# IEEE P802.21/D00.05

# Draft IEEE Standard for Local and Metropolitan Area Networks: Media Independent Handover Services

Sponsor

**LAN MAN Standards Committee**
**of the**
**IEEE Computer Society**

**Abstract:** This standard specifies 802 media access-independent mechanisms that optimize handovers between heterogeneous 802 systems and between 802 systems and cellular systems..
**Keywords:** media independent handover

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# Introduction

The IEEE 802.21 standard defines extensible media access independent mechanisms that enable the optimization of handovers between heterogeneous 802 systems and may facilitate handovers between 802 systems and cellular systems.

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To be supplied by IEEE

# Editor's Foreword

**[Notes]**

[Throughout this document all notes such as this one are temporary notes inserted by the Editors for a variety of purposes; these notes and the Editor's Forward will all be removed prior to publication and are not part of the normative text.]

[**Comments and participation in 802.21 standards development**

Comments on this draft are encouraged. **PLEASE NOTE: All issues related to IEEE standards presentation style, formatting, spelling, etc. are routinely handled between the 802.21 Editor and the IEEE Staff Editors prior to publication, after balloting and the process of achieving agreement on the technical content of the standrad is complete.** Readers are urged to devote their valuable time and energy only to comments that materially affect either the technical content of the document or the clarity of that technical content. Comments should not simply state what is wrong, but also what might be done to fix the problem.

Full participation in the deveopment of this draft requires individual attendance at IEEE 802.21 meetings. Information on 802.21 activities, working documents and email distribution lists etc.can be found on the 802.21 website:

http://ieee802.org/21

Comments on this document may be sent to the 802.21 mailing reflector, to the Editor, or to the Chairs of the 802.21 Working Group.

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**[The draft text and accompanying information**

This document currently comprises:

— A temporary cover page, preceding the Editor's Forewords. This cover page will be removed following working group approval of this draft, i.e. prior to sponsor ballot.
— IEEE boilerplate text.
— The Editor's foreword, including this text.
— A title page for the propose standard including an Abstract and Keywords. This title page will be retained following approval.
— A record of participants
— An Annex Z comprising the editor's discussion of issues. This annex will be deleted from the document prior to sponsor ballot.

**History and Scope**

A PAR (Project Authorization request) for this project was drafted at the November 2003 meeting, forwarded for SEC consideration by vote of the 802.21 ECSG during the January 2004 meeting of P802 and approved by the IEEE-SA Standards Board with the following Scope and Purpose:

**Scope of the Proposed Project:**

> This standard defines extensible 802 media access independent mechanisms that enable the optimization of handover between heterogeneous 802 systems and may facilitate handover between 802 systems and cellular systems.

**Purpose of the Proposed Project:**

> The purpose is to improve the user experience of the mobile devices by facilitating handover betwen 802 networks whether or not they are of different media types, including both wired and wireless, where handover is not otherwise defined and to make it possible for mobile devices to perform seamless handover where the network environment supports it. These mechanisms may also be useable for handovers between 802 networks and non 802 networks.

**The joint harmonized contribution was confirmed during the May 2005 meeting and the first WG draft was produced in the July 2005 meeting.]**

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# Draft IEEE Standard for Local and Metropolitan Area Networks: Media Independent Handover Services

## 1. Overview

### 1.1 Scope

The scope of the IEEE 802.21 (Media Independent Handover) standard is to develop a specification that provides link layer intelligence and other related network information to upper layers to optimize handovers between heterogeneous media. This includes links specified by 3GPP, 3GPP2 and both wired and wireless media in the IEEE 802 family of specifications.

### 1.2 Purpose

The purpose of the IEEE 802.21 standard is to enhance user experience of mobile devices by supporting handovers between heterogeneous networks.

This document describes a standard to satisfy the requirements for media independent handover as outlined in [1]. The standard addresses the support of handovers for both mobile and stationary users. For mobile users, handovers may occur due to a changes in wireless link conditions. Alternatively, handovers may occur due to gaps in radio coverage that result from terminal movement. For the stationary user, handovers may become imminent when the surrounding environment changes, making one network more attractive than another. Another possibility is that the user may choose an application which requires a handover to a higher data rate channel, for example during download of a large data file. In all cases service continuity should be maximized during the handover. As an example when making a network transition during a phone call the handover procedure should be executed during a pause in the conversation so as to minimize any perceptible interruption in service.

The IEEE 802.21 standard supports cooperative use of both mobile terminals and network infrastructure. The mobile terminal is well-placed to detect available networks. The network infrastructure is well-suited to store overall network information, such as neighborhood cell lists, location of mobile devices, higher layer services available and thus help in optimum network selection. Both the mobile terminal and the network can make decisions about connectivity. In general, both the terminals and the network points of attachment such as base stations and access points can be multi-modal, i.e. capable of supporting multiple radio standards and simultaneously transmitting on more than one interface.

The overall network can include both micro cells (for IEEE 802.11 or IEEE 802.15 coverage) and macro cells (for 3GPP, 3GPP2, or IEEE 802.16 coverage) which will in general intersect. The handover process is typically conditioned by measurements and triggers supplied by the link layers on the terminal. The measurements may report signal quality, synchronization time differences, transmission error rates, etc. and are some of the metrics used in handover algorithms. Specifically the standard consists of the following elements:

a) A framework that enables transparent service continuity while a mobile node (MN) switches between heterogeneous link-layer technologies. The framework relies on the identification of a mobility-management protocol stack within the network elements that support the handover. The description of the framework does not address implementation details and does not provide indication of preferred implementations of the IEEE 802.21 standard. The framework presents the MIH Reference models for different link layer technologies.

b) A set of handover-enabling functions within the protocol stacks of the network elements and the creation therein of a new entity called the MIH Function. A media independent Service Access Point (called the MIH_SAP) and associated primitives are defined to provide MIH users with access to the services of the MIH Function. The MIH Function provides the following services.
   1) The Media Independent Event service detects events and delivers triggers from both local as well as remote interfaces.
   2) The Media independent Command service provides a set of commands for the MIH users to control handover relevant link states.
   3) The Media Independent Information service provides the information model and an information repository, for query and response, thus enabling making of more effective handover decisions across different heteroeneous networks.

c) The definition of new link layer SAPs and associated primitives for each media specific technology. The new primitives help the MIH Function collect link information and control link behavior during handovers. If applicable, the new SAPs shall be recommended as amendments to the respective media specific technology standard specification.

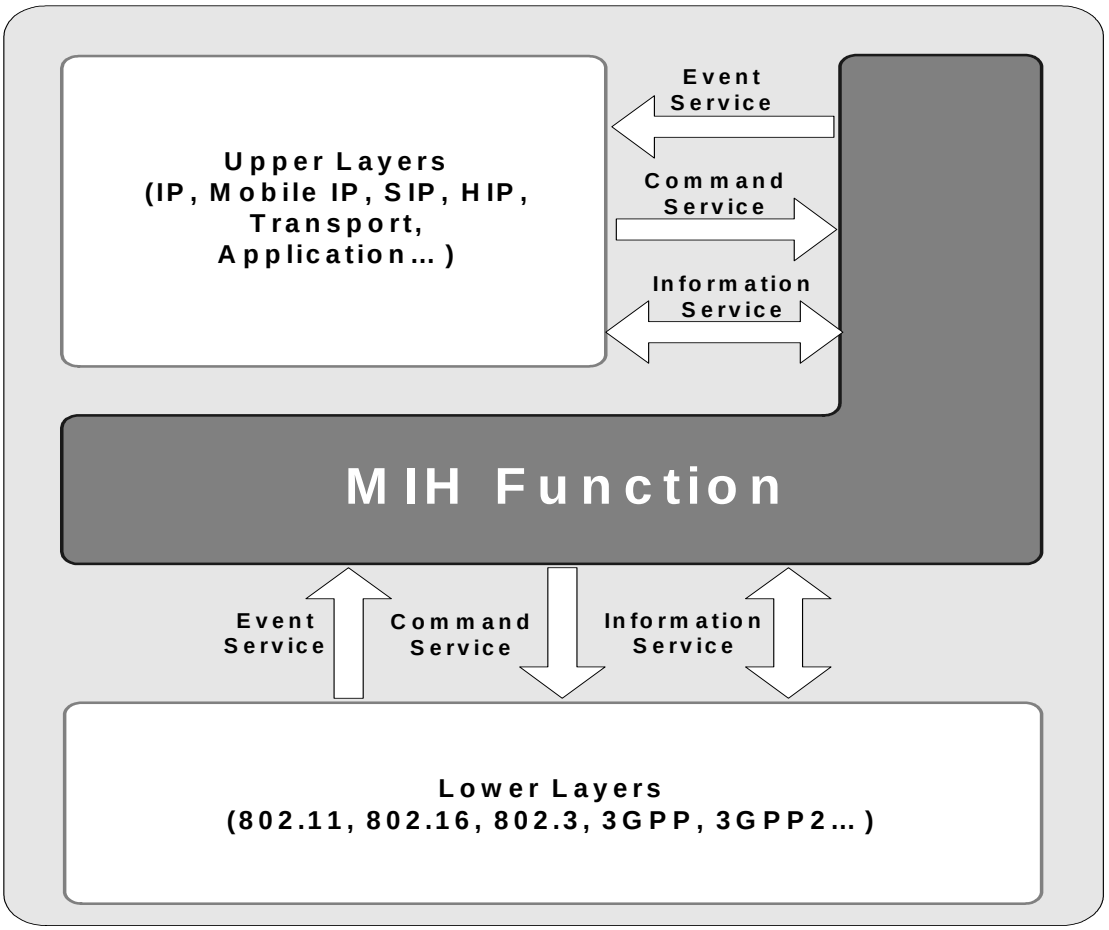


**Figure 1 — MIH Function Location and Key Services**

Figure 1 shows the placement of the MIH Function within the mobility-management protocol stack for handovers associated with heterogeneous link switches. The MIH Function provides services to the upper layers through a single technology-independent interface (the MIH SAP) and obtains services from the lower layers through a variety of technology-dependent interfaces (media-specific SAPs).

## 1.3 Assumptions

The following assumptions have been made in the development of this standard.

1) The mobile node is capable of supporting multiple interfaces, which can be both wireless and wired.
2) The MIH Function is a logical entity, whose definition has no implications on the way the MIH functionality is implemented either on the mobile node or in the network.
3) The MIH Function either on the mobile node or in the network, can receive and transmit information about the performance of access networks around the MN. This information typically originates at different layers of the protocol stack within the MN or other network elements.
    i) When the information originates at a remote network element, the MIH Function on the mobile node obtains it through MIH message exchanges with a peer MIH Function entity that resides in the remote network element.

ii) When the information originates at a lower layer of the protocol stack within the MN, the MIH Function on the mobile node obtains the information locally through the primitives of the (SAPs) that define the interface of the MIH Function with the originating lower layers.

## 1.4 Media Independence

The intent of the IEEE802.21 specification is to provide as much generic link layer intelligence as possible without tying the consumers of that intelligence into the features or specifics of particular terminals or radio networks. As such the IEEE 802.21 specification is intended to provide a generic interface between the link layer users in the mobility-management protocol stack and existing media-specific link layers, such as those specified by 3GPP, 3GPP2 and the IEEE 802 family of standards.

## 1.5 Media Dependence

The IEEE802.21 specification shall define generic SAPs and primitives that provide generic link layer intelligence. Individual media specific technologies thereafter need to enhance their media specific SAPs and primitives to satisfy the generic abstractions of the IEEE 802.21 specification. Suitable amendments may be required to link layer (MAC/PHY) specifications of different media specific technologies such as IEEE 802.11, IEEE 802.16, 3GPP, 3GPP2, etc. to satisfy the requirements of generic link layer intelligence identified by 802.21. This process may be carried out once the core elements of the IEEE 802.21 specification are developed.

## 1.6 Inter-operability and Compliance

The following compliance clauses shall be observed:

1) An implementation must allow the services described in the MIH_SAP to be provided to and accessed by an MIH user. The definition of the MIH_SAP service primitives does not specify how they are to be implemented. However, the formats and semantics of the service parameters of the MIH_SAP primitives shall be implemented as per IEEE 802.21 and shall be subject to standards compliance.
2) The protocol specified in IEEE 802.21 standard, including message exchanges, protocol data units and the state machine, shall be implemented according to the standard and shall be subject to standards compliance. Various classes of inter-operability and implementation compliance shall be specified based on the set of mandatory and optional features in the specification.

## 2. References

The following standards and technical specifications contain provisions which through references in this text constitute provisions of this standard. At the time of publication, the editions indicated were valid. Al standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below.

IEEE Std 802.11, 1999 Edition [ISO/IEC 8802-11: 1999], Information Technology- Telecommunications and information exchange between system-Local and metropolitan area networks-Specific Requirements-Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

IEEE Std 802.16, 2004 Edition [ISO/IEC 8802-16: 2004], Information Technology- Telecommunications and information exchange between system-Local and metropolitan area networks-Specific Requirements-Part 16: Air Interface for Fixed Broadband Wireless Access Systems.

IEEE Std 802.16, 2004 Edition [ISO/IEC 8802-16: 2004], Information Technology- Telecommunications and information exchange between system-Local and metropolitan area networks-Specific Requirements-Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems (Amendment for Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands).

IEEE Std 802.3-2002, Information Technology- Telecommunications and information exchange between system-Local and metropolitan area networks-Specific Requirements-Part 3: Carrier Sense Multiple Access with Collision Detection (CSMA/CD) Access Method and Physical Layer Specifications.

3GPP TS 23.002, "Network Architecture."

3GPP TS 23.060, "General Packet Radio Service (GPRS); Service Description; Stage 2."

3GPP TS 23.234, “3GPP system to Wireless Local Area Network (WLAN) inter-working; System description.”

3GPP TR 24.007 “Mobile Radio Interface Signaling Layer 3”

3GPP TS 25.331 “Radio Resource Control Specification”

3GPP TR 43.901 “Feasibility Study on Generic Access to A/Gb Interface.”

IETF RFC 3753, “Mobility Related Terminology”, J. Manner, M. Kojo

IETF RFC 1661, "The Point-to-Point Protocol (PPP) ", W. Simpson, July 1994

IS-2000.4-D "Signaling Link Access Control (LAC) Standard for cdma2000 Spread Spectrum Systems - Release D"

W3C Recommendation, “RDF Vocabulary Description Language 1.0: RDF Schema”, http://www.w3.org/TR/rdf-schema/.

W3C Recommendation, “SPARQL Query Language for RDF”, http://www.w3.org/TR/2004/WD-rdf-sparql-query-20041012/.

W3C Recommendation, “Resource Description Framework (RDF) – Concepts and Abstract Syntax”, http://www.w3.org/TR/rdf-concepts/.

W3C Recommendation, “RDF/XML Syntax Specification”, http://www.w3.org/TR/rdf-syntax-grammar/.

W3C Recommendation, "OWL Web Ontology Language Reference", http://www.w3.org/TR/owl-ref/.

IEEE P802.21 Media Independent Handover Service, Document 21-04-0087-12-0000, Draft Technical Requirements, Sept. 21, 2004. Available at: http://www.ieee802.org/21/sept04_meeting_docs/ 21-04-0087-12-0000-Draft_Technical_Requirements.doc

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## 3. Definitions

*For the purpose of this standard*, the following terms and definitions apply.

**Handover** – The process by which a mobile node obtains the preservation of facilities for supporting traffic flows upon occurrence of a link-switch event. The mechanisms and protocol layers involved in the handover may vary with the type of the link-switch event (i.e., with the type of the serving and target point of attachment and the respective subnet associations). Different types of handover are defined based on the way facilities for supporting traffic flows are preserved.

*Hard Handover* – Handover where facilities for supporting traffic flows are subject to complete unavailability between their disruption on the serving link and their restoration on the target link (break-before-make).

*Soft Handover* – Handover where facilities for supporting traffic flows are continuously available while the mobile-node link-layer connection transfers from the serving point of attachment to the target point of attachment. The network allocates transport facilities to the target point of attachment prior to the occurrence of the link-switch event (make-before-break).

*Seamless Handover* – Handover associated with a link switch between heterogeneous interfaces, where the mobile node either experiences no degradation in service quality, security, and capabilities, or experiences some degradation in service parameters that is mutually acceptable to the mobile subscriber and to the network that serves the newly connected interface.

**Handover Policies** – A set of rules that contribute to shaping the handover decision for a mobile node.

**Higher Layers** – These are the layers that make use of the services provided by the MIH Function and hence can be refered to as MIH users. Examples of higher layers are: IP, Mobile IP, SIP, TCP, UDP, Application layer, etc.

**Link** – A communication facility or medium over which L2 network nodes can communicate for exchange of L2 messages. Each link is associated with a minimum of two endpoints. Each link endpoint has a unique link-layer identifier.

**Link Layer** – Conceptual layer of control or processing logic that is responsible for maintaining control of the data link. The data link layer functions provide an interface between the higher-layer logic and the data link.

**Link Indication** – Information provided by the link layer to higher layers regarding the state of a link.

**Link Switch** – The process by which a mobile node changes the link that connects it to the network. Changing link implies changing the remote link endpoint and therefore the point of attachment of the mobile node.

**Lower Layers**– These are the layers located at OSI Level 2 and below across different media specific technology standards supported by the 802.21 specification. As an example, for 802.11 Lower Layers are the MAC Layer and the PHY layer and for 3GPP Lower Layers are the MAC and UMTS layers. The term "Lower Layers" also includes Logical Link Control Layers such as 802.2 LLC or 3GPP RLC. The MIH Function uses the services provided by these layers.

**Message** – The sequence of contiguous octets delivered as a unit by the N-user to the N-SAP and destined for a remote N-user.

**MIH Network Entity** – Network Entity with MIH Function capability.

**MIH Function** – A functional implementation of MIH services.

**MIH Pairing** – The communication relationship that exists between distinct MIH-Function instances when they exchange MIH messages or MIH information.

**MIH Point of Service (MIH PoS)** – Network-side MIH-Function instance that exchanges MIH messages with a MN-based MIH Function. The same MIH Network Entity includes a distinct MIH PoS for each MIH-enabled MN with which it exchanges MIH messages. A single MIH PoS may host more than one MIH service. The same MIH Network Entity can include multiple MIH Point of Services that can provide different combinations of MIH services to the respective MN's based on subscription or roaming conditions. Note for a network entity comprising of multiple interfaces, the notion of MIH PoS is associated with the network entity itself and not with just one of its interfaces.

**MIH PoS Network Entity** – MIH Network Entity that can exchange MIH messages with MIH-enabled MN.

**MIH Users –** MIH users are entities that use the services provided by the MIH Function. MIH Users use the MIH_SAP SAP to interact with the MIH Function.

**Mobile Node** – Network node that can change its point of attachment from one link to another at any time. The mobile node can either be in close proximity of or coincide with the mobile terminal.

**Mobile Node Association** – The connectivity state where the mobile node is ready to exchange user data (like TCP/UDP packets) with the network point of attachment.

**Mobile Terminal** – User interfacing network node that includes protocol stack layers above the link layer. The mobile terminal can either be in close proximity of or coincide with the mobile node.

**N-entity** – Abstraction of a functional component of a network element, whose control resides within the N-layer. See also peer N-entity.

**N-event** – A change of state in an entity whose control resides within the N-layer (N-entity). An N-event can be notified to an N-user through an indication service primitive, or stimulated by an N-user through a request service primitive.

**N-layer** – A subdivision of the layered protocol architecture, constituted by subsystems of the same rank (N).

**N-trigger** – N-event notification to an N-user, typically conveyed by an indication service primitive. See also remote N-trigger.

**N-user** – An (N+1)-layer entity that uses the services of the N-layer and lower layers to communicate with another (N+1)-layer entity.

**Network Detection** – The process by which a mobile node collects information on its neighboring networks, identifies its current point of attachment, and ascertains the validity of its link-layer configuration.

**Network Entity –** Communication node inside the network.

**Network Point of Attachment (Network PoA)** – Network-side endpoint of a link that includes a MN as an endpoint. Note: The PoA definition is associated with an interface instead of a node. Here, the term ‘network’ means subnet, or subnet + VLAN, or broadcast domain, or routing domain, as opposed to media type or the entire set of connections behind the PoA. Two network points of attachment are involved in a link switch event as follows:

*Serving Point of Attachment* – The point of attachment of the mobile node prior to the link-switch event.

*Target Point of Attachment* – The point of attachment of the mobile node that results from the link-switch event.

**Network Selection** – The process by which a mobile node or a network entity collects policy information on its neighboring networks and selects a link (possibly out of many available) to establish network-layer connectivity.

**Network Selector** – The entity that undertakes the Network Selection decision that may lead to a handover.

**Non-PoS MIH Network Entity** – The MIH Network Entity that cannot exchange MIH messages with MIH enabled MN, but only with other MIH Network Entities.

**Peer N-entity** – N-entity residing in a network element, defined with reference to its N-layer communication (messaging) with another N-entity in a different network element. See also N-entity.

**Protocol Data Unit** – The sequence of contiguous octets delivered as a unit by the N-user to the N-SAP and destined for a remote N-user.

**Remote N-trigger** – Notification to an N-user of an N-event affecting a remote N-entity, typically conveyed by the sequence of an N-PDU transmitted from the remote N-entity to the local N-entity and an indication service primitive passed from the local N-entity to the destination N-user. See also N-trigger.

**Service Access Point (SAP)** – The point in a protocol stack where the services of a lower layer are made available to its next higher layer.

**Service Continuity** – Transparent maintenance of an active service while the mobile node transitions across wireless or wire-line coverage.

**Service Data Unit** – The sequence of contiguous octets transmitted as a unit from one N-SAP to another N-SAP.

**Service Primitive** – Conceptual abstraction describing the information transfer the occurs between N-user and N-layer in the provision of a service. The abstraction resides in the exclusive specification of the service provided and not in the means by which the service is provided.

# 4. Abbreviations and acronyms

The following abbreviations and acronyms are used in this standard.

| | |
|---|---|
| 3G | Third Generation |
| 3GPP | 3G Partnership Project |
| 3GPP2 | 3G Partnership Project 2 |
| AAA | Authentication, Authorization, and Accounting |
| ACK | Acknowledgement |
| AN | Access Network |
| ANI | Access Network Information |
| AP | Access Point |
| AR | Access Router |
| AS | Access Stratum |
| ASN.1 | Abstract Syntax Notation One |
| BS | Base Station |
| BSC | Base Station Controller |
| BSSID | Basic Service Set Identifier |
| BTS | Base Transceiver Station |
| ESS | Extended Service Set |
| CN | Core Network |
| CS | Convergence Sublayer |
| CSME | Convergence Sublayer Management Entity |
| FA | Foreign Agent |
| FMIP | Fast Handover Mobile IP |
| GGSN | Gateway GPRS Support Node |
| GMII | Gigabit Media Independent Interface |
| GMM | GPRS Mobility Management |
| GPRS | General Packet Radio Service |
| GSM | Global System for Mobile Communication |
| HA | Home Agent |
| HIP | Host Identity Protocol |
| HLSI | Higher Layer Service Information |
| HMIP | Hierarchical Mobile IP |
| ICMP | Internet Control Message Protocol |
| IEEE | Institute of Electrical and Electronics Engineers |
| IETF | Internet Engineering Task Force |
| ICMP | Internet Control Message Protocol |
| IP | Internet Protocol |
| ISP | Internet Service Provider |
| ITU | International Telecommunications Union |
| L1 | Layer 1 (PHY) |
| L2 | Layer 2 (MAC and LLC) |
| L3MP | Layer 3 Mobility Management Protocol |
| LAN | Local Area Network |
| LLC | Logical Link Control |
| LLI | Link Layer Information |
| LTE | Long Term Evolution |
| MAC | Medium Access Control |
| MAP | Mobility Anchor Point |
| MDI | Medium Dependent Interface |
| MICS | Media Independent Command Services |
| MIES | Media Independent Event Services |
| MII | Media Independent Interface |

| | |
|---|---|
| MIH | Media Independent Handover |
| MIHO | Media Independent Handover |
| MIHF | Media Independent Handover Function |
| MIHS | Media Independent Handover Services |
| MIIS | Media Independent Information Service |
| MIP | Mobile IP |
| MLME | MAC Layer Management Entity |
| MMS | Multimedia Message Service |
| MN | Mobile Node |
| MS | Mobile Station |
| MSS | Mobile Subscriber Station |
| MSDU | Medium Access Control (MAC) Service Data Unit |
| MSME | MAC Common Part Sublayer Management Entity |
| MT | Mobile Terminal |
| N/A | Not Applicable |
| NAS | Non-access Stratum |
| NAK | Negative Acknowledgement |
| NMS | Network management system |
| PCS | Physical Coding Sublayer |
| PHY | Physical Layer |
| PLMN | Public Land Mobile Network |
| PLME | Physical Layer Management Entity |
| PMA | Physical Medium Attachment |
| PMD | Physical Medium Dependent |
| PoA | Point of Attachment |
| PoS | Point of Service |
| QoS | Quality of Service |
| RFC | Request for Comment |
| RLC | Radio Link Control |
| RNC | Radio Network Controller |
| RRC | Radio Resource Control |
| SAE | System Architecture Evolution |
| SAP | Service Access Point |
| SDO | Standards Development Organization |
| SDU | Service Data Unit |
| SGSN | Serving GPRS Support Node |
| SM | Session Management |
| SME | Station Management Entity |
| SNDCP | Sub-Network Data Convergence Protocol |
| SNR | Signal-to-Noise Ratio |
| SS | Subscriber Station |
| STA | Station |
| TCP | Transmission Control Protocol |
| TLV | Type-Length-Value message |
| UDP | User Datagram Protocol |
| UE | User Equipment |
| UMTS | Universal Mobile Telecommunications System |
| VPN | Virtual Private Network |
| WLAN | Wireless Local Area Network |
| WMAN | Wireless Metropolitan Area Network |
| WPAN | Wireless Personal Area Network |
| XML | Extensible Mark-up Language |

# 5. General Architecture

## 5.1 Introduction

The IEEE 802.21 specification is intended to facilitate a variety of handover methods. Such methods are generally classified as 'hard' or 'soft', depending on whether the handover procedure is “break before make” or “make before break” with respect to the data transport facilities that support the exchange of data packets between the mobile node and the network.

In general, handover involves cooperative use of both mobile terminal and network infrastructure in order to satisfy network operator and end user needs. Handover control, handover policies and other algorithms involved in handover decision making are generally handled by communication system elements which do not fall within the scope of the IEEE 802.21 standard. However, it is beneficial to describe certain aspects of the overall handover procedure so that the role and purpose of MIH Event Service, MIH Command Service, MIH Information Service and MIH Function in overall handover process is clear.

The following subsections give an overview of how the different factors that may affect handovers are addressed within the current standard.

### 5.1.1 Service Continuity

Handovers may occur either between two different access networks or between two different points of attachment of a single access network. In such cases service continuity is defined as the continuation of the service during and after the handover while minimizing aspects such as data loss and break time during the handover without requiring any user intervention. The change of access network may or may not be noticeable to the end user, but there should be no need for the user to re-establish the service. There may be a change in service quality as a consequence of the transition between different networks due to the varying capabilities and characteristics of the access networks. For example if the QoS supported by new access network is unacceptable, higher layer entities may decide not to handover or may terminate the current session after the handover based on applicable policies. This specification specifies essential elements which enable service continuity.

### 5.1.2 Application Class

Various applications have different tolerance characteristic for delay and data loss. Application aware handover decisions can be enabled by making a provision for such characteristics. For example, when a network transition due to impending handover is made during the pause phase of conversation in an active voice call, the perceptible interruption in the service is minimized.

### 5.1.3 Quality of Service (QoS)

QoS is an important factor to consider in the handover decision making. In general the handover decision entity shall try to select the network with the most appropriate QoS support level for handover in an effort to maintain the level of user experience. Hence to enable seamless handover operations, it is necessary that the 802.21 standard specify the means by which QoS information can be obtained for each of the supported access networks and be made available to the upper layers involved in handover decision making.

### 5.1.4 Network Discovery

Network discovery is essential to provide new possibilities for network selection to suit the need of the applications and mobility. Thus, it is necessary that 802.21 defines the network information and specifies the means by which such information can be obtained for supported access networks and made available to the

MIH users. The network information could include information about link type, link identifier, link availability, link quality, etc.

### 5.1.5 Network Selection

Network Selection is the process by which a mobile node or a network entity collects policy information on its neighboring networks and selects a link (possibly out of many available) to establish network-layer connectivity. The selection can be based on various criteria such as required QoS, cost, user preferences, policies, etc. If the selected network is not the currently used network, then a handover to the preferred network may be required. The 802.21 standard may specify the means for such information to be made available to the upper layers to enable effective network selection.

### 5.1.6 Security

Events, commands and information messages carried between a MT (Mobile Terminal) and a network PoA (Point of Attachment) cannot be secured until the MT is securely associated with the network PoA. This association can be achieved either via lower or higher layers security mechanisms. Once such a secure association has been established between the MT and the network PoA, any messages exchanged between two MIH Function entities should retain integrity and be replay protected over a secure transport. Otherwise the exchanged MIH messages are prone to integrity, replay and man-in-the-middle attacks. The 802.21 standard may specify the means for security information to be made available to the upper layers to setup secure connections.

### 5.1.7 Power Management

This specification provides information that helps to preserve battery life. For example efficient 'sleep modes' can be managed based on real time link status, efficient scanning is achieved using neighbor maps of different networks and readily available reports of optimum link layer parameters. Power management is dependent on particular access technology in use.

### 5.1.8 Handovers due to Mobile Terminal Movement

Handovers due to the mobile node movement are facilitated by providing timely information about changing link conditions and different access networks in neighboring micro and macro cells.

### 5.1.9 Handover Policy

The primary role of the MIH Function is to facilitate handovers and provide intelligence to the network selector entity or the mobility management entity responsible for handover decision as described by other standards or proprietary implementations. The MIH Function aids the network selector entity with the help of Event service, Command service and Information service. The network selector entity and the handover policies that control handovers are outside the scope of MIH Function. Description of specific handover policies and the details of network selector entity are outside the scope of 802.21 standards as well.

The IEEE 802.21 specification defines services that enhance handovers between heterogeneous access links. This is achieved through facilitating handover process by providing link layer intelligence relevant in handover detection, handover initiation and candidate link selection by MIH user.

1) A Media Independent Event Service (MIES) which provides event classification, event filtering and event reporting corresponding to dynamic changes in link characteristics, link status, and link quality.
2) A Media independent Command Service (MICS) which enables MIH user to manage and control link behavior relevant to handovers and mobility.

3) Media Independent Information Service (MIIS) which provides details on the characteristics and services provided by the serving and surrounding networks. The information enables effective system access and effective handover decisions.
4) The above services are supported by the Media Independent Handover Function (MIHF) to facilitate a MIH user in mobility management and handover process. The MIH Function provides convergence of link-layer state information from multiple heterogeneous access technologies into a unified presentation to the upper layers of the mobility-management protocol stack.

## 5.2 General Design Principles

The 802.21 standard is based on the following general design principles.

a) The Media Independent Handover (MIH) Function is logically defined as a shim layer in the mobility-management protocol stack of both the mobile node and the network elements that provide mobility support. MIH is a helper and facilitator function which helps in handover decision making. Upper layers make handover decisions and link selection based on inputs and context from MIH. Facilitating the recognition that a handover should take place is one of the key goals of MIH Function. Discovery of information on how to make effective handover decisions is also a key component.
e) MIH Function provides abstracted services to higher layers. From that perspective MIH offers a unified interface to the upper layers. The service primitives exposed by this unified interface are independent of the technology specific protocol entities of the different access networks. The MIH Function communicates with the lower layers of the mobility-management protocol stack through technology-specific interfaces. The specification of the MIH interfaces with the lower layers generally does not fall within the scope of this standard. Such interfaces are already specified as service access points (SAPs) within the standards that pertain to the respective access technologies, such as IEEE 802.1, IEEE 802.3, IEEE 802.11, IEEE 802.16, 3GPP and 3GPP2. This standard may contain recommendations to amend the existing access technology specific standards when modifications of the lower-layer interfaces may enable or enhance MIH functionality.
f) Handover signaling (as part of handover execution and subsequent updates) may not be part of the standard. Different networks support different intra-roaming handover mechanisms (mobile initiated, network initiated, etc.). Handover initiation trigger may be useful in heterogeneous handovers when not done as per the homogeneous scheme.
g) MIH Function may do further processing on MAC/PHY triggers and other related events. Definition of this processing is outside the scope of the standard. The standard shall provide support for Remote Events as well. Some of these events may encapsulate messages related to network selection (such as Link Going Down) that may be exchanged between different MIH entities. Events are advisory in nature. The decision to cause a handover or not based on these events is outside the scope of the standard.
h) The standard shall specify mechanisms to support MN-initiated, MN-controlled, network-initiated and network-controlled handovers.
i) The standard should support transparent inter-working with legacy equipment. Thus 802.21 compatible equipment should be able to co-exist with legacy non 802.21 compliant equipment.

## 5.3 Media Independent Handover Reference Framework

The following sections describe the key salient points with regards to communication between different MIH entities in the client device (MN) and the network.

### 5.3.1 MIH Communication Model

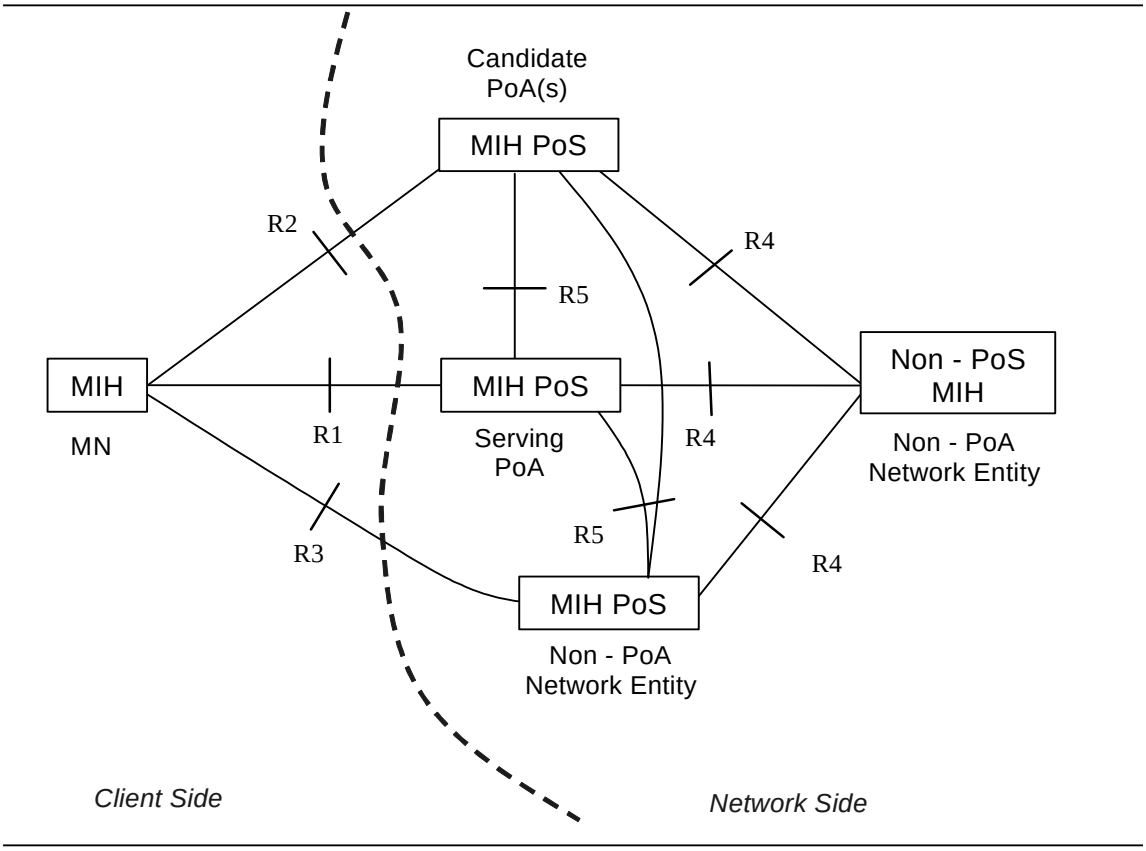



**Figure 2 — MIH Communication Model**

MIH functions communicate with each other for various purposes. The client device (User Equipment) exchanges MIH information with its MIH Point of Service. The MIH function in any Network Entity becomes a MIH PoS when it communicates directly with a MN based MIH function. In a network model that encompasses a MIH proxy, the MIH Network Entity that interfaces with the MIH proxy does not have a direct connection to the MN and therefore does not constitute a MIH PoS for that particular MN. The same MIH Network Entity can still act as MIH PoS for a different MN.

MIH communication may not take place on all L2 interfaces of a MIH capable MN. As an example, on an MIH capable MN with three L2 interfaces namely 802.11, 802.16, and 802.3, the 802.3 interface may be used only for system administration and maintenance operations, while the 802.11 and 802.16 interfaces may engage in the provision of MIH services. The MN may use L2 transport for exchanging MIH information with a MIH PoS that resides in the same Network Entity as its Network PoA. The MN may use L3 transport for exchanging MIH information with a MIH PoS that may not reside in the same Network Entity as its Network PoA.

Figure 2 — shows the MIH communication model. The model shows MIH Functions in different distinctive roles and the communication relationships amongst them. The communication relationship shown in the above figure applies only to MIH Functions. It is important to note that each of the communication relationships in the communication model does not imply a particular interface or transport mechanism. Rather, a communication relationship only intends to show that MIH related information passing is possible between

the two distinctive MIH Functions. Moreover, each communication relationship shown in the diagram may encompass different type of interfaces, different transport mechanisms used (e.g., L2, L3), and different MIH service related content being passed (e.g., IS, CS, ES, etc.).

The communication model assigns different roles to the MIH Function depending on its position in the system.

1) MIH on the MN
2) MIH PoS on the Network Entity that includes the serving PoA of the MN
3) MIH PoS on the Network Entity that includes a candidate PoA for the MN (a candidate PoA is a PoA that the MN is aware of but not currently attached to; it becomes the target PoA if a handover eventually occurs)
4) MIH PoS on a Network Entity that does not include a PoA for the MN
5) Non-PoS MIH on a Network Entity that does not include a PoA for the MN.

The communication model also identifies the following communication reference points between different instances of MIH Functions.

1) **Communication reference point R1**: Reference Point R1 refers to MIH procedures between the MIH Function on the MN and the MIH PoS on the Network Entity of its serving PoA. R1 may encompass communication interfaces over both L2 and L3 and above, and content passed over R1 can be related to MIIS, MIES, or MICS.
2) **Communication reference point R2**:Reference Point R2 refers to MIH procedures between the MIH Function on the MN and the MIH PoS on the Network Entity of a candidate PoA. R2 may encompass communication interfaces over both L2 and L3 and above, and content passed over R2 can be related to MIIS, MIES, or MICS.
3) **Communication reference point R3**: Reference Point R3 refers to MIH procedures between the MIH Function on the MN and the MIH PoS on a non-PoA Network Entity. R3 may encompass communication interfaces over L3 and above and possibly L2 transport protocol like Ethernet bridging, MPLS, etc. MIH content passed over R3 may be related to MIIS, MIES, or MICS.
4) **Communication reference point R4**: Reference Point R4 refers to MIH procedures between an MIH PoS in a Network Entity and a non-PoS MIH Function instance in another Network Entity. R4 may encompass communication interfaces over L3 and above, and MIH content passed over R4 may be related to MIIS, MIES, or MICS.
5) **Communication reference point R5**: Reference Point R5 refers to MIH procedures between two MIH PoS instances in distinct Network Entities. R5 may encompass communication interfaces over L3 and above, and MIH content passed over R5 may be related to MIIS, MIES, or MICS.

**Table 1—Summary of Communication Reference Points**

| Reference Point | Description | Transport Choices | Scope of Definition |
|---|---|---|---|
| R1 | Between the MIH on a MN and an MIH PoS on the Network Entity of the serving PoA. | Usually L2 (L3 possible) | In scope of 802.21 |
| R2 | Between the MIH on a MN and a MIH PoS on the Network Entity of the candidate PoA. | Usually L2 (L3 possible) | In scope of 802.21 |
| R3 | Between the MIH on a MN and a MIH PoS on a non-PoA network entity. | Usually L3 (L2 possible) | In scope of 802.21 |

**Table 1—Summary of Communication Reference Points**

| Reference Point | Description | Transport Choices | Scope of Definition |
|---|---|---|---|
| R4 | Between a MIH PoS and a non-PoS MIH Function instance in distinct Network Entities. | Usually L3 | In scope of 802.21 |
| R5 | Between two MIH PoS instances in distinct Network Entities. | Usually L3 | In scope of 802.21 |

### 5.3.2 Logical Network Reference Model

A MIH logical network reference model is shown in Figure 3. The model includes a MIH capable mobile node that supports multiple access-technology options. Each access technology either advertises its MIH capability or responds to MIH terminal queries. The model assumes that the provisioning service provider either operates multiple access technologies or allows its user to roam into visited networks when SLA in support of interworking has been established. The service provider allows access to one or more Points of Service including access to the operator's Information Server located in a MIH PoS node. When provisioned the MN relies on periodic access to its operator MIIS to obtain pertinent information such as new roaming lists, priorities and any other related information that would enable to utilize services in various access networks. It is possible for the mobile node to also obtain MIH information services from the visited network to obtain information about the visited network or information elements from the home network via the visited network PoS. On the network side, the location of a MIH PoS node is not deterministic and may vary based on operator deployment scenario or the technology-specific MIH architecture. A MIH PoS may reside next to or co-located with the PoA in the access network or alternatively deeper inside the access or core networks. The interaction of visited and home network could be either for control and management purposes or for data transport purposes. It is also possible that due to roaming or SLA agreements, the home network may allow the MN to access the public Internet directly through the visited network.

As shown in Figure 3, the MIH entity in the MN could be communicating with MIH network entities either by R1, R2 or R3 over any access network and two MIH network entity communicate with each other via R4 or R5 reference points. When the PoA in the serving access network has a co-located MIH function, then R1 reference point terminates at PoA while the R3 reference point would be terminated at any non-PoA MIH network entity located either in the visited core network or the home network. The MIH capable PoA can also communicate with other MIH network entities via R3 and R4 reference points. The MIH capable MN could have a MIH communication with other PoA in the candidate access networks via R2 reference point to obtain information services about the candidate network. The IEEE 802.3 enabled wire-line access network may work in a similar fashion to the wireless access network if the MN were to use the home operator subscription services. Although not shown in the current figure, in an enterprise environment the 802.3 wireline access may gain direct access to the Internet from its PoA.

In Figure 3, the cellular access network is shown to be owned by the home operator that provisioned the user, however it is possible that cellular roaming may involve accessing other cellular access networks owned by other networks when SLA is established. For cellular access cases, the definition and location of PoA will be determined by the relevant cellular standard or the network operator (e.g. BS or RNC or GGSN in 3GPP and PDSN in 3GPP2). For this reason, the location of the PoA could either be in the visiting network or the home operator network. Hence, reference points R1 is shown to terminate MIH PoS and PoA at the cellular home network when the MIH PoA is located at the GGSN/PDSN elements. The home network may utilize R3 and R4 interfaces to access other MIH entities like the Home or Visited MIH information server.

Events can originate at both sides of an active R1 link. However, the MN is typically the first node to react to link-state change events. The overall mobility management architecture may include Mobile IP infrastruc-

ture (client, FA, HA, H-AAA), SIP mobility infrastructure (client, SIP servers), combination of the two (MIP and SIP) or any other mobility schemes. The mobility management is not part of the MIH architecture but may be one of its users. Mobility management entities are merely shown as a possible scenario of interaction with mobility and security frameworks.

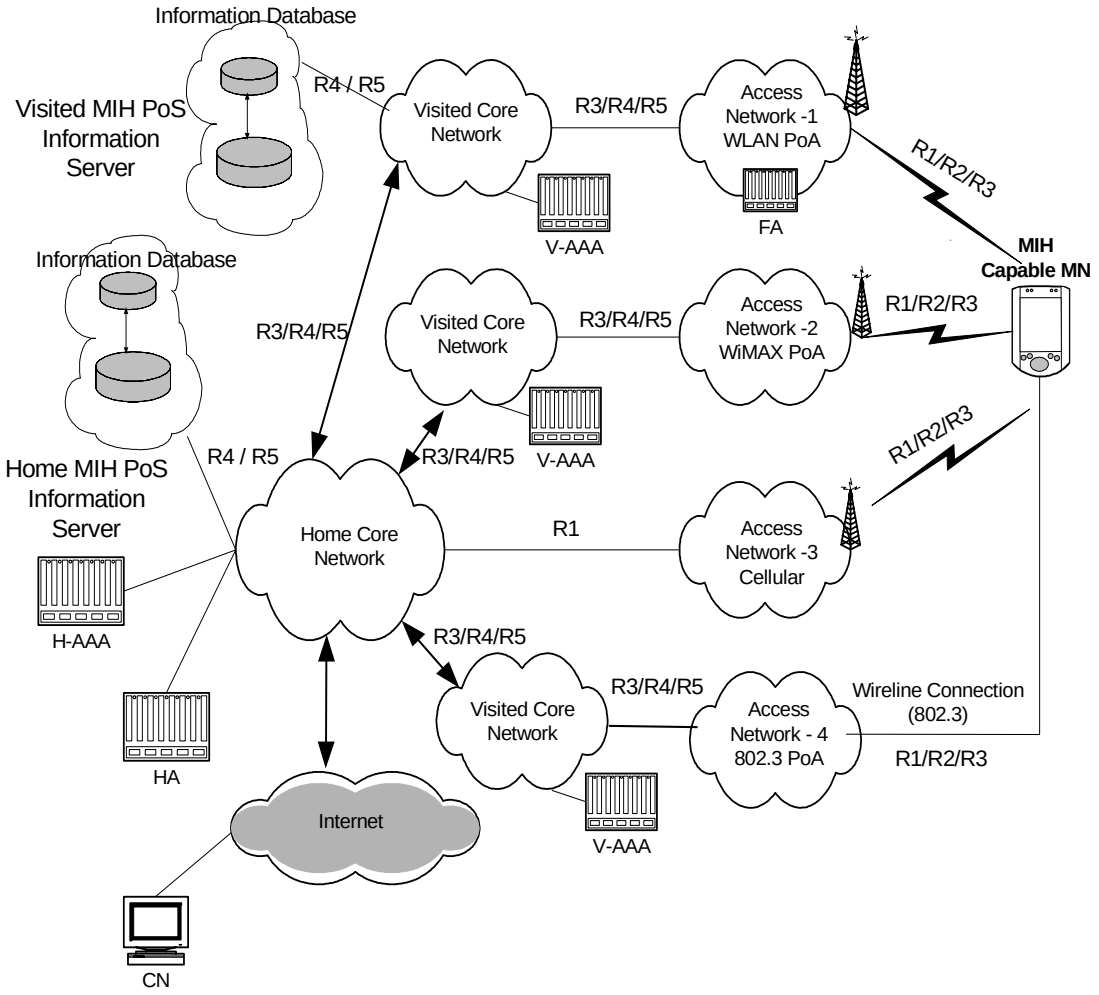



**Figure 3 — Logical Network Reference Model**

## 5.4 MIH Function Services

The MIH Function provides asynchronous and synchronous services through well defined SAPs for link layers and MIH users. In the case of a system with multiple network interfaces of arbitrary type, the upper layers can use the Event service, Command service and Information service provided by MIH to manage, determine, and control the state of the underlying interfaces.

These services provided by MIH help the upper layers in maintaining service continuity, service adaptation to varying quality of service, battery life conservation, and network discovery and link selection. In a system

containing heterogeneous network interfaces of 802 types and cellular 3GPP, 3GPP2 types, the Media Independent Handover Function can help the upper layers to implement effective procedures to couple services across heterogeneous network interfaces. Upper layers may utilize services provided by the MIH Function across different entities to query and reserve resources required for a handover operation between heterogeneous networks.

MIH services in mobile devices facilitate seamless handover between heterogeneous networks. A MIH user such as a mobility management protocol (example Mobile IP) could be supported for handover and seamless session continuity. This shall not preclude other protocols in addition to Mobile IP and even other upper layers from making use of MIH services to optimize handovers.

Mobile terminals employing the MIH services would receive indications from link layers for asynchronous operations like Event service. The interaction with Command service and Information service will be through synchronous query and response type of mechanisms.

The MIH Function would also provide the functionality for the exchange of information between the network and host entities of the same media type. Note, if mechanism for such information exchange already exists with a given type of media (such as with some cellular media types), the MIH Function will make use of the existing mechanism whenever possible.

### 5.4.1 Media Independent Event Service

Events can indicate changes in state and transmission behaviour of the physical, data link and logical link layers, or predict state changes of these layers. The Event Service can also be used to indicate management actions or command status on part of network or some such management entity.

#### 5.4.1.1 Event Origination

Events can originate from the MIH Function (MIH Events) or any lower layer (Link Events).

#### 5.4.1.2 Event Destination

The destination of an event may be the MIH Function or any upper layer entity. The recipient of the event can be located within the stack that originated the event or within a remote stack . The destination of an event is established dynamically with a registration mechanism that enables an endpoint to register its interest in particular event types.

#### 5.4.1.3 Event Flow

In case of local events, messages typically propagate from the lower layers (PHY, MAC, GMM...) to the MIH Function and from MIH Function to any upper layer. In case of remote events, messages propagate from the MIH Function in one stack to the MIH Function in the peer stack. Events may then be further propagated to any upper layer. One of the stack may be present in a client or mobile terminal type of device while the other may be present in a fixed network entity. This network entity can be a point of attachment or any node not directly connected to the other stack.

#### 5.4.1.4 Event service use cases and functions

The event service will typically be used to detect need for handovers. For example an indication that the link will cease to carry MAC SDUs at some point in the near future may be used by upper layers to prepare a new point of attachment ahead of the current point of attachment ceasing to carry frames. This has the potential to reduce the time taken to handover between attachment points. Events defined include Link Up, Link Down, Link Parameters Change, Link Going Down, and L2SDU Transmission Status, Link Event Rollback, etc.

Events may carry additional context data. For example a Link Up event may carry information including layer 2 & layer 3 identification, identifier of serving entities where these identifiers can be acquired. A Link Up event may also carry IP address renewal indication which can inform upper layers of the need to initiate a layer 3 handover . This can serve to improve the performance of layer 3 handovers.

### 5.4.2 Media Independent Command Service

The command service enables higher layers to control the physical, data link and logical link layers (also know as "lower layers"). The higher layers may control the reconfiguration or selection of an apropriate link through a set of handover commands.

#### 5.4.2.1 Command Origination

Commands can be invoked from upper layers (MIH Commands) as well as from the MIH Function (Link Commands).

#### 5.4.2.2 Command Destination

The destination of a command may be the MIH Function or any lower layer. The recipient of a command can be located within the stack that originated the command, or within a remote stack.

#### 5.4.2.3 Command Flow

In case of local commands, messages typically propagate from the upper layers (policy engine…) to the MIH Function and then from MIH Function to lower layers. In case of remote commands, messages may propagate from upper layers via MIH Function in one stack to the MIH Function in a peer stack (with the use of the MIH Protocol). Commands may then be further propagated to any lower layer. One of the stack may be present in a client or mobile terminal type of device while the other may be present in a fixed network entity. This network entity can be a point of attachment or any node not directly connected to the other stack.

#### 5.4.2.4 Command service use cases

The commands generally carry the upper layer decisions to the lower layers on local device entity or at remote entity. For example the command service may be used by the policy engine of an entity in the network to request a terminal to switch between links (remote command to lower layers on terminal stack). Comamnds defined include MIH_Switch, MIH_Get_Status, etc.

### 5.4.3 Media Independent Information Service

Media Independent Information Service (MIIS) provides a framework and corresponding mechanisms by which a MIHF (Media Independent Handover Function) entity can discover and obtain network information existing within a geographical area to facilitate the handovers. MIIS primarily provides a set of information elements (IEs), the information structure and its representation and a query/response type of mechanism for information transfer. This contrasts with the asynchronous push model of information transfer for the event service. The information may be present in some information server from where the MIH Function in the station can access it. The definition of the information server and the mechanism to access it are outside the scope of this standard.

The information can be made available via both lower as well as higher layers. Information can be made available at L2 through both a secure and an insecure port. Information available through insecure port would typically be less sensitive and would typically allow the mobile terminal or the network to make a quick handover decision before incurring the overhead of authentication and establishing a secure L2 connection with the network.

In certain scenarios L2 information may not be available or sufficient to make intelligent handover decision. In such cases, higher layer information service is required. The capability of such network information service can be obtained via schema access. The structure and definition of a schema can be represented in a high level language such as XML. However the transport and security of this information are outside the scope of IEEE 802.21.

The Information service also provides access to static information such as neighbor reports. This information helps in network discovery. The service may also provide access to dynamic information which may optimize link layer connectivity with different networks. This could include link layer parameters such as channel information, MAC addresses, security information, etc. Information about available higher layer services in a network may also help in more effective handover decision making before the mobile terminal actually attaches to any particular network.

While selecting for an appropriate syntax for information exchange it is desired that:

1) The information exchange should be done fast
2) The overhead in exchange of information should be as less as possible
3) The extraction of the information at the terminal should not include high computational complexity

The information provided by Information service conforms to structure and semantics specified within 802.21. The Media Independent Information service specifies a common (or media independent) way of representing this information across different technologies by using a standardized format such as XML or ASN.1

MIIS provides the ability to access this information about all heterogeneous networks in a geographical area from any single L2 network, depending on how the 802.21 MIIS service is implemented. MIIS either relies on existing access media specific transports and security mechanisms or L3 transport and L3 security mechanisms to provide access to the information. How this information is developed and deployed in a given L2 network is outside the scope of the standard. A media independent neighbor graph may be abstracted obtaining the neighbor reports from media specific technology, however, the generation and maintenance of this media independent neighbor graph is out of scope of this standard. Typically, in a heterogeneous network composed of multiple media types, it is the handover decision module or higher layer mobility management will collect information from different media types and assemble a consolidated view to facilitate its inter-media handover decision.

Some networks such as the cellular networks already have an existing means of detecting a list of neighborhood base stations within the vicinity of an area via the broadcast control channel. Other IEEE groups define similar means and supports clients in detecting a list of neighborhood access points within the vicinity of an area via either beaconing or via the broadcast of MAC management messages. The Media Independent Information service (MIIS) provides a unified framework to help the higher layer entities across the heterogeneous network environment to facilitate discovery and selection of multiple types of networks existing within a geographical area. In the larger scope, the macro objective is to help the higher layer mobility protocol to acquire a global view of the heterogeneous networks to facilitate seamless handover when roaming across these networks.

## 5.5 MIH Reference Model for Access Networks

The MIH Function provides asynchronous and synchronous services through well defined Service Access Points for upper layers. The following sections describe the reference model for various access networks with MIH functionality.

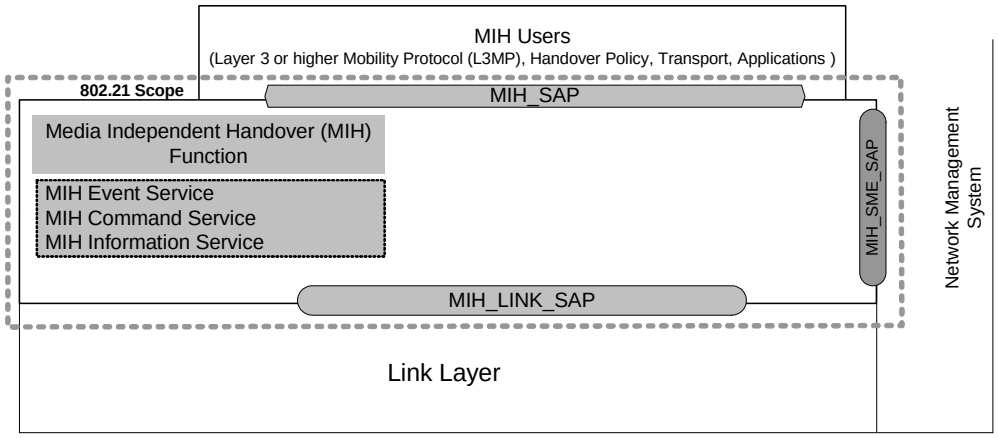



**Figure 4 — General MIH Reference Model and SAPs**

Figure 4 — illustrates the position of MIH Function in different protocol stacks and the interaction of MIH Function with other different elements of the system. All exchanges between the MIH function and other functional entities occur through service primitives, grouped in Service Access Points (SAPs). The media agnostic General MIH Reference Model includes the following SAPs:

a) MIH_SAP: Media-independent interface of MIH Function with the upper layers of the protocol stack.
d) MIH_LINK_SAP: Generic SAP which represents the abstract media-dependent interface of MIH Function with the lower layers of the protocol stacks.
e) MIH_NMS_SAP: Media-independent interface of MIH Function with the network management system.

In the media specific reference models, the media-independent SAPs (MIH_SAP and MIH_NMS_SAP) always maintain the same name and same set of primitives. The media-dependent SAP (MIH_LINK_SAP), assumes media-specific names and sets of primitives, often reusing names and primitives that already exist in the respective media specific pre-existing lower-layer SAP's. Priitives defined in MIH_LINK_SAP result in amendments to media specific SAP's due to additional functionality defined for interfacing with MIH Function.

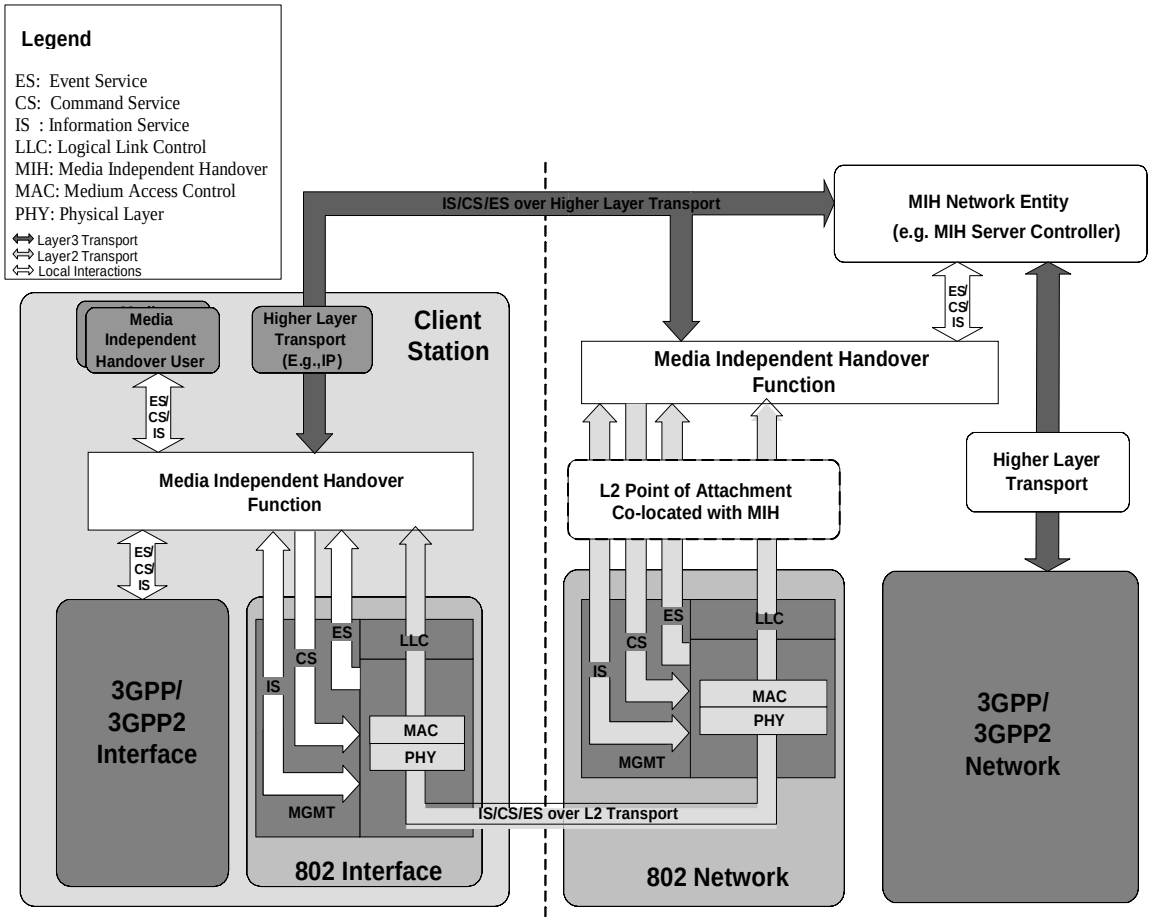



**Figure 5 — MIH Reference Model across Different Networks**

### 5.5.1 MIH Reference Model for 802.3

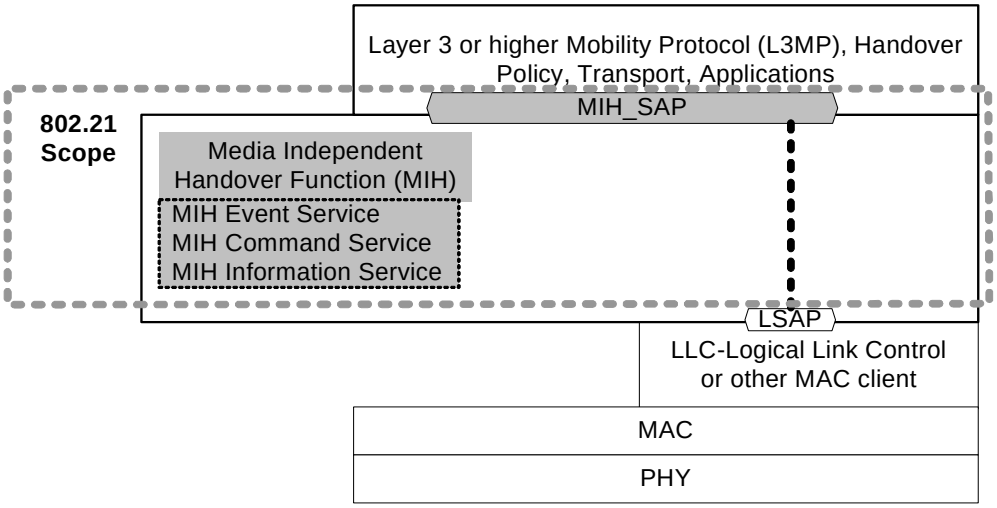



**Figure 6 — MIH Reference Model for 802.3**

The MIH reference model for 802.3 is illustrated above in Figure 6 —. The IEEE 802.21 standard supports the Media Independent Event service, Media Independent Command service and Media Independent Information service. In case of wired ethernet networks the payload of MIH services is supported over the data plane by using existing primitives defined by the LSAP.

### 5.5.2 MIH Reference Model for 802.11

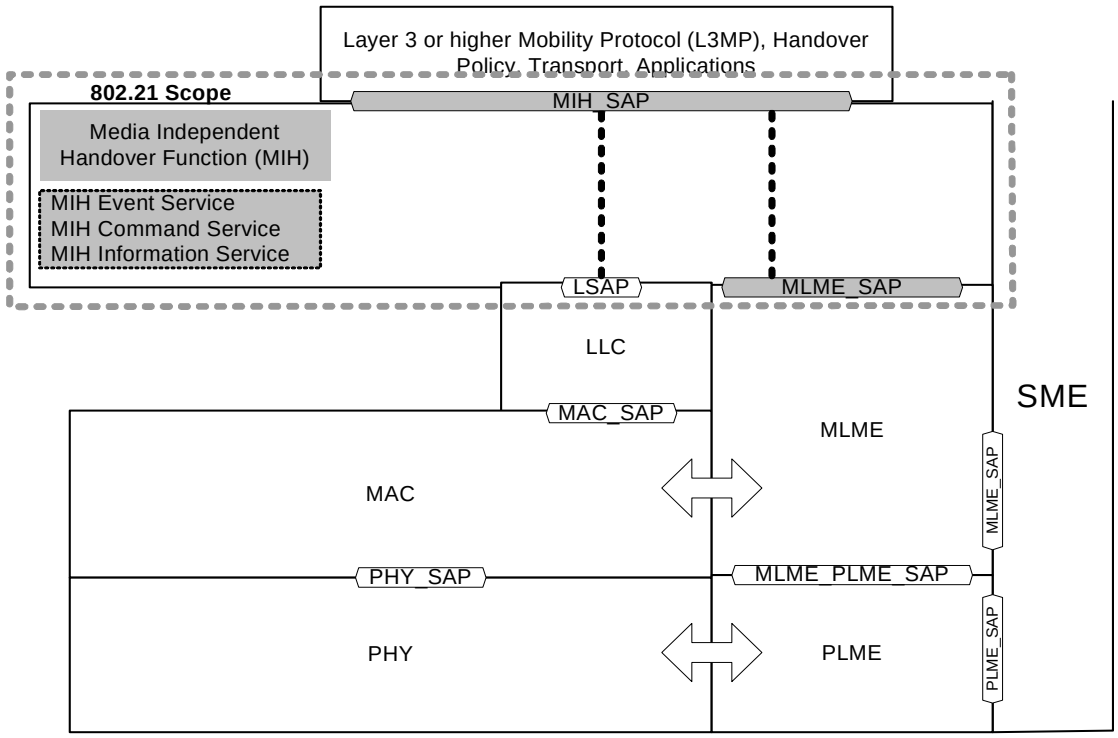



**Figure 7 — MIH Reference Model for 802.11**

Figure 7 — shows the MIH functions for 802.11 stations and network PoA (APs). The LSAP defines the MIH interface to the data plane and can encapsulate MIH payload in data packets. However, since 802.11 does not currently support Class 1 data frames, traffic can be sent over the data plane only when the client has associated with the AP.

The MLME_SAP specifies the interface between MIH and the management plane (MLME) and allows MIH payload to be encapsulated in management frames (such as action frames). Thus primitives specified by MLME_SAP can be used to transfer packets before a station has associated with an AP, whereas the LSAP SAP can be used to transfer packets after association has been established with an AP.

The MIH_SAP specifies the interface of MIH Function with other higher layer entities such as transport, handover policy function and L3 Mobility protocol.

### 5.5.3 MIH Reference Model for 802.16

Figure 8 — shows the MIH function for 802.16 based system. The M_SAP and C_SAP service access points are common between the MIH Function and NCMS. These SAPs specify the interaction between MIH Function and the control and management plane entities respectively and they also help in transporting MIH messages across to peer MIH Function entities. The MIH_SAP specifies the interface of MIH Function with other higher layer entities such as transport, handover policy engine, layer 3 mobility protocol, etc.

