ENABLING EFFICIENT AND OPERATIONAL MOBILITY IN LARGE HETEROGENEOUS IP NETWORKS

Optimized FMIPv6 Handover using IEEE802.21 MIH Services

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Information Society Technologies

Outline

- Motivation
- Background
- Mobile IPv6 Handovers
- Fast Handover Mobile IPv6 (FMIPv6) Issues
- IEEE802.21 Media Independent Handover (MIH) Framework
- Proposed Mechanism
- Discussion

Motivation

- To use IEEE802.21 MIH services to optimize the Fast Handovers for Mobile IPv6 (FMIPv6) procedure
- To address issues that are critical to the FMIPv6 handover performance, such as
  - radio access discovery
  - candidate access router discovery
- To increase the probability of a predictive mode of operation in FMIPv6
- To reduce the overall expected handover latency in FMIPv6

Background

- Seamless mobility support across heterogeneous access networks (WiFi, WiMAX, Cellular) is requisite in 4G Communications
- Handover performance control is vital for QoS provisioning of real time services across heterogeneous networks
- Handover events involves actions at network layer (IP) and lower layers (link layer)
- Mobile IPv6 (MIPv6) and its extension protocols such as Fast Handovers for MIPv6 (FMIPv6) are designed to tackle such issues

Mobile IP Handovers

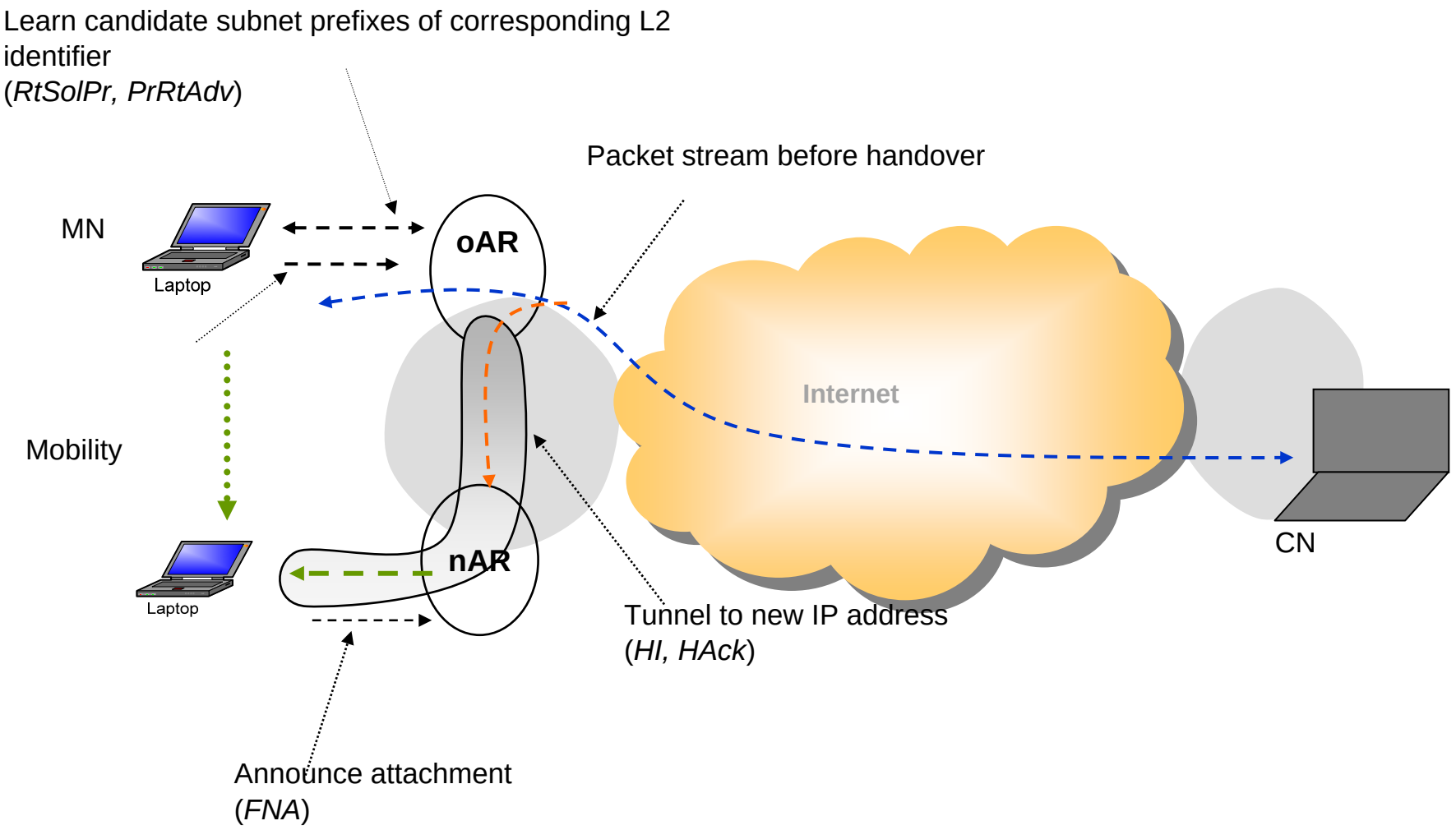
- Slow, because of the delays caused by
  - IP layer movement detection by listening to router advertisements
  - New IP address configuration (by DHCP or IPv6 address auto-configuration)
  - Sending Binding Update to Home Agent
- Doing these after the handover is initiated will cause considerable delays for IP-layer connectivity
  - Intolerable packet loss & delay during handover for realtime applications

