SIGMA: An End-to-End Mobility Management Scheme for Space Networks

Presentation at

Fifth Space Internetworking Workshop
September 12-13, 2006, Baltimore, MD.

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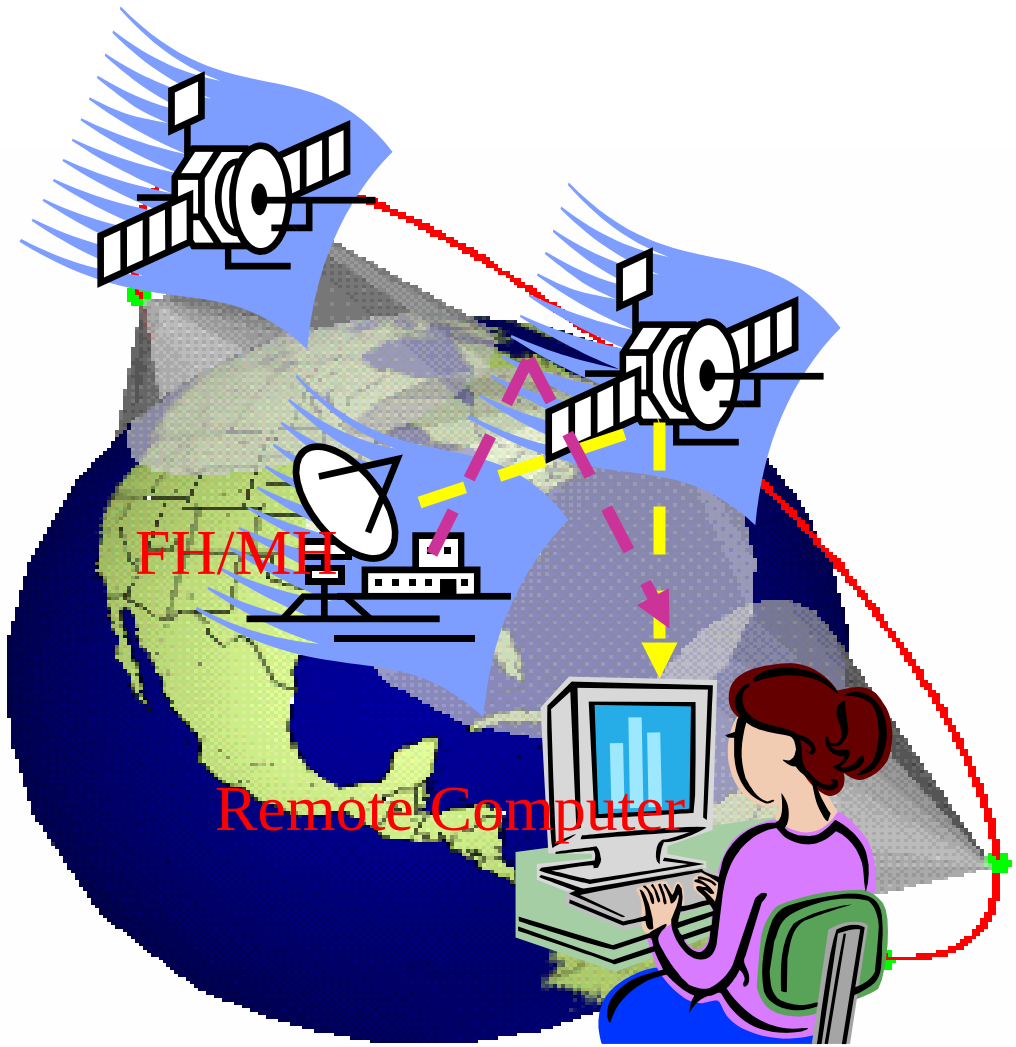
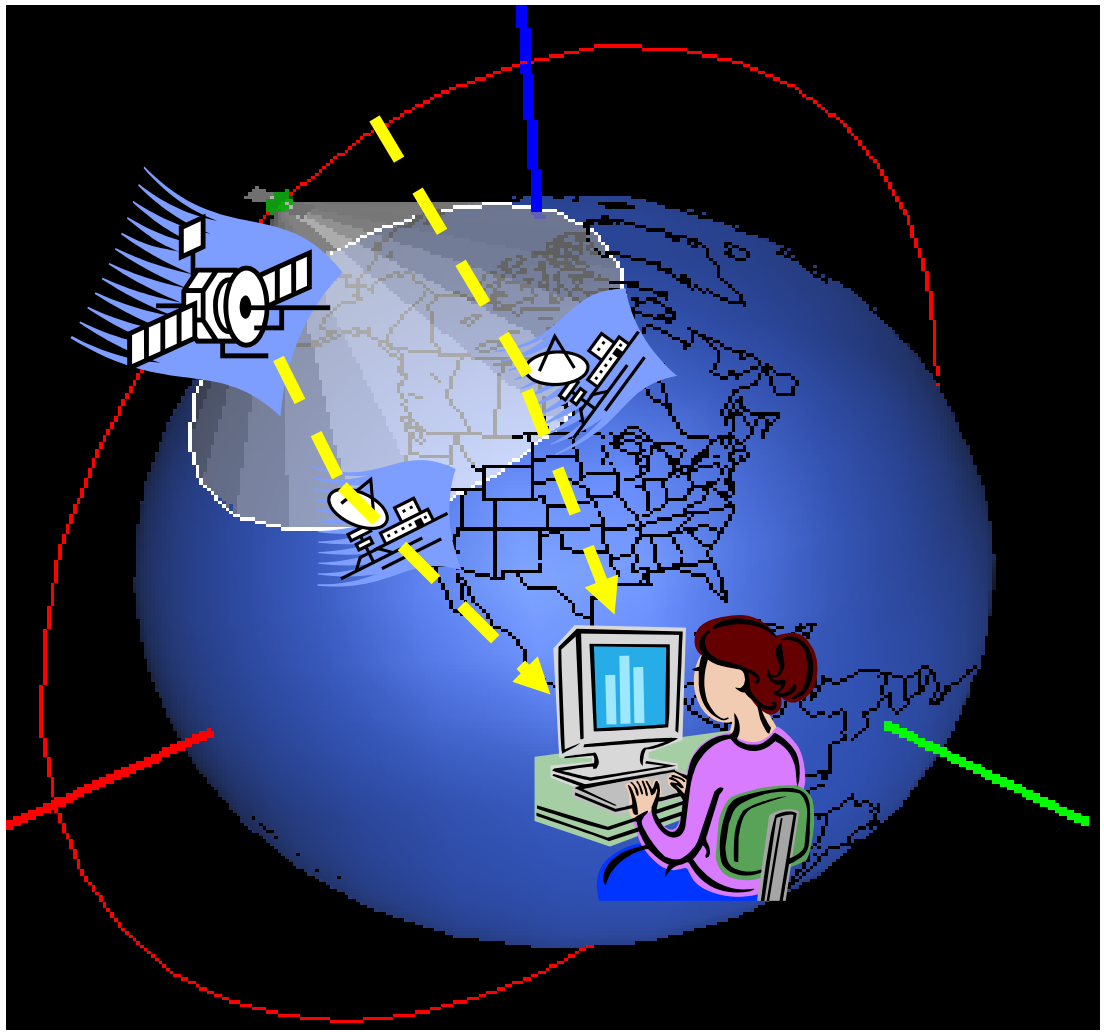
Network Layer Handoff
Case 1: satellite as a router

- 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.



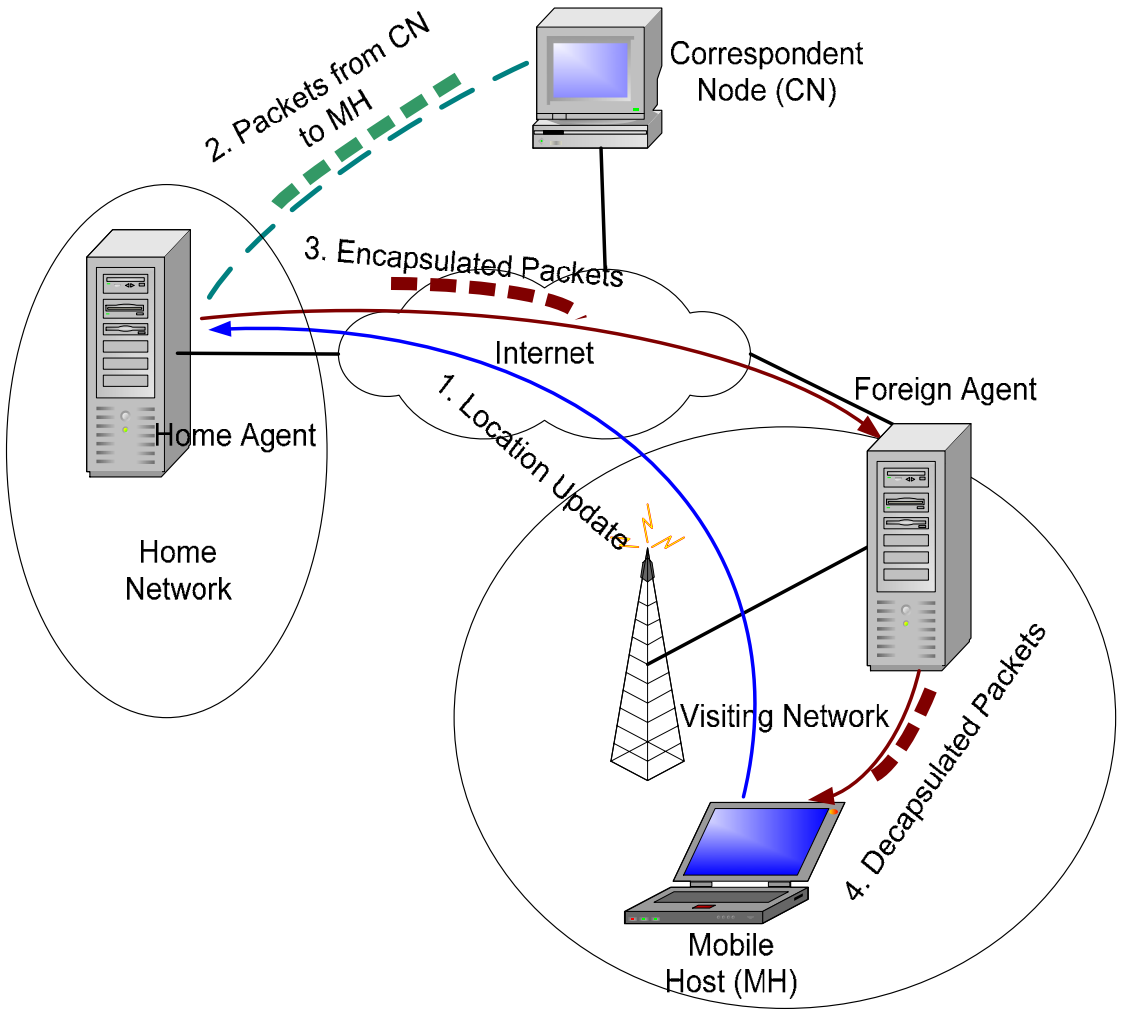
Network Layer Handoff
Case 2: satellite as a mobile host

- 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.



Mobile IP: Enabling IP host mobility

- 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: A Seamless IP-diversity based Generalized Mobility Architecture

SIGMA: Motivation

- Several NASA projects considered 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)
  - VMOC demonstration

Develop an efficient, secure and seamless handoff scheme which would be suitable for both satellite and terrestrial environment.

SIGMA: Objectives

- No new hardware or software component in Internet infrastructure.
- Low handoff latency and packet loss rate.
- Efficient data path
- Cooperate with existing network security mechanisms.
- Increased survivability, scalability and manageability.
- Suitable for satellite IP handoffs.

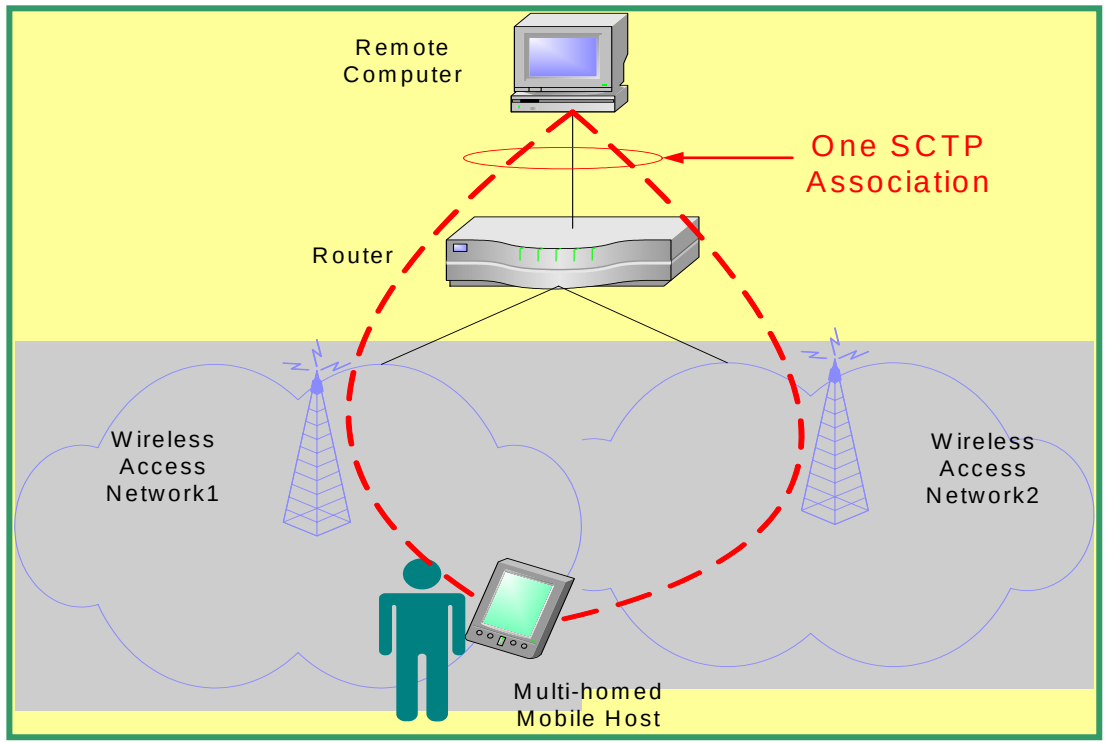
SIGMA: Basic concepts

- Decouple location management from handoff
- 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).

Decouple location management from handoff and
IP-diversity for seamless handoff

SIGMA: Basic concepts (2)

- 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 setup 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.

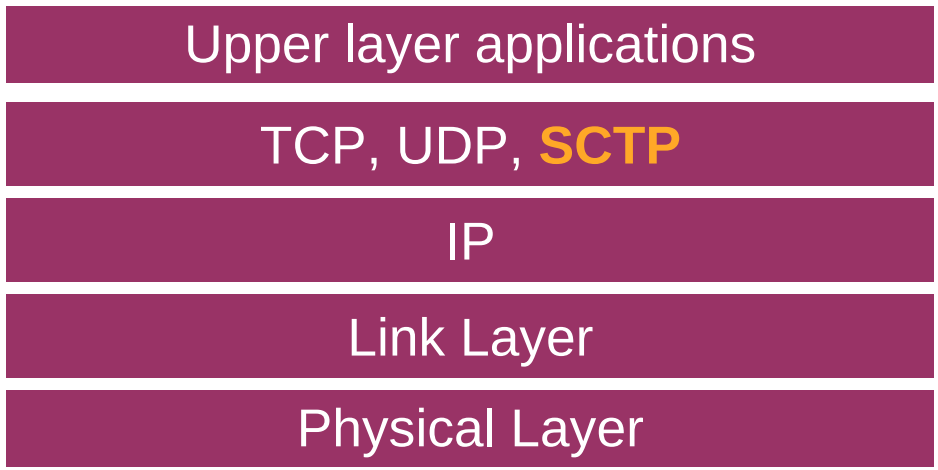
SCTP: A new Transport Protocol for Internet

What is SCTP?

- SCTP: "Stream Control Transmission Protocol"
- Originally designed to support SS7 signaling messages over IP networks. Currently supports most of the features of TCP
- Standardized by IETF RFC 2960
- Reliable transport protocol on top of IP

TCP and SCTP compared

- Both of them are reliable transport protocols;
- Similar Congestion Control algorithms (slow start, congestion avoidance);
- SCTP has two new features:
  - Multihoming
  - Multistreaming



Signaling

SIGMA: Signaling Procedures

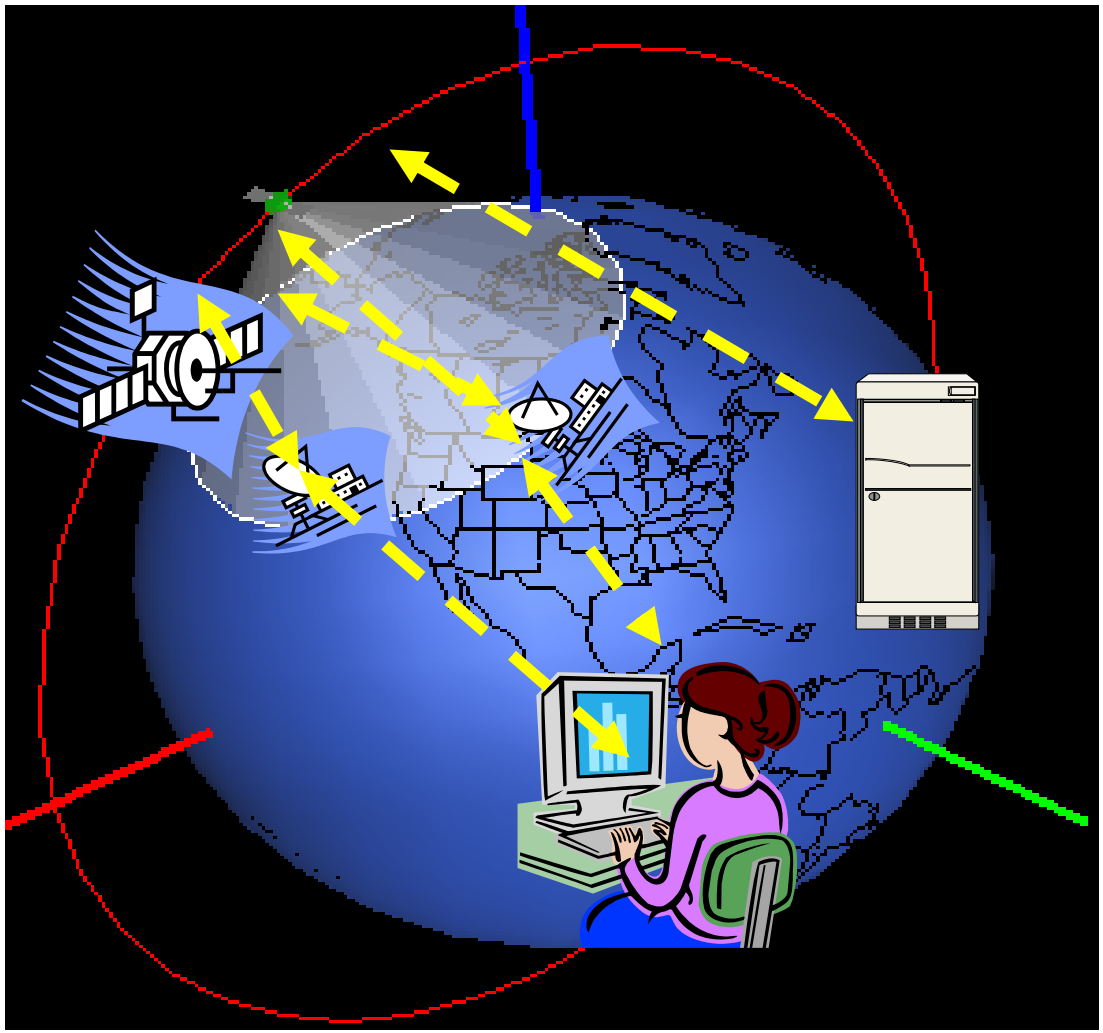
1.Satellite obtain a new IP address in new domain.

2. Satellite notify remote computer about the new IP address

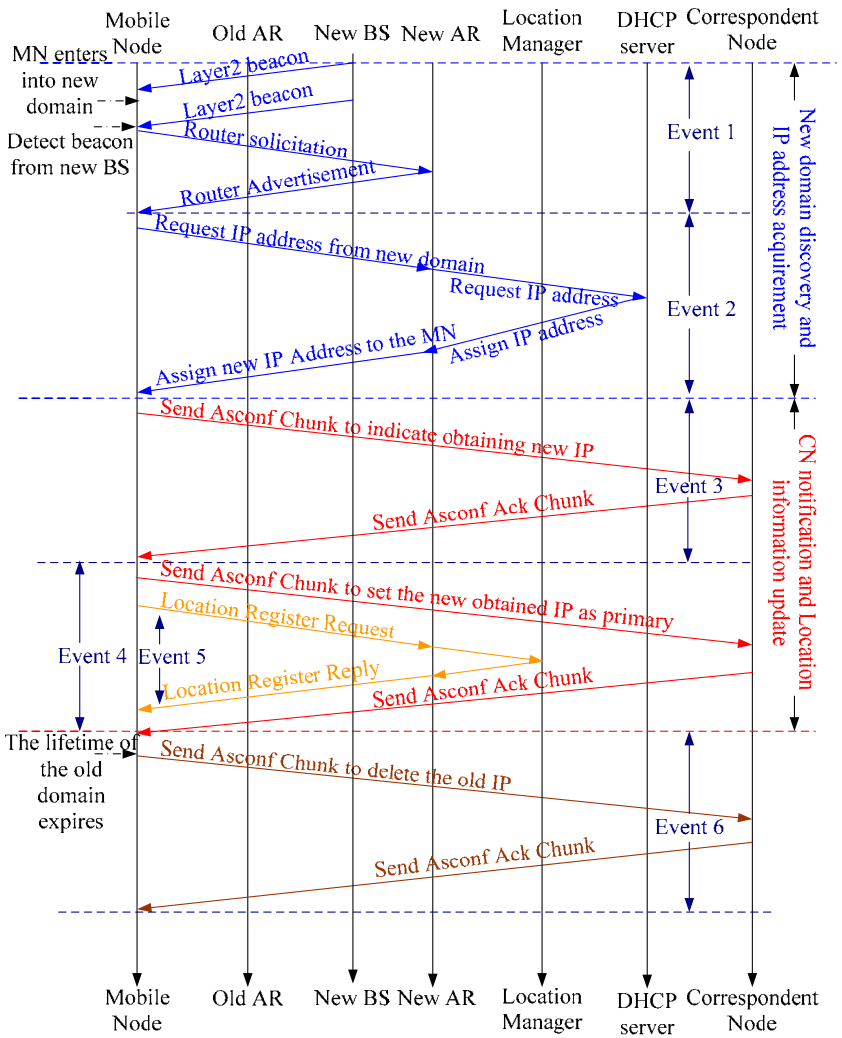
3. Satellite lets remote computer set primary address to new IP address.

4.Update Location Manager.

5. Delete or deactivate old IP address.



SIGMA: Timing Diagram

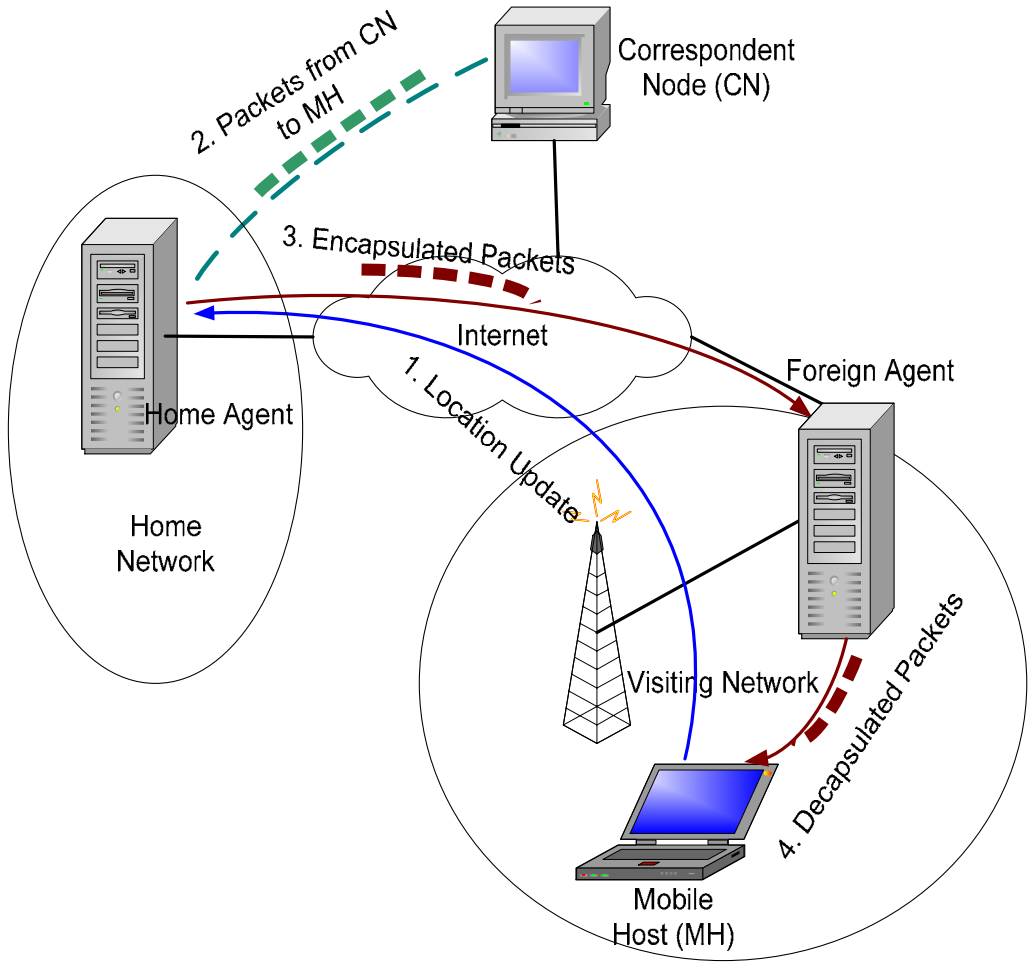


Timeline for SCTP based handover in concept

Survivability and Location Management

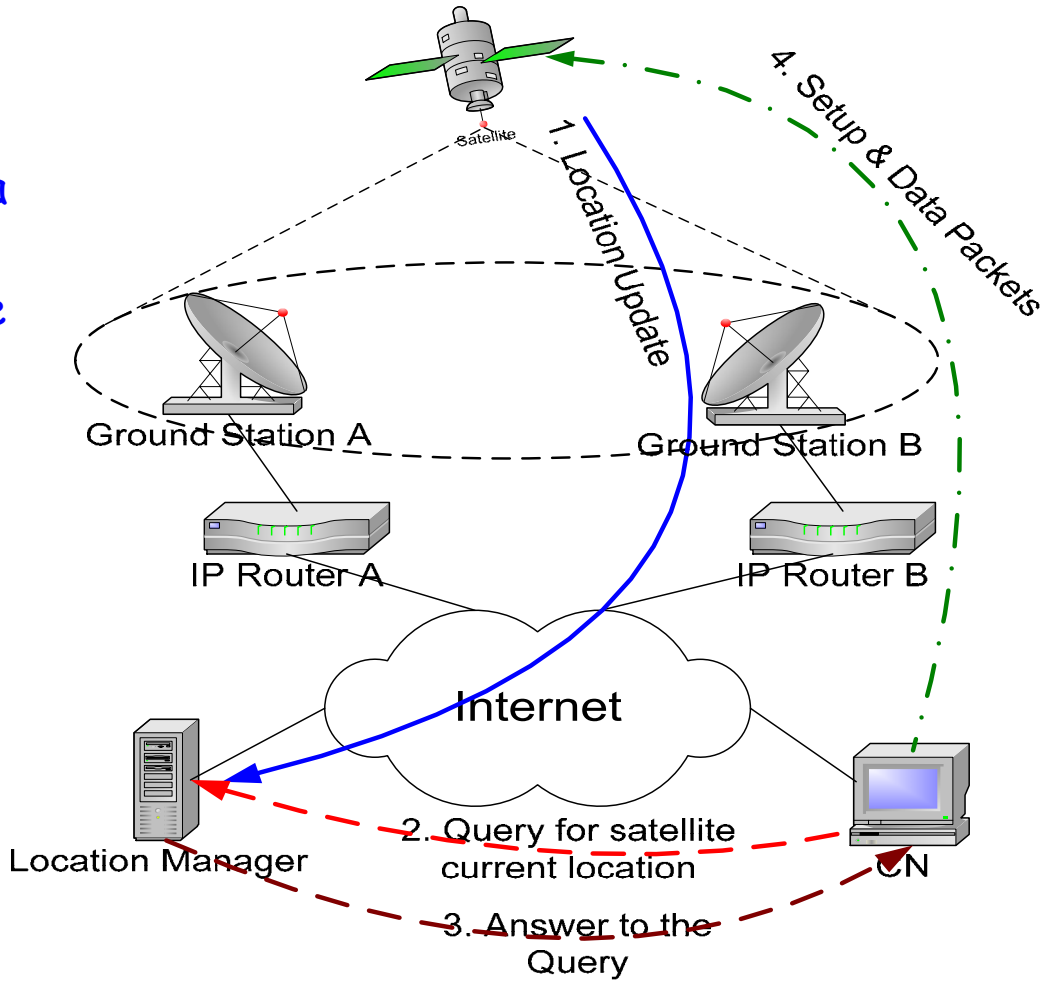
Mobile IP: Survivability due to location management

- In Mobile IP, Home Agent must reside in MH's home network to intercept packets sent from CN to MH.
- In situations where the home network is vulnerable to failure, this becomes a serious problem.
- It is difficult to replicate the Home Agent at various locations distributed throughout the network in order to achieve survivability.



SIGMA: Survivability and Location Management

- Only location update/query needs to be directed to Location Manager (LM). Thus LM need not to be located in a specific network to intercept data packets.
- It is easy to replicate the Location Manager at distributed secure locations to improve survivability.
- LM can further be integrated with DNS server to reduce system complexity.



More Benefits of Centralized Location Management

- Security: Storing user location information into a central secure databases is much more secure than scattering it in various Home Agents located at different sub-networks (in the case of Mobile IP).

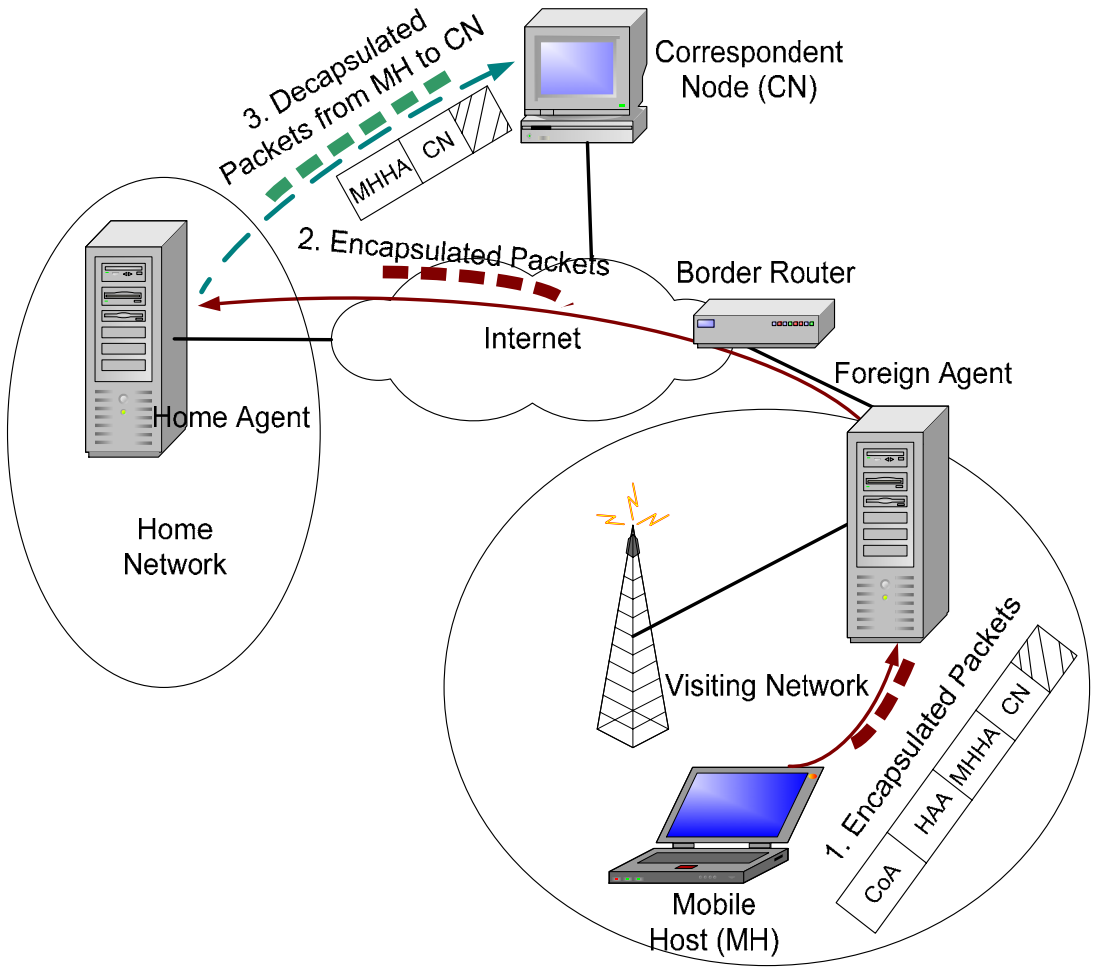
- Scalability: Location servers do not intervene into data forwarding task, which adapts to the growth in the number of mobile users gracefully.

- Manageability: Centralized location management provides a way for an organization/service provider to control user accesses from a single server.

Security

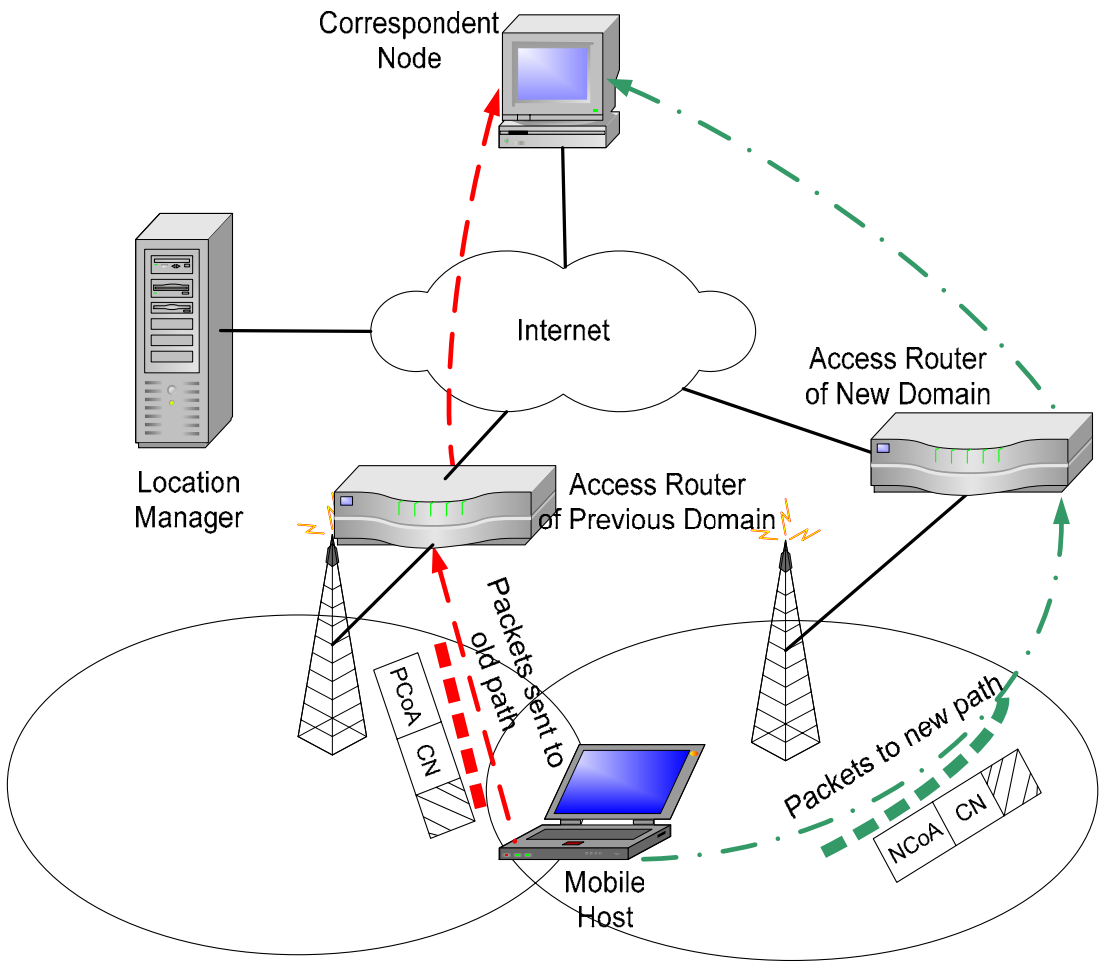
Mobile IP: Interoperability with Ingress Filtering

- Ingress filtering is heavily used in current Internet to prevent IP spoofing and DoS attack.
- Ingress filtering border routers enforce topologically correct source IP address.
- Topological correctness requires MH using COA as the source IP address.
- Applications built over TCP/UDP requires MH always using its home address as source address.
- **Solution: reverse tunneling**



SIGMA: Interoperability with Ingress Filtering

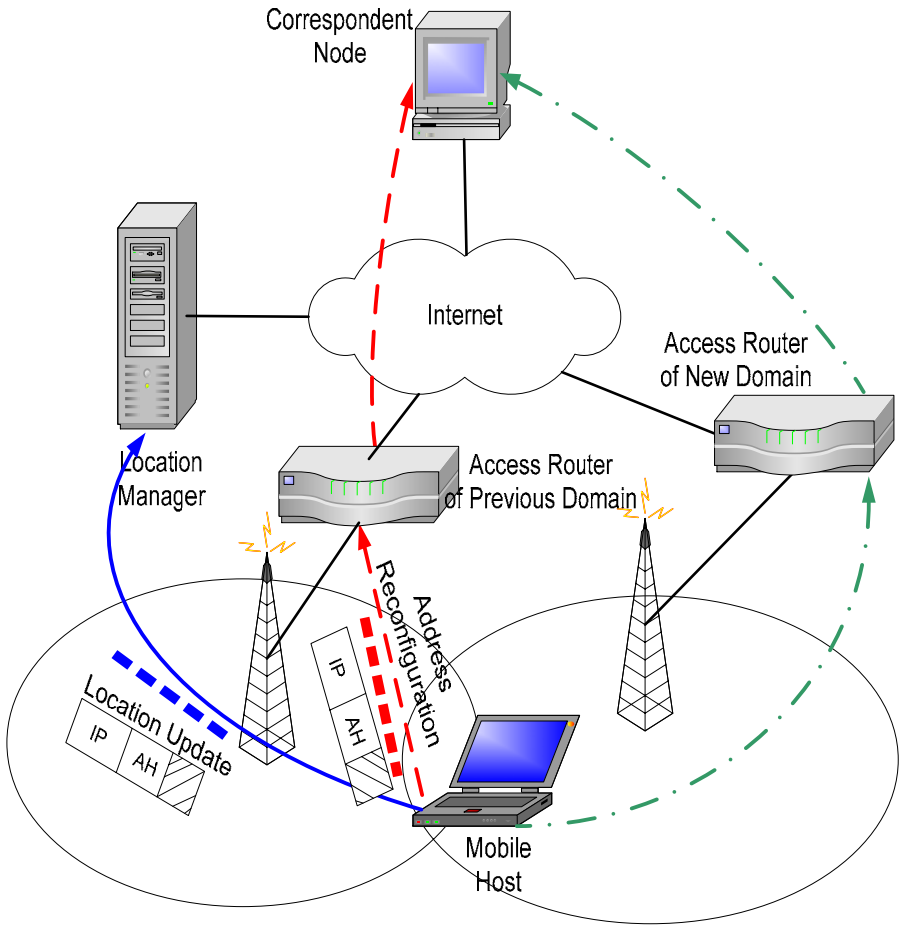
- In SIGMA, MH uses new CoA address directly to communicate with CN, it is already topologically correct.



SIGMA works with ingress filtering without any tunneling

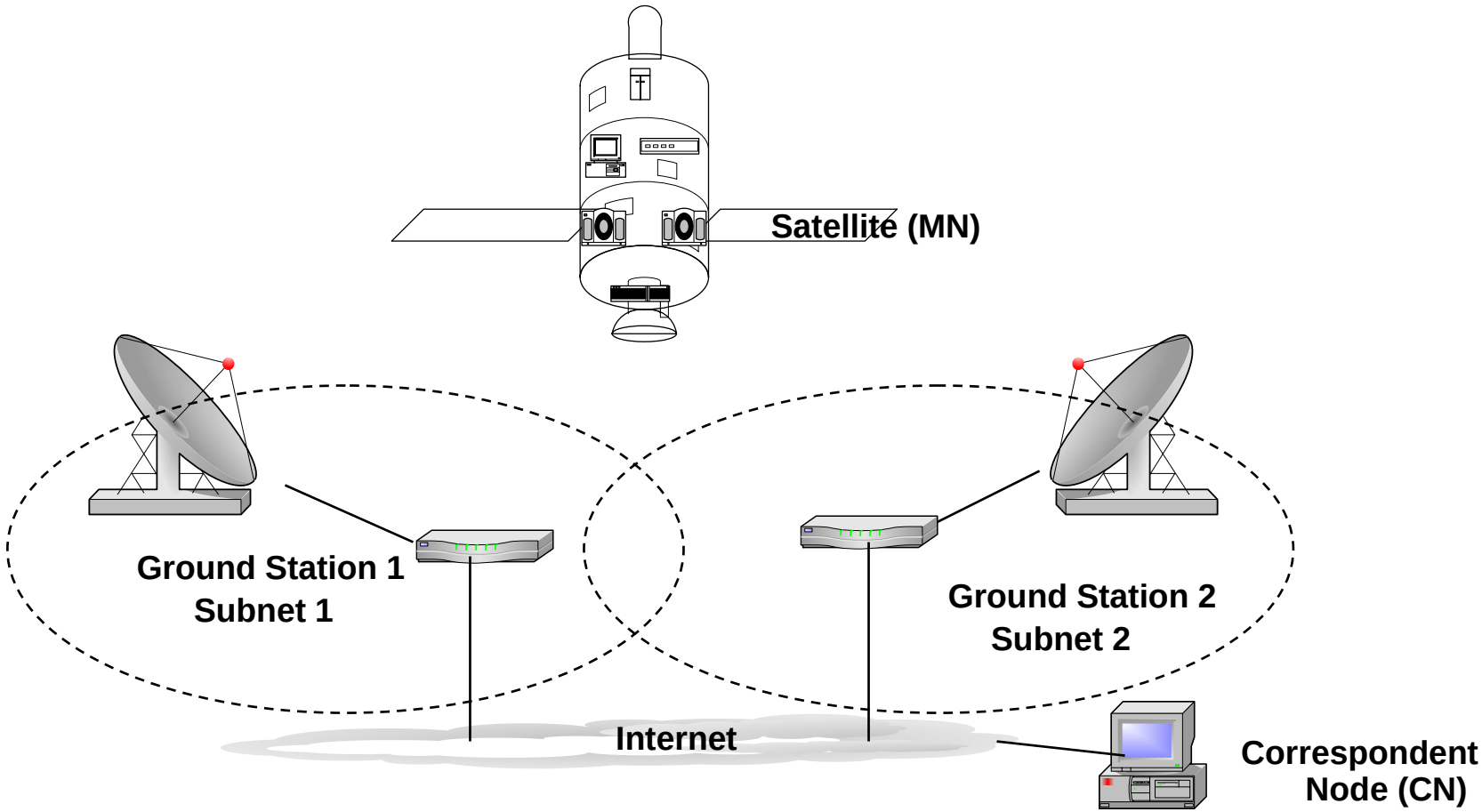
SIGMA: Increasing security by IPSEC

- SIGMA depends on dynamic address reconfiguration, which makes the association more vulnerable to be hi-jacked.
- An attacker can also send an bogus update to location manager, resulting all further association setup messages sent to illegal IP addresses---generally called redirection attack.
- All location update and address reconfiguration messages sent to LM and CN should be protected by IPSEC AH header.

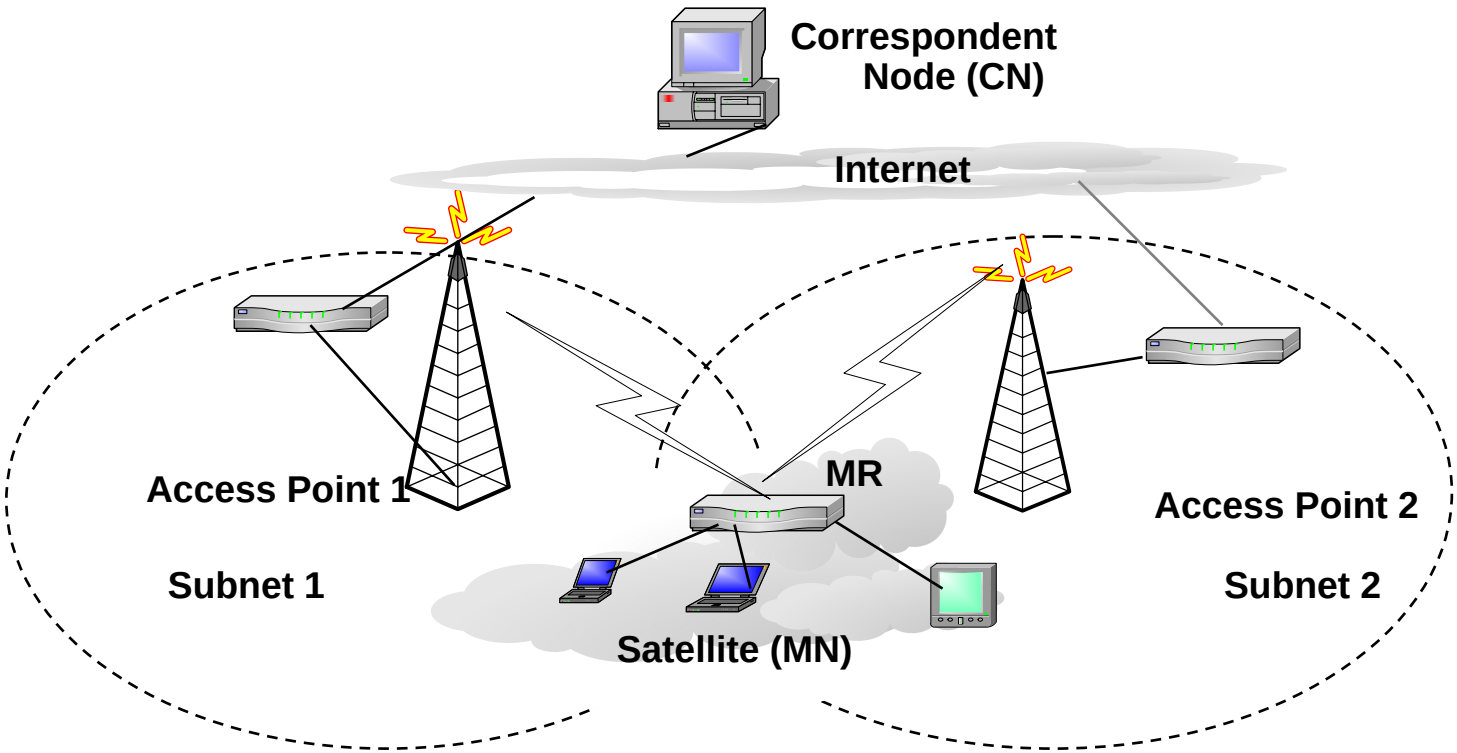


Network Mobility

Testbed for NEMO Protocols

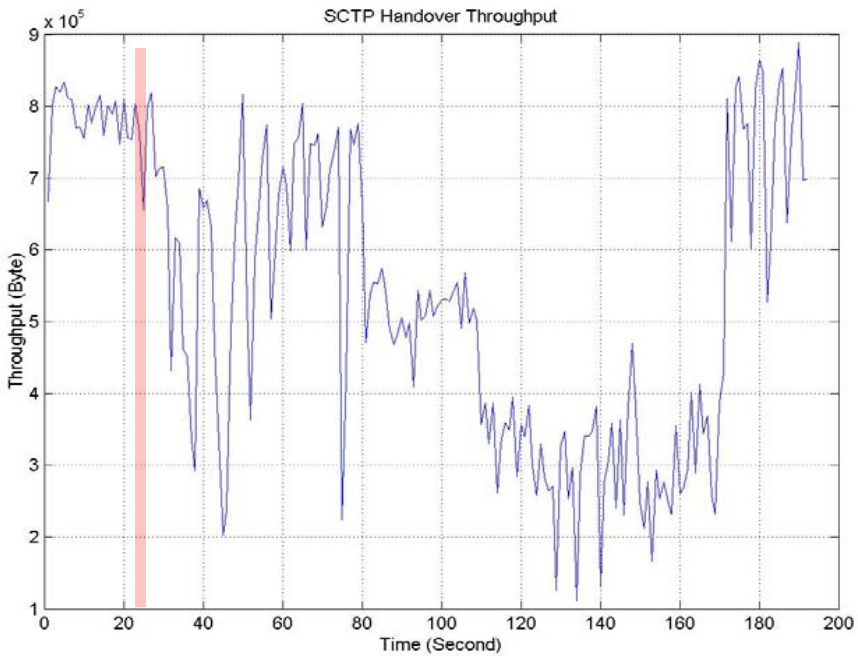


Testbed for NEMO Protocols

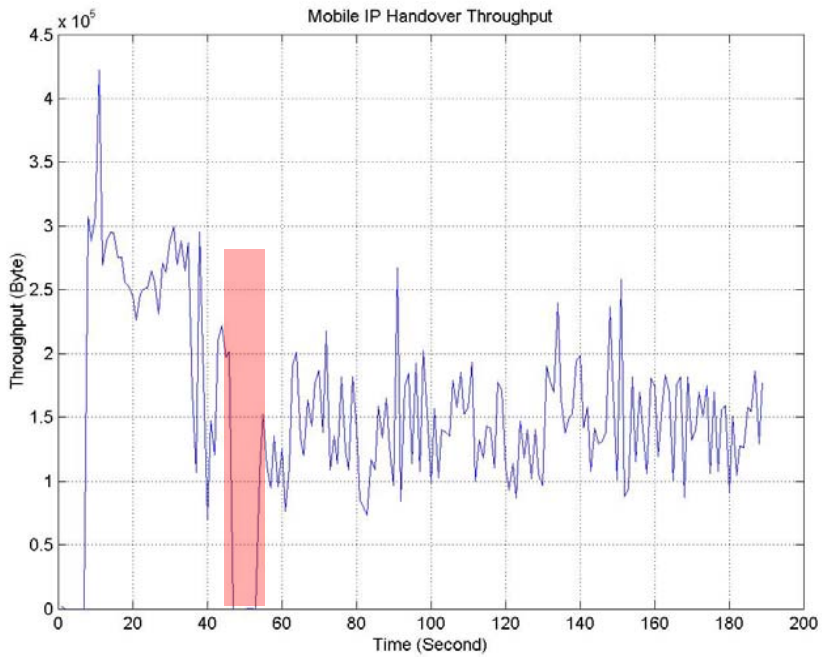


Results

Throughput comparison



SIGMA



Mobile IP

SIGMA achieves seamless handoff with no drop in throughput

Conclusions

Conclusions

- Compared SIGMA and Mobile IP
- Implemented testbeds for comparing Mobile IP and SIGMA
  - Linux based system using open source lk-sctp implementation
- SIGMA has been shown to be suitable for managing satellite handovers

Acknowledgements

- National Aeronautics and Space Administration (NASA)
- The following people are participating/participated in the design, development and testing of SIGMA:
  - Shaojian Fu
  - Yong-Jin Lee
  - Justin Jones
  - Suren Sivagurunathan
  - Abu Sayeem Reaz
  - Pulak Chowdhury
  - William Ivancic

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