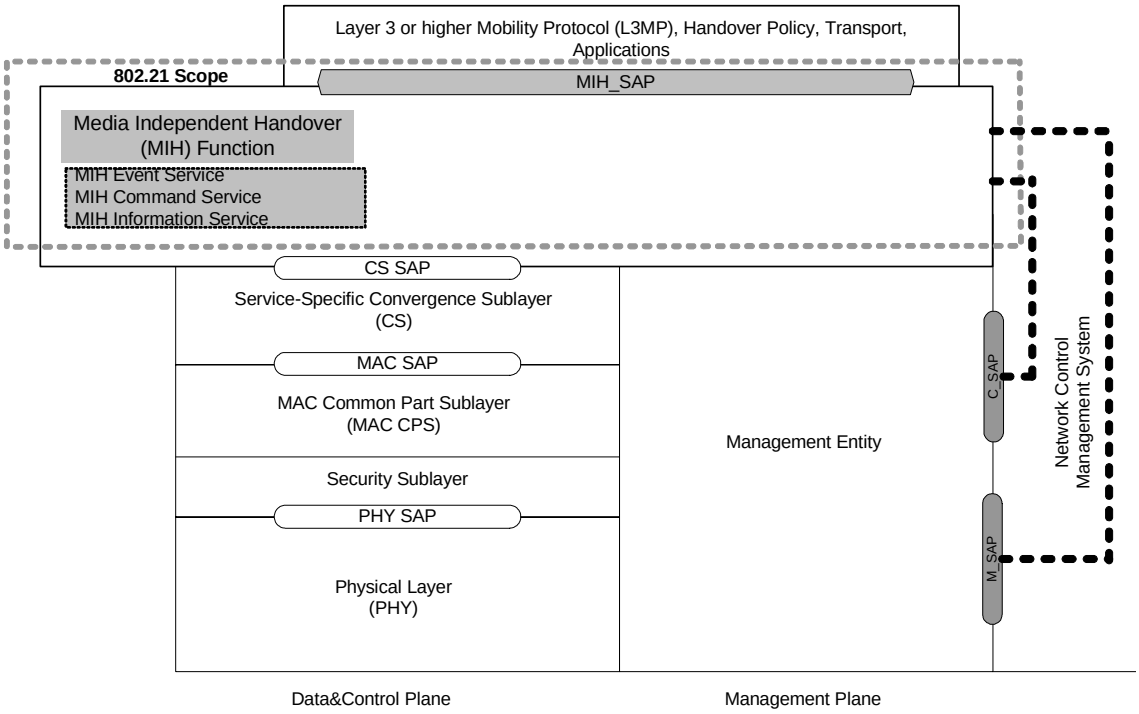



**Figure 8 — MIH Reference Model for 802.16**

### 5.5.4 MIH Reference Model for 3GPP

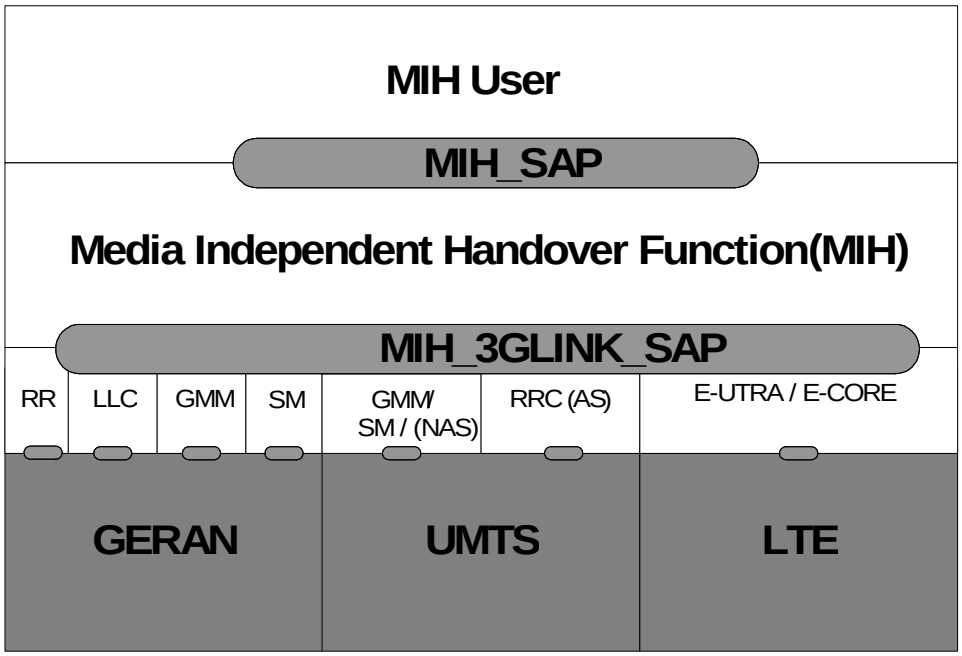



**Figure 9 — MIH Reference Model for 3GPP enabled Mobile Stations**

Figure 9 — illustrates the interaction between MIH Function and 3GPP based system. The MIH Function services are specified by the MIH_3GLINK_SAP. However no new primitives or protocols need to be

defined in 3GPP specification for accessing these services. The MIH Function services can be easily mapped to existing 3GPP primitives. The architecture placement of the MIH Function shall also be decided by the 3GPP standard. The figure above is for illustrative purposes only and shall not constrain implementations.

### 5.5.5 MIH Reference Model for 3GPP2

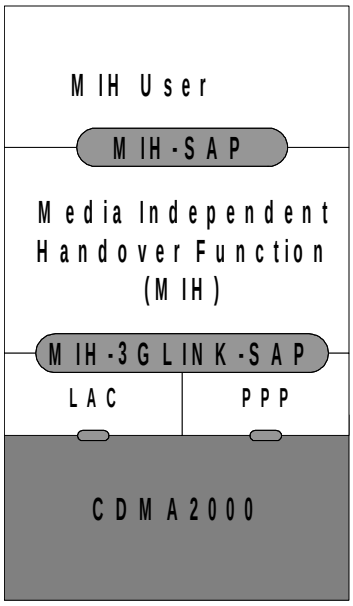



**Figure 10 — MIH Reference Model for 3GPP2 enabled Mobile Stations**

Figure 10 — illustrates the interaction between IEEE 802.21 services and 3GPP2 based systems. IEEE 802.21 services are accessed through the MIH-3GLINK-SAP. However, no new primitives or protocols need to be defined within 3GPP2 specification. Instead, a mapping between IEEE 802.21 Link Layer primitives and 3GPP2 primitives is established. Primitive information available from a layer such as LAC and PPP can be directly used by mapping LAC SAP and PPP SAP primitives to 802.21 service primitives in order to generate an event.

This mapping is illustrated in Table 20— which provides an example of how 3GPP and 3GPP2 primitives can be mapped to IEEE 802.21 primitives. For example events received through LAC layers SAP such as "L2.Condition.Notification" can be mapped and generated through the MIH-3GLINK-SAP as a Link Up, Link Down or Link Going Down. Likewise events generated at the PPP SAP within the PPP layer, such as LCP-Link-Up or IPCP_LINK_OPEN could be mapped and generated through the MIH-3GLINK-SAP as a Link Up event.

There will be no direct communication between the PHY and MAC layers with the MIH layer. For the case where MIH function is placed in the 3GPP2 network, its PoS may be remote. The architecture placement of any MIH function shall be determined by the 3GPP2 SDO in this case.

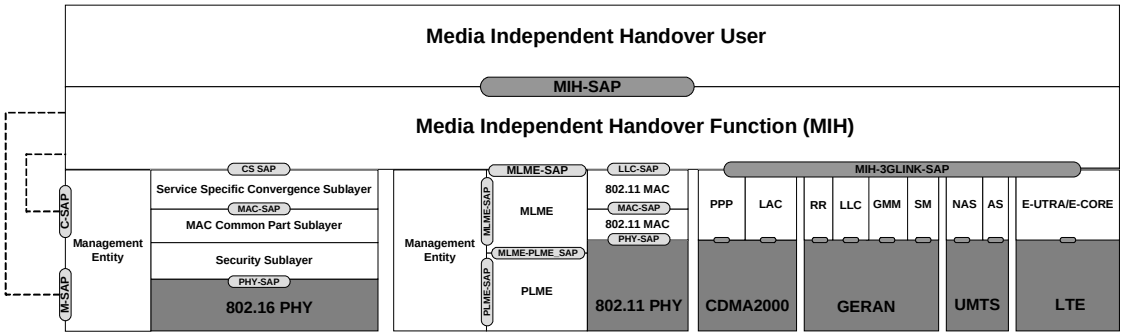



**Figure 11 — MIH Reference Model for Mobile Stations with Multiple Protocol Stacks**

## 5.6 Service Access Points (SAPs)

The MIH Function exchanges messages with other layers and functional planes using Service Access Points (SAPs). Each SAP consists of a set of service primitives that specify the information to be exchanged and the format of the information exchanges.

The specification of the MIH Function includes the definition of SAPs that are media-independent (i.e., insensitive to the interface types that the mobile terminal can support) and recommendations to define or extend other SAPs that are media-dependent. Media-independent SAPs allow the MIH Function to provide services to the upper layers of the mobility-management protocol stack, the network management plane, and the data bearer plane. The MIH_SAP and associated primitives provide the interface from MIH Function to the upper layers of the mobility-management stack. Upper layers need to register with MIH Function as users to receive MIH Function generated events and also for link layer events that originate at layers below the MIH Function but can be passed on to upper layers through MIH Function. Upper layers can directly send commands to MIH Function. Similarly MIH Function entities can also send commands to other remote (peer) MIH Function entities. Primitives corresponding to all these services described above are within the scope of MIH_SAP.

Media-dependent SAPs allow the MIH Function to use services from the lower layers of the mobility-management protocol stack and their management planes. All inputs (including the events) from the lower layers of the mobility-management stack into the MIH Function are provided through existing media-specific SAPs such as MAC SAPs, PHY SAPs, and LLC SAPs. Link Commands generated by the MIH Function to control the PHY and MAC layers during the handover are part of the media specific MAC/PHY SAPs and are already defined elsewhere. Figure 12 — shows the key MIH related SAPs for different networks.

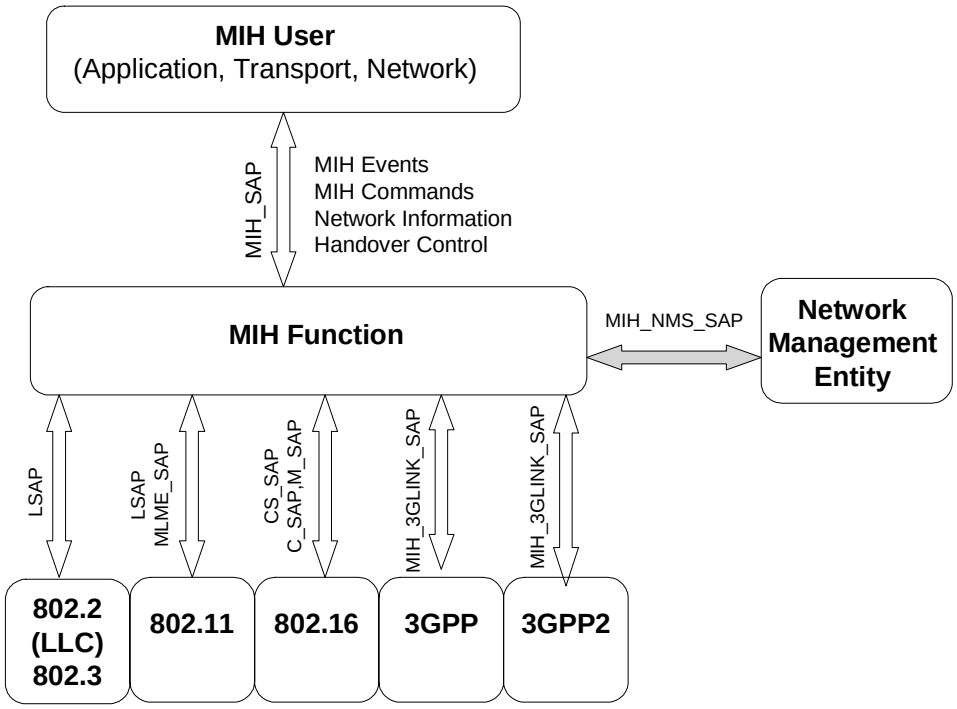



**Figure 12 — Relationship between different MIH SAPs**

### 5.6.1 Media Specific SAPs

#### 5.6.1.1 MLME_SAP

This SAP defines the interface between the MIH Function and the management plane of 802.11 network. This SAP can be used for sending MIH messages between MIH Function and local link layer entities as well as between peer MIH Function entities. Messages based on management frames can be sent in the unauthenticated state as well.

#### 5.6.1.2 M_SAP

This SAP defines the interface between the MIH Function and the management plane of 802.16 network.

#### 5.6.1.3 C_SAP

This SAP defines the interface between the MIH Function and the control plane of 802.16 network.

#### 5.6.1.4 MIH_3GLINK_SAP

This SAP defines the interface between the MIH Function and the different protocol elements (such as RRC) of the 3G system. The existing service primitives as defined in 3GPP specification can be directly mapped to MIH Function services, and hence no new primitives need to be defined in case of 3GPP specification.

### 5.6.2 Media Independent SAPs

#### 5.6.2.1 MIH_LINK_SAP

This SAP defines the generic media independent link layer interface between MIH Function and different link layer technologies. Amendments are suggested for different layer technology specific SAPs based on the definition of this particular SAP.

#### 5.6.2.2 MIH_SAP

This SAP defines the interface between MIH Function and MIH Users such as an upper layer mobility protocol, or a handover function which might reside at higher layer or a higher layer transport entity as well. The definition of this SAP is required to define the scope and functionality of MIH Function.

### 5.6.3 Network Management SAPs

#### 5.6.3.1 MIH_NMS_SAP

This SAP defines the interface between MIH Function layer and the Network Management Entity or the Network Management System. This SAP defines the interface of MIH Function with the system and is used for configuration and operation of MIH Function in any given system.

## 5.7 Media Independence

### 5.7.1 MIH Protocol

The IEEE 802.21 standard supports the Media Independent Event service, Media Independent Command service and Media Independent Information service. The MIH protocol defines the format of the messages (i.e. MIH packet with header and payload) that are exchanged between remote MIH entities and the transport mechanisms that support the delivery of the messages. The selection of the transport mechanism is dependent on the access technology that connects the MN to the network. The packet payload for these services may be carried over L2 management frames, L2 data frames or other higher layer protocols. Wireless networks such as 802.11 and 802.16 have a management plane and support management frames which could be suitably enhanced for carrying the above payloads. However the wired Ethernet network does not have management plane and can carry the above payloads only in data frames.

The IEEE 802.21 standard should define the packet format and payloads in media independent manner in standard TLV format. Thereafter these packets can be encapsulated in a L2 MIH Protocol using MIH ethertype when the payload needs to be sent over normal data frames as in case of ethernet. In other cases the TLV based messages and payload can be directly encapsulated in media specific management frames.

The IEEE 802.21 standard defines the format of MIH protocol data unit (PDU) header and payload. Standard TLV format provides media-independent representation for the PDU payload contents. The MIH PDUs are encapsulated in data frames with MIH EtherType over 802 links. For 802.11 and 802.16 links extensions of media-specific management frames are recommended for carrying MIH messages. No assumptions are made in this standard regarding the transport of MIH messages over 3GPP and 3GPP2 access links at L2.

## 5.8 Media Dependence

The MIH Function aggregates disparate interfaces with respective media-dependent lower-layer instances (media-dependent service access points) into a single interface with the upper layers (the MIH SAP), making the inter-media differences fully transparent to the upper layers.

The MIH Function features media-dependent interfaces with IEEE 802 link-layer technologies (802.2, 802.3, 802.11, and 802.16) and cellular technologies (3GPP and 3GPP2). The MIH Function for the most part uses existing primitives and functionality provided by different access technology standards. Amendments to existing standards are recommended only when deemed necessary to fulfill the MIH Function capabilities.

The sections below list general amendments recommended to different underlying access technology standards due to the enhanced heterogeneous handover capability provided by MIH Function.

### 5.8.1 802 Amendments

The MIH Function interacts with the MAC and PHY layers in the IEEE 802 family of standards to monitor the status of each interface. In general, the IEEE 802 standards provide both control, data plane Service Access Points (SAPs) and management plane SAPs for the MAC and PHY layers. The MIH Function utilizes these existing SAPs and primitives wherever possible. Extensions of existing IEEE 802 standard primitives are proposed for link layer events and indications and additional information elements are identified which can help with effective heterogeneous handovers. Mechanisms to discover MIH capability through broadcast and specific query and response type mechanisms are also proposed.

These recommendations should be handled by specific IEEE 802 working groups, e.g. IEEE802.11 and IEEE802.16. For the better understanding of this specification, some examples are provided as informative recommendations in the Appendix.

### 5.8.2 3GPP and 3GPP2 Amendments

The amendments suggested in this section emphasize reuse of 3GPP and 3GPP2 functionality. 3GPP system already broadcast information regarding other Radio Access Technologies. It is recommended extending this concept so that 802 RATs be also considered along with other existing RATs such as 3GPP2, GERAN and UTRAN.

3GPP services primitives provide access to the underlying layers that support GSM, UMTS and LTE/SAE connections including session management, mobility management and radio resource management. As described in table 33a, a direct mapping can be established between these primitives and primitives defined in this standard, in order to access 3GPP services provides through existing 3GPP SAPs. This does not require addition of extra primitives although extensions might be useful. Therefore no new 3GPP primitives are foreseen.

The following recommendations are suggested:

— Include 802.xx Radio Access Technology within the Inter-RAT cell info list information element broadcast by 3GPP systems.
— Extend existing primitives to reflect awareness of 802.xx RATs

### 5.8.3 Upper Layer Amendments

Existing mobility mechanism based on different upper layer protocols such as MIP, SIP etc. are based on layer 3 procedures that are unaware of the operational state of the underlying link that supports the communication channel. This constraint affects the delivery of service that require low delay and low latency, as packets are dropped or delayed when the terminal is required to connect to a new network point of attachment.

The MIH Function helps to mitigate this problem by providing link-level and other information that can be used by a mobility management entity to characterize the conditions of both the existing communication link and potential candidates. Upper layers can interface with the MIH SAP to effectively use these services.

# 6. MIH Function Services

The MIH Function provides Media Independent Event Service, Media Independent Command Service and Media Independent Information Service which facilitate handovers across heterogeneous networks. This section provides a general description of these services.

## 6.1 Media Independent Event Service

### 6.1.1 Introduction

In general handovers can be initiated either by the mobile terminal or by the network. Events that can initiate handover may originate from MAC, PHY or MIH Function either at the mobile node or at the network point of attachment. This could be due to user or terminal mobility, state change in the environment or because of some management function on part of the network. Thus, the source of these events can be either local or remote. A transport protocol is needed for supporting remote events. Security is another important consideration in such transport protocols.

Multiple higher layer entities may be interested in these events at the same time. Thus these events may need to have multiple destinations. Higher layer entities can register to receive event notifications from a particular event source. The MIH Function can help in dispatching these events to multiple destinations.

These events are treated as discrete events. As such there is no general event state machine. However, in certain cases a particular event may have state information associated with it, such as the Link_Going_Down event discussed below. In such cases the event may be assigned an *identifier* and other related events may be associated with the corresponding event using this identifier.

From the recipient's perspective these events are mostly "advisory" in nature and not "mandatory". Layer 3 and above entities may also need to deal with reliability and robustness issues associated with these events. Higher layer protocols and other entities may prefer to take a more "defensive" approach when events originate remotely as opposed to when they originate locally.

The Event Service may be broadly divided into two categories, Link Events and MIH Events. Both Link and MIH Events typically traverse from a lower to higher layer. Link Events are defined as events that originate from event source entities below the MIH Function and typically terminate at the MIH Function. Entities generating Link Events include but are not restricted to various IEEE802-defined, 3GPP-defined and 3GPP2-defined interfaces. Within the MIH Function, Link Events may be further propagated, with or without additional processing, to upper layer entities that have registered for the specific event. Events that are propagated by the MIH to the upper layers are defined as MIH Events. This relationship is shown in Figure 13 —.

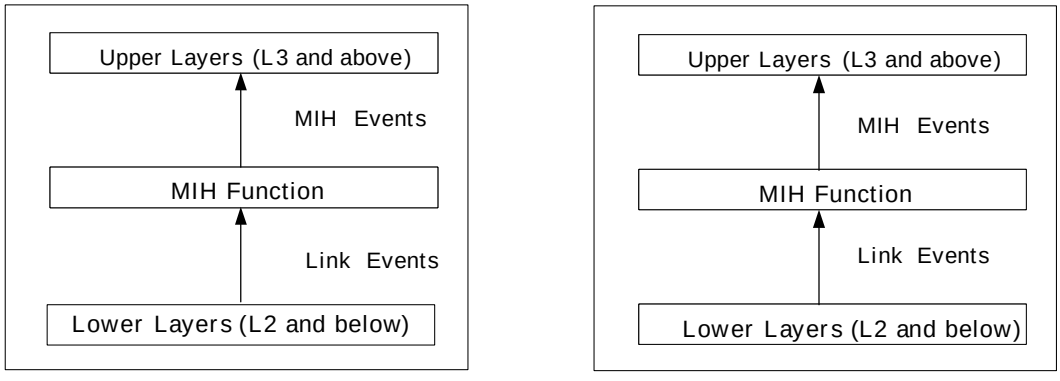


**Figure 13 — Link Events and MIH Events**

### 6.1.2 Types of Events

The Media Independent Event Service can support several types of events.

1) **MAC and PHY State Change events**: These events correspond to changes in MAC and PHY state. These events correspond to definite changes in state. For example Link Up event is an example of a state change event.

**2)** **Link Parameter events:** These events are due to change in link layer parameters. These events are triggered either synchronously (i.e. on a regular basis) or asynchronously (i.e. when the value of a given link layer parameter crosses a specified threshold). For example, the primitive Link_Parameter_Change is a Link Parameter event.

3) **Predictive events**: Predictive events express the likelihood of change in properties in future based on past and present conditions. For example, decay in signal strength of WLAN network may indicate loss of link connectivity in near future. Since they attempt to predict the future, they may be incorrect and hence there is a need to retract predictive events. Predictive events may carry predictive information including a ***time bound***, specifying the time interval in which the event is expected to occur and a level of ***confidence*** that the event shall occur in the specified time bound.

4) **Link Synchronous events**: These events give indications to upper layers about link layer activities (not related to any MAC/PHY state change) that are relevant in upper layer mobility management decision making. These events give indications of precise timing of L2 handover events that are useful to upper layer mobility management protocols. Link Synchronous events differ from Link State Change events in that they do not necessarily report a link state change that has occurred in the past. These events also differ from Predictive events in that they are deterministic and do not predict any future link state change that is only a possibility. An example of Link Synchronous event is the native link layer L2 handover/switching event that exists in many media types (e.g., Cellular, 802.16e). Native link layer handover/switching decision is deterministic and is made and executed autonomously at link layer, independent of the upper layer mobility management function. Indicating the occurrence of these link layer handover/switching events to upper layers facilitates upper layer mobility management decision making.

5) **Link Transmission events**: These events indicate the transmission status (e.g., success or failure) of higher layer PDUs by the link layer. This information can be used by upper layer to improve buffer management for achieving low-loss or no loss handovers. For example, the occurrence of a handover of a mobile node, from one access network to another will results in the reestablishment of a link layer connection to the target access network. When this occurs the upper layer may still have data that had been transmitted over the old link but has not been received by the receiver (e.g. the contents of the outstanding transmit and retransmit MAC ARQ queues in the old access network as well as the mobile node that need to be flushed out during the handover). This data will be lost because of the handover. If low-loss or no loss handover is desired, then upper layers will attempt to retransmit any lost data over the new link. But, before the retransmission can occur, the upper layer needs to first identify the lost data and then re-tag them in their internal buffers, including updating (if necessary) the source/destination IP addresses and re-fragmentation if the MTU of the new link demands so. The upper layer normally has to rely on the use of retransmission timer and end-to-end feedback (such as the ACK in the application or transport layer) to identify lost packets. The latency of this lost data detection based on retransmission time-out and end-to-end feedback often becomes a limiting factor to the handover performance as well as the overall data throughput, especially for time-sensitive applications operating over wireless links with long round-trip delay times. Link

Transmission events can significantly facilitate this process in the upper layer by providing a fast local indication on whether a particular PDU has been successfully transmitted over the link or not. This helps the upper layer to quickly identify lost packets and prepare for selective retransmission of the lost data if needed, without waiting for a retransmission timer expiration or end-to-end feedback.

### 6.1.3 Local and Remote Events

Local events are propagated across different layers within the local stack of a device or a system. All link events are local in nature. Remote events are indications that traverse across the network medium from one MIH Function to a peer MIH Function. MIH events can be local or remote. Remote MIH events originate at remote MIH Function. They traverse through the medium to local MIH Function and are then dispatched to MIH Users that have subscribed for these events within the local stack.

Remote MIH Events traverse from the remote MIH Function to the local MIH Function and then from the local MIH Function to the local upper layer entities as shown in Figure 14 —. This is with the assumption that the local upper layer entities have subscribed for the remote event. Link events that are received by MIH Function can also be sent to a remote entity as MIH event.

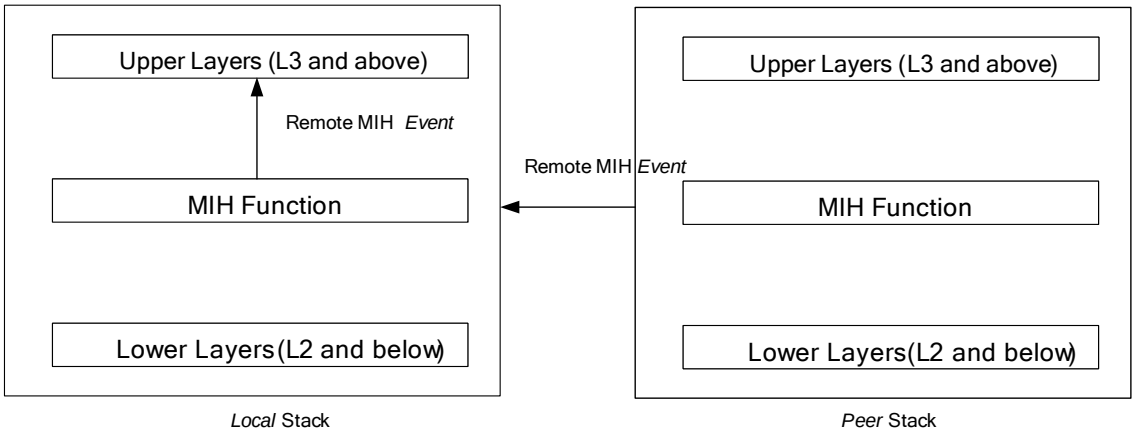



**Figure 14 — Remote MIH Events**

### 6.1.4 Event Flow Model

Figure 15 — shows the event flow model for link events and MIH events.

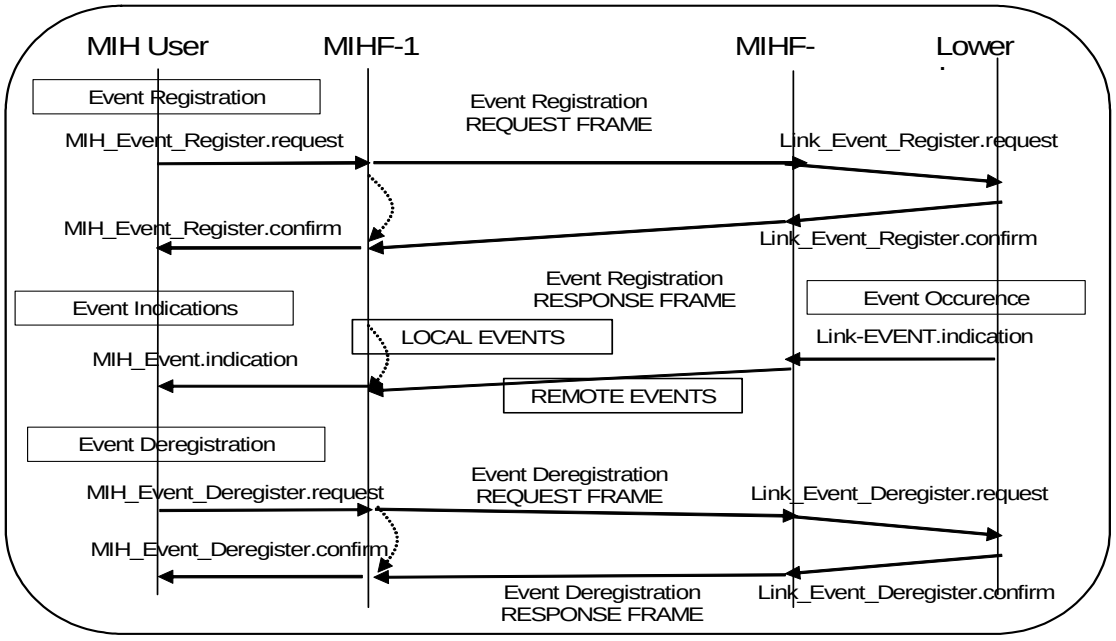



**Figure 15 — MIH Events Registration and Flow**

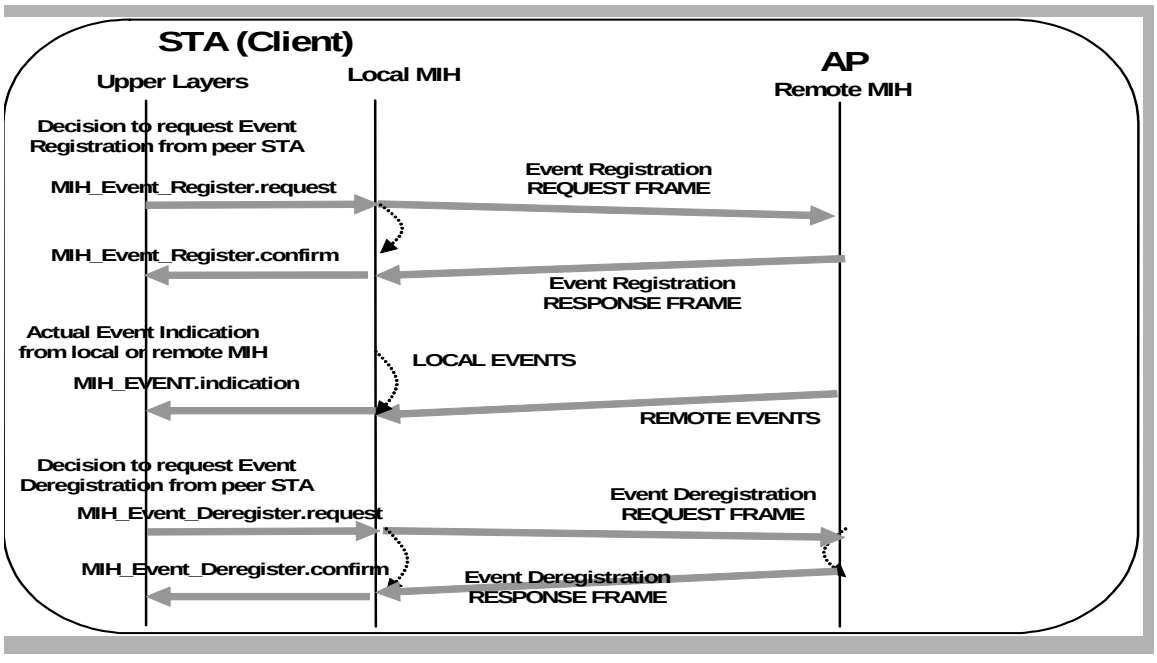



**Figure 16 — MIH Events Flow Model**

### 6.1.5 Event Registration

Event registration provides a mechanism for upper layer entities to selectively receive events. Registration may be divided into Link Events Registration and MIH Events Registration. Link Events Registration is performed by the MIH Function with the event source entities in order to determine the events that each event source (link) is able to provide. MIH Event Registration is performed by upper layer entities with the MIH Function to select the events to receive. It is possible for upper layer entities to register for all existing events or notifications that are provided by the event source entity even if no additional processing of the event is done by the MIH Function.

#### 6.1.5.1 Link Events Registration

It may be possible during initialization that the MIH Function actively searches for pre-existing interfaces, devices and modules that serve as link event sources in the Event service. In addition to the link event source entities that are present during the bootstrapping stage, allowances must be made for devices such as hot-plugged interfaces or an external module. The exact description and implementation of such mechanisms are out of scope of the standard. The MIH Function may then register individually with each of these link layers based on user preferences.

#### 6.1.5.2 MIH Events Registration

MIH Users that need to receive event notifications must register themselves with the MIH Function. After registration, the MIH Users may specify a list of events for which they wish to receive notifications from the MIH Function. MIH Users may specify additional parameters during the registration process in order to control the behaviour of the Event Service. Examples of these additional parameters include threshold values, request to receive events as a bundle and so forth. The description of the exact mechanism by which the MIH Function achieve this is outside the scope of the standard. MIH Users may also query on the availability of events from the MIH Function without prior registration. This query may have additional parameters. An example would be a query to retrieve a list of all events for IEEE802.11 defined interfaces only.

### 6.1.6 Primitives for Events

The generic model of Event Service primitives specifies the format of the events that are passed from the link layer to the MIH Function and also from the MIH Function to the upper layer entity. The Event primitive is defined as follows:

EventXX. indication (EventInformationSet) where,

— EventInformationSet: is an extensible parameter that may contain implementation specific information and may be different across different events. EventInformationSet completely describes the event that occurred.

Event notifications do not receive a response.

### 6.1.7 Link Events

The following set of link layer events are defined.

**Table 2—Link Events**

| No | Link Event Type | Link Event Name | Description |
|---|---|---|---|
| 1 | State Change | Link Up | L2 connection is established and link is available for use |

**Table 2—Link Events**

| | | | |
|---|---|---|---|
| 2 | State Change | Link Down | L2 connection is broken and link is not available for use |
| 3 | Predictive | Link Going Down | Link conditions are degrading & connection loss is imminent |
| 4 | State Change | Link Detected | New link has been detected |
| 5 | Link Parameters | Link Parameters Change | Link parameters have crossed specified threshold |
| 6 | Administrative | Link Event Rollback | Previous link event needs to be rolled back |
| 7 | Link Transmission | Link SDU Transmit Status | Indicate transmission status of all PDU segments |
| 8 | Link Synchronous | Link Handover Imminent | L2 handover is imminent based on changes in link conditions |
| 9 | Link Synchronous | Link Handover Complete | L2 link handover to a new PoA has been completed |

### 6.1.8 MIH Events

The following set of MIH events are defined.

**Table 3—MIH Events**

| No | MIH Event Type | MIH Event Name | (L) ocal (R) emote | Remote Direction | Description |
|---|---|---|---|---|---|
| 1 | State Change | MIH Link Up | L, R | Client -> Network<br>Network -> Network | L2 connection is established and link is available for use |
| 2 | State Change | MIH Link Down | L, R | Client -> Network<br>Network -> Network | L2 connection is broken and link is not available for use |
| 3 | Predictive | MIH Link Going Down | L, R | Client -> Network<br>Network -> Network<br>Network -> Client | Link conditions are degrading & connection loss is imminent |
| 4 | State Change | MIH Link Detected | L, R | Client -> Network<br>Network -> Network | New link has been detected |
| 5 | Link Parameters | MIH Link Parameters Report | L, R | Client -> Network<br>Network -> Network<br>Network -> Client | Link parameters have crossed specified threshold and need to be reported |
| 6 | Administrative | MIH Link Event Rollback | L, R | Client -> Network<br>Network -> Network<br>Network -> Client | Previous link event needs to be rolled back |
| 7 | Link Transmission | MIH Link SDU Transmit Status | L | N/A | Indicate transmission status of all PDU segments |

**Table 3—MIH Events**

| | | | | | |
|---|---|---|---|---|---|
| 8 | Link Synchronous | MIH Link Handover Imminent | L, R | Client -> Network<br>Network -> Network<br>Network -> Client | L2 handover is imminent based on changes in link conditions |
| 9 | Link Synchronous | MIH Link Handover Complete | L, R | Client -> Network<br>Network -> Network<br>Network -> Client | L2 link handover to a new PoA has been completed |

## 6.2 Media Independent Command Service

### 6.2.1 Introduction

Media Independent Command Service refers to the commands sent from the higher layers to the lower layers in the reference model. Upper layers and other MIH users may utilize command services to determine the status of links and/or control the multi-mode device for optimal performance. Command services may also enable MIH users to facilitate optimal handover policies. For example, the network may initiate and control handovers to balance the load of two difference access networks.

The link status varies with time and terminal mobility. Information provided by MICS is dynamic information comprising of link parameters such as signal strength, link speed, etc., where as information provided by MIIS is less dynamic or static in nature and is comprised of parameters such as network operators, higher layer service information, etc. MICS and MIIS Information could be used in combination by the terminal/network to facilitate the handover.

A number of commands have been added to allow the upper layers to configure, control, and get information from the lower layers. A set of command services that are provided by the L2 data link (MAC, functions such as MAC, Radio Resource Management etc. depending upon the L2 access link technology) and PHY should be defined in this specification.

The commands are classified into two categories: MIH Commands and Link Commands.

### 6.2.2 Primitives for Commands

The generic model of Command Service primitives specifies the format of commands that are passed from the MIH Function to the link layer and also from the upper layer entity to the MIH Function. The Command Service primitives are defined as follows.

CommandXX. request (SourceIdentifier, CommandInformationSet) where,

— SourceIdentifier: is used to identify the command source entity where the command originated
— CommandInformationSet: is an extensible parameter that may contain implementation specific information and may be different across different events. CommandInformationSet completely describes the command that is issued.

CommandXX. response (SourceIdentifier, CommandResultSet) where,

— SourceIdentifier: is used to identify the source entity where the response originated
— CommandResultSet: is an extensible parameter that may contain the result of the request and may be different across different commands.

### 6.2.3 MIH Commands

MIH Command includes the commands from upper layer to MIH (e.g. upper layer mobility protocol to MIH, or policy engine to MIH, etc.).

MIH Command may be local or remote. Local MIH Commands are issued by Upper Layers to MIH function in the local stack. Remote Command are issued by Upper Layers to MIH function in the peer stack.Figure 17 — and Figure 18 — illustrate the differences between local and remote MIH Commands.

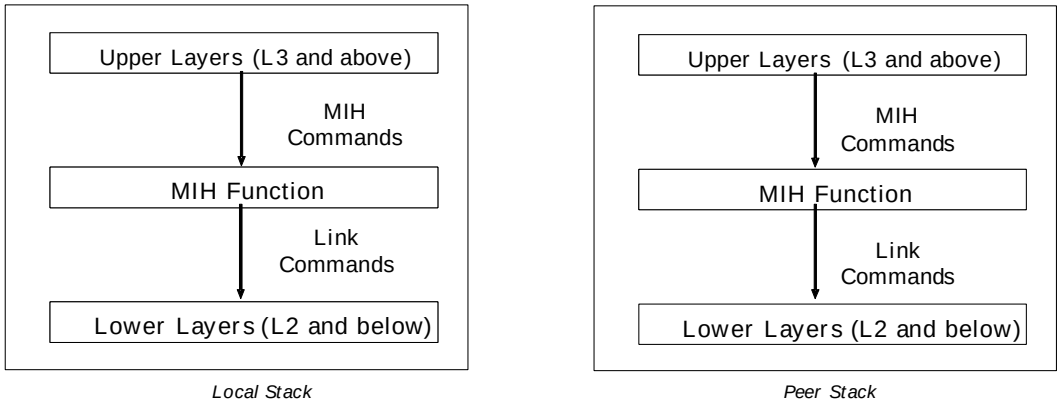



**Figure 17 — Local MIH Commands**

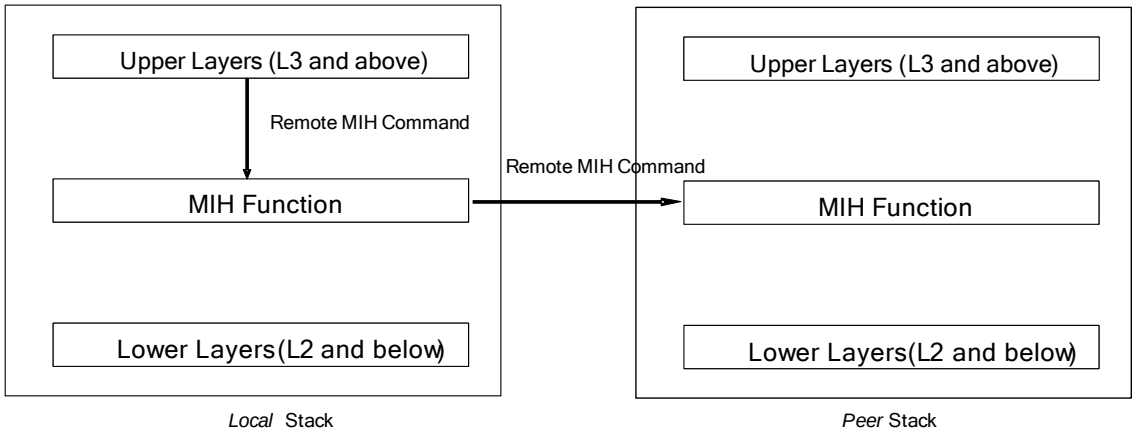



**Figure 18 — Remote MIH Command**

### 6.2.4 Link Commands

Link Command originate from MIH Function and are directed to lower layers (e.g. MIH Function to MAC, or MIH Function to PHY). These commands mainly control the behavior of lower layer entities. Link Commands are local only. Link Commands are issued by MIH Function to lower layers in the local stack. Whenever applicable the IEEE 802.21 specification shall use existing media specific link commands for interaction with specific access networks. New link commands if required, shall be defined as recommendations to media specific technology standards. It is to be noted that although Link Commands originate from the MIH Function, these commands are executed on behalf of MIH-User.

### 6.2.5 Command Service Flow Model

Figure 19 — and Figure 20 —show the flow for local and remote commands respectively.

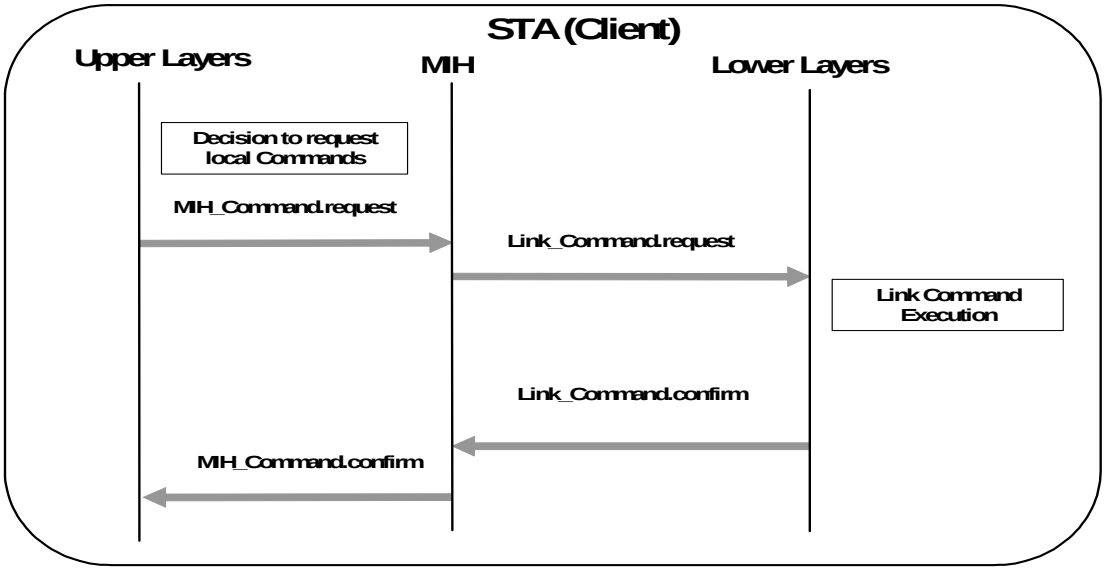



**Figure 19 — Local Command Service Flow**

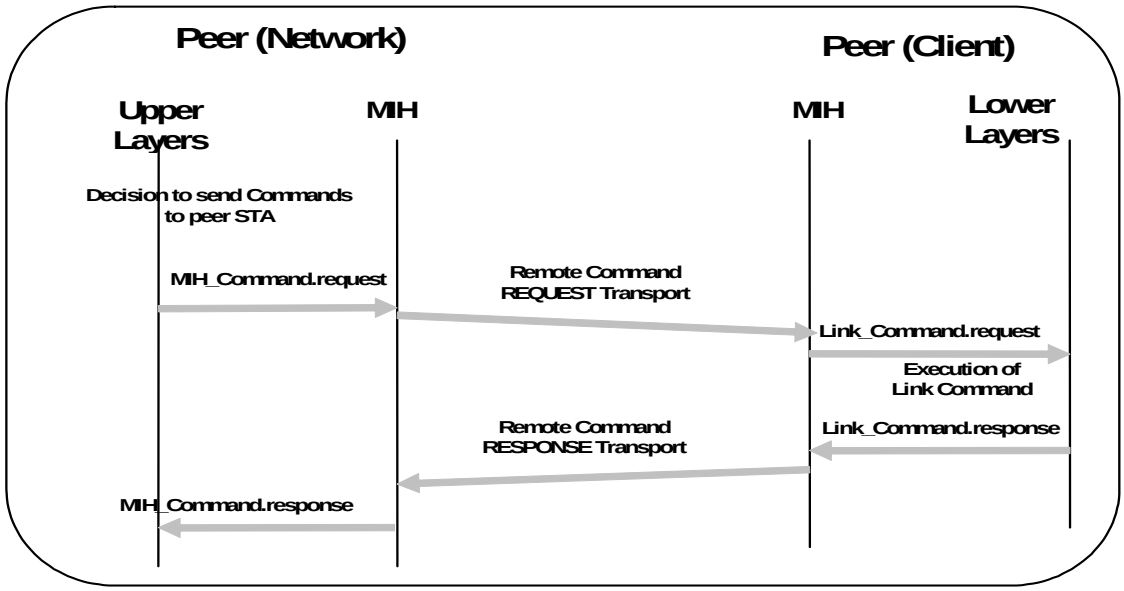



**Figure 20 — Remote Command Service Flow**

The use cases and handover scenarios for the commands defined in this section are provided in Appendix. Remote commands may be transported over network layer protocols or link layer protocols.

### 6.2.6 Command List

#### 6.2.6.1 MIH Commands

The following set of MIH Commands are defined.

**Table 4—MIH Commands**

| No | MIH Command | (L) ocal, (R) emote | Remote Direction | Comments |
|---|---|---|---|---|
| 1 | MIH Get Status | L, R | Network -> Client | Get the tatus of links |
| 2 | MIH Switch | L, R | Network -> Client | Switch the links as specified |
| 3 | MIH Configure | L, R | Network -> Client | Configure a link |
| 4 | MIH Configure Link Thresholds | L,R | Network-> Client | Configures thresholds for link events |
| 5 | MIH Scan | L, R | Network -> Client | Scan a link |
| 6 | MIH Handover Initiate | L, R | Client -> Network Network -> Client | Network initiates handover and sends a list of suggested networks and associated Points of Attachment |
| 7 | MIH Handover Prepare | L, R | Network -> Network | This command is sent by current MIHF entity to target MIHF entity to allow for resource query and handover preparation. |
| 8 | MIH Handover Commit | L, R | Client -> Network, Network -> Client | In this case the client commits to do the handover and sends it's choice of selected network and associated PoA. |
| 9 | MIH Handover Complete | L, R | Client -> Network, Network -> Network | Notification from new serving MIHF to previous serving MIHF indicating handover completion, and any pending packets may now be forwarded to the new MIHF. |
| 10 | MIH Network Address Information | L, R | Network -> Network | Sent from current serving MIHF entity to target MIHF entity to obtain reconfigured network address on target network for the client. |

#### 6.2.6.2 Link Commands

The following set of Link Commands are defined.

**Table 5—Link Commands**

| No | Link Command | Comments |
|---|---|---|
| 1 | Link Configure Thresholds | Configure the thresholds for various link layer events such as Link Going Down |
| | | |

## 6.3 Media Independent Information Service

### 6.3.1 Introduction

Media Independent Information Service (MIIS) provides a framework by which a MIH Function both in the mobile node and in the network can discover and obtain network information within a geographical area to facilitate handovers. The objective is to acquire a global view of all the heterogeneous networks in the area to facilitate seamless handovers when roaming across these networks.

Media Independent Information Service includes support for various Information Elements (IEs). Information Elements provide information that is essential for a handover module to make intelligent handover decision. Figure 21 — gives a high level description of scenarios that distinguish between two different types of mobility.

— **Horizontal handovers**: A horizontal handover is performed by switching between different points of attachment of the same access network. For example, switching between different APs within the 802.11 network (e.g. Inter ESS or inter subnet).
— **Vertical handover**s: A vertical handover is a handover from one access network to another access network. For example switching between different PoAs across heterogeneous technologies (e.g. from WLAN to GPRS).

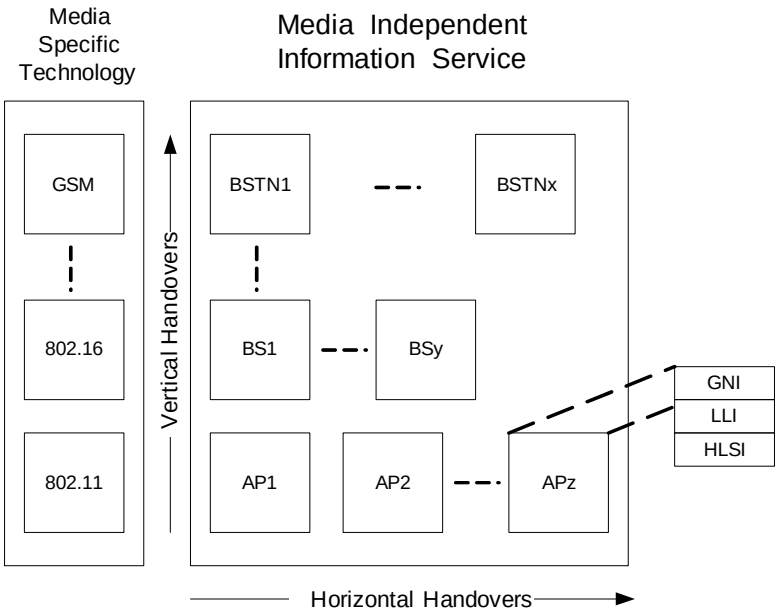



**Figure 21 — Horizontal and Vertical Handovers**

Depending on the type of mobility support for different types of information elements may be necessary for performing handovers. For example in case of horizontal handovers across different PoAs of the same access network information available from lower link layers of access network may be sufficient. In such cases information elements like intra-technology neighbor reports and other link layer information required during handovers is directly available from the access network. In such cases the availability of higher layer services offered by the network typically does not change appreciably across different network point of attachments. On the other hand during vertical handovers the terminal may move across different access networks. In such cases there is a need to select appropriate PoA in the new network based on both optimum

link layer connectivity as well as availability of appropriate higher layer services to permit service and session continuity for active user applications.

Media Independent Information Service (MIIS) provides the capability for obtaining the necessary information for handovers. This includes information about lower layers such as neighbor maps and other link layer parameters as well as information about available higher layer services such as access to internet connectivity, availability of VPN services, etc. The set of different higher layer services provided by the MIIS may constantly evolve. At the same time the list of access networks that are supported by MIIS may also evolve. As such there is a need for flexibility and extensibility in the way the MIIS provides support for different information elements. Towards this end the MIIS defines a schema. The schema helps a client of MIIS to discover the capabilities of MIIS and also discover the entire set of different access networks and IEs supported by a particular implementation. Schema representation also allows the terminal to query the information in a more flexible and efficient manner. As part of defining this schema the MIIS can also identify a set of basic information elements that can define the core functionality of different implementations of MIIS. Other information elements as they are added can become part of the more extended set of MIIS capabilities.

MIIS provides information about different access networks such as 802 networks, 3GPP networks and 3GPP2 networks. The MIIS also allows this collective information to be accessed from any single network. Thus for example using a 802.11 access network it may be possible to get information not only about all other 802 networks in a particular region but also that of 3GPP and 3GPP2 networks as well. Similarly using a 3GPP2 radio, it may be possible to get access to information about all 802 and 3GPP networks in a given region. This capability allows a terminal device to use its currently active access network and scan for other available access networks in a geographical region. Thus a terminal device is freed from the burden of powering up each of its individual radios and establishing network connectivity for the purpose of accessing heterogeneous network information. MIIS enables this functionality across all available access networks by providing uniform way to retrieve heterogeneous network information in any geographical area.

### 6.3.2 Information Service Elements

The main goal behind the Information service is to allow mobile terminals and network entities to discover information that can help/influence them in selection of appropriate networks during handovers. This information is intended to be primarily used by a policy engine type entity that can make effective handover decisions based on this information. This information service is expected to provide mostly static type of information. Other dynamic information about different access networks such as current available resource levels, state parameters, dynamic statistics etc. should be obtained directly from the respective access networks. Some of the key motivations behind the Information Service are as follows:

1) Provide information about different available access networks in a geographical area. Further this information could be retrieved using any wireless network. Thus in essence information about a nearby WiFi hotspot could be obtained by using a GSM or other cellular network
2) Provide static link layer information parameters that could help the mobile devices in selecting the appropriate access network. For example knowledge of whether security and QoS are supported on a particular access network may influence the decision to select such an access network during handovers.
3) The link layer information comprising of neighbor reports and information about capabilities of different PoAs could also aid in configuring the radios optimally (to the extent possible) for connecting to available/selected access networks. For example knowing about supported channels by different PoAs may help in configuring the channels optimally as opposed to scanning, beaconing etc. and then finding out this information. However for most part dynamic link layer parameters have to be obtained or selected based on direct interaction with the access networks and the Information Service may not be able to help much in that regard.
4) Provide an indication of higher layer services supported by different access networks and other relevant information that may aid in making handover decisions. Such information may not be available (or could not be made available) directly from MAC/PHY layers of specific access

networks, but could be provided as part of the Information service. For example in certain cases classification of different networks into categories such as public, enterprise, home, others etc. may influence the decision to handover. Other information here may be more vendor/network specific in nature and could be specified in that form.

The information service elements can be classified into three groups:

1) General Access Network Information: These information elements give a general overview of the different networks providing coverage within an area such as list of available networks and their associated operators, roaming agreements between different operators, cost of connecting to the network and network security and quality of security capabilities.
2) Information about Points of Attachment: These information elements provide information about different PoAs for each of the available access networks. These IEs include PoA addressing information, PoA location, data rates supported, the type of PHY and MAC layers and any channel parameters to optimize link layer connectivity. This may also include higher layer services and individual capabilities of different PoAs.
3) Other Information: This could be vendor specific information and vendor specific IEs.

**Table 6—Information Elements**

| No | Name of Information Element | Description | Representation | Length (octets) |
|---|---|---|---|---|
| General Information Elements | | | | |
| 1.1 | TYPE_IE_LIST_OF_NETWORKS | List of Neighboring Access Networks.<br><br>Link types of the networks that are available in a given geographical area | For example, RADIUS NAS-Port-Type attribute value which is a unique identifier defined in http://www.iana.org/assignments/radius-types, e.g.,<br>15: Ethernet<br>18: Wireless - Other<br>19: Wireless - IEEE 802.11<br>22: Wireless - CDMA2000<br>23: Wireless - UMTS<br>24: Wireless - 1X-EV<br>etc. | 4 |
| 1.2 | TYPE_IE_NUMBER_OF_OPERATORS | Number of distinct operators for each available link type.<br>There maybe multiple operators for each link type. | If networks of same link type have different operators then they are classified as different networks. Thus there may be three different 802.11 networks in an area, each supported by a different operator | 4 |
| 1.3 | TYPE_IE_LIST_OF_OPERATORS | Network Operator List for each type of link.<br><br>This includes the list of network operators for each of the access networks. | | Variable |
| Access Network specific information<br>For each (Link Type and Operator) combination following information may be provided | | | | |

**Table 6—Information Elements**

| No | Name of Information Element | Description | Representation | Length (octets) |
|---|---|---|---|---|
| 2.1 | TYPE_IE_NUMBER_POA | Number of Point of Attachments (PoA) for a specific Access Network in the Neighborhood. Number of APs, BSs etc. in the vicinity of client device | This can be gotten from Neighbor Reports | 4 |
| 2.2 | TYPE_IE_OPERATOR_IDENTIFIER | Network Operator<br><br>The operator of a network. | A combination of RADIUS Operator-Namespace and Operator-Name attributes defied in draft-ietf-geopriv-radius-lo-04.txt.<br><br>Operator Name space: {GSM, CDMA, REALM,..}<br>Operator Name: | Variable |
| 2.3 | TYPE_IE_ROAMING_PARTNERS | Roaming Partners.<br><br>Operators with which the current network operator has direct roaming agreements. | Each operator has the same structure as Network Operator information element. | Variable |
| 2.4 | TYPE_IE_COST | Cost<br>Indication of cost for service or network usage | Should include the following:<br>Value: (Actual cost denomination)<br>Unit: (Country/Currency code) - enumerated<br>Time Duration: Duration for which cost is applicable - enumerated<br>Service Info: (whether unrestricted or restricted) | Variable |
| 2.5 | TYPE_IE_NETWORK_SECURITY | Security characteristics of the link layer. | Authentication Methods, Cipher Suites<br>The security capabilities type can be defined by media-specific MIB | Variable |
| 2.6 | TYPE_IE_QOS | QoS (Quality of Service) characteristics of the link layer | The QoS classes and traffic type can be defined by media-specific MIB | Variable |
| PoA specific information<br>For each PoA of each (Link Type + Operator) following IEs may be provided | | | | |
| 3.1 | TYPE_IE_POA_ADDRESS | MAC Address of PoA | Link-layer address of PoA<br>(Usually the MAC Address of the PoA) | Variable |

**Table 6—Information Elements**

| No | Name of Information Element | Description | Representation | Length (octets) |
|---|---|---|---|---|
| 3.2 | TYPE_IE_POA_LOCATION | Location of PoA<br><br>Geographical location of a given PoA. Multiple location types are supported including coordinate-based location information and civic address | Two types of location information are supported in draft-ietf-geopriv-radius-lo-04.txt, i.e., geospatial location information and civic location information.<br><br>Geospatial location information consists of:<br>- Latitude Resolution<br>- Latitude<br>- Longitude Resolution<br>- Longitude<br>- Altitude Type {Floor, Meters)<br>- Altitude Resolution<br>- Altitude<br>- Map Datum (Co-ordinate reference system)<br><br>Civic location information consists of:<br>- Country Code<br>- Civic address elements<br><br>Method of obtaining location information<br>- GPS<br>- Manual | Variable |
| 3.3 | TYPE_IE_POA_DATA_RATE | Data Rate<br>The minimum and maximum value of data rate supported by the link layer of a given PoA | A data rate is represented as a 32-bit unsigned integer in unit of Kbps. | 4<br>(32-bit unsigned integer) |
| 3.4 | TYPE_IE_POA_PHY_TYPE | The media PHY type. | Classification of the PHY layer | Variable |
| 3.5 | TYPE_IE_POA_MAC_TYPE | The media MAC type. | Classification of the MAC layer | Variable |
| 3.6 | TYPE_IE_POA_CHANNEL_RANGE | Channel Range/Parameters<br>Spectrum range supported by the Channel for that PoA | (Low, High range) MHz | 4,4<br>(32-bit unsigned integer) |
| Higher layer services/information per PoA | | | | |
| 4.1 | TYPE_IE_POA_SUBNET_INFORMATION | Information about subnets supported by a typical PoA | (IPv4/IPv6)<br>Each PoA may be assigned to multiple subnets | Variable |

**Table 6—Information Elements**

| No | Name of Information Element | Description | Representation | Length (octets) |
|---|---|---|---|---|
| 4.2 | TYPE_IE_POA_ CAPABILITIES | Bitmap of PoA capabilities | Security Available Y/N<br>QoS Available Y/N<br>Internet Access Available Y/N<br>IP Version 4 supported Y/N<br>IP Version 6 supported Y/N<br>Emergency Services available Y/N<br>Others: | |
| Other Information Elements | | | | |
| 5.1 | Vendor Specific IEs | Vendor Specific Services | These can be defined by individual vendors. | |

The MIH Function in a network entity can extract the Information Elements either from media specific broadcast information or by sending a specific request/response primitive. Before sending a request or response frame, the MIH Function should have the knowledge that the network supports the IEEE 802.21 specification. The MIH Function in MN may request the network side MIH Function for such information. It is important to note that before a MN is authenticated to the PoA and ready to transfer data, it should be able to obtain all the information elements listed above. These information elements may be used by the handover policy function to determine the appropriate PoA to attach.

### 6.3.3 Definition of Information Element Name Space

The 802.21 Information Elements can be assigned identifiers (IDs) as follows. Each Information Element ID can be a 32 bit value.

**Table 7—Information Elements Name Space**

| Range | Description | Comments |
|---|---|---|
| 0x00000000 | Reserved | |
| 0x00000001 - 0x1FFFFFFF | Reserved for 802.21 | Core 802.21 specific IEs |
| 0x2 \|\| (16 bit OUI) \|\| (14 bit ID) | Vendor specific IE | IEs defined on a per vendor basis.<br>16 bit OUI: Vendor Id<br>14 bit ID: |
| 0x30 \|\| (8 bit Working Group identifier) \|\| (16 bit WG specific ID of IEs) | Reserved for different Working Groups. | Can be reserved for other different SDOs and 802 WGs such as 802.11, 802.16 etc., if they want to define anything specific for heterogeneous handovers |
| 0x31 \|\| (24 bit ID) | Reserved for IETF. | Can be reserved for IETF protocols and other higher layer IEs. |

**Table 7—Information Elements Name Space**

| Range | Description | Comments |
|---|---|---|
| 0x32 \|\| ( 24 bits) | Reserved for playpen area. | Can be used in development and testing. Should not be used in released products. Avoids collision during development. |
| 0x33000000 – 0xFFFFFFFF | Reserved | For future use |

### 6.3.4 TLV Representation of Information Elements

The Information Elements can be represented in Type Length Value form as follows.

| Type (4 octets) | Length (Variable octets) | Value (Varable octets) |
|---|---|---|
| Represents the type or ID of the Information Element | Length of the Value field of the IE | The value of the IE |

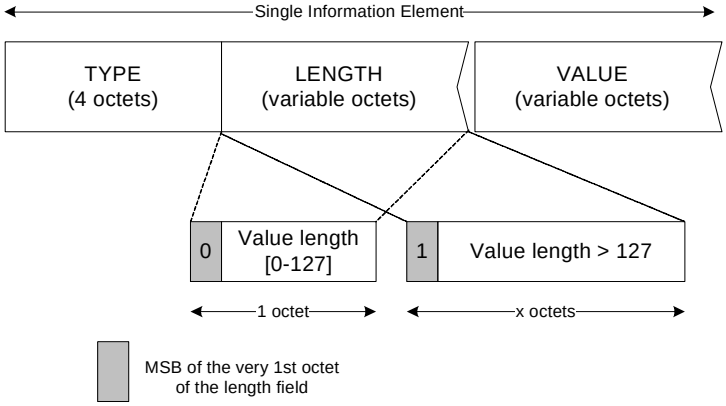



**Figure 22 — TLV Representation of Information Elements**

The Length field can be interpreted as follows.

Case 1: If the number of octets occupied by the value field is less than 128, the size of the length field is always 1 octet and the MSB of the octet is set to the value '0'.

Case 2: If the number of octets occupied by the value field is greater than 127, then the length field is always greater than 1 octet. The MSB of the first octet of the length field is set to the value '1' and the remaining 7 bits of the first octet indicate the number of octets that are appended further. The number represented by the 2nd octet of the length field indicates the total size of the value field.

#### 6.3.4.1 General Information Information Elements

##### 6.3.4.1.1 List of Neighboring Access Networks

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_LIST_OF_NETWORKS | List of Neighboring Access Networks | Variable | List of different link types.<br>4 octets for each link |

##### 6.3.4.1.2 Number of Operators for each Access Network

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_NUMBER_OF_OPERATORS | Number of operators for each link type | 2 octets | Number of different operators for each link type |

##### 6.3.4.1.3 List of Operators for each Access Network

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_LIST_OF_OPERATORS | List of Network Operators for a specific link | Variable | List of different operators for each link. The value field contains zero or more Operator Identifier TLVs. |

##### 6.3.4.1.4 Operator Identifier

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_OPERATOR_IDENTIFIER | An identifier of an operator | Variable | A combination of operator namespace and operator name is encoded in this field. The encoding format is defined as table below. |

**Table 8—Operator Identifier Encoding**

| Syntax | Length (octets) | Note |
|---|---|---|
| L_OperatorNamespace | 1 | Length of **OperatorNamespace** in octets |
| L_OperatorName | 1 | Length of **OperatorName** in octets |
| OperatorNamespace | Variable | A value of RADIUS Operator-Namespace attribute defined in draft-ietf-geopriv-radius-lo-04.txt:<br>GSM : GSM Association TADIG WG<br>CDMA : IMSI Oversight Council<br>REALM: IANA or delegate |
| OperatorName | Variable | A value of RADIUS Operator-Name attribute defined in draft-ietf-geopriv-radius-lo-04.txt. The value is a non-NULL terminated string whose Length MUST NOT exceeds 253 bytes. The value uniquely identifies the operator name within the scope of the operator namespace. |

#### 6.3.4.2 Access Network specific information Elements

#### 6.3.4.2.1 Number of PoAs (for Access network + Operator)

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_NUMBER_OF_POA | Number of PoAs | 2 octets | Number of PoAs for a specific link type + Operator combination |

#### 6.3.4.2.2 Roaming Partners (for Access Network + Operator)

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_ROAMING_PARTNERS | Roaming partners | Variable | List of different operators. The value field contains zero or more Operator Identifier TLVs. |

#### 6.3.4.2.3 Cost (for Access Network + Operator)

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_COST | Cost | Variable | Cost of accessing the network. |

An example can be as follows:

— Currency/Unit : Enumerated values can be taken from standard values like in http://www.jhall.demon.co.uk/currency/by_country.html
— Value: The actual cost value in above specified currency/units.
— Duration: {year, month, week, day, hour, minute, second}
— Service-Info: {Unrestricted, Restricted }

#### 6.3.4.2.4 Security of Network (for Access Network + Operator)

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_NETWORK_SECURITY | Security of Network | Variable | Authentication Methods and Cipher suites used. The length, format and semantics of this field are specific to each link type and defined by each media-specific WG or SDO. In many cases, this field contains values of media-specific MIB objects used for representing security characteristics of the media. |

#### 6.3.4.2.5 QoS in Network (for Access Network + Operator)PoA specific information

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_NETWORK_QOS | QoS of Network | Variable | QoS classes and Traffic Specifications. The length, format and semantics of this field are specific to each link type and defined by each media-specific WG or SDO. In many cases, this field contains values of media-specific MIB objects used for representing QoS characteristics of the media. |

### 6.3.4.3 Point of Attachment specfic Information Elements

#### 6.3.4.3.1 PoA Location (for each PoA of Access Network + Operator combination )

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_POA_LOCATION | PoA Location | Variable | The Value field of RADIUS Location-Information attribute is encoded in this field. The encoding format is defined in draft-ietf-geopriv-radius-lo-04.txt. |

Please refer to Table 9—, Table 10— and Table 11— for more details.

**Table 9—Value field format of PoA Location TLV**

| Syntax | Length (octets) | Notes |
|---|---|---|
| LocationFormat | 1 | Format of location information<br>0: Civic location information<br>1: Geospatial location information |
| Method | 1 | Way location information was derived or discovered:<br>0: GPS<br>1: Assisted GPS<br>2: Manual<br>3: Provided by DHCP<br>4: Triangulation<br>5: Cell<br>6: IEEE 802.11 WLAN Access Point |
| L_LocationInformation | 1 | Length of **LocationInformation** in octets |
| LocationInformation | Variable | Civic location or Geospatial location information attributes |

**Table 10—Value field format of PoA Location Information (Civic Address)**

| Syntax | Length (octets) | Notes |
|---|---|---|
| Country Code | 2 | Two-letter ISO 3166 country code in capital ASCII letters |
| L_CivicAddressElements | 1 | Length od **CivicAddressElements** in octets |
| CivicAddressElements | Variable | Civic address elements |

**Table 11—Value field format of PoA Location Information (Geospatial location)**

| Syntax | Length (bits) | Notes |
|---|---|---|
| LatitudeResolution | 6 | |
| Latitude | 34 | |
| LongitudeResolution | 6 | |
| Longitude | 34 | |
| AltitudeType | 4 | Following codes are defined:<br>1: Meters<br>2: Floors |
| AltitudeResolution | 6 | |
| Altitude | 30 | |
| Datum | 8 | 1: WGS<br>2: NAD 83 (with associated vertical datum for North American vertical datum for 1998)<br>3: NAD 83 (with associated vertical datum for Mean Lower Low Water (MLLW)) |

### 6.3.4.3.2 PoA Data Rate (for each PoA of Access Network + Operator combination )

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_POA_DATA_RATE | PoA Data Rate | 4 octets | Data rate |

#### 6.3.4.3.3 PoA MAC Type (for each PoA of Access Network + Operator combination )

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_POA_MAC_TYPE | MAC Type | Variable | The length, format and semantics of this field are specific to each link type and defined by each media-specific WG or SDO. In many cases, this field contains values of media-specific MIB objects used for representing a MAC type of the media. An example for 802.16 is WmanIfMacVersion (of type INTEGER) of WMAN-IF-MIB. Another example for 802.11 is dot11StationConfigEntry (of type Dot11StationConfigEntry) of IEEE802dot11-MIB. |

#### 6.3.4.3.4 PoA Channel Range (for each PoA of Access Network + Operator combination )

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_POA_CHANNEL_RANGE | Channel range | 8 octets | Channel Range (Low, High) |

#### 6.3.4.3.5 PoA Subnet Information

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_POA_SUBNET_INFORMATION | PoA subnet Info | Variable | This field contains a list of subnets to which the link of the PoA belongs. The encoding format is defined in Table 12— |

**Table 12—Value field format of PoA Subnet Information TLV**

| Syntax | Size (octets) | Notes |
|---|---|---|
| N_Subnet | 1 | The number of Subnets. |
| For (i=0; i<N_Subnet; i++) { | | |
| Address | Variable | An IP address of the PoA encoded as Address base type of Diameter protocol (RFC3588). AddressType is encoded in the first 2-octet, which must be either 1 (IPv4) or 2 (IPv6). |
| L_Prefix | 1 | The bit length of the prefix of the subnet to which **Address** belongs. **L_Prefix**<=32 for IPv4 subnet and **L_Prefix**<=128 for IPv6 subnet |
| } | | |

#### 6.3.4.3.6 PoA Capabilities (for each PoA of Access Network + Operator combination )

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_POA_CAPABILITIES | PoA Capabilities | 4 octets | PoA Capability bitmap<br><br>Bit 0: Security Y/N<br>Bit 1: QoS Y/N<br>Bit 2: Internet Access Y/N<br>Bit 3: IP Version 4 Y/N<br>Bit 4: IP Version 6 Y/N<br>Bit 5: Emergency Services Y/N<br>Bit 6-31 : Reserved |

#### 6.3.4.3.7 PoA PHY Type (for each PoA of Access Network + Operator combination )

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_POA_PHY_TYPE | PHY Type | Variable | The length, format and semantics of this field are specific to each link type and defined by each media-specific WG or SDO. In many cases, this field contains values of media-specific MIB objects used for representing a PHY type of the media. An example for 802.16 is an OID suffix (4-octet integer) of an object defined as a subclass of wmanIfBsPhy in WMAN-IF-MIB. Another example for 802.11 is the value of dot11PHYType instance (of type INTEGER) in IEEE802dot11-MIB. |

#### 6.3.4.3.8 PoA Address

| Type | Description | Length | Value |
|---|---|---|---|
| TYPE_IE_POA_ADDRESS | Link-layer address of PoA | Variable | The link-layer address of the PoA encoded as Address base type of Diameter protocol (RFC3588). AddressType is encoded in the first 2-octet. |

### 6.3.5 Request for Information Elements

The client sends an Information Request to the MIH PoS. The Information request contains query for Information Elements. The MIH PoS sends an Information response which contans the response of the query back to the client.

Information Request (From Client to Information Server)

| Type | Length | Additional Parameters |
|---|---|---|
| Type values of IEs queried | Length of any Additional Parameters | Any other parameters required for request |

Information Response (from Information Server to Client)

| Type | Length | Value |
|---|---|---|
| Type value of IEs | Length of Value field | Value field of different IEs |

Below are few examples of request and response for different Information Elements.

#### 6.3.5.1 List of Networks (Link Types)

##### 6.3.5.1.1 Request for List of Networks

| Type | Length | Additional Parameters |
|---|---|---|
| TYPE_IE_LIST_OF_NETWORKS | 0 | |

##### 6.3.5.1.2 Response for List of Networks

| Type | Length | Value |
|---|---|---|
| TYPE_IE_LIST_OF_NETWORKS | Variable | List of different link types.<br>Four (4) octets for each link |

#### 6.3.5.2 Number of Operators (for each link type)

##### 6.3.5.2.1 Request for Number of Operators

| Type | Length | Additional Parameters |
|---|---|---|
| TYPE_IE_NUMBER_OF_OPERATORS | 4 | Link type (4 octets) |

##### 6.3.5.2.2 Response for Number of Operators

| Type | Length | Value |
|---|---|---|
| TYPE_IE_NUMBER_OF_OPERATORS | 4 | Number of Operators for specified link type |

#### 6.3.5.3 List of Operators (for each link type)

##### 6.3.5.3.1 Request for List of Operators

| Type | Length | Additional Parameters |
|---|---|---|
| TYPE_IE_LIST_OF_OPERATORS | 4 | Link Type (4 octets) |

#### 6.3.5.3.2 Response for List of Operators

| Type | Length | Value |
|---|---|---|
| TYPE_IE_LIST_OF_OPERATORS | Variable | Number of Operators (4 octets) followed by TLV for each Operator Identifier |

### 6.3.6 Information Reports

Information Reports allow client devices to query the informaton server for a pre-defined report. The format of these reports are well established in advance. Some of these reports and their format are described below.

#### 6.3.6.1 General Information Report

This report provides information about the General Information Elements.

#### 6.3.6.1.1 Request for General Network Information Report (for all link types)

| Type | Length | Additional Parameters |
|---|---|---|
| TYPE_REPORT_GENERAL_INFORMATION | 0 | |

#### 6.3.6.1.2 Response for General Network Information Report (for all link types)

| Type | Length | Value (octets) | | |
|---|---|---|---|---|
| TYPE_REPORT_GENERAL_INFORMATION | Variable | Number of Links (1) | | |
| Include an entry for each link specified in Number of Links | | Link Type_1 (4) | Number of Operators for Link_Type_1 (1) | List of Operators TLV for Link_Type_1 (Variable) |
| | | Link Type_2 (4) | Number of Operators for Link_Type_2 (1) | List of Operators TLV for Link_Type_2 (Variable) |
| | | Link Type_3 (4) | Number of Operators for Link_Type_3 (1) | List of Operators TLV for Link_Type_3 (Variable) |
| | | ..... | ..... | ..... |

#### 6.3.6.2 Access Network Information Report

This report provides information about Access Networks. Two different report formats are available. The client can obtain information about a single access network by specifying the Link Type and Operator Identifier fields in the request.Alternately the client can also obtain information about all access networks in the neighborhood as well.

#### 6.3.6.2.1 Request for Access Network Information Report (for each link type and Operator)

| Type | Length | Additional Parameters | |
|---|---|---|---|
| TYPE_REPORT_ACCESS_NETWORK | Variable | Link Type (4) | Operator Identifier TLV (Variable) |

#### 6.3.6.2.2 Response for Access Network Information Report (for each link type and Operator)

| Type | Length | Value (octets) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TYPE_REPORT_ACCESS_NETWORK | Variable | Link Type (4) | Operator Identifier TLV (Variable) | Number of PoAs (1) | List of Roaming Partner TLVs (Variable) | Cost TLV (Variable) | QoS TLV (Variable) | Network Security TLV (Variable) |

#### 6.3.6.2.3 Request for Access Network Information Report (for all link types)

| Type | Length | Additional Parameters |
|---|---|---|
| TYPE_REPORT_ALL_ACCESS_NETWORKS | Variable | |

#### 6.3.6.2.4 Response for Access Network Information Report (for all link types)

| Type | Length | Value (octets) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TYPE_REPORT_ALL_ACCESS_NETWORKS | Variable | Number of Links (1) | | | | | | |
| Include an entry for each Link Type in Number Of Links | | Link Type_1 (4) | Operator Identifier TLV (Variable) | Number of PoAs (1) | List of Roaming Partner TLVs (Variable) | Cost TLV (Variable) | QoS TLV (Variable) | Network Security TLV (Variable) |
| | | Link Type_2 (4) | Operator Identifier TLV (Variable) | Number of PoAs (1) | List of Roaming Partner TLVs (Variable) | Cost TLV (Variable) | QoS TLV (Variable) | Network Security TLV (Variable) |
| | | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

### 6.3.6.3 Point of Attachment Information Report

This report provides information about Points of Attachment of different access networks. The client can obtain PoA report for any single access network by specifying the Link Type and Operator Identifier parameters in the request.

#### 6.3.6.3.1 Request for PoA Information Report (for each link type and Operator)

| Type | Length | Additional Parameters | |
|---|---|---|---|
| TYPE_REPORT_POA | Variable | Link Type (4) | Operator Identifier TLV (Variable) |

#### 6.3.6.3.2 Response for PoA Information Report (for each link type and Operator)

| Type | Length | Value (octets) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| TYPE_REPORT_POA | Variable | Link Type (4) | Operator Identifier TLV (Variable) | Number of PoAs (1) | | | | | |
| Include an entry for each PoA in Number of PoAs | | PoA_1 Address TLV (Variable) | PoA_1 Location TLV (Variable) | PoA_1 Data Rate TLV (Variable) | PoA_1 PHY Type TLV (Variable) | PoA_1 MAC Type TLV (Variable) | PoA_1 Channel Range TLV (Variable) | PoA_1 Subnet Information TLV (Variable) | PoA_1 capability bitmap TLV (Variable) |
| | | PoA_2 Address TLV (Variable) | PoA_2 Location TLV (Variable) | PoA_2 Data Rate TLV (Variable) | PoA_2 PHY Type TLV (Variable) | PoA_2 MAC Type TLV (Variable) | PoA_2 Channel Range TLV (Variable) | PoA_2 Subnet Information TLV (Variable) | PoA_2 capability bitmap TLV (Variable) |
| | | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |

### 6.3.7 Primitives for Information Service

The generic model of Information Service primitives specifies the format of information requests that are passed from the MIH Function on the mobile node or client device to the MIH Function on the network. The Information Service primitives are defined as follows:

InformationXX. request (RequestSource, InformationRequestSet) where,

— RequestSource: is used to identify the source entity where the query for information originated
— InformationRequestSet: is an extensible parameter that may contain implementation specific information and may be different across different queries. InformationRequestSet completely describes the query that is issued

InformationXX. response (ResponseSource, InformationResultSet) where,

— ResponseSource: is used to identify the source entity where the response for information originated
— InformationResultSet: is an extensible parameter that may contain the result of the request and may be different across different queries.

### 6.3.8 Information Service Schema

A schema defines structure of information. A schema is used in the 802.21 information service to define the structure of each information element as well as the relationship among different information elements sup-

ported. The 802.21 information service schema needs to be supported by every MIH Function that implements the MIIS to support flexible and efficient information queries. The 802.21 information service defines the various information elements and their structure. The various IEs represent information about lower layers of network stack as well as about higher layer services available in different access networks. A schema is defined by a language and can be represented in multiple ways. Examples include Resource Description Framework (RDF) which is based on XML, ASN.1 which is used in 802 MIBs, Variants or a simple TLV representation of different information elements.The MIIS schema is classified into two major categories.

— Basic schema that is essential for every MIH to support and
— Extended schema that is optional and can be vendor specific

#### 6.3.8.1 RDF Schema Representation

This section gives an example of schema using Resource Description Framework (RDF) [8]. RDF uses

SPARQL as a query language for querying information. Both RDF schema and SPARQL are represented in XML. .An RDF schema defines the structure of set of expressions, where the underlying structure of any expression is a collection of triples, each consisting of a subject, a predicate and an object. XML syntax for RDF called RDF/XML. RDF has the following advantages:

— Supports both hierarchical and non-hierarchical information structure
— Allows for flexible data query
— Allows for distributed schema definition
— Easier way to change the schema definition

In order to strictly define each information element in an RDF schema, the schema is augmented with Web Ontology language (OWL) [OWL]. OWL is a Web Ontology language. OWL uses both URLs for naming and the description framework provided by RDF to add the following capabilities to ontologies:

— Ability to be distributed across many systems
— Scalability
— Compatibility with other Web standards for accessibility and internationalization
— Openness and extensibility

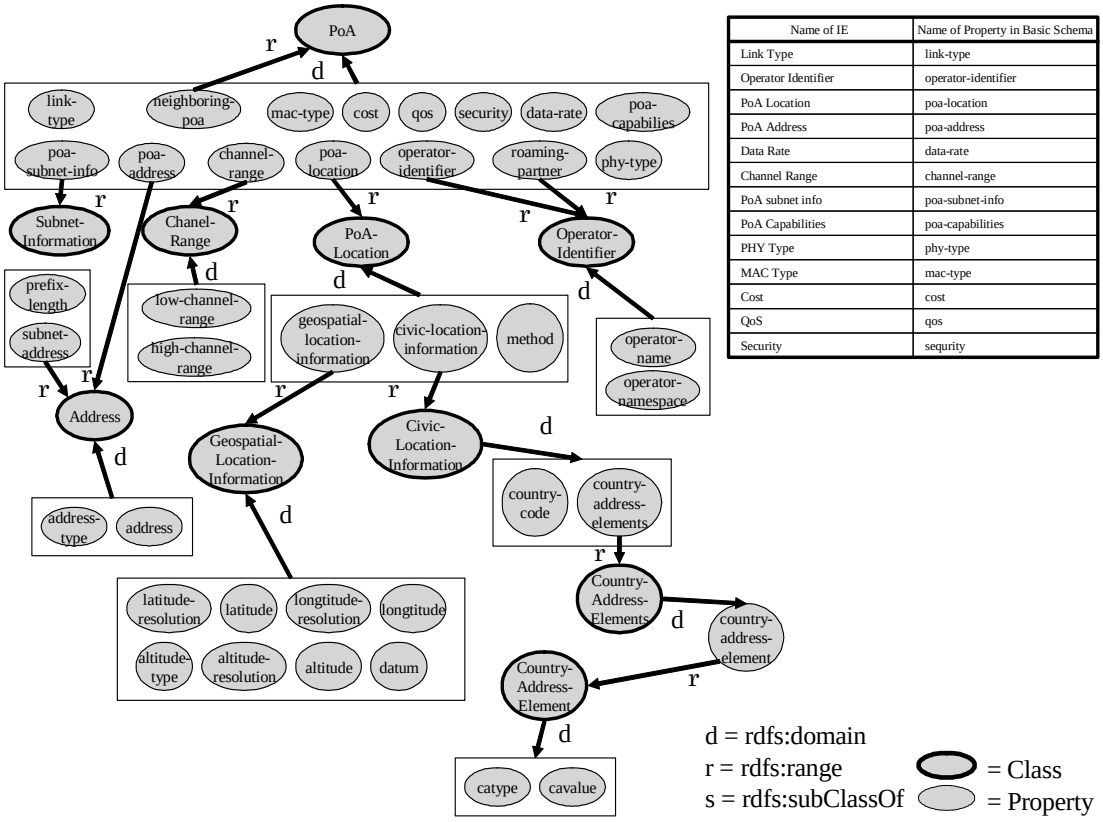
OWL builds on RDF and RDF Schema and adds more vocabulary for describing properties and classes: among others, relations between classes (e.g. disjoint-ness), cardinality (e.g. "exactly one"), equality, richer typing of properties and characteristics of properties (e.g. symmetry), and enumerated classes.

As described earlier, the RDF schema definition for MIIS consists of two parts; the basic and the extended schema. The basic schema is not supposed to be updated. An MIH entity is pre-provisioned with the basic schema for ease of implementation of schema-based query. In scenarios where the basic schema is not pre-provisioned methods such as DHCP may be used to access URL of the basic schema.

Unlike the basic schema, the extended schema is expected to be updated periodically, e.g., when a new link-layer technology is introduced. The extended schema can be retrieved from the specified URL via the IEEE 802.21 information service using the schema query capability without any pre-provision of such extended schema. The URL of the extended schema can also be obtained via the schema URL query capability. Alternatively other methods such as DHCP may be enabled for finding out the URL of extended schema. The extended schema is defined as an extension of the basic schema and includes data structure and relationship of media-specific or higher-layer information. In that sense extended schema is the complement of basic schema.

Figure 23 — shows an example graphical representation of the 802.21 MIIS basic schema in which 'PoA' ,'Subnet-Information', 'Address', 'Channel-Range', 'PoA-Location', 'Operator-Identifier', 'Geospatial-Loca-

tion-Information', 'Civic-Location-Information', 'Country-Address-Elements' , 'Country-Address-Element' are represented as classes, while all others are properties of classes. The lines indicate either the range or domain of a property or a sub-class of a class. In particular 'r' represents the range of a property and 'd' represents domain of a property. 'Domain' defines the class that a particular property belongs to and 'range' defines a type of a particular property.




| Name of IE | Name of Property in Basic Schema |
|---|---|
| Link Type | link-type |
| Operator Identifier | operator-identifier |
| PoA Location | poa-location |
| PoA Address | poa-address |
| Data Rate | data-rate |
| Channel Range | channel-range |
| PoA subnet info | poa-subnet-info |
| PoA Capabilities | poa-capabilities |
| PHY Type | phy-type |
| MAC Type | mac-type |
| Cost | cost |
| QoS | qos |
| Security | sequrity |

**Figure 23 — A Graphical Representation of basic schema**

### 6.3.8.2 The MIIS Schema

The basic and extended schema and their textual description in different formats are included in Annex C. Basic schema is normative and contains list of mandatory information elements and their properties. Extended schema is optional and contains an exhaustive list of information resources and properties.

### 6.3.9 Information Flow

Figure 24 — describes an information flow based on L2 transport. MIIS within MIHF (MIH Function) is communicating with the remote MIHF that is residing within the access network. MIH PoA in this figure is either an AP or a BS. Link_Get_Information from the MN is carried over L2 frame and delivered to the remote MIH. Remote MIH returns the necessary information via appropriate response frame.

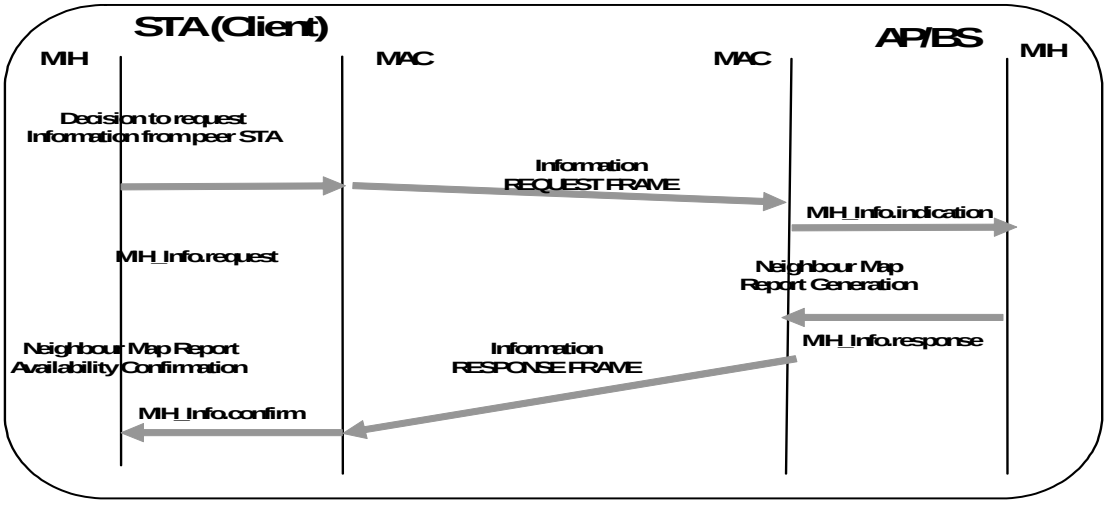



**Figure 24 — L2-based MIIS information flow**

Figure 25 — describes an information flow based on L3 transport. MIIS within MIHF (MIH Function) is communicating with the remote MIHF that is residing either within the access network or in the core network. MIH PoA in this figure is either an AR or some other entity in the network. MIH_Get _Information from the MN is carried over L3 frame and delivered to the remote MIH. Remote MIH returns the necessary information via appropriate response frame.

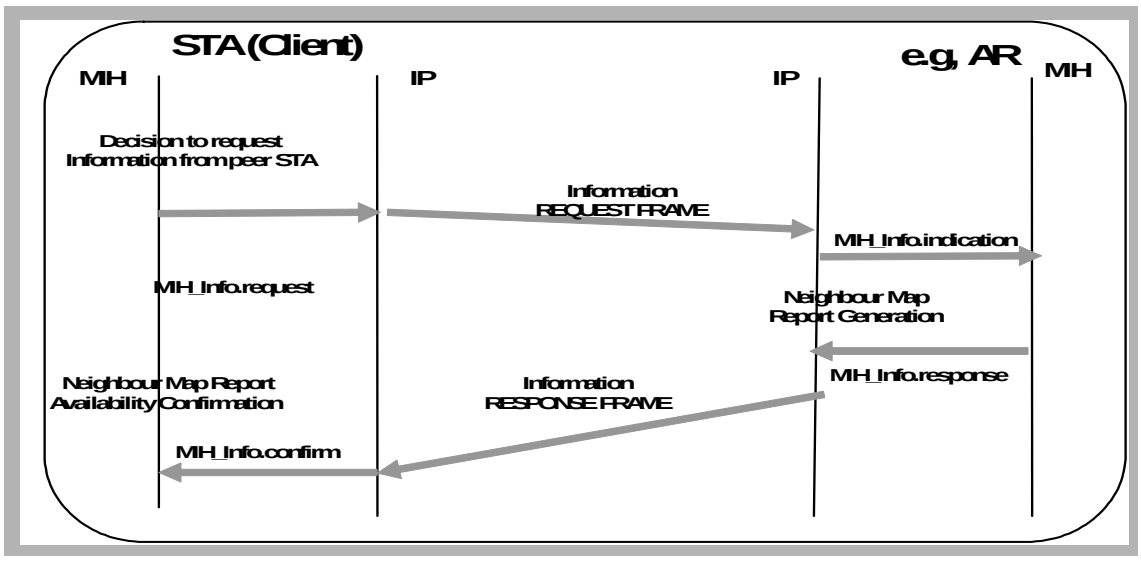



**Figure 25 — L3-based MIIS information flow**

# 7. Service Access Points (SAPs) and Primitives

## 7.1 Introduction

The MIH Function uses the following key SAPs for interfacing with other entities.

### 7.1.1 Media Dependent SAPs

1) MLME_SAP: The MIH Function uses this SAP for interfacing with link layer of 802.11 networks. Primitives defined as part of this SAP are recommended as enhancements to 802.11 link layer SAPs.
2) M_SAP: The MIH Function uses this SAP for interfacing with the Management plane of the 802.16 network.
3) C_SAP: The MIH Function uses this SAP for interfacing with the Control plane of the 802.16 network.
4) MIH_3GLINK_SAP: This SAP defines the interface between the MIH Function and the different protocol elements of the 3G system.

### 7.1.2 Media Independent SAPs

1) MIH_SAP: This SAP defines the interface between MIH Function and MIH Users.

### 7.1.3 Network Management SAPs

1) MIH_NMS_SAP: The MIH Function uses this SAP for interfacing with the Network Management entity in the 802.11 network.

## 7.2 SAPs

### 7.2.1 Media Dependent SAPs

#### 7.2.1.1 MLME_SAP

<TBD>

#### 7.2.1.2 M_SAP

M_SAP is defined by IEEE 802.16g and it may include, but is not limited to primitives related to:

— System configuration
— Monitoring Statistics
— Notifications/Triggers

#### 7.2.1.3 C_SAP

C_SAP is defined by IEEE 802.16g and it may include, but is not limited to primitives related to:

— Handovers (e.g. notification of HO request from MS, etc.)
— Idle mode mobility management (e.g. Mobile entering idle mode)
— Subscriber and session management (e.g. Mobile requesting session setup)
— Radio resource management
— AAA server signaling (e.g. EAP payloads)
— Media Independent Function Services

The key primitives defined as part of C_SAP are described in the table below.

**Table 13—C_SAP Primitives**

| No | Primitives | Description |
|---|---|---|
| 1. | M_Ranging | Upper layers can control ranging procedure with these primitives. Upper layers shall commence 802.16 link setup procedure by sending M_Ranging.request primitive through NCMS. Note: M_Ranging.request primitive with ranging type: "initial" is an 802.16 Link Switch Link Command (link setup) which corresponds to Link Switch MIH command |
| 2. | M_Registration | Upper layers can control registration procedure with these primitives. Upper layers are notified of link setup by M_Registration.confirmation. Note: M_Registration.confirmation primitive is an 802.16 Link_Up Link Event. |
| 3. | M_Neighbor | When 802.16 MAC receives neighbor advertisement (MOB_NBR-ADV), this primitive is used to deliver the information to upper layers. Upper layers can schedule scanning period with BS. During scanning period BS may buffer downlink traffic to the mobile terminal. |
| 4. | M_ScanScheduling | When 802.16 MAC receives neighbor advertisement (MOB_NBR-ADV), this primitive is used to deliver the information to upper layers. Upper layers can schedule scanning period with BS. During scanning period BS may buffer downlink traffic to the mobile terminal. |
| 5. | M_Scanning | Upper layers can command autonomous scanning with these primitives. Note: These primitives are Scan Link Command for MIH Scan command in 802.21. |
| 6. | M_ScanReport | Delivery of the primitives shall be based on the pre-registration procedure between upper layer management entities and NCMS. Scan report can be made remotely to the BS or locally to the upper layer entity depending on the report target value in M_ScanReport.request. |
| 7. | M_MACHandover | Upper layers can control handover procedure by using these primitives. Note: These primitives can be used as link commands for MIH_Handover_initiate.request/response. For remote command service, 802.16 MAC management messages shall be used. (MOB_MSHO-REQ/ MOB_BSHO-REQ/MOB_BSHO-RSP) Currently only parameters relevant to 802.16 handover are included. Parameters for Media Independent Handover shall be identified and added. |
| 8. | M_HOIND.reqyest/ confirmation | An MS transmits a MOB_HO-IND message for final indication that is about performing a HO. Note: This primitive is a Link Command of MIH_Handover_Commit.request/response MIH Command in the .21 draft. For remote service, 802.16 MAC management message shall be used. (MOB_HO-IND). Currently only parameters relevant to 802.16 handover are included. Parameters for Media Independent Handover shall be identified and added. |
| 9. | M_Management | These primitives are used to manage the status of mobile terminal. Upper layer can change the status of mobile terminal into power on/down/hold/de-register, etc. Note: These can be mapped to MIH Configure MIH Command Service. For remote service, 802.16 MAC management messages can be used. (RES-CMD/ DREG-CMD |

#### 7.2.1.4 MIH_3GLINK_SAP

3GPP and 3GPP2 service primitives for GSM, UMTS, LAC, PPP and LTE/SAE can be use to access IEEE 802.21 services. This can is done by establishing a relationship between the 3GPP/3GPP2 primitives and IEEE 802.21 primitives at both the link layer and at the MIH level.

Table 20— lists this mapping. Note that a 3GPP primitive group can be mapped to more than one IEEE 802.21 primitives. E.g., "SMREG-PDP-MODIFY" can be mapped to a Link Up Primitive and it could also indicate the successful completion of a Handover, thereby mapping to a Handover Complete MIH-primitive as well. Likewise "L2 Condition Notification" as defined in reference [2] can be mapped to a Link Down Indication.

### 7.2.2 Media Independent SAPs

#### 7.2.2.1 MIH_SAP

The key primitives defined as part of MIH_SAP are described in Table 14—.

**Table 14—MIH_SAP Primitives**

| No | Primitives | Service Category | Description |
|---|---|---|---|
| 1 | MIH Capability Discover | System Management | Discover list of Events and Commands supported by MIH Function. |
| 2 | MIH Event Register | Event | Register for MIH event notifications |
| 3 | MIH Event DeRegister | Event | Deregister for MIH event notifications |
| 4 | MIH Link Up | Event | L2 connection has been established |
| 5 | MIH Link Down | Event | L2 connectivity is lost |
| 6 | MIH Link Going Down | Event | L2 connectivity is predicted to go down |
| 7 | MIH Link Event Rollback | Event | Predicted event has not occurred and hence must be rolled back |
| 8 | MIH Link Parameters Report | Event | Link parameters have crossed specified threshold |
| 9 | MIH Link SDU Transmit Status | Event | Indicate transmission status of all PDU segments |
| 10 | MIH Link Handover Imminent | Event | L2 handover is imminent |
| 11 | MIH Link Handover Complete | Event | L2 handover has been completed |
| 12 | MIH Get Status | Command | Get the status of link |

**Table 14—MIH_SAP Primitives**

| No | Primitives | Service Category | Description |
|---|---|---|---|
| 13 | MIH Switch | Command | Switch session between specified links |
| 14 | MIH Configure | Command | Configure link parameters and parameter thresholds |
| 15 | MIH Configure Link Thresholds | Command | Configure thresholds for Link events |
| 16 | MIH Scan | Command | Scan the network |
| 17 | MIH Handover Initiate | Command | Initiate handover |
| 18 | MIH Handover Prepare | Command | Prepare for handover and query available resources |
| 19 | MIH Handover Commit | Command | Terminal has committed to handover |
| 20 | MIH Handover Complete | Command | Handover has been completed |
| 21 | MIH Network Address Information | Command | Obtain network address on new link |
| 22 | MIH Get Information | Information | Request to get information from repository |

#### 7.2.2.2 MIH_LINK_SAP

The key primitives defined as part of MIH_LINK_SAP are described in Table 15—.

**Table 15—MIH_LINK_SAP Primitives**

| No | Primitives | Service Category | Description |
|---|---|---|---|
| 1 | Link Event Discover | System Management | Discover link capabilities |
| 2 | Link Event Register | Event | Register for event notifications |
| 3 | Link Event Deregister | Event | Deregister for event notifications |
| 4 | Link Configure Thresholds | Command | Configure link thresholds for Link events |
| 5 | Link Up | Event | L2 connectivity is established |
| 6 | Link Down | Event | L2 connectivity is lost |
| 7 | Link Going Down | Event | L2 connectivity loss is imminent |
| 8 | Link Event Rollback | Event | Predicted event has not occurred and hence must be rolled back. |
| 9 | Link Parameters Change | Event | Link parameters have crossed specified thresholds |

**Table 15—MIH_LINK_SAP Primitives**

| No | Primitives | Service Category | Description |
|---|---|---|---|
| 10 | Link SDU Transmit Status | Event | Indicate transmission status of all PDU segments |
| 11 | Link Handover Imminent | Event | L2 handover is imminent |
| 12 | Link Handover Complete | Event | L2 handover has been completed |
| 13 | Link Get Information | Information | Request for IEs |

### 7.2.3 Network Management SAPs

#### 7.2.3.1 MIH_NMS_SAP

The key primitives defined as part of MIH_NMS_SAP are described in Table 16—.

**Table 16—MIH_NMS_SAP Primitives**

| No | Primitives | Service Category | Description |
|---|---|---|---|
| 1 | Initialize | System Mgmt | Initializes the MIH Function |
| 2 | Reset | System Mgmt | Resets the MIH Function |
| 3 | Install link | System Mgmt | Informs the MIH Function of a new link that has been added to the terminal device or the network. The interface to new link may have been hot plugged or powered on. |
| 4 | Remove link | System Mgmt | Informs the MIH Function of an existing link interface that has been removed. The interface to new link may have been removed dynamically or shut down. |

## 7.3 Link Layer Primitives

### 7.3.1 Link_Event_Discover.request

#### 7.3.1.1 Function

This primitive is used by MIH Function to query and discover the list of supported link layer events.

#### 7.3.1.2 Semantics of service primitive

The primitive parameters are as follows:

Link_Event_Discover.request ( )

#### 7.3.1.3 When generated

This primitive is generated by an upper layer entity of type MIH User that is seeking to receive link layer event notifications.

#### 7.3.1.4 Effect on receipt

The recipient responds immediately with Link_Event_Discover.confirm primitive.

### 7.3.2 Link_Event_Discover.confirm

#### 7.3.2.1 Function

This primitive returns the result of the query to discover link layer events request

#### 7.3.2.2 Semantics of service primitive

The primitive parameters are as follows:

Link_Event_Discover.confirm (
SupportedEventList
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| SupportedEvent List | Set of Event IDs | N/A | List of link layer events supported by the link layer |

#### 7.3.2.3 When generated

This primitive is generated in response to a Link_Event_Discover.request primitive.

#### 7.3.2.4 Effect on receipt

The recipient may examine the returned event list and register for selective link layer indications.

### 7.3.3 Link_Event_Register.request

#### 7.3.3.1 Function

This primitive is used by MIH Function (the registrant) to register an interest in a particular or group of event types from a particular event origination point. The response indicates which of the requested event types were successfully registered. Event types not successfully registered will not be delivered to the registrant.

#### 7.3.3.2 Semantics of service primitive

The primitive parameters are as follows:

Link_Event_Register.request (
RequestedEventList

)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| RequestedEvent List | Set of Event IDs | Set of Valid link events | List of link layer events that the endpoint would like to receive indications for, from the Event Source |

#### 7.3.3.3 When generated

This primitive is generated by a registrant such as MIH Function that is seeking to receive event primitives from a point in the protocol stacks terminating either end of the link.

#### 7.3.3.4 Effect on receipt

The recipient responds immediately with Link_Event_Register.confirm primitive.

### 7.3.4 Link_Event_Register.confirm

#### 7.3.4.1 Function

This primitive returns the result of the registration request.

#### 7.3.4.2 Semantics of service primitive

The primitive parameters are as follows:

Link_Event_Register.confirm (
ResponseEventList
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| ResponseEvent List | Set of Event IDs and their registration status | N/A | List of link layer events along with their registration status |

#### 7.3.4.3 When generated

This primitive is generated in response to a Link_Event_Register.request primitive.

#### 7.3.4.4 Effect on receipt

The recipient may examine the returned event list and learn about the registration status of different events.

### 7.3.5 Link_Event_Deregister.request

#### 7.3.5.1 Function

This primitive is used by MIH Function (the registrant) to deregister for a set of link layer events.

#### 7.3.5.2 Semantics of service primitive

The primitive parameters are as follows:

Link_Event_Deregister.request (
RequestedEventList
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| RequestedEvent List | Set of Event IDs | Set of Valid link events | List of link layer events for which indications need to be deregistered from the Event Source |

#### 7.3.5.3 When generated

This primitive is generated by a registrant such as MIH Function that is seeking to deregister for already registered set of events.

#### 7.3.5.4 Effect on receipt

The recipient responds immediately with Link_Event_Deregister.confirm primitive.

### 7.3.6 Link_Event_Deregister.confirm

#### 7.3.6.1 Function

This primitive returns the result of the deregistration request.

#### 7.3.6.2 Semantics of service primitive

The primitive parameters are as follows:

Link_Event_Deregister.confirm (
ResponseEventList
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| ResponseEvent List | Set of Event IDs and their Deregistration status | N/A | List of link layer events along with their deregistration status |

#### 7.3.6.3 When generated

This primitive is generated in response to a Link_Event_Deregister.request primitive.

#### 7.3.6.4 Effect on receipt

The recipient may examine the returned event list and learn about the deregistration status of different events.

### 7.3.7 Link_Configure_Thresholds.request

#### 7.3.7.1 Function

This primitive is used by MIH Function or the link layer to configure a thresholds for Link Parameters Change indication.

#### 7.3.7.2 Semantics of service primitive

The primitive parameters are as follows:

Link_Configure_Thresholds.request (
LinkParameter,
InitiateActionThreshold,
RollbackActionThreshold,
ExecuteActionThreshold
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Link Parameter | Link Speed,<br>Link Bit Error Rate,<br>Link Frame Loss Rate before retransmission,<br>Link Signal Strength | | Parameters for which thresholds can be set |
| InitiateActionThreshold | Threshold values are dependent on parameter for which they are being set. | | Threshold value which may cause Upper layers to start “setup” type activities in response to actual parameter values crossing this threshold. |
| RollbackActionThresh-old | Threshold values are dependent on parameter for which they are being set. | | Threshold value which may cause Upper layers to cancel or rollback the above setup type operation if the actual parame-ter values retreat to this threshold. |
| ExecuteActionThresh-old | Threshold values are dependent on parameter for which they are being set. | | Threshold value which may cause Upper layers to execute taking appropriate action if the actual parameter values cross this threshold. |

#### 7.3.7.3 When generated

This primitive is generated by an upper layer entity that may need to set threshold values for different link parameters.

#### 7.3.7.4 Effect on receipt

The recipient responds immediately with Link_Configure_Threshold.confirm primitive.

### 7.3.8 Link_Configure_Thresholds.confirm

#### 7.3.8.1 Function

This primitive is sent in response to the Link_Configure_Threshold.request primitive. This primitive specifies the status of threshold configuration operation.

#### 7.3.8.2 Semantics of service primitive

The primitive parameters are as follows:

Link_Configure_Thresholds.confirm(
LinkParameter,
Status
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Link Parameter | Link Speed,<br>Link Bit Error Rate,<br>Link Frame Loss Rate before retransmission,<br>Link Signal Strength | | Parameters for which thresholds can be set |
| Status | | | Success<br>Error |

#### 7.3.8.3 When generated

This primitive is generated in response to the Link_Configure_Thresholds.request operation

#### 7.3.8.4 Effect on receipt

The recipient prepares to receive Link Parameter Change notifications on successful execution of this primitive.

### 7.3.9 Link_Up.indication

#### 7.3.9.1 Function

This notification is delivered when a layer 2 connection is established on the specified link interface and when L3MP and other upper layers can send higher layer packets. All layer 2 activities in establishing the link connectivity are expected to be completed at this point of time.

Parameters:

| Name | Type | Valid Range | Description |
|---|---|---|---|
| MacMobileTerminal | MAC Address | | MAC Address of Mobile Terminal |

| Name | Type | Valid Range | Description |
|---|---|---|---|
| LinkIdentifer | Media Specific | | Unique link identifier that can be used to detect changes in network PoA. (SSID+BSSID) serves as unique network identifier for 802.11 networks |
| MacNewPoA | MAC Address | | MAC Address of New PoA (AP/BS) |
| MacOldAccessRouter | MAC Address (Optional) | | MAC Address of old Access Router (if any) |
| MacNewAccessRouter | MAC Address (Optional) | | MAC Address of new Access Router (if any) |
| IP_Renewal_Indicator | Flag (Optional) | | Indicates whether the MN shall change IP Address in the new PoA<br>0 : Change Required<br>1 : Change Not required |
| Mobility Management Protocol Support Type bitmap | BITMAP (Optional) | | Indicates the type of Mobility Management Protocol supported by the new PoA<br>0 : Mobile IPv4 with FA (FA-CoA)<br>1 : Mobile IPv4 without FA (Co-located CoA)<br>2 : Mobile IPv6<br>3 : Mobile IPv6 with DHCPv6<br>4 : SIP |

#### 7.3.9.2 When generated

This notification is generated when a layer 2 connection is established for the specified link interface.

#### 7.3.9.3 Effect on receipt

Higher layers may take different actions on this notification. The handover policy function may start collecting routing metrics for this link and may consider this link as a potential candidate for establishing future connections. When higher layer connections are being established over this link, the Transport layer may adjust transport (TCP) related parameters based on link properties.

### 7.3.10 Link_Down.indication

#### 7.3.10.1 Function

This notification is delivered when a layer 2 connection is broken on the specified link and when no more packets can be sent on the specified link

Event Source:{Local Link}

Parameters:

| Name | Type | Valid Range | Description |
|---|---|---|---|
| MacMobileTerminal | MAC Address | | MAC Address of Mobile Terminal |
| MacoldPoA | MAC Address | | MAC Address of old PoA |

| Name | Type | Valid Range | Description |
|---|---|---|---|
| MacOldAccessRouter | MAC Address (Optional) | | MAC Address of old Access Router (if any) |
| ReasonCode | REASON_CODE _TYPE | | Reason for why the link went down such as disassociated with PoA, failure in transmitting/acknowledging the frames, etc. |

The reason code for Link_Down can be one or combination of the following reasons.

| Reason Code Id | Reason Code | Meaning |
|---|---|---|
| 1 | RC_EXPLICIT_DISCONNECT | The link is down because of explicit disconnect procedures initiated either by client or network |
| 2 | RC_PACKET_TIMEOUT | The link is down because no acknowledgements were received for transmitted packets within the specified time limit. |
| 3 | RC_FAIL_NORESOURCE | The link is down because there were no resources to maintain the connection |
| 4 | RC_FAIL_NO_BROADCAST | The link is down because broadcast messages (control frames such as beacons) could not be received by client device |
| 5 – 127 | Reserved | Reserved |
| 128 - 255 | RC_VENDOR_SPECIFIC | Vendor Specific reason code. |

#### 7.3.10.2 When generated

This notification is generated when layer 2 connectivity is lost. Layer 2 connectivity may be lost explicitly in cases where the terminal may initiate disassociate type procedures. In other cases the terminal may infer loss of link connectivity due to successive timeouts for acknowledgements of retransmitted packets along with loss of reception of broadcast frames.

#### 7.3.10.3 Effect on receipt

Higher layers may take different actions on this notification. The handover policy may eliminate this link from list of active links for routing connections and may consider handing over any potential active connections to other more suitable links.

### 7.3.11 Link_Going_Down.indication

#### 7.3.11.1 Function

This notification is delivered when a Layer 2 connection is expected (predicted) to go down (Link_Down) within a certain time interval. Link_Going_Down event may be the indication to initiate handover procedures. Different applications may have different requirements with respect to the time interval required to anticipate in advance a link going down and make adequate a priori preparation to handover a connection depending on Application Class. Hence upper layers such as a L3 mobility protocol may actually configure the time interval in which a Link_Going_Down event may be delivered. This would allow the flexibility for the time interval to be in msecs, 100s of msecs or even seconds.

Event Type:Predictive

Parameters:

| Name | Type | Valid Range | Description |
|---|---|---|---|
| MacMobileTerminal | MAC Address | | MAC Address of Mobile Terminal |
| MACNewPoA | MAC Address (Optional) | | MAC Address of New PoA |
| MacOldAccessRouter | MAC Address (Optional) | | MAC Address of old Access Router (if any) |
| MacNewAccessRouter | MAC Address (Optional) | | MAC Address of new Access Router (if any) |
| TimeInterval | Time in msecs | | Time Interval in which the link is expected to go down. The link connectivity is expected to be available at least for time specified by *TimeInterval* |
| ConfidenceLevel | Percentage (0-100) | | The confidence level for link to go down within the specified time interval |
| UniqueEventIdentifer | 0 – 65535 | | Used to uniquely identify the event. To be used in case of event rollback |

#### 7.3.11.2 When generated

A Link_Going_Down event implies that a Link_Down is imminent within a certain time interval. If Link_Down is NOT received within specified time interval then actions due to previous Link_Going_Down may be rejected.

A 100% confidence would indicate certainty that the link is definitely going down within the specified time interval. For example a BS that may have decided to shut down for administrative reasons may send down a Link_Going_Down trigger with 100% confidence level. Predictions based on changes in link parameters such as signal strength values would typically have a lower confidence level. Different links would typically use implementation specific methods to predict future loss in link connectivity.

#### 7.3.11.3 Effect on receipt

Higher layers may take different actions on this notification. Upper layers may prepare to initiate handovers based on the confidence level reported as part of the event.

### 7.3.12 Link_Event_Rollback.indication

#### 7.3.12.1 Function

Link_Event_Rollback is used in conjunction with Link_Going_Down. In case of Link_Going_Down if the link is no longer expected to go down in the specified time interval, then a Link_Event_Rollback message is sent to the Event destination. The destination should disregard or rollback the changes associated with the event identifier in such cases.

Event Type:Administrative

Parameters

| Name | Type | Valid Range | Description |
|---|---|---|---|
| MacMobileTerminal | MAC Address | | MAC Address of Mobile Terminal |
| UniqueEventIdentifer | 0 – 65535 | | Used to identify the event which needs to be rolled back |

#### 7.3.12.2 When generated

This notification is generated when a predictive even expected to occur within a certain time interval is no longer expected to occur before the expiry of the indicated time interval.

#### 7.3.12.3 Effect on receipt

Higher layers may reevaluate the link under consideration by retrieving other link quality related parameters. Any handover procedures that may have already been initiated may need to be rescinded.

### 7.3.13 Link_Detected.indication

#### 7.3.13.1 Function

Link_Detected indicates that a new type of link has been detected for use. This may imply that the terminal is in the coverage area and can listen to a beacon, or that the terminal may have received a response to a probe. Link_Detected does not guarantee that the terminal would be able to establish connectivity with the detected link, but just that the terminal can attempt to gain connectivity. Upper layers including MIH Function may evaluate additional properties of the link before attempting to establish a L2 connection with the link.

Event Type:State Change

Parameters:

| Name | Type | Valid Range | Description |
|---|---|---|---|
| MacMobileTerminal | MAC Address | | MAC Address of Mobile Terminal |
| MIH Capability | Flag | | 0 : MIH Capability Not Supported<br>1 : MIH Capability Supported |
| Link Type | Enumerated link types | | Type of link |
| MACNewPoA | MAC Address (optional) | | MAC Address of New PoA |

#### 7.3.13.2 When generated

This notification is generated when a new link type is detected. The detection can be based on a beacon or response to a probe or even through the Information Service.

#### 7.3.13.3 Effect on receipt

Upper layers include MIH Function may discover additional properties of the link before selecting it for establishing connectivity.

### 7.3.14 Link_Parameters_Change.indication

#### 7.3.14.1 Function

Link_Parameters_Change indicates changes in link parameters have crossed specified threshold levels. This may include link layer parameters such as Speed of the link, QoS, BER, etc. The threshold level for each such parameter may have to be configured through a separate command to link layer.

Event Type:State Change

Parameters:

| Name | Type | Valid Range | Description |
|---|---|---|---|
| MacMobileTerminal | MAC Address | | MAC Address of Mobile Terminal |
| MacAccessRouter | MAC Address (Optional) | | MAC Address of current Access Router (if any) |
| Link Parameter Type | Enumerated link types | | Media specific parameter types that have crossed thresholds |
| oldValueOfLinkParam-eter | | | Specify the old value of link parameter |
| newValueOfLinkParam-eter | | | Specify the new value of link parameter |

Examples of link layer parameters that could trigger this event include:

— Link Speed
— Link Bit Error Rate
— Link Frame Loss Rate before Retransmission
— Link Received Signal Strength

#### 7.3.14.2 When generated

This notification is generated when a link layer parameter crosses a configured threshold.

#### 7.3.14.3 Effect on receipt

Higher layers may take different actions on this notification. If parameters related to link quality cross a certain threshold then that link may need to be evaluated for handing over current connections. The MIH Function may collectively evaluate different parameters and give appropriate indications to higher layers regarding suitability of different links.

### 7.3.15 Link_SDU_Transmit_Status.indication

#### 7.3.15.1 Function

Link_SDU_Transmit_Status indicates the transmission status of the higher layer PDU. A success status indicates that all segments belonging to a higher layer packet (PDU) have been successfully delivered from the ARQ module of link layer in current node to the ARQ module in link layer in peer node. A higher layer intermediate buffer management entity could use this indication to flush higher layer packets stored in any intermediate buffers. A failure status indicates that at least one segment belonging to a higher layer packet (PDU) was not delivered successfully from the ARQ module of link layer in current node to the ARQ module in link layer in peer node.

Event Type:Link Transmission

Parameters:

| Name | Type | Valid Range | Description |
|---|---|---|---|
| MacMobileTerminal | MAC Address | | MAC Address of Mobile Terminal |
| PacketIdentifier | N/A | | Identifier for higher layer data packet that was delivered successfully. |
| Status | | | 0: Success<br>1: Failure |

#### 7.3.15.2 When generated

A success notification is generated when all the link layer segments belonging to a higher layer PDU are successfully transmitted over the link.. A failure notification is generated when any link layer segment corresponding to a higher layer PDU was not transmitted successfully.

#### 7.3.15.3 Effect on receipt

Higher layers may take different actions on this notification. A higher layer intermediate buffer management entity in MIH could use the success indication to flush higher layer packets stored in any intermediate buffers and a failure indication to retransmit higher layer packets stored in any intermediate buffers, especially if there are changes in access network during handovers.

### 7.3.16 Link_Handover_Imminent. Indication

#### 7.3.16.1 Function

Link Handover Imminent is generated when a native link layer handover or switching decision has been made and its execution is imminent (as opposed to Link Going Down which only indicates that a link is losing connectivity due to a change in certain link condition such as signal strength, but does not guarantee that an autonomous link switchover has been decided by the link layer). It contains information about the new point of attachment of the mobile node. It also contains information about any application specific data that might be useful for the application running on the mobile node. Link Handover Imminent can be used by upper layers (e.g., transport ) to initiate handover specific adaptation and as an enabler for initiating effective make-before-break handovers thereby reducing packet loss due to link layer handovers. This is a link layer

event that exists for intra-technology handovers defined in many media types (e.g., cellular, 802.16e). MIH can receive the Link Handover Imminent events from the link layer and pass them to upper layer as MIH events for both inter-technology and intra-technology handover cases.

Event Type:Link Synchronous

Parameters:

| Name | Type | Valid Range | Description |
|---|---|---|---|
| MacMobileTerminal | MAC Address | | MAC Address of Mobile Terminal |
| MACNewPoA | MAC Address | | MAC Address of New AP/BS |
| MacOldAccessRouter | MAC Address | | MAC Address of old Access Router (if any) |
| MacNewAccessRouter | MAC Address | | MAC Address of new Access Router (if any) |

#### 7.3.16.2 When generated

Depending on whether it is the Mobile node or the Network, it is generated when a native link layer handover or switching decision has been made and its execution is imminent.

#### 7.3.16.3 Effect on receipt

Application may take necessary actions to minimize the effect of the pending native link layer handover or switching on user data transfer. For example, to cover the handover period (when packets cannot be transferred), the network can proactively start sending the additional data as soon as it has received indication about the event and should expect a request from the mobile specifying how much data it needs to cover the handover period. This event may also be used as an indication to start buffering packets.

### 7.3.17 Link_Handover_Complete.Indication

#### 7.3.17.1 Function

Link Handover Complete event is generated whenever a native link layer handover/switching has just been completed (as opposed to Link Up which only indicates that a link has been brought up for L2 connectivity, but does not indicate that a native link handover/switchover has just been completed by the link layer). Notifying the upper layer of this event can improve transport, session and application layer responsiveness to autonomous link changes. They can better adapt their data flows by resuming flows upon receiving this indication. The upper layer can also use this event to check whether its IP configuration needs to be updated. This is a link layer event that exists for intra-technology handovers defined in many media types (e.g., cellular, 802.16e). This event is applicable for terminal side only and is valid only for intra-technology handovers. MIH Function can receive the Link Handover Complete events from the link layer and pass them to upper layer as MIH events.

Event Type:Link Synchronous

Parameters:

| Name | Type | Valid Range | Description |
|---|---|---|---|
| MacMobileTerminal | MAC Address | | MAC Address of Mobile Terminal |
| MACNewPoA | MAC Address | | MAC Address of New AP/BS |
| MacOldAccessRouter | MAC Address | | MAC Address of old Access Router (if any) |
| MacNewAccessRouter | MAC Address | | MAC Address of new Access Router (if any) |

#### 7.3.17.2 When generated

This is generated whenever a L2 link layer handover or switching has just been completed.

#### 7.3.17.3 Effect on receipt

Upon reception of this event, an upper layer (e.g., transport) can stop any handover adaptation that it has engaged to cope with the just completed native link layer handover/switching and resume normal data transfer. This event may also be used as an indication that a re-verification of the IP parameter should be considered.

### 7.3.18 Link_Get_Information.request

#### 7.3.18.1 Function

This primitive is used by the link layer to retrieve values of specified Information Elements.

#### 7.3.18.2 Semantics of service primitive

The primitive parameters are as follows:

Link_Get_Information.request (
RequestSource,
InformationElementType,
InformationElementReqParams
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Request Source | INFORMATION_SOURCE | N/A | The origination point from where information request originated |
| InformationElementType | Type value of IE | | This identifies the IE uniquely. The IE can be nested as well. |
| InformationElementReqParams | Other parameters that may need to be specified as part of the information request. | | Request specific additional parameters. |

INFORMATION_SOURCE is defined as follows.
{Local Node, Remote Node}. Local and remote is referred with respect to origination of request

#### 7.3.18.3 When generated

This primitive is generated by an upper layer entity that may need to get values of certain Information Elements

#### 7.3.18.4 Effect on receipt

The recipient responds immediately with Link_Get_Information.response primitive.

### 7.3.19 Link_Get_Information.response

#### 7.3.19.1 Function

This primitive is issued in response to Link_Get_Information.request to provide values of requested Information Elements.

#### 7.3.19.2 Semantics of service primitive

The primitive parameters are as follows:

Link_Get_Information.response (
ResponseSource,
InformationElementType,
InformationElementValueLength,
InformationElementValues
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Request Source | INFORMATION_SOURCE | N/A | The origination point from where information request originated |
| InformationElementType | Type value of IE | | This identifies the IE uniquely. The IE can be nested as well. |
| InformationElementValueLength | | | Specifies the length of each IE value in the response frame |
| InformationElementValue | | | Specifies value of each IE requested |

INFORMATION_SOURCE is defined as follows.
{Local Node, Remote Node}. Local and remote is referred with respect to origination of request

#### 7.3.19.3 When generated

This primitive is generated in response to the Link_Get_Information.request primitive

#### 7.3.19.4 Effect on receipt

The recipient retrieves the value of requested IEs and proceeds to use them in handover operations.

## 7.4 MIH Primitives

The key primitives defined as part of MIH_SAP are described below.

### 7.4.1 MIH Capability Discover

#### 7.4.1.1 MIH_Capability_Discover.request

##### 7.4.1.1.1 Function

This primitive is used by MIH Users to discover MIH capability of different links.

##### 7.4.1.1.2 Semantics of service primitive

MIH_Capability_Discover.request (
SourceIdentifier,
DestinationIdentifier,
SupportedEventList,
SupportedCommandList
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| SupportedEventList | Flag | Set of supported events | List of supported events on the client |
| SupportedCom-mandList | Flag | Set of supported com-mands | List of supported commands on the client |

##### 7.4.1.1.3 When generated

This primitive is generated by MIH Users that need to determine MIH capability information of the link layers.

##### 7.4.1.1.4 Effect on receipt

MIH Function capable entities may respond with MIH_Capability_Discover.response primitive.

#### 7.4.1.2 MIH_Capability_Discover.response

##### 7.4.1.2.1 Function

This primitive is used by MIH Function to convey supported MIH capabilities about Event Service, Command Service and Information Service.

#### 7.4.1.2.2 Semantics of service primitive

MIH_Capability_Discover.response (
SourceIdentifier,
DestinationIdentifier,
SupportedEventList,
SupportedCommandList
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| SupportedEventList | Flag | Set of supported events | List of supported events on MIHF |
| SupportedCommandList | Flag | Set of supported commands | List of supported commands on MIHF |

#### 7.4.1.2.3 When generated

This primitive is generated when MIH_Capability_Discover.request primitive is received by MIH Function.

#### 7.4.1.2.4 Effect on receipt

Upon reception of this primitive the receiving entity becomes aware of supported MIH capabilities.

### 7.4.2 MIH Event Register

Please see the description for Link Event Register command

### 7.4.3 MIH Event Deregister

Please see the description for Link Event Deregister command

### 7.4.4 MIH Event Configure

Please see the description for Link Configure Thresholds command

### 7.4.5 MIH Events

Most of the MIH events directly correspond to link layer events. Please see the description for corresponding link layer events. Other MIH events which are different than link events are described in the below section.

#### 7.4.5.1 MIH_Link_Parameters_Report.indication

#### 7.4.5.2 Function

MIH_Link_Parameters_Report notification is sent by the MIH Function to upper layers to indicate various values of link parameters. The list of available link parameters is TBD.

The event can be local or remote.

Parameters:

| Name | Type | Valid Range | Description |
|---|---|---|---|
| MacMobileTerminal | MAC Address | | MAC Address of Mobile Terminal |
| LinkIdentifier | | | Unique link identifier that can be used by the upper layer to identify from which link this parameter report is issued. |
| Link Parameter Type | Enumerated link types | | Media specific parameter types that have crossed thresholds |
| LinkParameterList | | | A list of triples of {LinkParameterType, oldValueofLinkParameter, newValueOf-LinkParameter) |

Examples of link layer parameters that could trigger this event include:

— Link Speed
— Link Bit Error Rate
— Link Frame Loss Rate before Retransmission
— Link Received Signal Strength

#### 7.4.5.3 When generated

This notification is generated either at a predefined regular interval determined by a user configurable timer or when a specified parameter of the currently active interface crosses a configured threshold.

#### 7.4.5.4 Effect on receipt

Upper layer entities may take different actions on this notification. For example, a Mobility Management entity locally or remotely located from the event origination may take these events into account in its decision algorithm.

### 7.4.6 MIH Get Status

A MIH Get Sttaus command is issued by upper layer entities to discover and monitor the status of the currently connected and potentially available links. A MIH Get Status command may be local or remote. For example, a local get status may help the policy function that resides out of MIH to make optimal handover decisions for different applications when multiple links are available in a terminal. A remote initiated MIH Get Status from the network side may enable the network to collect the status information on multiple links in a terminal through the currently connected link.

Upper layer entities may query the lower layers periodically in a specified interval or based on the preferences in a policy engine, which is out of the scope of the standard.

#### 7.4.6.1 MIH_Get_Status.request

##### 7.4.6.1.1 Function

This primitive is issued by uppers to discover the status of the currently connected and potentially available links.

##### 7.4.6.1.2 Semantics of the service primitive

The parameters of the primitive are as follows:

```
MIH_Get_Status.request   (
                         SourceIdentifier,
                         DestinationIdentifier,
                         GetStatusRequestSet
                         )
```

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| Get Status Request Set | Set of status requests | Set of status requests | Containing a set of interested status information. |

##### 7.4.6.1.3 When generated

This primitive is generated when L3 or upper layers request the status information from lower layer links.

##### 7.4.6.1.4 Effect of receipt

A local MIH Get Status command causes the specified link to issue a Link Get Status command to get the information on the status of the links. A remote MIH Get Status command causes the peer MIH entity to issue the local MIH Get Status command.

#### 7.4.6.2 MIH_Get_Status.response

##### 7.4.6.2.1 Function

This primitive is issued by the MIH entity to report the status of the links in response to the requests of upper layers.

##### 7.4.6.2.2 Semantics of the service primitive

The parameters of the primitive are as follows:

```
MIH_Get_Status.response (
                        SourceIdentifier,
                        DestinationIdentifier,
                        GetStatusRequestSet
                        )
```

#### 7.4.6.2.3 When generated

This primitive is generated when MIH receive the status information and report to L3 or upper layers.

#### 7.4.6.2.4 Effect of receipt

Upon receipt of the link status information, the upper layers make decisions and take actions.

| Name (Get Status Requests) | Type | Valid Range | Description |
|---|---|---|---|
| NETWORK_TYPES | Integer | 0x01 – 802.3<br>0x02 – 802.11<br>0x03 – 802.16<br>0x04 – 3GPP<br>0x05 – 3GPP2 | The network type of the link that is queried. Upper layers may selectively query a certain link type. |
| DEVICE_INFO | N/A | N/A | Information on manufacturer, model number, revision number of the software/firmware and serial number in displayable text are returned. |
| OPERATION_MODE | Integer | 0x00 – Normal Mode<br>0x01 – Power Saving Mode<br>0x02 – Power Down | Returns the link's current power mode. |
| NETWORK_ID | N/A | N/A | Return the ID of the network that the link is currently configured to communicate with. |
| CHANNEL_ID | | | The ID of the channel currently in use |
| CHANNEL_QUALITY | | | Current Connection Quality |
| LINK_SPEED | | | Bits per second |
| BATTERY_LEVEL | Integer | 0-100; battery level in percentage;<br>-1; unknown battery level | |
| Media Dependent | N/A | N/A | TBD |

### 7.4.7 MIH Switch

#### 7.4.7.1 MIH_Switch.request

##### 7.4.7.1.1 Function

This primitive is generated by upper layers to switch an active session from one link to another. After upper layer entities makes handover decision, a MIH Switch command may be issued by upper layer entities to switch the active session from one link to another. MIH Function may execute the MIH_Switch command by using combination of a set of Link Command. For example, the MIH entity may establish new connection by Link Connect command, and disconnect the old link by Link Disconnect command, or turn the old link to sleep mode by Link Sleep command, or even power down it by Link Power Down command.

##### 7.4.7.1.2 Semantics of the service primitive

The parameters of the primitive are as follows:

MIH_Switch.request (
SourceIdentifier,
DestinationIdentifier,
HandoverMode,
OldLinkIdentifier,
OldLinkActions
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| HandoverMode | Enumerate | Make-before-Break<br>Break-before-Make | The handover mode decides the sequence of the execution of link command. If it is make-before-break, the Link Connect of the new link is executed before Link Disconnect of old link; if it is break-before-make, Link Connect is after the Link Disconnect |
| New Link Identifier | | | |
| Old Link Identifier | | | |
| Old Link Actions | Enumerate | Link Disconnect;<br>Link Sleep;<br>Link Power Down | Upper layers may choose which action the old link should takes. |

##### 7.4.7.1.3 When generated

This primitive is generated when L3 or upper layers makes handover decision and try to disconnect the old link and establish the new link.

#### 7.4.7.1.4 Effect of receipt

Upon receipt of the MIH Switch command, MIH checks the HandoverMode field first. If it is make-before-break, MIH tries to execute Link Connect to establish the new link before the old link is gone. If it is break-before-make, MIH tries to disable the old link before the new link is established. Depending on the Old Link Actions, MIH may select the ways to disable the old link: disconnect the old link by calling Link Disconnect; turn the link to sleep mode by calling Link Sleep; or shut down the old link by Link Power Down.

### 7.4.7.2 MIH_Switch.response

#### 7.4.7.2.1 Function

This primitive is issued by the MIH entity to report the result of the MIH Switch command.

#### 7.4.7.2.2 Semantics of the service primitive

The parameters of the primitive are as follows:

MIH_Switch.response (
SourceIdentifier,
DestinationIdentifier,
ResultCode
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| ResultCode | | Success;<br>Failure; Rejected | Result of trying to switch the link |

#### 7.4.7.2.3 When generated

This primitive is generated when MIH receive the results of the Link Commands.

#### 7.4.7.2.4 Effect of receipt

Upon receipt of the result code, the upper layers make evaluations and take actions.

### 7.4.8 MIH Configure

MIH Configure may be issued by upper layer entities to control the behavior of lower layer, for example, to set some feature of the driver of a specific link. MIH Configure may contain the configuration commands for multiple lower layer links. When MIH receives MIH Configure, it issues the Link Configure Thresholds commands to corresponding links. The configuration parameter are passed on to Link Configure Thresholds commands.

#### 7.4.8.1 MIH_Configure.request

##### 7.4.8.1.1 Function

This primitive is issued by uppers to control the behavior of a set of lower layer links.

##### 7.4.8.1.2 Semantics of the service primitive

The parameters of the primitive are as follows:

```
MIH_Configure.request   (
                        SourceIdentifier,
                        DestinationIdentifier,
                        ConfigurationRequestsSets
                        )
```

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| Configuration Request Sets | Set of configuration parameters for corresponding interfaces | Set of configuration parameters for corresponding interfaces each defined in Table 7.2. | Containing a set of configuration parameters. |

##### 7.4.8.1.3 When generated

This primitive is generated when L3 or upper layers attempt to control the behaviors of lower layer links, for example, set some features in the drivers.

##### 7.4.8.1.4 Effect of receipt

A local configure command causes the MIH to issue a Link Configure Threshold command to set the thresholds for lower layers according to the specified configuration parameters. A remote configure command causes the MIH in the peer entity to issue a Link Configure Threshold command. If multiple links need to be configured then Link Configure Threshold command should be sent to each of the links.

| Name | Type | Valid Range | Description |
|---|---|---|---|
| NETWORK_TYPES_IN_USE | Integer | 0x01 – 802.3<br>0x02 – 802.11<br>0x03 – 802.16<br>0x04 – 3GPP<br>0x05 – 3GPP2 | Set the network type that should be used for the lower layer entity, e.g., a driver. |
| OPERATION_MODE | Integer | 0x00 – Normal Mode<br>0x01 – Power Saving Mode<br>0x02 – Power Down | Change the device's power mode |

| | | | |
|---|---|---|---|
| DISABLE_TRANSMITTER | N/A | N/A | Enable/disable the transmitter of the interface. |
| NETWORK_ID | N/A | N/A | Change to the specified network of an interface. |
| CURRENT_ADDRESS | | | Change the current address to the value specified |
| SUSPEND_DRIVER | N/A | N/A | Suspend or resume of the specified interface. |

#### 7.4.8.2 MIH_Configure.response

##### 7.4.8.2.1 Function

This primitive is issued by the MIH entity to report the result of the MIH Configure command.

##### 7.4.8.2.2 Semantics of the service primitive

The parameters of the primitive are as follows:

MIH_Configure.response (
SourceIdentifier,
DestinationIdentifier,
ResultCode
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| ResultCode | | Success;<br>Failure;<br>Rejected | Result of trying to confiure the link |

##### 7.4.8.2.3 When generated

This primitive is generated when MIH receive the results of the Link Commands.

##### 7.4.8.2.4 Effect of receipt

Upon receipt of the result code, the upper layers make evaluations and take actions.

### 7.4.9 MIH Scan

A MIH Scan command is issued by upper layer entities to discover the neighboring POA of the access networks. MIH Scan may contain the scan command for multiple links. The scan command for each link is defined in the related SDO and beyond the scope of the standard. If the currently active link is required to scan, it is most likely that the on-going session is interrupted.

#### 7.4.9.1 MIH_Scan.request

##### 7.4.9.1.1 Function

This primitive requests a survey of potential PoA that the MN may later elect to try to join.

##### 7.4.9.1.2 Semantics of the service primitive

The parameters of the primitive are as follows:

MIH_Scan.request (
SourceIdentifier,
DestinationIdentifier,
ScanResultSets
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| Scan Request | Defined in related SDOs. | Defined in related SDOs. | Defined in related SDOs. |

##### 7.4.9.1.3 When generated

This primitive is generated when L3 or upper layers request a survey of access networks.

##### 7.4.9.1.4 Effect of receipt

If multiple links are requested, multiple Link Scan commands are issued to the specified MACs, carrying the media specific Scan Request information. The Link Scan should be defined in related SDOs.

#### 7.4.9.2 MIH_Scan.response

##### 7.4.9.2.1 Function

This primitive returns the descriptions of the set of PoAs detected by the scan process.

##### 7.4.9.2.2 Semantics of the service primitive

The parameters of the primitive are as follows:

MIH_Scan.response (
SourceIdentifier,
DestinationIdentifier,
Scan Response Sets
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| Scan Response Set | Defined in related SDOs. | Defined in related SDOs. | Defined in related SDOs. |

#### 7.4.9.2.3 When generated

This primitive is generated by the MIH as a result of a MIH_Scan.request.

#### 7.4.9.2.4 Effect of receipt

Upper layers act on the scan results.

### 7.4.10 MIH Handover Initiate

#### 7.4.10.1 MIH_Handover_Initiate.request

#### 7.4.10.1.1 Function

This primitive is used by MIH Function on a termina or network to communicate with peer MIH Function on a network or a terminal. The primitive is used to communicate intent of handover initiation. The handover can be initiated either by the client or by the network.

#### 7.4.10.1.2 Semantics of service primitive

The parameters of the primitive are as follows:

MIH_Handover_Initiate.request (
SourceIdentifier,
DestinationIdentifier,
CurrentLinkIdentifier,
SuggestedNewLinkIdentifier,
SuggestedNewPoAIdentifier,
HandoverMode,
CurrentLinkAction,
)

Local or Remote: Both

MIHF (Terminal) <> MIHF (Network)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| CurrentLinkIdentifier | NetworkIdentifier. Can be one of different 802 and Cellular networks. | | This identifies the current access network over which the command needs to be sent. This is valid only for remote commands which need to be sent to remote MIHF. The command is then sent either at L2 or at L3. |
| SuggestedNewLinkIdentifier | NetworkIdentifier. Can be one of different 802 and Cellular networks | | This is the identifier of new network to which handover needs to be initiated. |
| SuggestedNewPoAIdentifier | MAC_ADDRESS (Optional) | | This is the preferred Point of Attachment (AP/BS) on new network |
| HandoverMode | Make-before_Break Break-before-Make | | The handover mode may influence the manner in which links are prepared for handover |
| CurrentLinkAction | LINK_DISCONNECT LINK_LOW_POWER LINK_POWER_DOWN LINK_NO_ACTION | | Specifies suggested action on old link once handover procedures have been executed. |
| QueryResourceList | BOOL | | Flag to query the available list of resources on the new link |

#### 7.4.10.1.3 When generated

This primitive is generated by an upper layer entity such as a Handover Policy engine, L3 Mobility protocol like MIP, Application or some other entity that may want to cause a change in the current selected link. This command can be sent either to just the local MIH Function or it can be sent to the remote MIH Function as well.

#### 7.4.10.1.4 Effect on receipt

The remote MIH Function responds with MIH_Handover_Initiate.response primitive. If the recipient of the command is a network MIH function, it may perform a MIH_Handover_Prepare message exchange with the MIH Function in the target link under consideration before sending the response message.

#### 7.4.10.2 MIH_Handover_Initiate.response

##### 7.4.10.2.1 Function

This primitive is used by a peer MIH Function to communicate with the MIH Function that sent out a MIH_Handover_Initiate.request. The primitive is used to communicate the response of handover initiation request. The response can be sent either by the client or the network depending on where the request was initiated.

##### 7.4.10.2.2 Semantics of service primitive

The parameters of the primitive are as follows:

```
MIH_Handover_Initiate.response  (
                                SourceIdentifier,
                                DestinationIdentifier,
                                CurrentLinkIdentifier,
                                HandoverAck,
                                PreferredLinkIdentifier,
                                PreferedPoAIdentifier,
                                AbortReason
                                )
```

Local or Remote: Both
MIHF (Terminal) <> MIHF (Network)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| CurrentLinkIdentifier | NetworkIdentifier. Can be one of different 802 and Cellular networks. | | This identifies the current access network over which the command needs to be sent. This is valid only for remote commands which need to be sent to remote MIHF. The command is then sent either at L2 or at L3. |
| HandoverAck | BOOL | 0 or 1 | 1: Initiate Handover<br>0: Abort Handover<br>If the handover has to be aborted then a reason code is provided |
| PreferredLinkIdentifier | NetworkIdentifier. Can be one of different 802 and Cellular networks | | This is the identifier of new network to which handover needs to be initiated. This may be different than the network that was suggested in the handover request. |

| | | | |
|---|---|---|---|
| PreferredPoAIdentifier | MAC_ADDRESS | | This is the preferred Point of Attachment (AP/BS) on new network. This may be different than what was suggested in handover request. |
| AbortReason | | | Lists the reason for aborting/declining the handover request. |
| Available Resource List | | | List of available rsources on new link |

#### 7.4.10.2.3 When generated

The MIH Function responds with this primitive in response to a MIH_Handover_Initiate.request command from a peer MIH Function entity.

#### 7.4.10.2.4 Effect on receipt

On receiving the response the entity which originally initiated the handover request may decide to carry out the handover or abort it based on the response. If the recipient of the command is a client MIH function and in case the handover is to be executed, it may also provide information about selected network and selected PoA on the selected network with a MIH Handover Commit message.

### 7.4.11 MIH Handover Prepare

#### 7.4.11.1 MIH_Handover_Prepare.request

#### 7.4.11.1.1 Function

This primitive is used by a MIH function on the serving network to communicate with its peer MIH function on the candidate network. This is used to prepare the new link resource for impending handover and to query the available link resource of the candidate network.

#### 7.4.11.1.2 Semantics of service primitive

The parameters of the primitive are as follows:

MIH_Handover_Prepare.request (
SourceIdentifier,
DestinationIdentifier,
CurrentLinkIdentifier,
QueryResourceList,
)

Local or Remote: Both
MIHF (old Network) <> MIHF (new Suggested Network)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |

| | | | |
|---|---|---|---|
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| CurrentLinkIdentifier | NetworkIdentifier. Can be one of different 802 and Cellular networks. | | This identifies the current access network over which the command needs to be sent. This is valid only for remote commands which need to be sent to remote MIHF. The command is then sent either at L2 or at L3. |
| QueryResourceList | | | List of resources to be queried at the new candidate network. |

#### 7.4.11.1.3 When generated

This primitive is generated after receving the MIH_Handover_Initiate.request protocol message from the MIH function on the terminal in case of terminal initiated handover. In case of network initiated handover case, this can be generated by the upper layer entity such as a Handover Policy engine.

#### 7.4.11.1.4 Effect on receipt

This peer MIH function on the candidate network identifies the link resource usage and prepares resources for the impending handover.

### 7.4.11.2 MIH_Handover_Prepare.response

#### 7.4.11.2.1 Function

This primitive is used by a MIH function on the candidate network to communicate with its peer MIH function on the serving network which sent out a MIH_Handover_Prepare.request. This is used to respond the result of resource preparation of the impending handover and to notify the MIH function on the serving network of the link resource status of the candidate network

#### 7.4.11.2.2 Semantics of service primitive

The parameters of the primitive are as follows:

MIH_Handover_Prepare.response (
SourceIdentifier,
DestinationIdentifier,
CurrentLinkIdentifier,
ResourceStatus,
AvailableResourceList,
)

Local or Remote: Both
MIHF (old Network) <> MIHF (new Suggested Network)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |

| | | | |
|---|---|---|---|
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| CurrentLinkIdentifier | NetworkIdentifier. Can be one of different 802 and Cellular networks. | | This identifies the current access network over which the command needs to be sent. This is valid only for remote commands which need to be sent to remote MIHF. The command is then sent either at L2 or at L3. |
| ResourceStatus | | | Specifies whether requested resources are available or not at the new PoA. |
| AvailableResourceList | | | List of resources actually available at the new suggested network and the new networkPoA. |

#### 7.4.11.2.3 When generated

The MIH Function on the candidate network responds with this primitive in response to a MIH_Handover_Prepare.request from a peer MIH Function entity on the serving network.

#### 7.4.11.2.4 Effect on receipt

After receiving the response, the MIH Function on the serving network can send MIH_Handover_Initiate.response to terminal.

### 7.4.12 MIH_Handover_Commit

### 7.4.12.1 MIH_Handover_Commit.request

#### 7.4.12.1.1 Function

This primitive is used by a peer MIH Function to communicate with the remote MIH Function on network. The primitive is used to communicate commitment to perform handover based on selected choices for candidate network and PoA.

#### 7.4.12.1.2 Semantics of service primitive

The parameters of the primitive are as follows:

```
MIH_Handover_Commit.request   (
                              SourceIdentifier,
                              DestinationIdentifier,
                              NewLinkIdentifier,
                              MACNewPoA,
                              CurrentLinkAction
                              )
```

Local or Remote: Both

MIHF (Terminal) <> MIHF (Network)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| NewLinkIdentifier | Can be one of different 802 or cellular networks | | This specifies the new network to which the connection needs to be handed over. |
| MACNewPoA | MAC Address. | | MAC Address of New PoA |
| CurrentLinkAction | Bitmap | | Specifies suggested action on old link once handover procedure has been excuted:<br>0: LINK_DISCONNECT<br>1: LINK_LOW_POWER<br>2: LINK_POWER_DOWN<br>3: LINK_NO_ACTION<br>4: Reserved |

#### 7.4.12.1.3 When generated

This primitive is generated when successful MIH_Handover_Initiate.response is received to allow a terminal to begin handover and the mobile terminal decides to perform actual handover based on suggested choices for candidate network and PoA.

#### 7.4.12.1.4 Effect on receipt

The receipient may identify that the terminal starts handover to the selected network.

### 7.4.12.2 MIH_Handover_Commit.response

#### 7.4.12.2.1 Function

This primitive is used by a peer MIH Function to communicate with the MIH Function that has sent out the MIH_Handover_Commit.request. The primitive is used to communicate the response of a handover commit request.

#### 7.4.12.2.2 Semantics of service primitive

The parameters of the primitive are as follows:

```
MIH_Handover_Commit.response (
                                DestinationIdentifier,
                                SourceIdentifier,
                                CurrentLinkAction,
                                HandoverStatus
                                )
```

Local or Remote: Both

MIHF (old Network) <> MIHF (new Suggested Network)

#### 7.4.12.2.3 When generated

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| CurrentLinkAction | Bitmap | | Specifies suggested action on old link once handover procedure has been excuted:<br>0: LINK_DISCONNECT<br>1: LINK_LOW_POWER<br>2: LINK_POWER_DOWN<br>3: LINK_NO_ACTION<br>4: Reserved |
| HandoverStatus | Boolean | 0,1 | 0: Abort handover<br>1: Perform handover |

This primitive is generated in response to MIH_Handover_Commit.request primitive.

#### 7.4.12.2.4 Effect on receipt

The client recipient may initiate handover process and begin setting up of new layer 2 connection. The network recipient may determine that the handover procedure is in progress to the intended network.

### 7.4.13 MIH_Handover_Complete

### 7.4.13.1 MIH_Handover_Complete.request

#### 7.4.13.1.1 Function

This primitive is used by a peer MIH Function to communicate with the remote MIH Function. This is used to communicate the completion of handover operation.

#### 7.4.13.1.2 Semantics of service primitive

The parameters of the primitive are as follows:

```
MIH_Handover_Complete.request (
                                SourceIdentifier,
                                DestinationIdentifier,
                                CurrentLinkIdentifier
                                )
```

Local or Remote: Both

MIHF (old Network) <> MIHF (new Suggested Network)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| CurrentLinkIdentifier | NetworkIdentifier. Can be one of different 802 and Cellular networks. | | This identifies the current access network over which the command needs to be sent. This is valid only for remote commands which need to be sent to remote MIHF. The command is then sent either at L2 or at L3. |

#### 7.4.13.1.3 When generated

The MIH Function responds with this primitive when handover operations to the new network PoA have been completed.

#### 7.4.13.1.4 Effect on receipt

Upon receipt, the receiving MIH Function in the old link can start forwarding any pending or remaining packets and also release any resources in use by the old link. Upon receipt, the receiving MIH Function on the new link must forward the message to the MIH Function in the old link.

### 7.4.13.2 MIH_Handover_Complete.response

#### 7.4.13.2.1 Function

This primitive is used by a peer MIH Function to communicate with the MIH Function that has sent out the MIH_Handover_Complete.request. This primitive is used to send a response to the handover complete request.

#### 7.4.13.2.2 Semantics of service primitive

The parameters of the primitive are as follows:
MIH_Handover_Complete.response (
SourceIdentifier,
DestinationIdentifier,
CurrentLinkIdentifier
)

Local or Remote: Both
MIHF (old Network) <> MIHF (new Suggested Network)

| Name | Type | Valid Range | Description |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| CurrentLinkIdentifier | NetworkIdentifier. Can be one of different 802 and Cellular networks. | | This identifies the current access network over which the command needs to be sent. This is valid only for remote commands which need to be sent to remote MIHF. The command is then sent either at L2 or at L3. |

#### 7.4.13.2.3 When generated

The MIH Function responds with this primitive after processing the handover complete request.

#### 7.4.13.2.4 Effect on receipt

Upon receipt, the client MIH Function can determine that the handover complete request was processed successfully. Upon receipt, the MIH Function in the new network may forward this message to the client.

### 7.4.14 MIH_Network_Address_Information

#### 7.4.14.1 MIH_Network_Address_Information.request

#### 7.4.14.1.1 Function

This primitive is delivered from MIH Function on old PoA to another MIH Function on new PoA in order to discover mobile terminal's network address related information before handover. Upon reception of this message, the MIHF on new PoA can either interact with upper layer to achieve enough information or further deliver this message to the MIHF in the network, e.g Access Router with MIHF which may have enough information on this message. This also can trigger the network entity, e.g, Access Router or Foreign Agent to send out Mobility related messages directly to the mobile terminal.

#### 7.4.14.1.2 Semantics of service primitive

The parameters of the primitive are as follows:

```
MIH_Network_Address_Information.request (
                                        SourceIdentifier,
                                        DestinationIdentifier,
                                        CurrentLinkIdentifier,
                                        MACMobileTerminal,
                                        HomeAddress,
                                        CoA,
                                        OldAccessRouterAddress,
                                        OldFAAddress
                                        )
```

Local or Remote: Both

MIHF (Network) <> MIHF (Network)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| CurrentLinkIdentifier | NetworkIdentifier. Can be one of different 802 and Cellular networks. | | This identifies the current access network over which the command needs to be sent. This is valid only for remote commands which need to be sent to remote MIHF. The command is then sent either at L2 or at L3. |
| MACMobileTerminal | MAC Address | | MAC Address of Mobile Terminal |
| Home Address | IP Address | | Home IP address of Mobile Terminal |
| CoA | IP Address | | Care of Address of Mobile Terminal |
| Old FA Address | IP Address | | IP address of old Foreign Agent.<br>This parameter is only included when mobile terminal is using Mobile IPv4, |
| Old Access Router Address | IP Address | | IP address of old Access Router<br>This parameter is only included when mobile terminal is using IPv6 |

#### 7.4.14.1.3 When generated

When the mobile terminal initiates handover which may be informed by Link_Going_Down remote event service, old PoA generates this message to achieve network address related information prior to the handover.

#### 7.4.14.1.4 Effect on receipt

Upon reception of this primitive, the MIHF on new PoA can either interact with upper layer to achieve enough information or further deliver this message to the MIHF in the network, e.g Access Router with MIHF which may have enough information on this message. When this primitive is delivered to the upper layer of the MIHF in the network, e.g, Access Router with MIHF, this can trigger to send network address related information, e.g, Router Advertisement either directly to the mobile terminal or to MIHF.

### 7.4.14.2 MIH_Network_Address_Information.response

#### 7.4.14.2.1 Function

This primitive is used by a peer MIH Function to communicate with the MIH Function that sent out a MIH_Network_Address_Infomration.request. The primitive is used to communicate the response of MIH_Network_Address_Information.request. The response can be sent either by the new PoA or the network entity, e.g, Access Router or Foreign Agent, depending on where the related information is available.

#### 7.4.14.2.2 Semantics of service primitive

The parameters of the primitive are as follows:

MIH_Network_Address_Information.response (
SourceIdentifier,
DestinationIdentifier,
CurrentLinkIdentifier,
MACMobileTerminal,
HomeAddress,
FAAddress,
AccessRouterAddress,
NetworkAddressInformation
)

Local or Remote: Both
MIHF (Network) <> MIHF (Network)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Source Identifier | Identifier | Any valid individual or group identifier | The identifier of entity where the request is initiated. This field may be optionally left empty if the command is local. |
| Destination Identifier | Identifier | MIH_LOCAL, MIH_REMOTE | The destination identifier of request or response. This is the identifier of local or peer MIH Function. |
| CurrentLinkIdentifier | NetworkIdentifier. Can be one of different 802 and Cellular networks. | | This identifies the current access network over which the command needs to be sent. This is valid only for remote commands which need to be sent to remote MIHF. The command is then sent either at L2 or at L3. |
| MACMobileTerminal | MAC Address | | MAC Address of Mobile Terminal |
| Home Address | IP Address | | Home IP address of Mobile Terminal |
| FA Address | IP Address | | IP address of Foreign Agent.<br>This parameter is only included when mobile terminal is using Mobile IPv4, |

| | | | |
|---|---|---|---|
| Access Router Address | IP Address | | IP address of Access Router<br>This parameter is only included when mobile terminal is using IPv6 |
| Network Address Information | | | In case of Mobile IPv4, Agent Advertisement is encapsulated and in case of Mobile IPv6, Router Advertisement is encapsulated. |

#### 7.4.14.2.3 When generated

The MIH Function responds with this primitive in response to a MIH_Network_Address_Information.request command from a peer MIH Function entity. The old PoA can also generate this message to deliver the received network address information further to the mobile terminal.

#### 7.4.14.2.4 Effect on receipt

When the new PoA receives this message from the network entity, new PoA further delivers this primitive to the old PoA. When the mobile terminal receives this primitive, MIHF delivers this to the mobility management protocol or handover policy engine.

### 7.4.15 MIH Get Information

#### 7.4.15.1 MIH_Get_Information.request

#### 7.4.15.1.1 Function

This primitive is used by a station's MIH (or an application on behalf of MIH) to request information either from the network or from a remote MIH. The information query can be related to a specific interface, attributes to the network interface as well as entire network capability. The service primitive has the flexibility to query either a specific data within a network interface or extended schema of a given network.

#### 7.4.15.1.2 Semantics of service primitive

The parameters of the primitive are as follows:

```
MIH_Get_Information.request     (
                                InfoQueryFilter,
                                InfoQueryParameters
                                )
```

| Name | Type | Valid Range | Description |
|---|---|---|---|
| InfoQueryType | An integer value corresponding to one of the following types:<br>1: TLV<br>2: RDF_DATA<br>3: RDF_SCHEMA_URL<br>4: RDF_SCHEMA | N/A | The type of query that is specified |

| | | | |
|---|---|---|---|
| InfoQueryParameters | Query type specific parameters | N/A | Query type specific parameters which indicate the type of information the client may be interested in. |

InfoQueryType:

- TLV: When this InfoQueryType is specified, the InfoQueryParameters must be a binary string which encodes an Information Element TLV that carries a Request defined in Section "Information Request and Response".
- RDF_DATA: When this InfoQueryType is specified, InfoQueryParameters is a string which contains a SPARQL (Protocol and RDF Query language) query [2] where the SPARQL query is supposed to contain an appropriate query for obtaining expected RDF/XML data.
- RDF_SCHEMA_URL: When this InfoQueryType is specified, InfoQueryParameters is a null string. This InfoQueryType is used for obtaining the URL of the extended schema.
- RDF_SCHEMA: When this InfoQueryType is specified, InfoQueryParameters carries either the URL of the extended schema the querer wants to obtain or a null string when the URL of the extended schema is unknown.

#### 7.4.15.1.3 When generated

This primitive is generated by a MIH User that is seeking to retrieve information.

#### 7.4.15.1.4 Effect on receipt

The recipient tries to interpret the query request and retrieve the specified information. Once the information is retrieved the recipient responds with MIH_Get_Information.response primitive.

### 7.4.15.2 MIH_Get_Information.response

#### 7.4.15.2.1 Function

This primitive is used by MIH to respond to a MIH_GET_Information.request primitive.

#### 7.4.15.2.2 Semantics of service primitive

The parameters of the primitive are as follows:

```
MIH_Get_Information.response (
                    InfoQueryType,
                    MIH_REPORT,
                    Status
                    )
```

| Name | Type | Valid Range | Description |
|---|---|---|---|
| InfoQueryType | An integer value corresponding to one of the following types:<br>1: TLV<br>2: RDF_DATA<br>3: RDF_SCHEMA_URL<br>4: RDF_SCHEMA | N/A | The type of query that is specified |

| | | | |
|---|---|---|---|
| MIH_REPORT | String | N/A | Report consisting of information requested by the MIH User |
| Status | Success/Failure | N/A | Specifies whether the information was successfully retrieved or not. |

InfoQueryType:

- TLV: When this InfoQueryType is specified, the InfoQueryParameters must be a binary string which encodes an Information Element TLV that carries a Request defined in Section "Information Request and Response".
- RDF_DATA: When this InfoQueryType is specified, InfoQueryParameters is a string which contains a SPARQL (Protocol and RDF Query language) query [2] where the SPARQL query is supposed to contain an appropriate query for obtaining expected RDF/XML data.
- RDF_SCHEMA_URL: When this InfoQueryType is specified, InfoQueryParameters is a null string. This InfoQueryType is used for obtaining the URL of the extended schema.
- RDF_SCHEMA: When this InfoQueryType is specified, InfoQueryParameters carries either the URL of the extended schema the querer wants to obtain or a null string when the URL of the extended schema is unknown.

#### 7.4.15.2.3 When generated

This primitive is generated by MIH Function that is responding to a previous query retrieve information.

#### 7.4.15.2.4 Effect on receipt

The MIH User thatrequested the information tries to interpret the MIH_REPORT and take suitable action.

### 7.4.15.3 Example Queries

#### 7.4.15.3.1 Example Query for TLV

An example query request and response when TLV is specified as InfoQueryType is shown below.

MIH_Information.request (TLV, Request IE)

MIH_Information.response (TLV, Response IE, Success)

#### 7.4.15.3.2 Example Query for RDF_DATA

An example query request and response when RDF_DATA is specified as InfoQueryType to obtain a list of 802.11 point of attachments (i.e., BSSIDs) around a specific location where the location is represented as an 802.11 point of attachment is shown below.

MIH_Information.request (RDF_DATA, "PREFIX mihbase: <URL_TO_BE_ASSIGNED>

SELECT ?poa-address

WHIRE {?x1 mihbase:neighboring-poa ?x2 .

?x2 mihbase:link-type 19 .

?x2 mihbase:poa-address ?poa-address .

?x1 mihbase:poa-address ?x3 .

?x3 mihbase:address "001122334455" }")

MIH_Information.response(RDF_DATA, "<?xml version="1.0"?>

<sparql xmlns="http://www.w3.org/2005/sparql-results#">

<head>

<variable name="poa-address"/>

</head>

<results>

<result>

<binding name="poa-address"><literal datatype="http://www.w3.org/2001/XMLSchema#hexBinary">aab-bccddeeff</literal></binding>

<binding name="poa-address"><literal datatype="http://www.w3.org/2001/XMLSchema#hexBinary">0123456789ab</literal></binding>

</result>

</results>

</sparql>", Success)

#### 7.4.15.3.3 Example Query for RDF_SCHEMA_URL

An example query request and response when XML_SCHEMA_URL is specified as InfoQueryType is shown below.

MIH_Information.request(RDF_SCHEMA_URL, "")

MIH_Information.response(RDF_SCHEMA_URL,

"http://www.networkdiscovery.org/2005/04/rdf-extended-schema/",Success)

#### 7.4.15.3.4 Example Query for RDF_SCHEMA

An example query request and response when RDF_SCHEMA is specified as InfoQueryType to obtain the extended schema is shown below.

MIH_Information.request(RDF_SCHEMA, "")

MIH_Information.response(RDF_SCHEMA,

"<?xml version="1.0"?>

<!DOCTYPE rdf:RDF [

```
<!ENTITY rdf 'http://www.w3.org/1999/02/22-rdf-syntax-ns#'>

<!ENTITY rdfs 'http://www.w3.org/2000/01/rdf-schema#'>

]>

<rdf:RDF xmlns:rdf="&rdf;" xmlns: :rdfs="&rdfs;">

…

</rdf:RDF>", Success)
```

# 8. Media Independent Handover Protocol

## 8.1 Introduction

The MIH Function provides asynchronous and synchronous services through well defined SAPs for lower layers and upper layers. The services provided include the Event Service (ES), Command Service (CS), and Information Service (IS). Detailed description about MIH services are found in Section 5.3. MIH SAPs include the MIH upper layer SAP, which is used by the users of MIH to gain access to various MIH Function services, and MIH lower layer SAPs, which are used by MIH Function to gain access and control of a variety of media dependent lower layer resources.

The Media Independent Handover protocol defines frame formats for exchanging messages between peer MIH Function entities. These messages are based on the primitives which are part of Media Independent Event service, Media Independent Command service and Media Independent Information service. IEEE802.21 supports Media Independent Handover Function in mobile terminal, and network. The MIHF Protocol allows peer MIH Function entities to interact with each other.

## 8.2 MIH Protocol Transport

The table below shows the various transport options for different media types.

**Table 17—Transport Options for MIH Protocol**

| No | Media Type | L2 Transport Description | L3 Transport Description |
|---|---|---|---|
| 1 | Ethernet | Data Frames | IP based |
| 2 | 802.11 | Data Frames, Management Frames | IP based |
| 3 | 802.16 | Data Frames, Management Frames | IP based |
| 4 | 3GPP | Not Applicable.<br>Requires protocol stack changes | IP based |
| 5 | 3GPP2 | Not Applicable.<br>Requires protocol stack changes | IP based |

### 8.2.1 L2 Data Frames Packet Format

The data frame packet format is described in Figure 26 —. The frame can be used for wired 802 technologis such as ethernet and also other wireless 802 technologies such as 802.11 and 802.16.The above frame structure can also be used with a standard L3 protocol (UDP/TCP) with a well defined MIH port as well. The discovery of MIH Function entities at L3 is outside the scope of the standard.

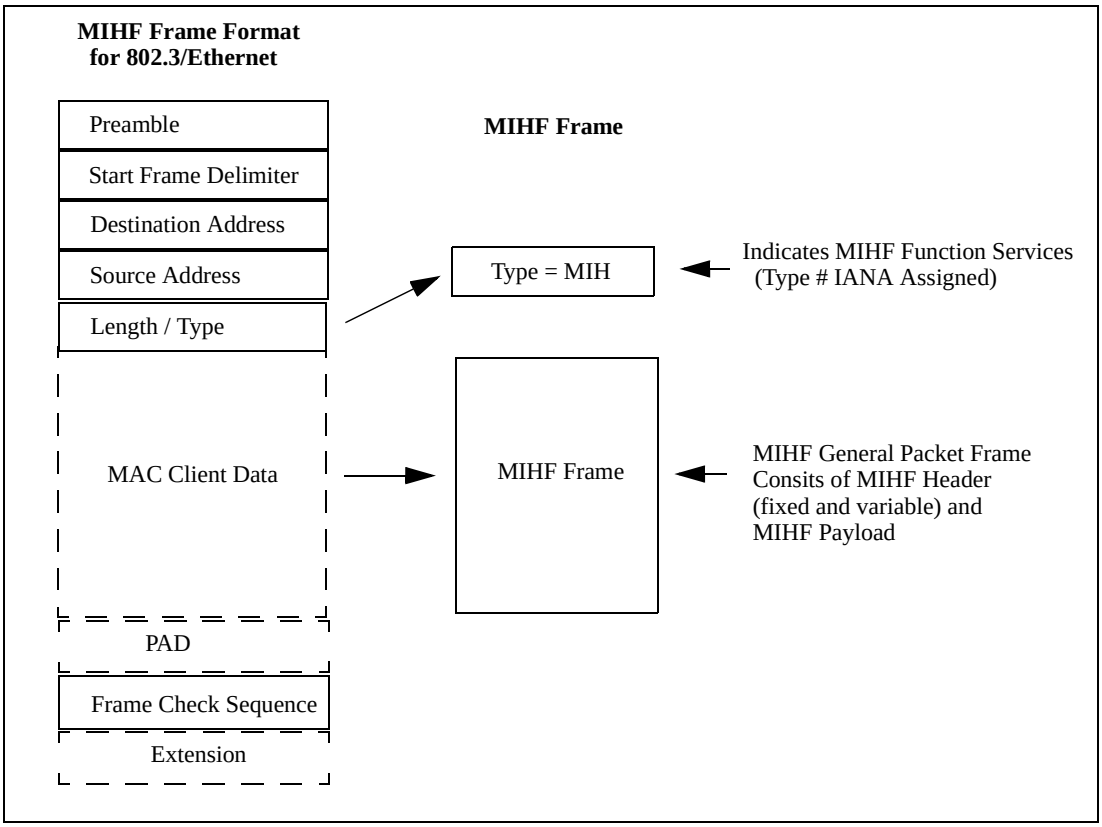



**Figure 26 — Common MIH Frame Format**

## 8.3 Description

The Media Independent Handover Protocol provides the following services:

[1] MIH capability discovery: MIHF in mobile terminal or MIHF in the network discovers which entity supports MIHF. Thereafter the peer MIH Functions negotiate/discover an optimum transport for communication. The MIH Function entities also discover list of supported events and commands. The MIH Function can also query the information schema for list of supported information elements.

[2] MIH remote registration: Remote MIHF in different entities can register with each other to receive Media Independent Handover Messages including remote MIES.

[3] MIH message exchange: MIHF can exchange MIH messages using MIH payload and MIH protocol over a suitable transport. As part of message exchange the peer MIH Function entities can use the MIES, MICS and MIIS for effective handovers.

The standard describes the MIH packet format, message formats, and the procedures for MIH message exchange to facilitate handover in a media independent manner. However, handover policy and handover decision making is outside the scope of the standard. Figure 27 — shows possible MIH message delivery and its relation with other protocol layers.

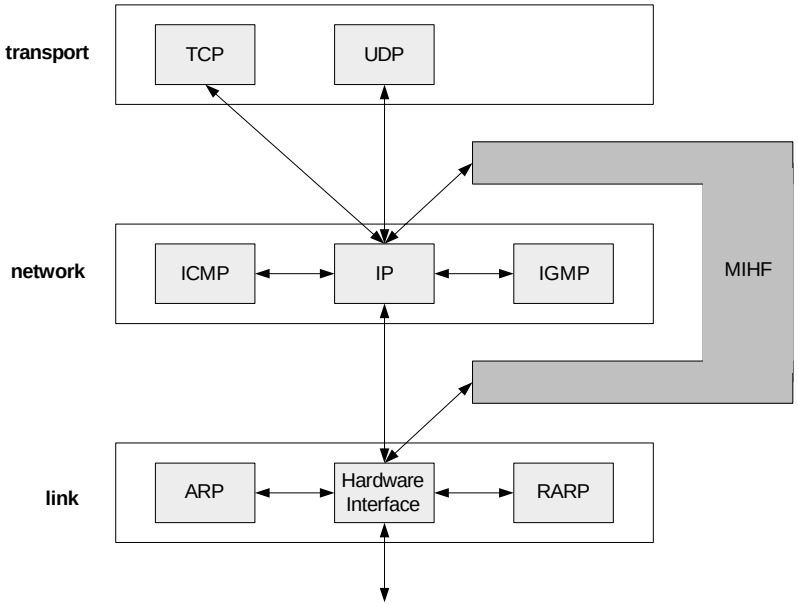



**Figure 27 — Interaction for MIHF- MIHF message exchange**

### 8.3.1 MIH General Packet Format

The MIH Function Header consists of a two parts; one with fixed length and another with variable length. The fixed length part of the header carries the essential information which is present in every packet and is important for parsing and analyzing the packet quickly. The variable length part of the header carries information which is optional in some cases.

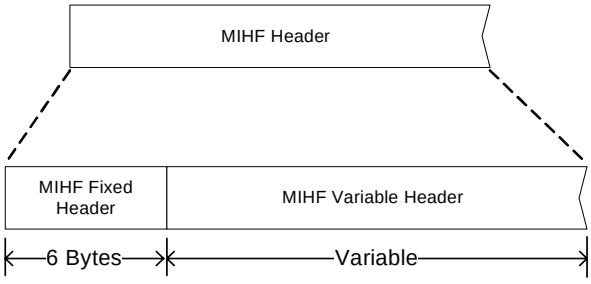



**Figure 28 — MIHF Header Format**

The MIHF header is split into two parts so as to introduce flexibility into the MIH Function protocol design. Please refer to Figure 28 —.

#### 8.3.1.1 MIHF Fixed Header

This part of the header content is mandatory. The following table shows the contents of the fixed part of the header.

**Table 18—MIHF Fixed Header description**

| Field Name | Size (bits) | Description |
|---|---|---|
| Version | 4 | This field is used to specify the version of protocol used. The importance of this is seen in downwards compatibility handling in the future. |
| Reserved | 4 | This field is intentionally kept reserved. In un-used case, it all the bits of this field are to be set to '0'. |
| MIH Message ID (MID) | 16 | Combination of the following 3 fields. |
| -- Service Identifier (SID) | 4 | Identifies the different MIH services, possible values are:<br>1: System Management<br>2: Event Service<br>3: Command Service<br>4: Information Service |
| -- Operation Code (Opcode) | 3 | Type of operation to be performed with respect to the SID, possible values are:<br>1: Request<br>2: Response<br>3: Indication |
| -- Action Identifier (AID) | 9 | This indicates the action to be taken w.r.t. the SID |
| Number of Additional Header Identifiers | 8 | Indicates the no. of header identifiers (TLV for each) included in the variable MIHF header part |
| Variable Load Length | 16 | Indicates the total length of the variable load embedded into the MIH Function frame and is the sum of MIHF variable header length and MIHF payload length. MIHF fixed header length is NOT included. |

### 8.3.1.2 MIHF Variable Header

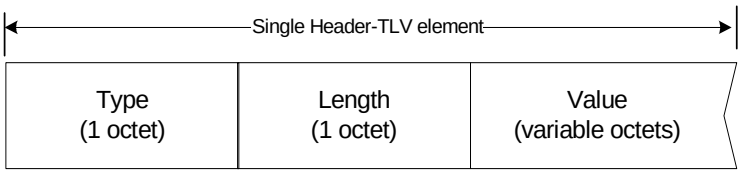



**Figure 29 — MIHF Header TLV Format**

Within the MIHF header, additional identifiers are present that help to analyze and coordinate the payload is embedded. All of these identifiers are represented in Header-TLV format. The syntax of this TLV format is shown in Figure 29 —. The Type field indicates which type of header identifier is embedded in the Value field. Some possible values for the Type field are as follows.

— Transaction ID (to match requests and responses )
— MIH Function ID / Session ID (to identify the communication peers)
— Synchronization Information (to identify the timestampof the received message)

### 8.3.1.3 MIHF Frame Format

Figure 30 —shows the components of MIHF frame. Figure 31 — shows the detailed format of the MIH Function frame.

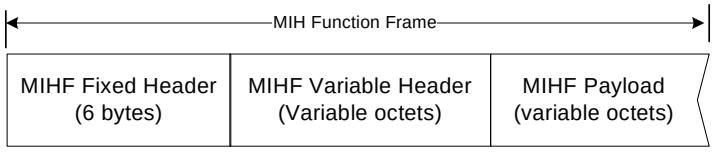



**Figure 30 — MIHF Frame**

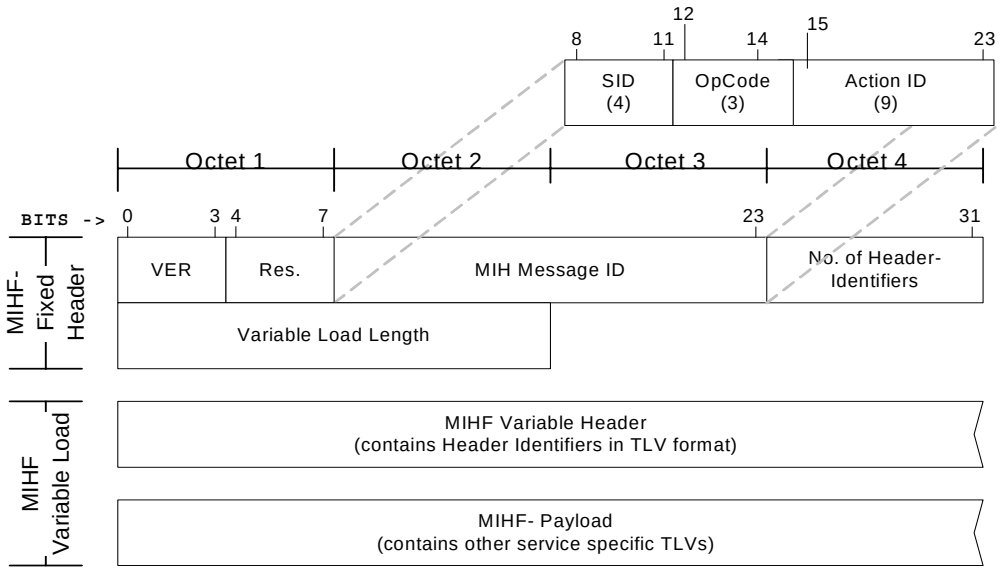



**Figure 31 — MIHF Frame Format**

### 8.3.2 MIH Function Messages

MIH Function messages are used to discover MIH Function capability in the peer MIH Function entities, register with peer MIHF entity and provide MIES, MICS and MIIS services to MIHF clients.

**Table 19—MIH Function Messages**

| No | MIH Message Identifier | MIH Opcode | MIH Service ID |
|---|---|---|---|

**Table 19—MIH Function Messages**

| | | | |
|---|---|---|---|
| 1 | MIH Capability Discover | Request, Response | System Management |
| 2 | MIH Event Register | Request, Response | Event Service |
| 3 | MIH Event Deregister | Request, Response | Event Service |
| | | | |
| 4 | MIH Link Up | Indication | Event Service |
| 5 | MIH Link Down | Indication | Event Service |
| 6 | MIH Link Going Down | Indication | Event Service |
| 7 | MIH Link Detected | Indication | Event Service |
| 8 | MIH Link Parameters Report | Indication | Event Service |
| 9 | MIH Link Event Rollback | Indication | Event Service |
| 10 | MIH Link Handover Imminent | Indication | Event Service |
| 11 | MIH Link Handover Complete | Indication | Event Service |
| | | | |
| 12 | MIH Get Status | Request, Response | Command Service |
| 13 | MIH Switch | Request, Response | Command Service |
| 14 | MIH Configure | Request, Response | Command Service |
| 15 | MIH Configure Link Thresholds | Request, Response | Command Service |
| 16 | MIH Scan | Request, Response | Command Service |
| 17 | MIH Handover Initiate | Request, Response | Command Service |
| 18 | MIH Handover Prepare | Request, Response | Command Service |
| 19 | MIH Handover Commit | Request, Response | Command Service |
| 20 | MIH Handover Complete | Request, Response | Command Service |
| 21 | MIH Network Address Information | Request, Response | Command Service |
| | | | |
| 22 | MIH Get Information | Request, Response | Information Service |
| | | | |

## 8.4 MIH Protocol Messages

This section specifes the MIH Function payload for different MIH Function messages. The payload consistst of a set of identifiers in TLV (Type, Length, Value) form. The representation of identifiers for different messages in TLV form is shown in below sections.

### 8.4.1 Messages for System Management Service Category

MIH frames for System Management Service category have MIH Service ID set to 1. The MIH Function payload for different messages in this service category is described below.

#### 8.4.1.1 MIH_Capability_Discover Request

This message may contain SupportedTransportList, SupportedEventList and SupportedCommandList in the MIH message data. If a requesting MIHF entity doesn't know the MIHF capable entity's addresses, requesting MIHF entity fills its source addresses and may broadcast this message. If a requesting MIHF entity knows the address of entity but doesn't know whether the entity is MIHF capable, this message is delivered to the entity in a unicast way.

#### 8.4.1.2 MIH_Capability_Discover Response

This message may contain SupportedTransportList, SupportedEventList and SupportedCommandList, in the MIH message data. Only MIHF capable entity can receive MIH_Capability_Discover.request. Upon reception of MIH_Capability_Discover.request, MIH_Capability_Discover.response is transmitted. Destination addresses are copied from the MIH_Capability_Discover.request and source addresses are filled with its addresses. An entity with MIHF may also broadcast unsolicited MIH_Capability_Discover.response message to advertise its MIH capability.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| SupportedEventList | 1 | Variable | Array of event codes formatted as messaged-id:<br><br>Event Code1, Event Code2, Event Code3, .... |
| SupportedCom-mandList | 2 | Variable | Array of command codes formatted as messaged-id:<br><br>Command Code1, Command Code2, Command Code3, .... |
| SupportedTransportList | 3 | 4 | Octet 1 specifies the transport option for the event service.<br>Octet 2 specifies the transport option for the command service.<br>Octet 3specifies the transport option for the information service.<br><br>For each bit location a value of '1' indicates that the transport option is supported.<br><br>Bit #0: L2<br>Bit #1: L3 or higher layer protocol<br>Bit #2~7: *Reserved* |

### 8.4.2 Messages for EventService Category

MIH frames for Event Service category have MIH Service ID set to 2. The MIH Function payload for different messages in this service category is described below.

#### 8.4.2.1 MIH_Event_Register Request

This message is used by remote MIH Function (the registrant) to register an interest in a particular or group of event types from a particular event origination point.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| RequestedEventList | 4 | Variable | Array of event codes formatted as messaged-id:<br>Event Code1, Event Code2, Event Code3, .... |

#### 8.4.2.2 MIH_Event_Register Response

The response indicates which of the event types were successfully registered.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| ResponseEventList | 5 | Variable | Array of event codes formatted as messaged-id:<br>Event Code1, Event Code2, Event Code3, .... |

#### 8.4.2.3 MIH_Event_Deregister Request

This message is sent by remote MIHF (the registrant) to deregister for a set of link layer events.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| RequestedEventList | 4 | Variable | Array of event codes formatted as messaged-id:<br>Event Code1, Event Code2, Event Code3, .... |

#### 8.4.2.4 MIH_Event_Deregister Response

The response indicates which of the event types were successfully deregistered.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| ResponseEventList | 5 | Variable | Array of event codes formatted as messaged-id:<br>Event Code1, Event Code2, Event Code3, .... |

#### 8.4.2.5 MIH_Link_Up Indication

This notification is delivered from MIHF in the PoA to MIHF in the network when a layer 2 connection is successfully established with mobile terminal.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| MacMobileTerminal | 6 | Variable | MAC Address |
| MacNewPoA | 7 | Variable | MAC Address of New PoA (AP) |
| MacOldAccessRouter | 8 | Variable | MAC Address of old Access Router (if any) |
| MacNewAccessRouter | 9 | Variable | MAC Address of new Access Router |
| IP_Renewal_Indicator | 10 | 1 | Indicates whether the MN shall change IP addressin the new PoA.<br>0: Change in IP Address required<br>1: Change in IP Address NOT required |
| MobilityMgmtProtocol-Support | 11 | 1 | Indicates type of Mobility Management Protocol supported by the new PoA<br>0: Mobile IPv4 with FA (FA-CoA)<br>1: Mobile IPv4 without FA (Co-located CoA)<br>2: Mobile IPv6<br>3: Mobile IPv6 with DHCPv6<br>4: SIP |

#### 8.4.2.6 MIH_Link_Down Indication

This notification is delivered from MIHF in the PoA to MIHF in the network when a layer 2 connection is disconnected due to certain reason with mobile terminal.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| MacMobileTerminal | 6 | Variable | MAC Address |
| MacNewPoA | 7 | Variable | MAC Address of New PoA (AP) |
| MacOldAccessRouter | 8 | Variable | MAC Address of old Access Router (if any) |
| ReasonCode | 12 | 1 | Reason for why the link went down<br>0: RC_EXPLICIT_DISCONNECT (<br>1: RC_PACKET_TIMEOUT<br>2: RC_FAIL_NORESOURCE<br>3: 127: *Reserved*<br>128~255: RC_VENDOR_SPECIFIC |

Note: Meaning of Reason code presented above is as following

[1] RC_EXPLICIT_DISCONNECT: The link is down because of explicit disconnect procedures initiated either by client or network

[2] RC_PACKET_TIMEOUT: The link is down because no acknowledgements were received for transmitted packets within the specified time limit.

[3] RC_FAIL_NORESOURCE: The link is down because there were no resources to maintain the connection

[4] RC_VENDOR_SPECIFIC: Vendor Specific reason code.

#### 8.4.2.7 MIH_Link_Going_Down Indication

This message is transmitted to the remote MIHF when a layer 2 connectivity is expected (predicted) to go down (Link_Down) within a certain time interval.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| MacMobileTerminal | 6 | Variable | MAC Address |
| MacNewPoA | 7 | Variable | MAC Address of New PoA (AP) |
| MacOldAccessRouter | 8 | Variable | MAC Address of old Access Router |
| MacNewAccessRouter | 9 | Variable | MAC Address of new Access Router |
| TimeInterval | 13 | 2 | Time Interval in which the link is expected to go down. The link connectivity is expected to be available at least for time specified by *TimeInterval* .<br>Unit: 1ms |
| Confidence Level | 14 | 1 | The confidence level for link to go down within the specified time interval<br>Expressed in percentage (0~100) |
| UniqueEventIdentifer | 15 | 2 | To be used in case of event rollback |

#### 8.4.2.8 MIH_Link_Detected Indication

This message is transmitted to the remote MIHF when a new link has been detected.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| MacMobileTerminal | 6 | Variable | MAC Address |
| MIH Capability Flag | 16 | 1 | 0: MIH Capability NOT supported<br>1: MIH Capability Supported |
| Link Identifier | 17 | Variable | Type of link |
| MacNewPoA | 7 | Variable | MAC Address of New PoA (AP) |

#### 8.4.2.9 MIH_Link_Parameters_Report Indication

This message indicates changes in link parameters have crossed pre-configured threshold levels.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| MacMobileTerminal | 6 | Variable | MAC Address |
| LinkParameterType | 18 | Variable | Media specific parameter types that have crossed thresholds |
| oldValueOfLinkParameter | 19 | Variable | Specify the old value of link parameter |
| newValueOfLinkParameter | 20 | Variable | Specify the new value of link parameter |

#### 8.4.2.10 MIH_Link_Event_Rollback Indication

This message is used in conjunction with Link_Going_Down. In case of Link_Going_Down if the link is no longer expected to go down in the specified time interval, the a Link_Event_Rollback message is sent to the remote Event destination.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| MacMobileTerminal | 6 | Variable | MAC Address |
| UniqueEventIdentifer | 15 | 2 | To be used in case of event rollback |

#### 8.4.2.11 MIH_Link_Handover_Imminent Indication

This message indicates that a link layer handover decision has been made and it’s execution is imminent.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| MacMobileTerminal | 6 | Variable | MAC Address |
| MacNewPoA | 7 | Variable | MAC Address of New PoA (AP) |
| MacOldAccessRouter | 8 | Variable | MAC Address of old Access Router |
| MacNewAccessRouter | 9 | Variable | MAC Address of new Access Router |

#### 8.4.2.12 MIH_Link_Handover_Complete Indication

This message indicates that a link layer handover has been completed.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| MacMobileTerminal | 6 | Variable | MAC Address |
| MacNewPoA | 7 | Variable | MAC Address of New PoA (AP) |
| MacOldAccessRouter | 8 | Variable | MAC Address of old Access Router |

| | | | |
|---|---|---|---|
| MacNewAccessRouter | 9 | Variable | MAC Address of new Access Router |

### 8.4.3 Messages for Command Service Category

MIH frames for CommandService category have MIH Service ID set to 3. The MIH Function payload for different messages in this service category is described below.

#### 8.4.3.1 MIH_Get_Status Request

This message is used to discover the status of currently available links.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| GetStatusRequestSet | 21 | 4 | Set of identifiers for which status is requested<br><br>Bit #0: Network Types<br>Bit #1: Device Information<br>Bit #2: Operation Mode<br>Bit #3: Channel Identifier<br>Bit #4: Channel Quality<br>Bit #5: Link Speed<br>Bit #6: Battery Level<br>Bit #7~31: *Reserved* |

#### 8.4.3.2 MIH_Get_Status Response

This message is used by MIH Function to report the status of currently available links.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| GetStatusRequestSet | 21 | 4 | Set of identifiers for which status was requested<br><br>Bit #0: Network Types<br>Bit #1: Device Information<br>Bit #2: Operation Mode<br>Bit #3: Channel Identifier<br>Bit #4: Channel Quality<br>Bit #5: Link Speed<br>Bit #6: Battery Level<br>Bit #7~31: *Reserved* |
| GetStatusResponsetSet | 22 | Variable | Status for each of the identifiers included in Get-StatusRequestSet |

#### 8.4.3.3 MIH_Switch Request

This message is used to switch an active session from one link to another.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| HandoverMode | 23 | 1 | 0: Make before break<br>1: Break before make |
| NewLinkIdentifier | 24 | Variable | The identifier of new network to which handover needs to be initiated |
| OldLinkIdentifier | 25 | Variable | The identifier of old network from which handover needs to be initiated |
| OldLinkAction | 26 | 1 | Specifies the suggested action on old link once the handover to new link has been completed. Combination of below choices are possble.<br>0: LINK_DISCONNECT<br>1:LINK_LOW_POWER<br>2:LINK_POWER_DOWN<br>3:LINK_NO_ACTION<br>4:LINK_RESOURCE_RETAIN<br>5:DATA_FORWARDING_REQUEST<br>6:BI_CASTING_REQUEST<br>7:HANDOVER_CANCEL |

#### 8.4.3.4 MIH_Switch Response

This message returns the response of trying to switch an active session from one link to another.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| SwitchResultCode | 27 | 1 | 0: Success<br>1: Failure<br>2: Rejected |

#### 8.4.3.5 MIH_Configure Request

This message is used to configure the link and ontrol the link behavior.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|

| | | | |
|---|---|---|---|
| ConfigureRequestSet | 28 | 4 | Set of identifiers which can be used to configure the link<br><br>Bit #0: Network Types In Use<br>Bit #1: Operation Mode<br>Bit #2: Transmitter Status<br>Bit #3: Current Address<br>Bit #4~31: *Reserved* |
| ConfigureReqSetParameters | 29 | Variable | Configuration values of different parameters |

#### 8.4.3.6 MIH_Configure Response

This message is used to configure the link and ontrol the link behavior.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| ConfigureStatus | 30 | 1 | Status of configuring different prameters.<br>0: Success<br>1: Failure<br>2: Rejected |

#### 8.4.3.7 MIH_Scan Request

This message is used to scan a list of PoAs for a specific link type.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| ScanLinkType | 31 | Variable | Identifier of link for which to scan |

#### 8.4.3.8 MIH_Scan Response

This message returns the list of PoAs for a specific link type after a scan operation.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| ScanLinkType | 31 | Variable | Identifier of link for which scan was conducted |
| ScanResponseSet | 32 | Variable | List of PoAs for the specified link type |

#### 8.4.3.9 MIH_Configure_Thresholds Request

This message is used to configure the thresholds for indications from link layer.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|

| | | | |
|---|---|---|---|
| LinkParameter | 33 | 2 | Pramaeters for which link thresholds need to be set.<br>Bit 0: Link speed<br>Bit 1: Link bit error rate<br>Bit 2: Link frame loss rate before retransmission<br>Bit 3: Link signal strength<br>Bit 4~15: Reserved |
| InitiateActionThreshold | 34 | Variable | LinkParamaeter specific threshold value that may cause upper layers to start “setup” type activities |
| RollbackActionThreshold | 35 | Variable | LinkParamaeter specific threshold value that may cause upper layers to rollback previously started setup type activities |
| ExecuteActionThreshold | 36 | Variable | LinkParamaeter specific threshold value that may cause upper layers to “execute” appropriate handover specific action |

#### 8.4.3.10 MIH_Configure_Thresholds Response

This message returns the response of configuring thresholds for link indications.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| ConfigureThresholdResult-Code | 37 | Variable | Status of configuring different thresholds.<br>0: Success<br>1: Failure<br>2: Rejected |

#### 8.4.3.11 MIH_Handover_Initiate Request

This message is used for communication between MIH Function on client with MIH Function on network. The function is used to communicate intent of handover initiation. The handover can be initiated either by the client or the network.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| SuggestedNewLinkIdentifier | 24 | Variable | This is the identifier of new network to which handover needs to be initiated. |
| SuggestedMACNewPoAId-entifier | 7 | Variable | This is the preferred Point of Attachment (AP/BS) on new network |
| HandoverMode | 23 | 1 | The handover mode may influence the manner in which links are prepared for handover<br>0: Make-before_Break<br>1: Break-before-Make |

| | | | |
|---|---|---|---|
| CurrentLinkAction | 26 | 1 | Specifies suggested action on old link once handover procedures have been executed.<br>LINK_DISCONNECT<br>LINK_LOW_POWER<br>LINK_POWER_DOWN<br>LINK_NO_ACTION |

#### 8.4.3.12 MIH_Handover_Initiate Response

This message is used for communication between MIH Function on client with MIH Function on network. The function is used to communicate response of intent of handover initiation. The handover can be initiated either by the client or the network.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| HandoverAck | 27 | 1 | Result of Handover Request<br>0: Initiate Handover<br>1: Abort Handover |
| PreferredLinkIdentifier | 28 | Variable | The identifier of new network to which handover needs to be initiated |
| PreferredPoAIdentifier | 29 | Variable | MAC Address of preferred PoA on new network |
| AbortReason | 30 | 1 | Specifies the reason for aborting the handover. |

#### 8.4.3.13 MIH_Handover_Commit Request

This message is used by MIH Function to communicate the intent to commit to a handover request to a specific link and PoA.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| NewLinkIdentifier | 24 | Variable | The identifier of new network to which handover needs to be initiated |
| NewPoAMAC | 7 | Variable | MAC Address of preferred PoA on new network |
| CurrentLinkAction | 26 | 1 | Specifies the suggested action on old link once the handover to new link has been completed. Combination of below choices are possble.<br>0: LINK_DISCONNECT<br>1:LINK_LOW_POWER<br>2:LINK_POWER_DOWN<br>3:LINK_NO_ACTION<br>4:LINK_RESOURCE_RETAIN<br>5:DATA_FORWARDING_REQUEST<br>6:BI_CASTING_REQUEST<br>7:HANDOVER_CANCEL |

#### 8.4.3.14 MIH_Handover_Commit Response

This message is used by MIH Function to communicate theresponse of request to commit to a handover request to a specific link and PoA.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| OldLinkAction | 26 | 1 | Specifies the suggested action on old link once the handover to new link has been completed. Combination of below choices are possble.<br>0: LINK_DISCONNECT<br>1:LINK_LOW_POWER<br>2:LINK_POWER_DOWN<br>3:LINK_NO_ACTION<br>4:LINK_RESOURCE_RETAIN<br>5:DATA_FORWARDING_REQUEST<br>6:BI_CASTING_REQUEST<br>7:HANDOVER_CANCEL |

#### 8.4.3.15 MIH_Handover_Complete Request

This message is used by MIH Function to communicate the status of handover operation. If the handover operation is successful the serving PoA can now start forwarding packets to target PoA.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| HnadoverStatus | 31 | 1 | Specifies the status of handover request. Combination of below choices are possble.<br>0: Success<br>1:Link Setup Failure<br>3-7: Reserved |

#### 8.4.3.16 MIH_Handover_Complete Response

This message is used by MIH Function to communicate the response to completion of handover operation. The message is basically used to communicate the preferred action to be taken w.r.t resources associated with previous connection. If the handover is successful the resources may be released.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| ResourceStatus | 32 | 1 | Specifies the preferred actio w.r.t resource retention request associated with previous connection.<br>0: Release resources<br>1: Retain resources |

#### 8.4.3.17 MIH_Network_Address_Information Request

The 'MIH_Network_Address_Information.request' is delivered from one MIHF in the network to another MIHF in the network in order to discover mobile terminal's network address related information before handover. Upon reception of this message, the receiving remote MIHF can either interact with upper layer to achieve enough information or further deliver this message to the MIHF which may have enough information on this message.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| MacMobileTerminal | 6 | Variable | MAC Address of Mobile Terminal |
| Home Address | 33 | 4 or 6 | Home IP address of Mobile Terminal |
| CoA | 34 | 4 or 6 | Care of Address of Mobile Terminal |
| Serving FA Address / Serving Access Router Address | 35 | 4 or 6 | In case of Mobile IPv4, this parameter represents "IP address of old Foreign Agent, and in case of Mobile IPv6, this parameter represents IP address of old Access Router. |

#### 8.4.3.18 MIH_Network_Address_Information Response

This is sent as a response to MIH_Network_Address_Information.request.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| MacMobileTerminal | 6 | Variable | MAC Address of Mobile Terminal |
| Home Address | 33 | 4 or 6 | Home IP address of Mobile Terminal |
| FA Address / Access Router Address | 35 | 4 or 6 | In case of Mobile IPv4, this parameter represents "IP address of Foreign Agent, and in case of Mobile IPv6, this parameter represents IP address of Access Router. |
| Network Address Information | 36 | Variable | In case of Mobile IPv4, Agent Advertisement is encapsulated and in case of Mobile IPv6, Router Advertisement is encapsulated. |

### 8.4.4 Messages for Information Service Category

MIH frames for Information Service category have MIH Service ID set to 4. The MIH Function payload for different messages in this service category is described below.

#### 8.4.4.1 MIH_Get_Information Request

This message is used by MIH Function to retrieve value of different Information Elements.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|

| | | | |
|---|---|---|---|
| InfoQueryType | 37 | 1 | Specifies the different types of supported IE formats.<br>1: TLV<br>2: RDF_DATA<br>3: RDF_SCHEMA_URL<br>4: RDF_SCHEMA |
| InfoQueryParameters | 38 | Variable | List of query specific parameters |

#### 8.4.4.2 MIH_Get_Information Response

This message is used by MIH Function to retrieve value of different Information Elements.

| Name | Type (1 octet) | Length (1 octet) | Value |
|---|---|---|---|
| InfoQueryType | 37 | 1 | Specifies the different types of supported IE formats.<br>1: TLV<br>2: RDF_DATA<br>3: RDF_SCHEMA_URL<br>4: RDF_SCHEMA |
| InfoQueryResponse | 39 | Variable | Includes the values of different IEs corresponding to the query request |
| QueryStatus | 40 | 1 | Status of the query operation<br>0: Success<br>1: Failure<br>2: Rejected |

## 8.5 Protocol Flow

### 8.5.1 MIH Capability Discovery

The network entities and the terminals with MIHF shall discover which entity supports MIHF in order to utilize MIHF for media independent handover. MIH capability discovery can be done through media specific broadcast messages or through on demand MIH capability discovery messages.

#### 8.5.1.1 MIH Capability Discovery through media specific broadcast messages

The network may be able to indicate to the mobile terminal if it is MIH capable by broadcasting MIH capability over the medium, e.g. beacon in 802.11 and DL-MAP in 802.16.

#### 8.5.1.2 On Demand MIH Capability Discovery

The MIH Function in mobile terminal or in the network can discover which entity in the network or which mobile terminal supports MIH capability by using MIH capability discovery procedure. MIH capability discovery procedure consists of capability discovery handshake and capability advertisement. MIH Function capability discovery can be achieved by exchanging MIH messages, MIH_Capability_Discover request and MIH_Capability_Discover response. The MIH Function entity may advertise its MIH capability to the neighbors by broadcasting MIH_Capability_Discover.response message. Figure 32 — shows the on demand MIH capability discovery procedure.

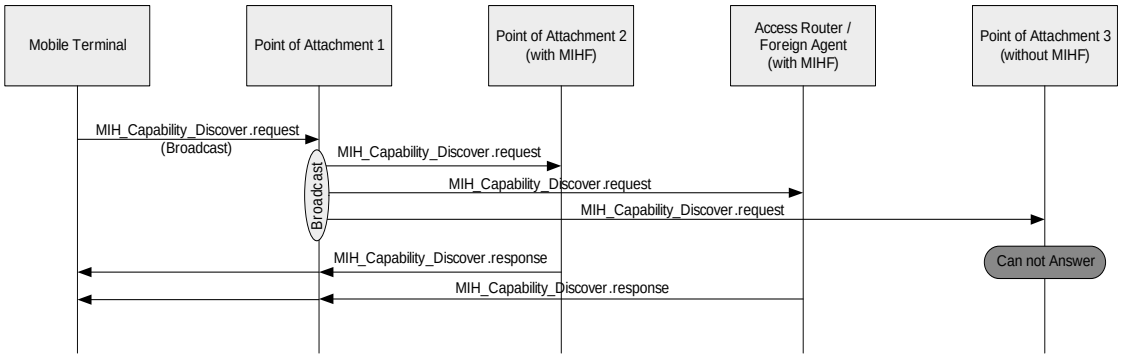



**Figure 32 — On demand MIH capability discovery procedure**

# Annexes

# Annex A-1

(informative)

# Handover Procedures

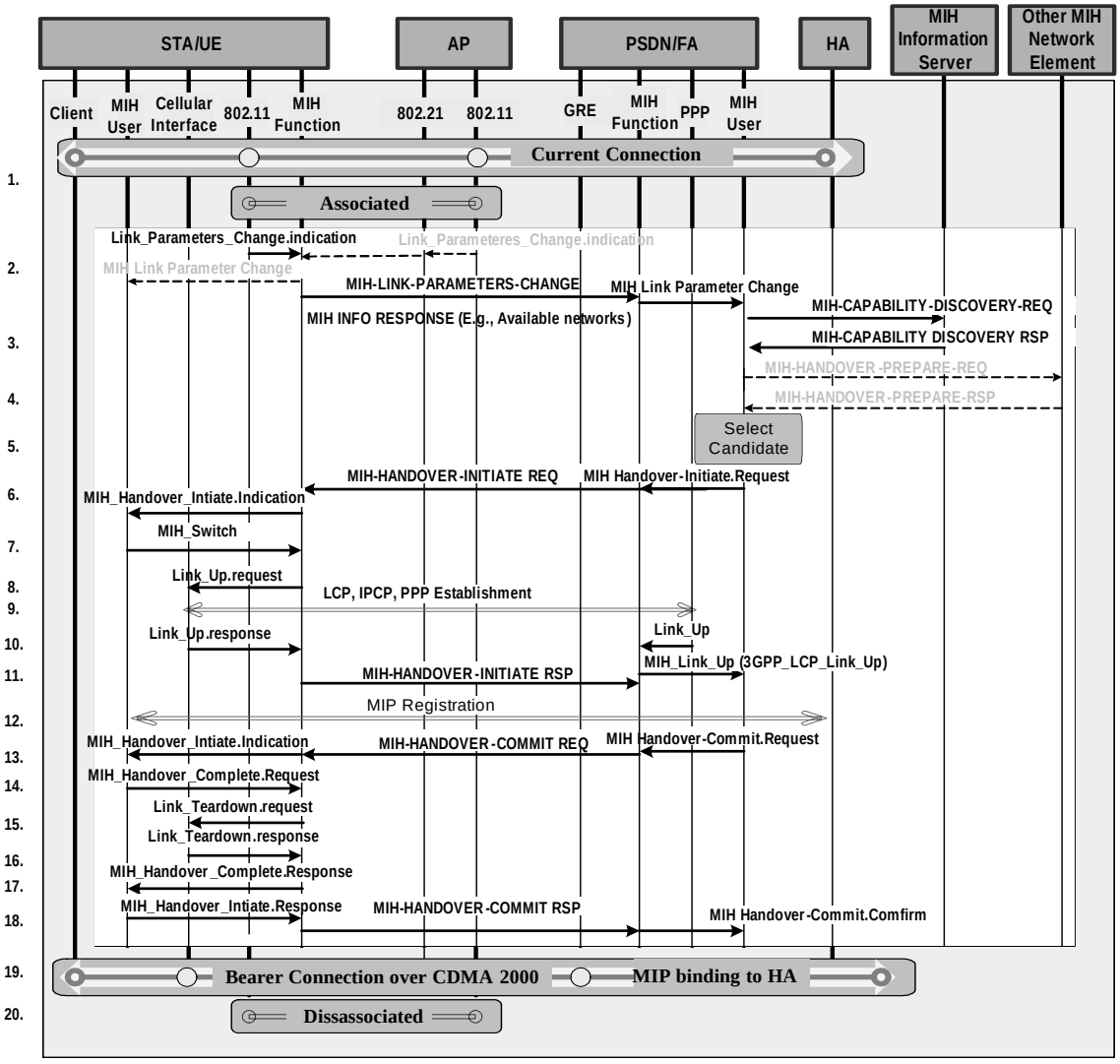



**Figure 33 — Handover from 802.11 to 3GPP2**

The following steps describe the flow depicted in Figure 33 —.

1) The UE is associated to an 802.11 AP and there is currently a session established through the corresponding Home Agent
2) An IEEE 802.21 Link Parameter change event is triggered due to E.g., undesirable radio conditions. The MIH function notifies the MIH user through a corresponding MIH Link Parameter Change message. The MIH might also notifies the local MIH User. This is illustrated with the dotted arrow.
3) The MIH Function notifies the MIH Peer at the network (which previously register for the event service) indicating that a Link Parameter Change has been triggered. The MIH user can optionally contact the MIH Information Server through an MIH Capability Discovery Request to query about the available network for the user that generated the event. Note that this information could have been previously obtained of it could be readily available within the network entity where the MIH user resides.
4) The MIH user might use a Handover Prepare message in order to request resource from alternate networks.
5) The MIH user selects a candidate based on the information received in through the relevant MIH event indication. How this is done is out of scope of the 802.21 specification
6) The MIH user generates a Handover Initiate Request toward its local MIH Function. In turn, the local MIH Function contacts its peer at the STA/UE to transfer the MIH Handover Initiate message. E.g., over a layer 3 transport using the MIH Protocol. The remote MIH Function at the UE relay the MIH Handover Initiate Request, using an MIH Handover.Indication primitive.
7) The MIH User issues an MIH Switch.Request towars its local MIH Function to initiate the establishment of a new radio connection according to the information received in the MIH Handover Initiate Message.
8) The MIH Function issues an Link Up request (Note to theEditor, please note that this command needs to be added to the relevant Link Technology if not already available).
9) The 3GPP2 network interface establishes a new radio connection and a new PPP session.
10) The cellular interface responds indicating the radio link is up.
11) An MIH Handover Initiate.Response message is sent to the requesting MIH User indicating the successful establishment of the new radio connection. Note that the MIH User might have direct access to the relevant cellular technology. This is however out of the scope of this specification. Note that the establishment of the PPP session might trigger a Link Up event at the network side.
12) Mobil IP registration might be now trigger.
13) An MIH Handover Commit message is sent to MIH User indicating the successful establishment of the new radio connection.
14) The MIH User can now tear down the connection using an MIH complete request. side
15) A Link Tear Down is use to release resources.
16) A Link Tear Down response is issue indicating success release of resources.
17) An MIH Handover Complete response is issue notifying the user of successful release of resources.
18) An MIH Initiate Response can now be issue toward the peer.
19) The session is now transferred toward the new link layer
20) The UE is disassociated from the previous PoA

# Annex A-2

# (informative)

**Table 20—MIH-3GLINK_SAP Primitives**

| 3GPP Layer | 3GPP Service Primitive Descriptions | 3GPP Primitive | 802.21 Service Primitive |
|---|---|---|---|
| RR | Page received by RR layer | GMRR-PAGE | Link Parameter Change |
| | Successful reception of data supporting specific QoS | GRR-DATA | Link Parameter Change |
| LLC | Peer LLC layer is established | LL-ESTABLISH | Link Up/Link Parameter Change |
| | Peer LLC layer is released | LL-RELEASE | Link Gong Down/Link Parameter Change |
| | LLC Layer unrecoverable error | LL-STATUS | Link Down |
| GMM | Station is attached | GMMREG-ATACH | Link Parameter Change |
| | Station is detached | GMMREG-DETACH | Link Parameter Change |
| SM | Data session active | SMSM-ACTIVE | Link Up/Link Parameter Change/ Handover Initiate/ Handover Prepare |
| | Data session is deactivated | SMSM-DEACTIVE-ATE | Link Down/Link Parameter Change/Handover Switch |
| | Data session modified | SMSM-MODIFY | Link Parameter Change |
| | Data session terminated due to unrecoverable error | SMSM-STATUS | Link Down |
| | PDP Context is active | SMREG-PDP-ACTIVATE | Link Up/Handover Complete/ Parameter Change/ Handover Complete |
| | PDP Context is modified | SMREG-PDP-MODIFY | Link Up/Parameter Change/ Handover Complete |
| | PDP Context is deactivated | SMREG-PDP-DEACTIVATE | Link Going Down/Link Down |

**Table 20—MIH-3GLINK_SAP Primitives**

| 3GPP Layer | 3GPP Service Primitive Descriptions | 3GPP Primitive | 802.21 Service Primitive |
|---|---|---|---|
| GMM/SM (NAS) | Station is attached | GMMREG-ATACH | Parameter Change |
| | Station is detached | GMMREG-DETACH | Parameter Change |
| | PDP Context is active | SMREG-PDP-ACTIVATE | Link Up/Handover Complete/ Parameter Change/Handover Initiate/Handover Prepare |
| | PDP Context is modified | SMREG-PDP-MODIFY | Parameter Change/ Link Up |
| | PDP Context is deactivated | SMREG-PDP-DEACTIVATE | Link Down/Link Parameter Change |
| | Radio Access Bearer is activated for data transfer | RABMSM-ACTIVATE | Link Up/Parameter Change/ Handover Complete |
| | Radio Access Bearer is deactivated for data transfer | RABMSM-DEACTIVATE | Link Down/Link Parameter Change |
| | Radio Access Bearer is modified for data transfer | RABMSM-MODIFY | Parameter Change/ Link Up/ Handover Complete |
| | Radio Access Bearer data transfer error | RABMSM-STATUS | Link Down |

**Table 20—MIH-3GLINK_SAP Primitives**

| 3GPP Layer | 3GPP Service Primitive Descriptions | 3GPP Primitive | 802.21 Service Primitive |
|---|---|---|---|
| RRC (AS) | Radio Access Bearer has been activated | RABMAS-RAB-ESTABLISH | Link Up/ Handover Initiate/ Handover Complete |
| | Radio Access Bearer has been released | RABMAS-RAB-RELEASE | Link Down |
| | AS failure Indication | RABMAS-STATUS | Link Down |
| | Information regarding geographical area. | Information Broadcast | Parameter Change/Information Request/Information Response |
| | Notification of paging for particular user or terminal | Paging Request | Parameter Change |
| | Notification for all users | Notification Broadcast | Parameter Change |
| | Notification information for a specific or for many user | Notification Indication | Parameter Change |
| | UE initiated connection establishment | Connection Establishment | Link Up |
| | Network initiated connection release | IF Initiated Connection Release | Link Down |
| | Network initiated Radio Access Bearer Establishment | IF Side Initiated Radio Access Bearer Establishment | Link Up/Link Detected |
| | Network initiated Radio Access Bearer Release | IF Side Initiated Radio Access Bearer Release | Link Down |
| | Indication that the connection might be aborted unless streamlining is done | Streamlining Require Indication | Link Going Down |
| | Location information provided by the network for a specific UE | UE location information | Parameter Change |
| | Connection loss indications | Connection loss indication | Link Down |
| E-UTRAN/ E-CORE* | The location of the UE is now know by the network | LTE-detached | Parameter Change |
| | The UE is known to the network but not transport channel is established | LTE-idle | Parameter Change/Link Down |
| | Radio resources have been established and the UE is able to perform uplink and downlink transport of PDU | LTE-Active | Link Up/Link Handover Complete |

**Table 20—MIH-3GLINK_SAP Primitives**

| 3GPP Layer | 3GPP Service Primitive Descriptions | 3GPP Primitive | 802.21 Service Primitive |
|---|---|---|---|
| 3GPP2 LAC | L3 is notified of a relevant event detected at Layer 2. E.g., an abnormal condition | L2.Condition.Notification | Link-Up/Link Down/Link Going Down |
| | Reception of the specified SDU was acknowledge at L2 | L2.Data.Confirm | Handover Complete |
| | L2 executes a control command as directed by L3 | L2.Supervision.Request | Handover Initiate |
| | | | |

# Annex A-3 (informative)

**Table 21—Mapping MIH Primitives to Reference Points**

| No | MIH Message Identifier | Operation code | Category | Reference Point |
|---|---|---|---|---|
| 1 | MIH Capability Discover | Request, Response | System Management | R1, R3 |
| 2 | MIH Event Register | Request, Response | Event Service | R1, R3 |
| 3 | MIH Event Deregister | Request, Response | Event Service | R1, R3 |
| 4 | MIH Link Up | Indication | Event Service | R1, R3 |
| 5 | MIH Link Down | Indication | Event Service | R1, R3 |
| 6 | MIH Link Going Down | Indication | Event Service | R1, R3, R2 |
| 7 | MIH Link Event Rollback | Indication | Event Service | R1, R3 |
| 8 | MIH Link Parameters Report | Indication | Event Service | R1, R3 |
| 9 | MIH SDU Transmit Status | Indication | Event Service | Local only |
| 10 | MIH Link Handover Imminent | Indication | Event Service | R1, R3, R2 |
| 11 | MIH Link Handover Complete | Indication | Event Service | R1, R3 |
| 12 | MIH Poll/Get Status | Request, Response | Command service | R1, R3, R2 |
| 13 | MIH Switch | Request, Response | Command service | R1, R3 |
| 14 | MIH Configure | Request, Response | Command service | R1, R3 |
| 15 | MIH Scan | Request, Response | Command service | R1, R3 |
| 16 | MIH Link Event Configure Thresholds | Request, Response | