td>Handover Packet Loss</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Deployment</td>
<td>Needs modification in Internet Infrastructure</td>
<td>Less modification is needed</td>
</tr>
<tr>
<td>Space Network Suitability</td>
<td>Suitable</td>
<td>Suitable</td>
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Results

Signaling cost vs. number of MH for different residence time.

Signaling cost of SINEMO is lower than BSP due to the fact that the LLM update does not incur any data transmission cost.
- NEMO BSP → Lot of signaling for nested mobility
- SINEMO → IP diversity based end to end mobility management with local location management
- SINEMO avoids packet encapsulation and uses optimal route
- Signaling cost of SINEMO is lower than NEMO BSP
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