Media Independent Handover in Heterogeneous Networks

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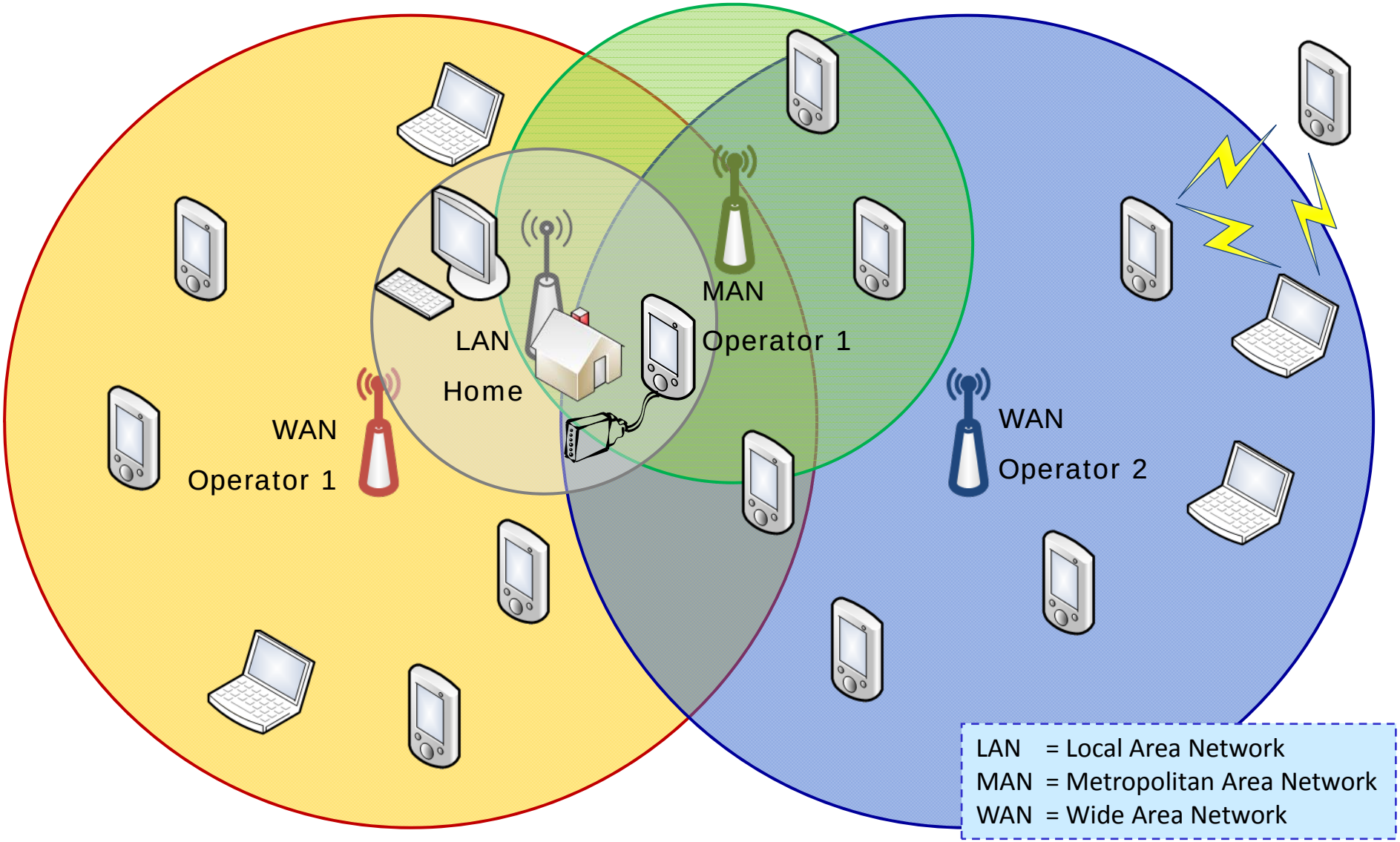
Outline

- Scenario: Heterogeneous Networks
- Media Independent Handover (MIH)
  - IEEE 802.21 (Draft Standard)
  - MIH Services
    - Event
    - Command
    - Information
  - Modelling of the MIH Protocol Acknowledgement Service
- Conclusion

IEEE = Institute of Electrical and Electronics Engineers
MIH = Media Independent Handover

Scenario: Heterogeneous Networks



Focus of IEEE 802.21

- Mobile terminals are surrounded by a multitude of
  - Devices
  - Networks
  - Different communication technologies
  - Business actors

- Problems to solve:
  - Handover between two link layer technologies has a break-before-make characteristic
  - IP connectivity may be lost completely => packet loss, high delays, and service disruption
  - Handover is not “seamless” for the application

“**The standard specifies IEEE 802 media access-independent mechanisms that optimize handovers between heterogeneous IEEE 802 systems and between IEEE 802 systems and cellular systems.**”

IEEE 802.21 has the goal to **facilitate handovers** and to **maximize handover efficiency**

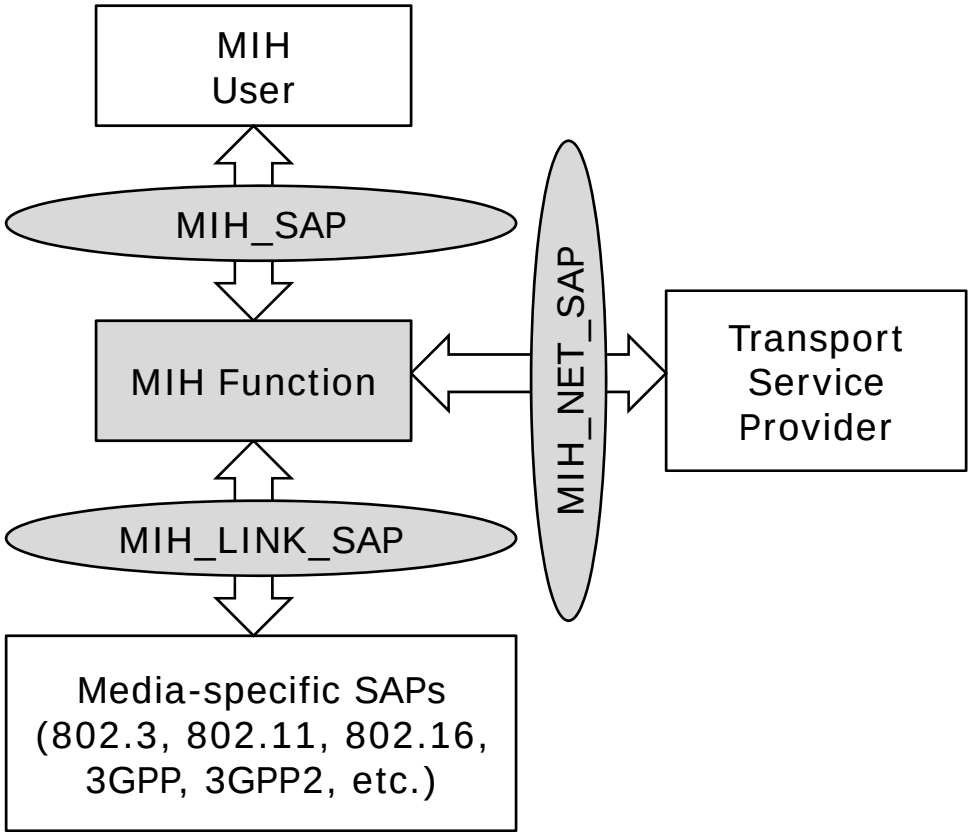
IP = Internet Protocol

Efficiency of Handovers

- Control Plane
  - Shorten/unify discovery, selection, and attachment phases
  - Support of make before break handovers
  - Minimize number of unnecessary handovers / handover signaling
- User Plane
  - Minimize impact of handovers on active services
  - MIH knows the following parameters
    - Packet Quality of Service (QoS) parameters
      - Minimum Packet Transfer Delay
      - Average Packet Transfer Delay
      - Maximum Packet Transfer Delay
      - Jitter
      - Packet Loss Rate
      - Packet Error Rate
    - Link QoS parameters
      - Link Throughput
      - Link Packet Error Rate
      - Supported Classes of Service
    - Class of Service (CoS) parameters
      - Class Minimum Packet Transfer Delay
      - Class Average Packet Transfer Delay
      - Class Maximum Packet Transfer Delay
      - Class Packet Delay Jitter
      - Class Packet Loss Rate
  - Mappings to technology specific parameters

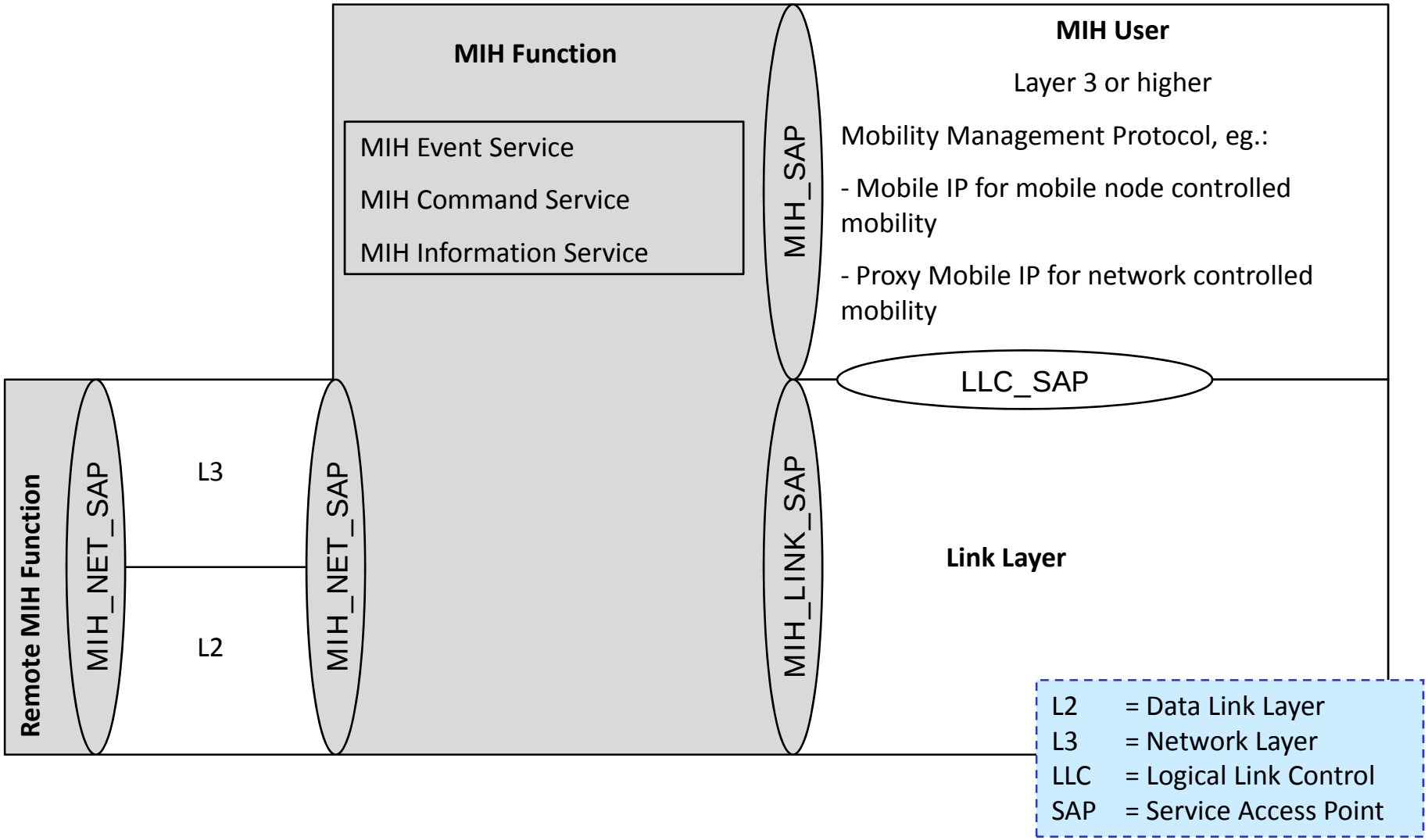
Cos = Class of Service
QoS = Quality of Service

MIH Function & Service Access Points



MIH = Media Independent Handover
NET = Network
SAP = Service Access Point

MIH General Reference Model



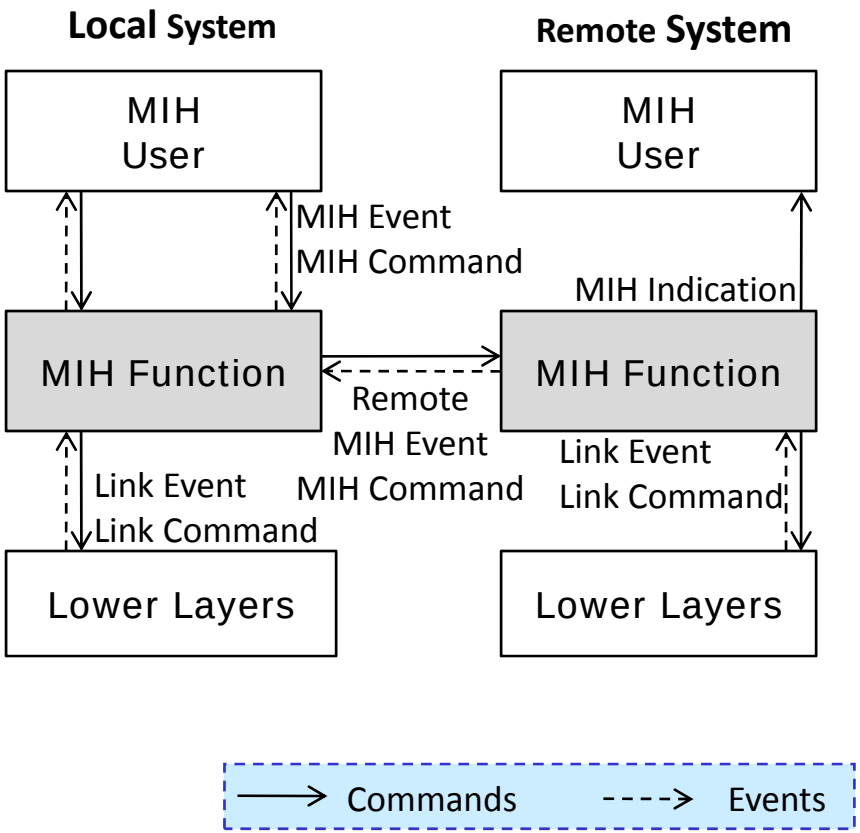
Event Service

- Link events are translated to media independent MIH events
- Subscription based
- Triggers may originate from local link events or in a remote system
- Several types of events
  - MAC and PHY state change events
  - Link parameter events
  - Predictive events
  - Link handover events
  - Link transmission events

MAC = Medium Access Control Sublayer
PHY = Physical Layer

Command Service

- Translates MIH commands to link commands
- Commands are used for
  - Handover signaling and execution
  - Control of the behavior of a link
  - Configuration of event creation
  - Information retrieval
- Command may have its sink in a
  - Local node
  - Peer node
- Place of command execution may be within the peer's
  - MIH user
  - MIH entity
  - Link layer



Information Service

- Data about neighboring networks in the geographical area of a mobile node
- Access network specific information
  - Operator
  - Roaming agreements
  - Costs
  - Security mechanisms
  - QoS
- Information for a dedicated point of access
  - Location
  - Data rate
  - Addressing
  - Type
  - Extensible with access network specific, service specific, or vendor specific information

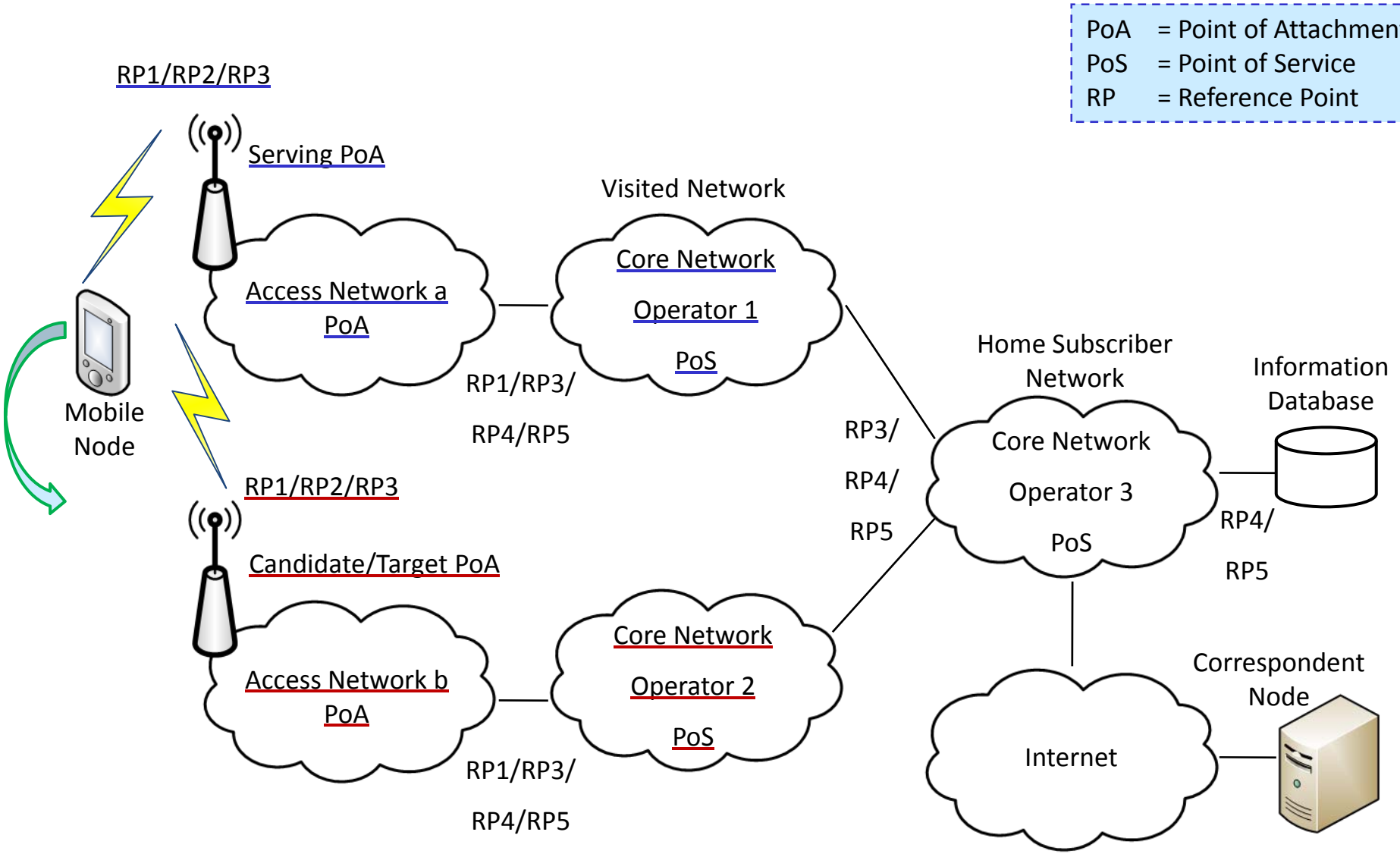
QoS = Quality of Service

Point of Service, Point of Attachment

- Mobile node have always an MIHF entity
- Network nodes that implement the MIHF are either called
  - MIH PoS if they exchange MIH messages with a mobile node
  - MIH non-PoS if they exchange messages only with other MIH network nodes
- Network node with a layer 2 connection to the mobile node is called PoA
- PoA of the current link is called serving PoA
- In case of handover
  - Candidate PoA
  - Target PoA
- Node that does not offer layer 2 connections to mobile nodes is a non-PoA

PoA = Point of Attachment
PoS = Point of Service

Example of an MIH Network



Services (contd.)

- Service management allows
  - Capability discovery of an MIHF entity
  - Registration of MIH users at the MIHF
  - Subscribtion to MIH events
  - Setup the communication between MIHF entities

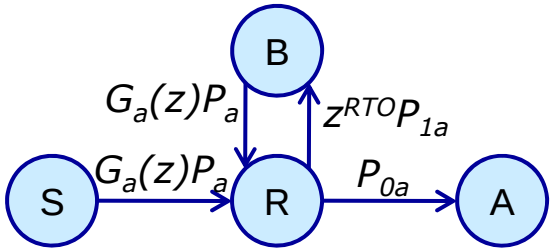
- Flow control
  - Limit rate of MIH messages
  - Rate-limiting of forwarded messages is out of scope
  - Token Bucket mechanism (RFC4443)

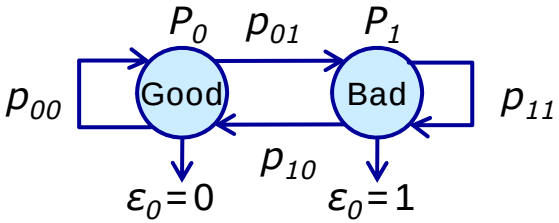
- MIH protocol acknowledgement service
  - Reliable data transport: message loss rate < 0.01
  - Acknowledged mode with retransmission timeout (RTO) calculation (RFC2988)

RFC = Request for Comments
RTO = Retransmission Timeout

Acknowledgement Service: Signal Flow Graph

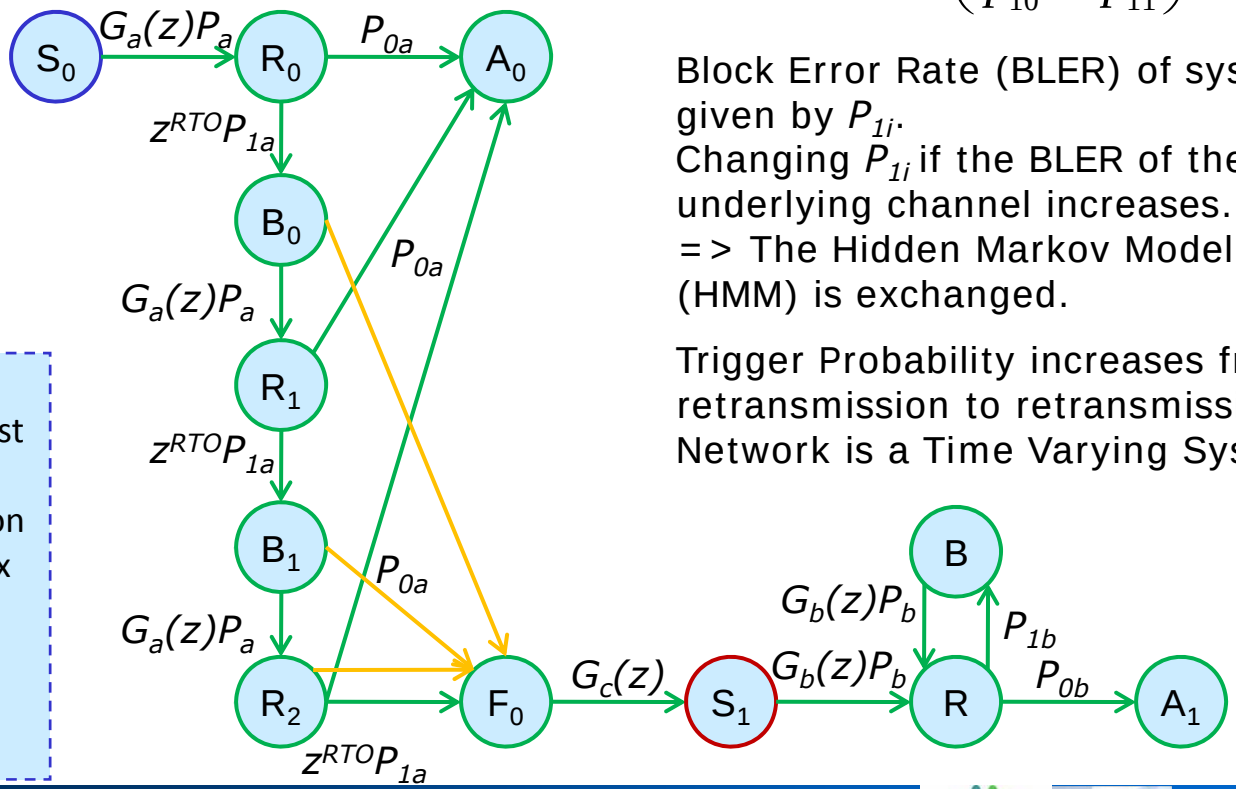
Delay investigation with an ARQ Model of System a:





$$P_a = \begin{pmatrix} p_{00} & p_{01} \\ p_{10} & p_{11} \end{pmatrix}$$

ARQ Model with 2 Retransmissions and handover from System a to System b:

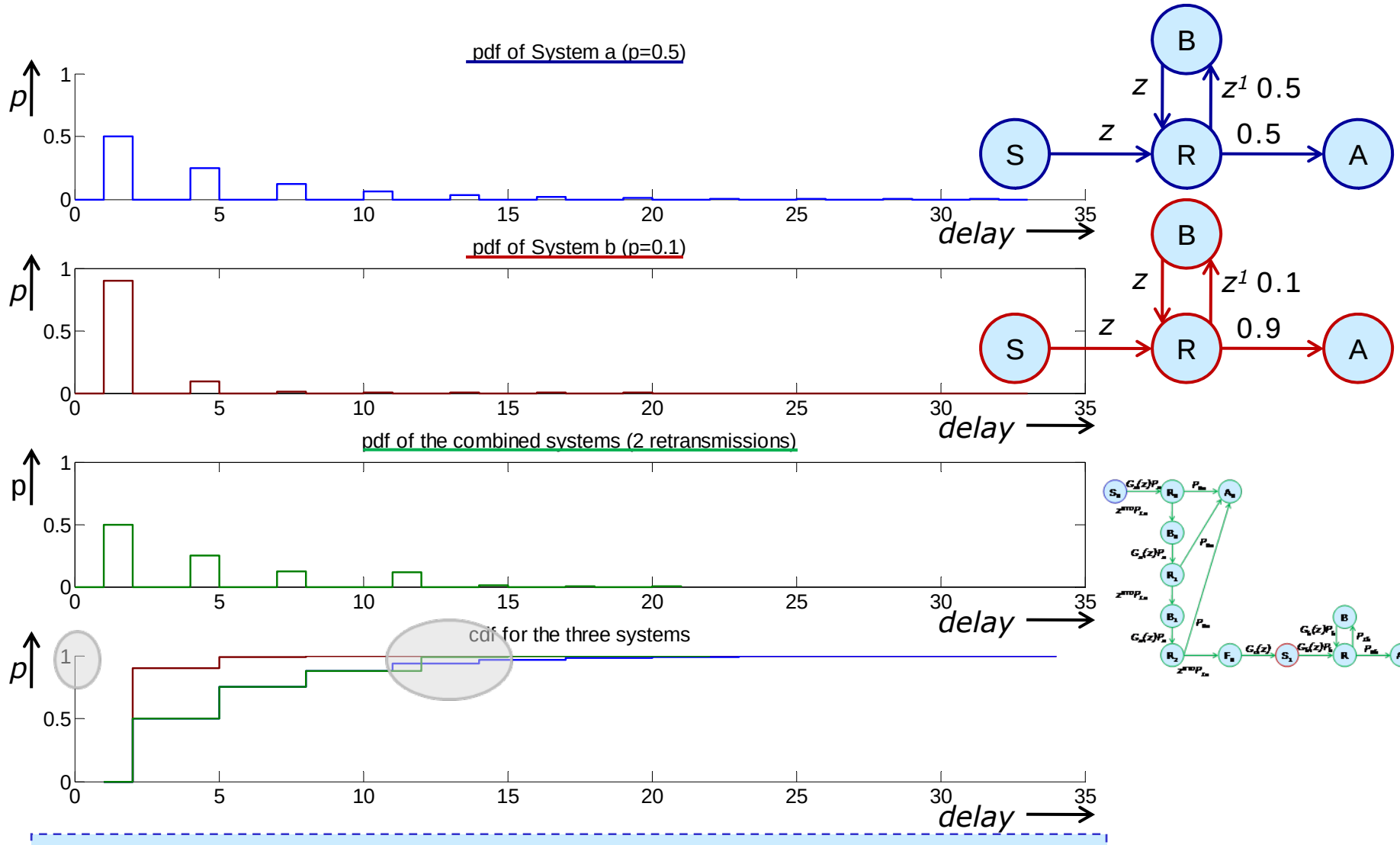


Block Error Rate (BLER) of system *i* given by P_{1i}.
Changing P_{1i} if the BLER of the underlying channel increases.
=> The Hidden Markov Model (HMM) is exchanged.

Trigger Probability increases from retransmission to retransmission.
Network is a Time Varying System.

A	= Successful Transmission
ARQ	= Automatic Repeat Request
B	= Retransmission State
G(z)	= Delay Generation Function
P	= Channel Transition Matrix
R	= Receive State
RTO	= Retransmission Timeout
S	= Send State
z	= Delay Operator

Acknowledgement Service: Analysis



cdf = Cumulative Distribution Function pdf = Probability Density Function

Conclusion

- IEEE802.21 Overview
  - MIH Services
  - MIH Deployment
- Signal Flow Graph Model of MIH Protocol Acknowledgement Service
  - Allows calculation of an appropriate number of retransmissions
  - Allows to include MIH triggers
  - Allows investigation of sensitivity to triggers and Retransmission Timeout
  - Outlook: Include aspects of Time Varying Systems

Thank you for your attention !

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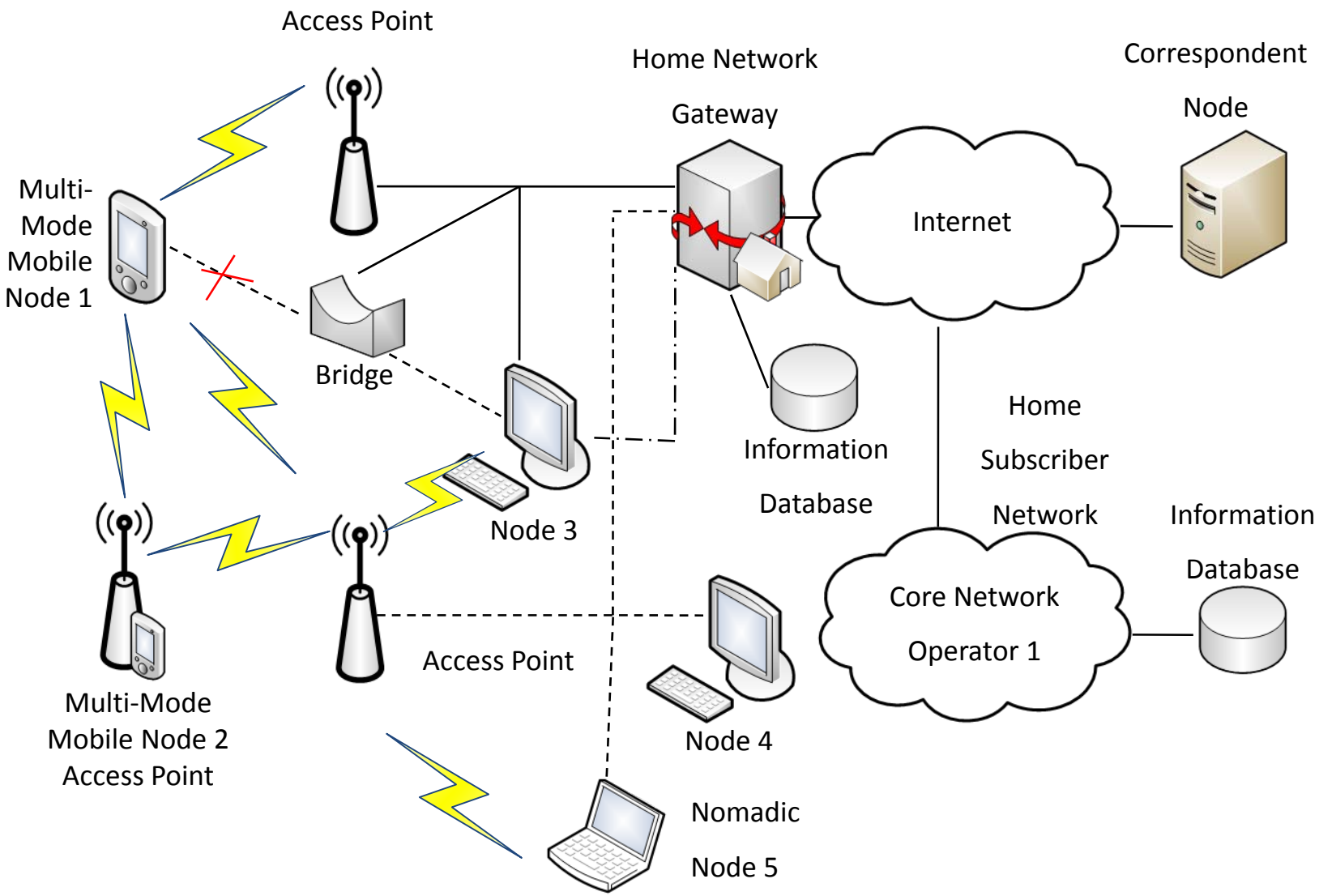
Backup Slides

I haven't lost my mind -- it's backed up on tape … somewhere.

Scenario: Heterogeneous Home Networks



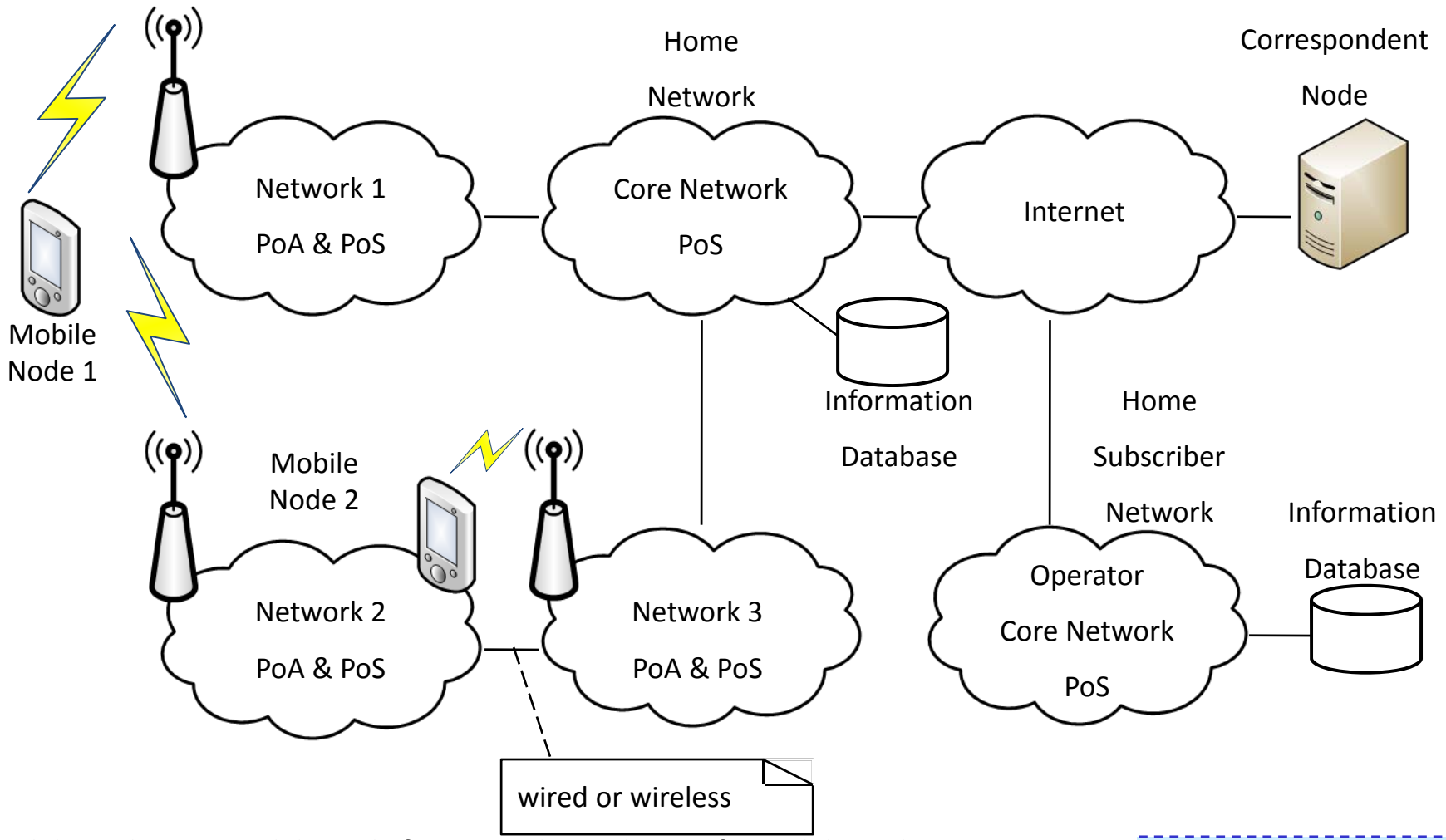
Services & Mobility Management

- The general model is specialized for the specific technologies IEEE 802.3, IEEE 802.11, IEEE 802.16, 3GPP, and 3GPP2
- MIHF offers three services:
  - MIH **Event** Service
  - MIH **Command** Service
  - MIH **Information** Service

- The MIH is implemented by a mobility management protocol, e.g.
  - Mobile IP (RFC3775) for mobile node controlled mobility
  - Proxy Mobile IP (PMIP) for network controlled mobility
  - The MIH standard does not rely on a specific mobility management protocol

MIHF = Media Independent Handover Function

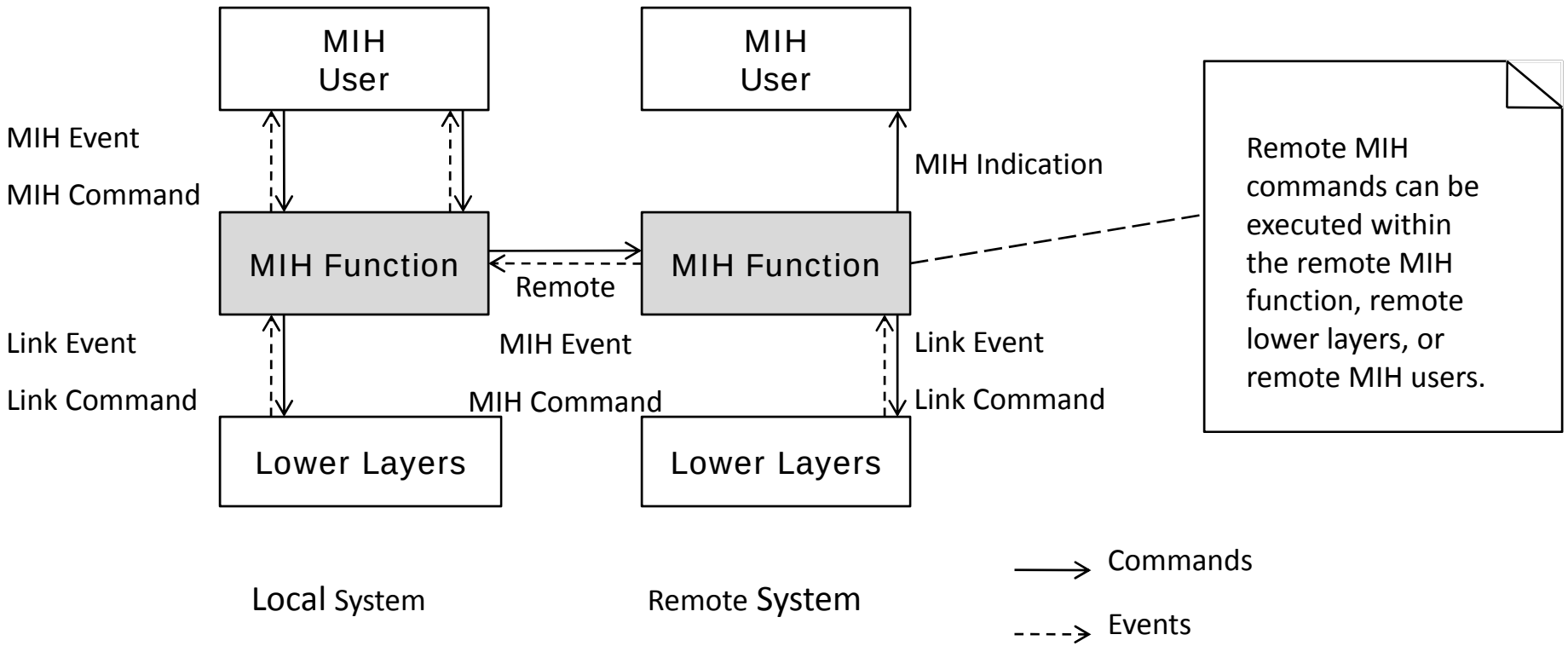
Example of IEEE802.21 in OMEGA



- Mobile Node 2 is a Mobile Node for Network 3 and a PoA for Mobile Node 1
- Direct communication between Mobile Node 1 and 2 is possible

PoA = Point of Attachment
PoS = Point of Service

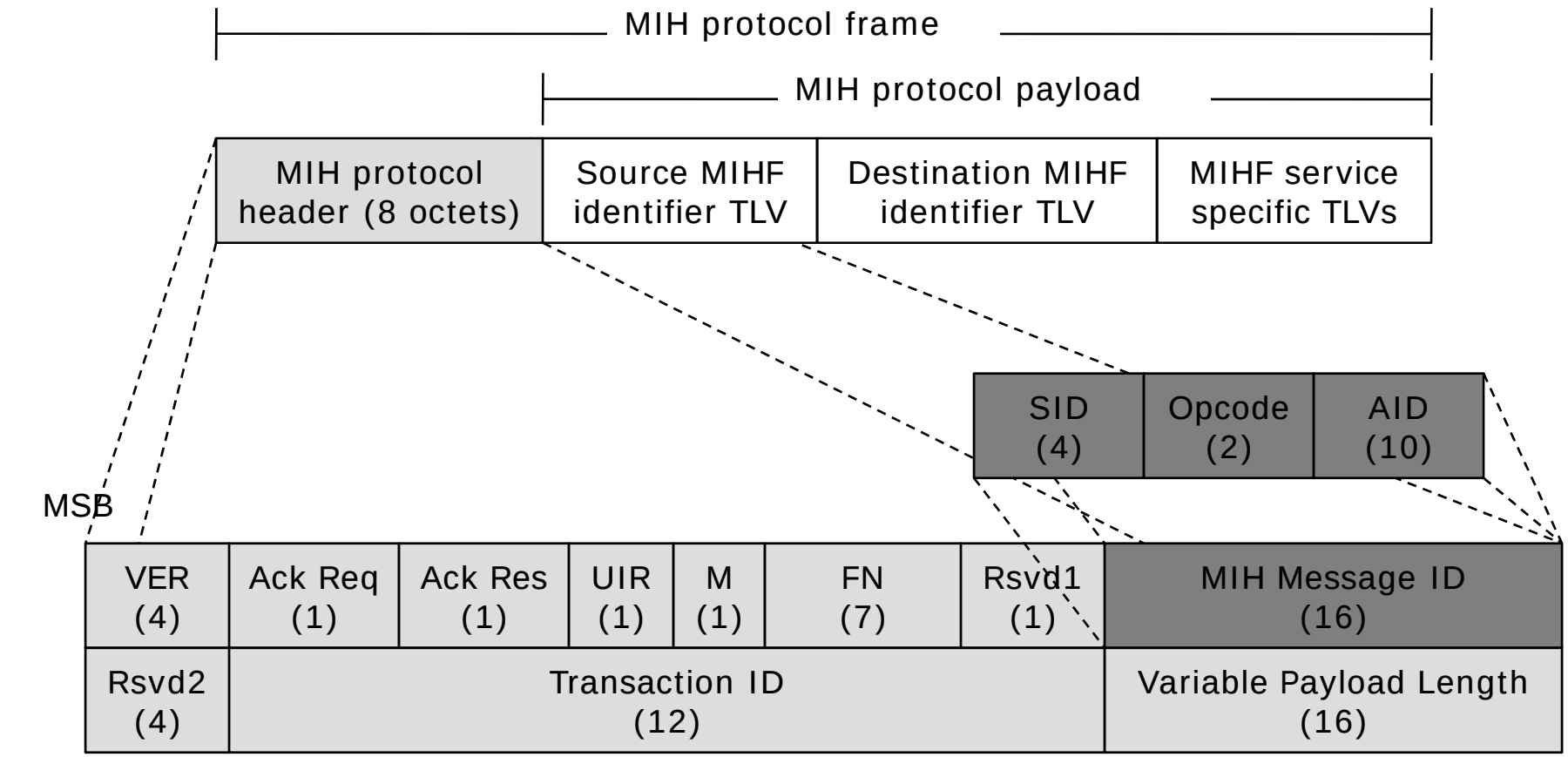
MIH Events & Commands



- MIH uses the four types of primitives: request, indication, response, and confirm
- Message exchange between the MIH function in the local and remote system via the MIH protocol

MIH = Media Independent Handover

MIH Protocol Frame & Header

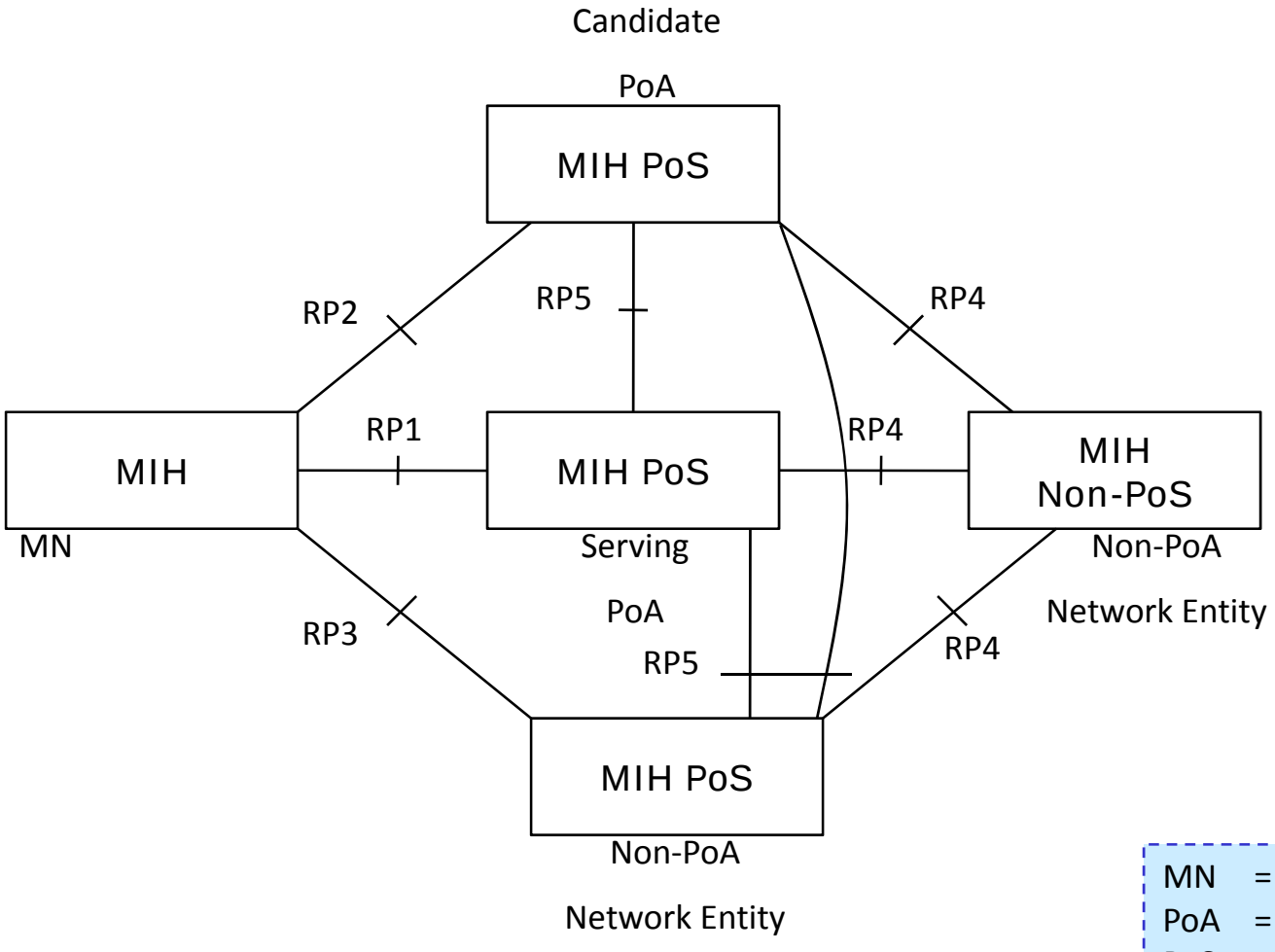


Ack	= Acknowledgement
AID	= Action Identifier
FN	= Fragment Number
MSB	= Most Significant Bit
LSB	= Least Significant Bit

M	= More Fragment
Opcode	= Operation Code
Req	= Request
Res	= Response
Rsvd	= Reserved

SID	= Service Identifier
UIR	= Unauthenticated Information Request
VER	= Version

MIH Reference Points



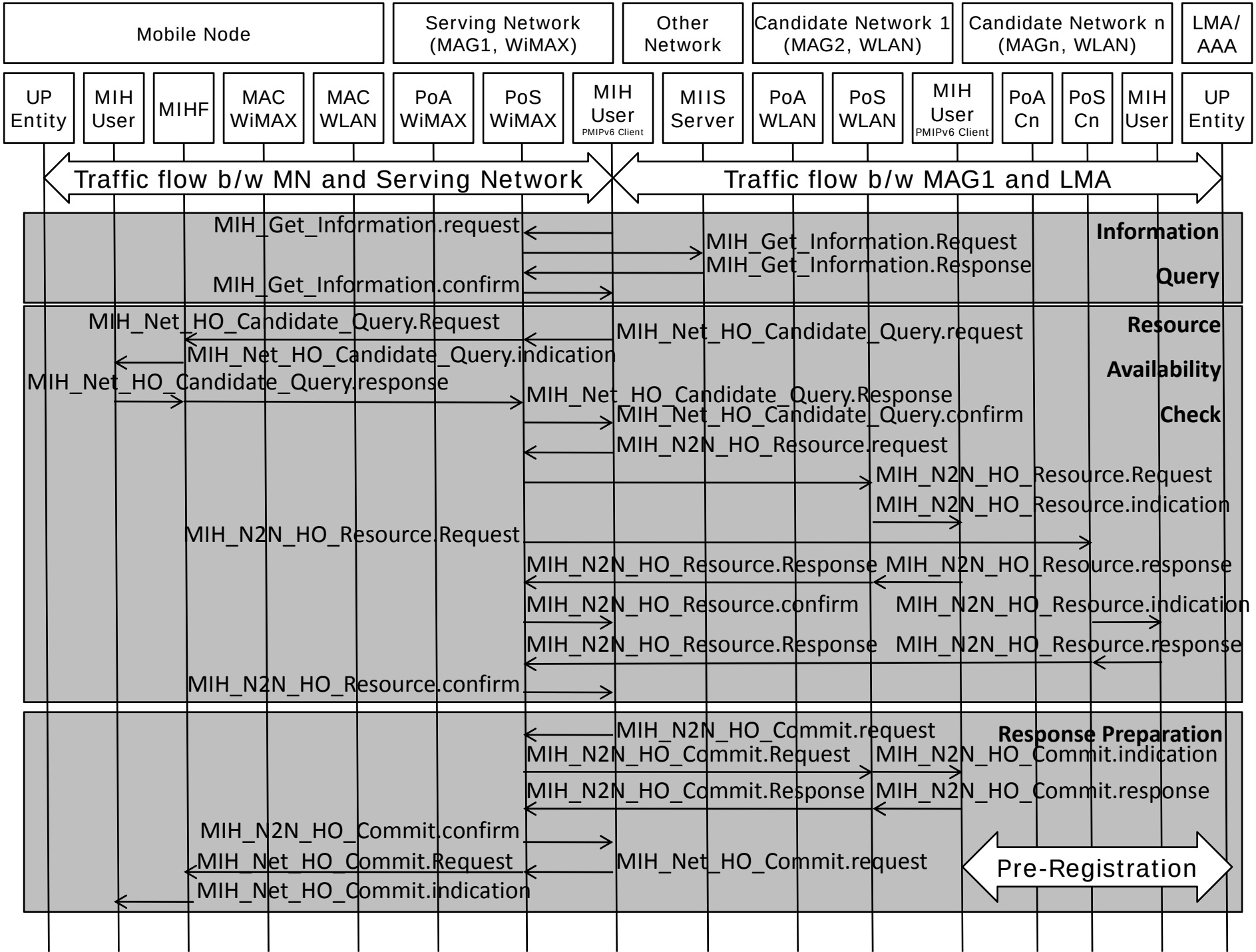
MN = Mobile Node
PoA = Point of Attachment
PoS = Point of Service
RP = Reference Point

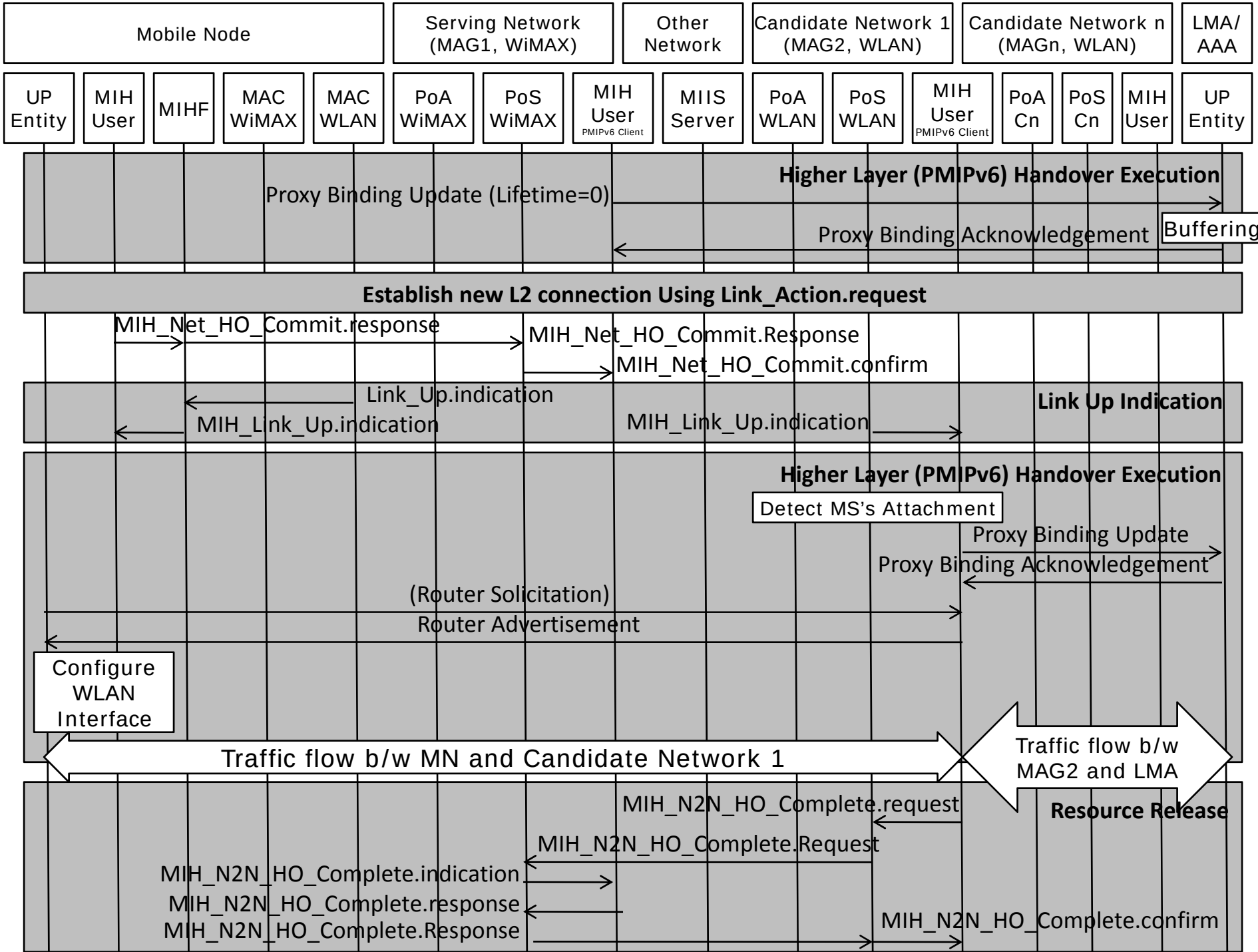
Flow Control (based on RFC 4443: ICMPv6)

- Limit rate of MIH messages
- Rate-limiting of forwarded messages is out of scope
- Token Bucket mechanism
  - Limiting the average rate of transmission to *N*, where *N* can be either packets/second or a fraction of the attached bandwidth of a link
  - Allowing up to *B* error messages to be transmitted in a burst, as long as the long-term average is not exceeded
  - The rate-limiting parameters should be configurable
  - In the case of a token-bucket implementation, the best defaults depend on where the implementation is expected to be deployed

ICMPv6 = Internet Control Message Protocol for the Internet Protocol version 6

Messsage Sequence Charts for Handover between WiMAX and two candidate WLAN access networks


Mobile Node
Serving Network (MAG1, WiMAX)
Other Network
Candidate Network 1 (MAG2, WLAN)
Candidate Network n (MAGn, WLAN)
LMA/ AAA
UP Entity
MIH User
MIHF
MAC WiMAX
MAC WLAN
PoA WiMAX
PoS WiMAX
MIH User PMIPv6 Client
MIIS Server
PoA WLAN
PoS WLAN
MIH User PMIPv6 Client
PoA Cn
PoS Cn
MIH User
UP Entity
Traffic flow b/w MN and Serving Network
Traffic flow b/w MAG1 and LMA
Information Query
MIH_Get_Information.request
MIH_Get_Information.Request
MIH_Get_Information.Response
MIH_Get_Information.confirm
Resource Availability Check
MIH_Net_HO_Candidate_Query.Request
MIH_Net_HO_Candidate_Query.request
MIH_Net_HO_Candidate_Query.indication
MIH_Net_HO_Candidate_Query.response
MIH_Net_HO_Candidate_Query.Response
MIH_Net_HO_Candidate_Query.confirm
MIH_N2N_HO_Resource.request
MIH_N2N_HO_Resource.Request
MIH_N2N_HO_Resource.indication
MIH_N2N_HO_Resource.Request
MIH_N2N_HO_Resource.Response
MIH_N2N_HO_Resource.response
MIH_N2N_HO_Resource.confirm
MIH_N2N_HO_Resource.indication
MIH_N2N_HO_Resource.Response
MIH_N2N_HO_Resource.response
MIH_N2N_HO_Resource.confirm
Response Preparation
MIH_N2N_HO_Commit.request
MIH_N2N_HO_Commit.Request
MIH_N2N_HO_Commit.indication
MIH_N2N_HO_Commit.Response
MIH_N2N_HO_Commit.response
MIH_N2N_HO_Commit.confirm
MIH_Net_HO_Commit.Request
MIH_Net_HO_Commit.request
MIH_Net_HO_Commit.indication
Pre-Registration


Mobile Node
Serving Network (MAG1, WiMAX)
Other Network
Candidate Network 1 (MAG2, WLAN)
Candidate Network n (MAGn, WLAN)
LMA/ AAA
UP Entity
MIH User
MIHF
MAC WiMAX
MAC WLAN
PoA WiMAX
PoS WiMAX
MIH User PMIPv6 Client
MIIS Server
PoA WLAN
PoS WLAN
MIH User PMIPv6 Client
PoA Cn
PoS Cn
MIH User
UP Entity
Higher Layer (PMIPv6) Handover Execution
Proxy Binding Update (Lifetime=0)
Buffering
Proxy Binding Acknowledgement
Establish new L2 connection Using Link_Action.request
MIH_Net_HO_Commit.response
MIH_Net_HO_Commit.Response
MIH_Net_HO_Commit.confirm
Link_Up.indication
Link Up Indication
MIH_Link_Up.indication
MIH_Link_Up.indication
Higher Layer (PMIPv6) Handover Execution
Detect MS's Attachment
Proxy Binding Update
Proxy Binding Acknowledgement
(Router Solicitation)
Router Advertisement
Configure WLAN Interface
Traffic flow b/w MN and Candidate Network 1
Traffic flow b/w MAG2 and LMA
MIH_N2N_HO_Complete.request
Resource Release
MIH_N2N_HO_Complete.Request
MIH_N2N_HO_Complete.indication
MIH_N2N_HO_Complete.response
MIH_N2N_HO_Complete.Response
MIH_N2N_HO_Complete.confirm