Fast Handovers for Mobile IPv6 (FMIPv6)

- Basic idea:
  - Anticipate movement with the help of link layer (triggers)
  - Prepare network and mobile host in advance
    - Anticipated handover: pre-configured CoA
    - Initiated by Mobile Nodes, Source/Target Network
  - Bi-directional Tunnel-based Handover: defer to acquire CoA
  - After Layer 2 movement, Layer 3 is ready to serve

- IETF WGs – MIPSHOP
  - RFC4068: Fast Handovers for Mobile IPv6
  - RFC4260: Mobile IPv6 Fast Handovers for 802.11 Networks
  - Mobile IPv6 Fast Handovers for 3G CDMA Networks (draft-ietf-mipshop-3gfh-01.txt)
  - Fast Handovers for Mobile IPv6 (draft-ietf-mipshop-fmipv6-rfc4068bis-00.txt)

FMIPv6 Operational Flow

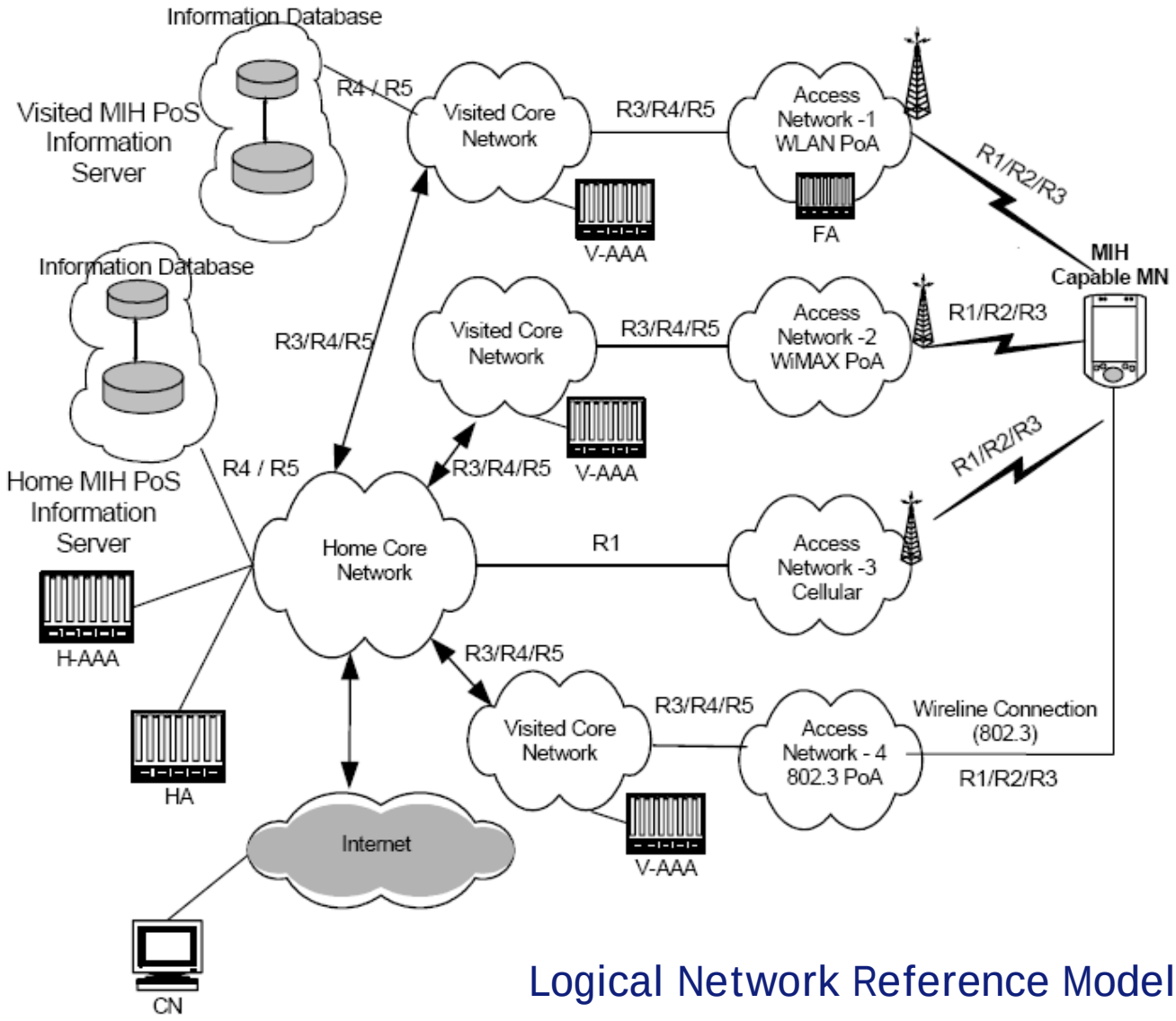


Issues with FMIPv6

- Neighbouring access network discovery
  - FMIPv6 does not address the issue of radio access network discovery
  - MNs have to scan for neighbouring APs, BSs etc
- Information exchange with neighbour ARs
  - How the neighbouring ARs exchange the AP-ID tuple information for the construction of PrRtAdv messages is not specified
- The Cost of Anticipation
  - There is no guarantee that the MN will be connected to the oAR long enough to send and receive all FMIPv6 messages. When anticipation is used, the MN may not have sufficient time to update the oAR with the FBU
- The Ping Pong Movement
  - Due to the dynamic nature of the overlapping cells, the MN may ping-pong between cells.
  - Hence, there could be premature forwarding of data by the oAR which could be harmful.

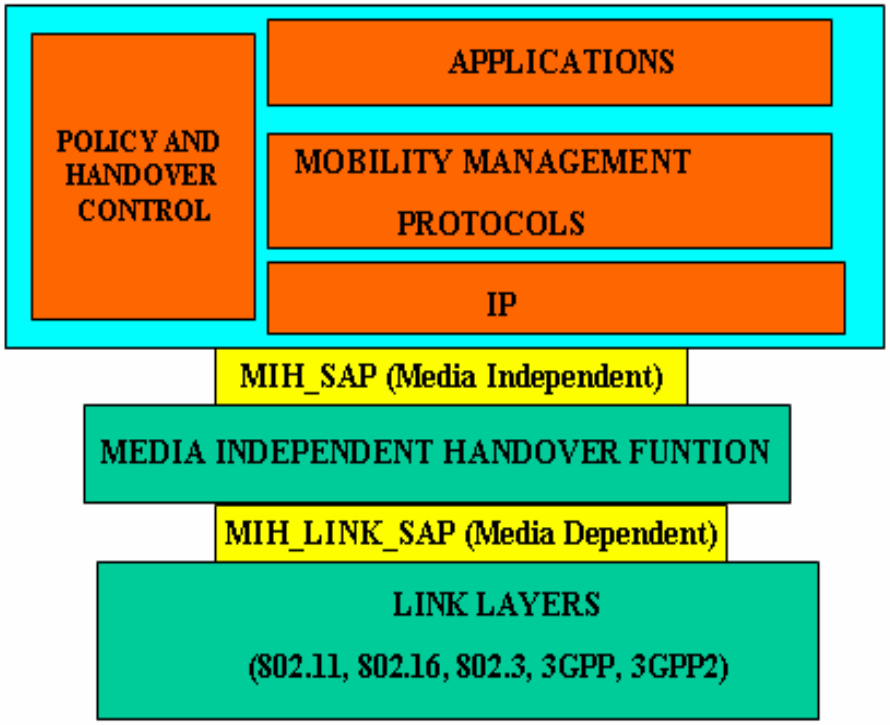
IEEE 802.21 Media Independent Handover (MIH) Framework

- IEEE 802.21 WG is developing standards to enable handover and interoperability between heterogeneous network types including both 802 and non 802 networks
- Aims to assist the upper layer and mobility management protocols to optimize the handover process
- Information at both MN and network infrastructure sides are used to satisfy user requirements
- Latest draft: **IEEE P802.21™/D01.00, March 2006**



Logical Network Reference Model

The MIH Functions



- The upper layer and lower layers are provided MIH services through unified interfaces known as Services Access Points (SAPs)
- The uppers are served by a media independent SAP known as the MIH_SAP
- The Lower are served by media dependent (i.e. access technology specific) SAPs.

What MIH service provides

- MIH service carry L2 information that is processed locally or carried to some other network nodes remotely

- MIH Services enable two facets of inter-technology handover
  - Inter-technology Network selection
  - Handover control

- MIH services are classified as 3 types
  - MIH Information Services (MIIS)
  - MIH Command Services (MICS)
  - MIH Event Services (MIES)

Overview of MIES, MICS and MIIS

- MIES (MIH event service) provide:
  - Indications from one layer or functionality to another about changes in the connectivity state
  - such as MIH Link Down, Link Up, Link Going Down
  - Remote MIES convey information from one network node to another

- MICS (MIH command service) provide
  - mechanisms/functions for controlling or aiding handovers
  - to establish, redirect, or remove state in either the network or the MN, so that handovers occur smoothly. e.g. MIH Link Switch
  - remote MICS convey information from one network node to another

Overview of MIES, MICS and MIIS - *continued*

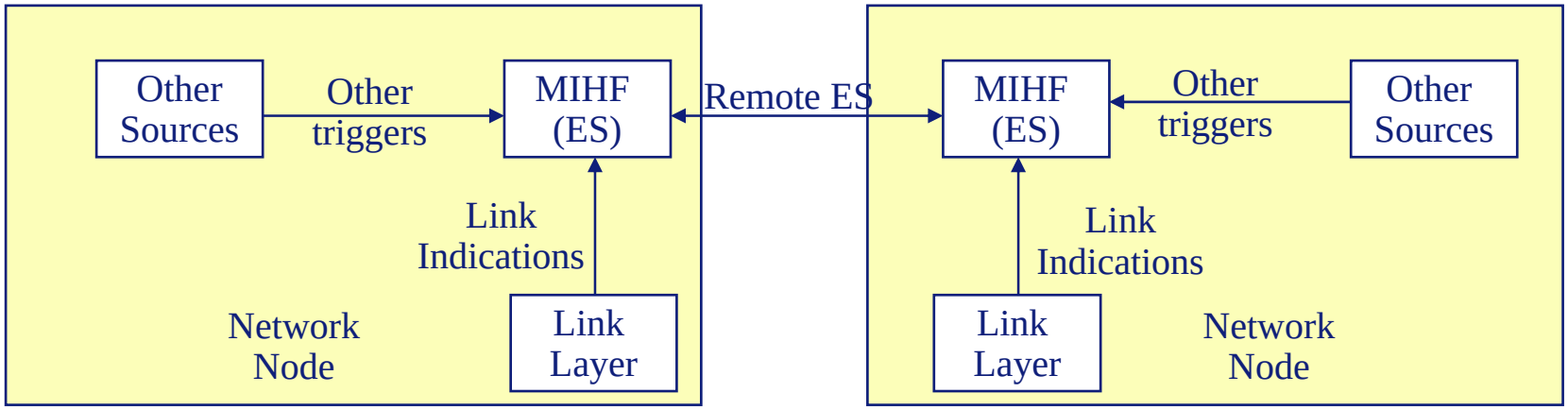
- MIIS (MIH information service) Provides:
  - a framework and mechanism to discover available neighbouring network information within geographical area to facilitate the handover process
  - a set of information elements obtained through a certain query/response mechanism
  - both static and dynamic network information
    - Keys for security → Not in current 802.21 draft, but could be used for user AA

More specifically, MIIS (MIH information service) could provide:

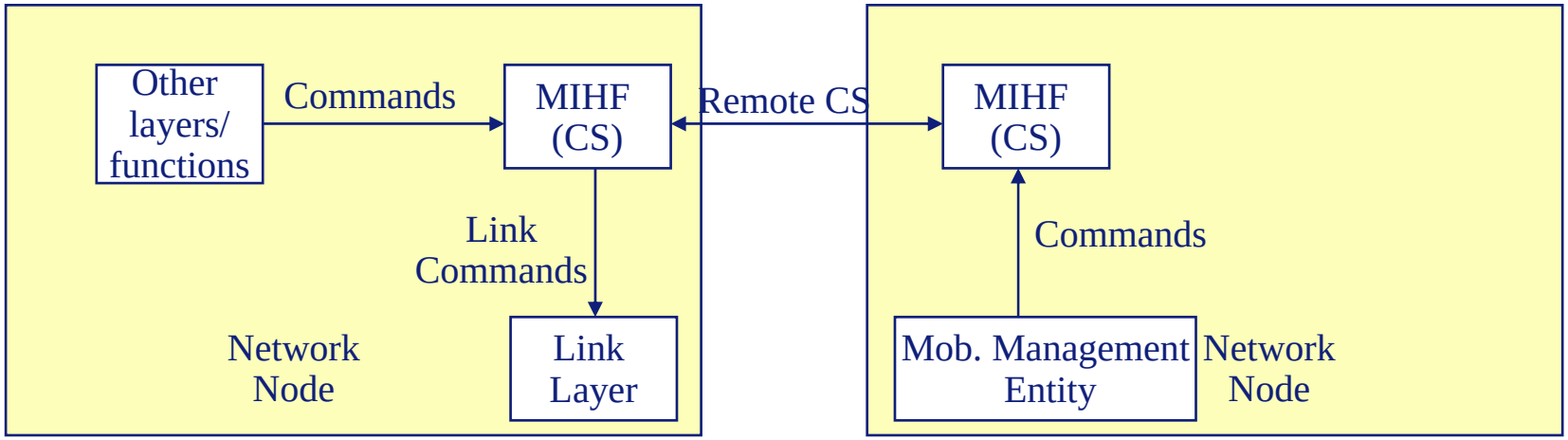
- General Access Network Information:
  - List of available networks
  - Associated operators
  - Roaming agreements
  - Cost of the link
  - and other QoS parameters (dynamic)
- Info. About PoA
  - Addressing info.
  - Location
  - Available data rate
  - Type of PHY and MAC and other channel parameters
- Other info.
  - such as Vendor info.

MIES/MICS Service Model

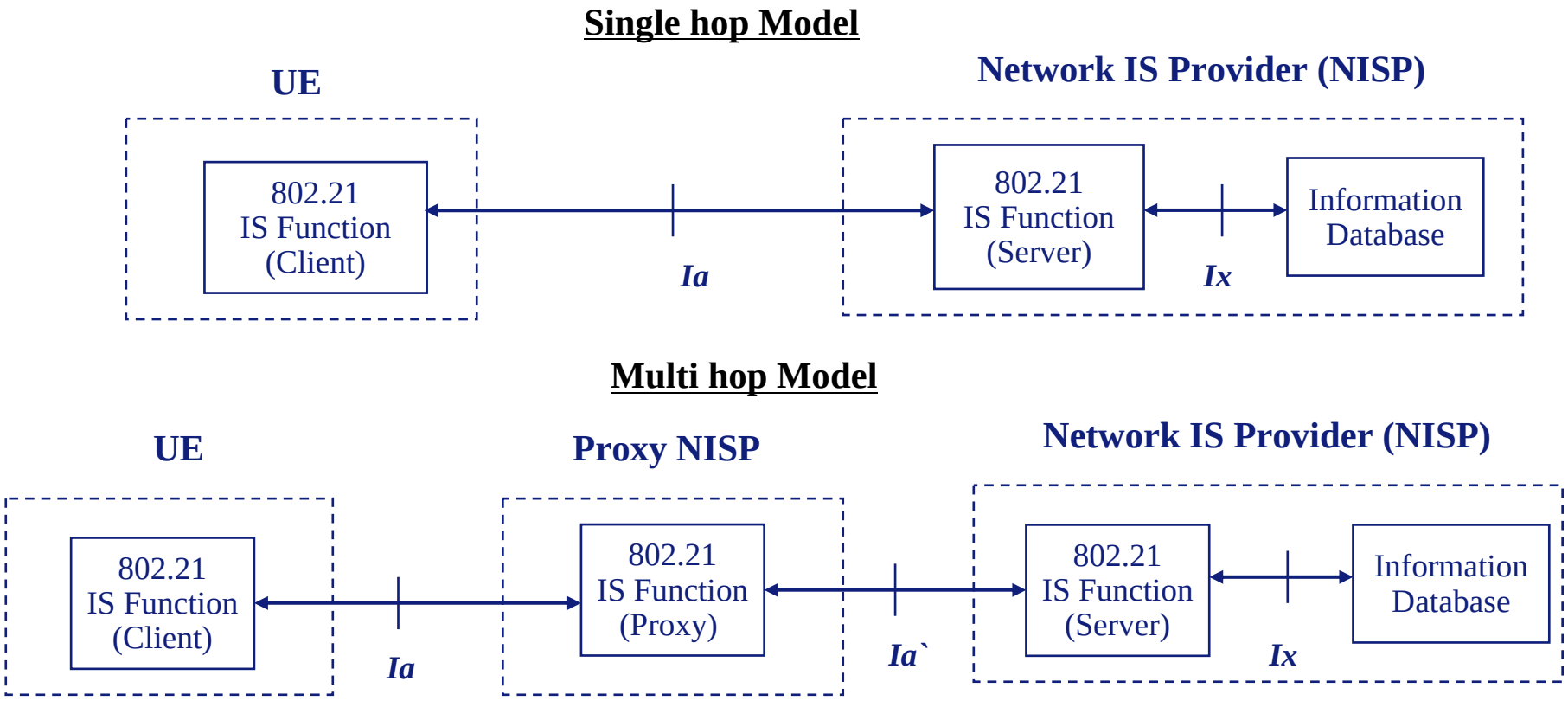
- Event service model



- Command service model



MIIS Reference Model



Ia : Interface between UE and Network IS provider
Ix: Interface between IS function and Information Database
Ia`: Interface between two Network IS providers

Figure: Information Service Reference Model

Proposed Mechanism

- Exploit MIH services, mostly MIH Information Service
- In the current 802.21 MIH Information Service,
  - a MN gets the heterogeneous neighbourhood information by requesting Information Elements (IEs) from the IS
  - In 802.21 draft, the defined IEs mostly provide static L2 information
  - neighbourhood information can be delivered to the MN by using pre-defined Information Reports.
- We propose to let IS to provide not only L2 information, but also L3 information of neighbouring access networks

Proposed Mechanism (continued...)

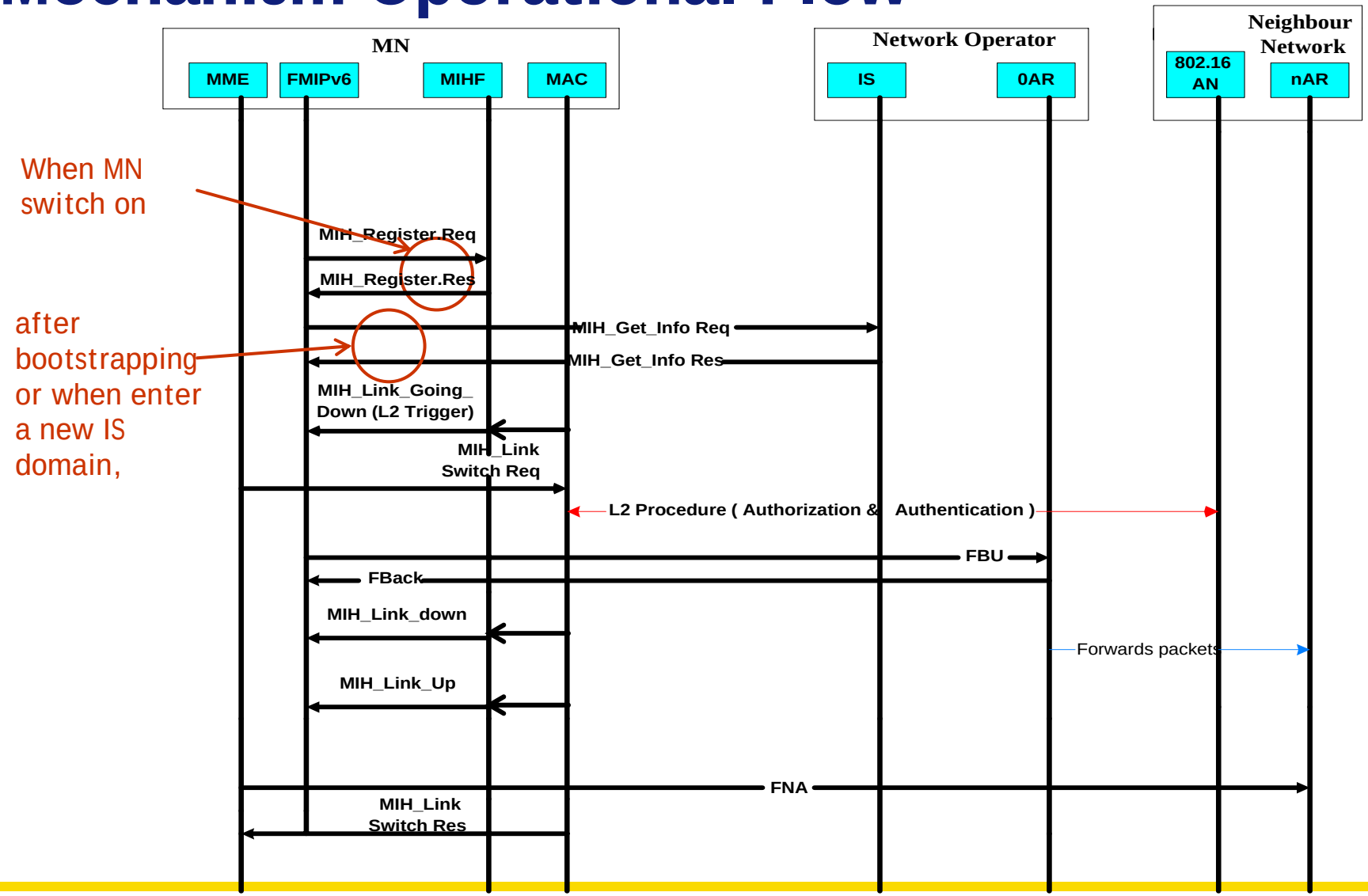
- In order to provide L2 and L3 information of neighbouring access networks
  - we define a new IE --'Subnet Prefix'-- to contain L3 information
  - Together with the L2 information, they form a pre-defined Heterogeneous Network Information (HNI) report.
  - In the HNI report, L2 Information will provide neighbouring PoA information, such as channel range, MAC address, data rates etc.
    - ❑ This eliminates the need for scanning/searching radio access networks. L2 handover will be optimized.
  - L3 Information will provide the MN of subnet prefixes of the nAR and form the NCoA prior to handover.
    - ❑ This reduces the router discovery time and the L3 handover latency in FMIPv6

Proposed Mechanism (continued...)

- The HNI report is refreshed whenever the MN enters a new IS domain
- or when time stamp expires
- or updated by the PoA advertise new IS information

- Furthermore, we propose to create a Neighbouring Network Report (NNR) Cache in the MN for storing and maintaining the HNI report
  - for reducing the adverse impacts of the long anticipation time in FMIPv6
  - and reducing the number of signalling messages during the anticipation phase, thereby reducing the overall anticipation time

Mechanism Operational Flow



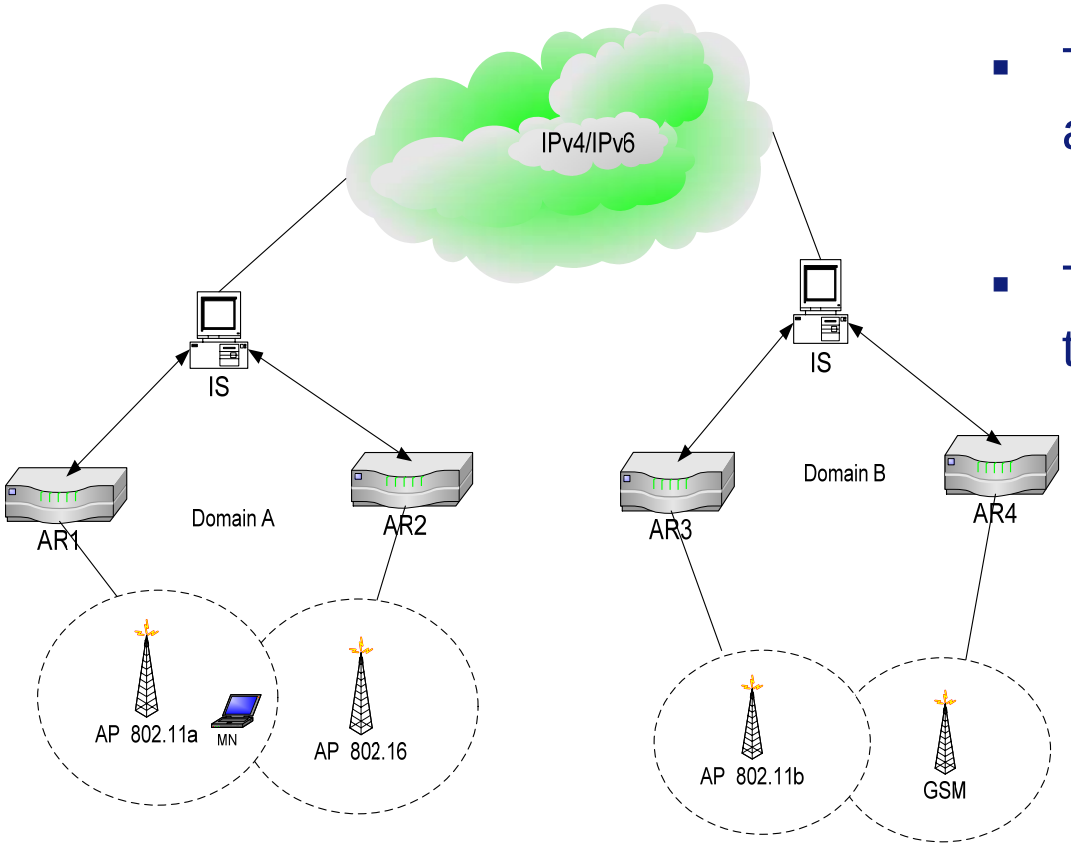
Handover process of the proposed mechanism

1. Event Registration:
   - The MN registers for MIES notifications (i.e. L2 triggers) within its local stack.
   - This done with MIES request/response primitives
2. IS Discovery and Usage:
   - The IS is discovered using the DHCP protocol, including the IS server's IP address, the IS server's FDQN (Fully Qualified Domain Name) and URI (Uniform Resource Identifier).
3. Security Associations:
   - The MN will establish SA with the IS to prevent from eavesdropping and keep MN anonymity.
   - TLS will be advised to use if upper layer protocols use TCP, whilst ESP using IPSec/ IKE will work in most situations.
4. Retrieval of Neighbouring Network Information (HNI Report) from the IS :
   - The HNI request/response will encoded in TLV (Type, Length Value) message. The 'MIH_Get_Information' primitive will be used for this purpose.
   - The MN will store the information in the HNI response message in it's NNR cache.

MIH services that will be used …

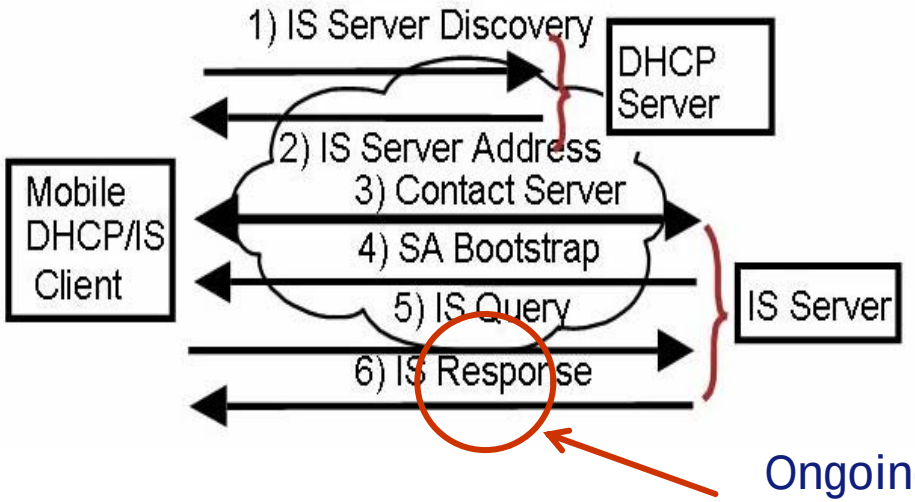
Primitives	Service	Parameter
MIH_Link_Going_Down	MIES	MN MAC Addr, MAC Addr of Curent PoA
MIH_Link_Up	MIES	MN MAC Addr, MAC addr of new PoA, Link ID
MIH_Link_Down	MIES	MN MAC Addr, MAC addr of new PoA, Reason Code
MIH_Link_Switch	MICS	Handover Mode, Old Link ID

Example of Information Server (IS) Deployment



- The HNI report will be stored in an IS
- The IS can be deployed outside the MN's subnet
  - In this way, ARs and other related network elements won't need to be upgraded
  - One IS server can serve several access subnets simultaneously

MN <-> IS Interaction



Ongoing work within the scope of IETF MIPSHOP

HNI Request/Response

- HNI request

Type	Length	Additional Parameters	
Type_HNI Report	Variable	Link Type	Operator Identifier

- HNI response

Type	Length	Value					
Type_HNI Report	Variable	Link Type	Operator Identifier	Number of PoAs			
Entry of Each PoA		PoA_1 MAC Addr IE	PoA_1 Data Rate IE	PoA_1 Channel Range IE	PoA_1 MAC Type IE	PoA_1 PHY Type IE	PoA1 Subnet Prefix IE

Ongoing work & Discussions

- Implementation of the proposed mechanism in NS2 is ongoing
- MIH protocol defined IEs for handover services, and specified the IEs can be delivered through L2 frames or L3 based transport protocols
- The ongoing work is on how to deliver it through L3 based protocols (generic transport protocol) independent of access technology
- Signaling between the end terminals (MNs, IS and other network entities) must be protected from security threats, eavesdropping, DoS attack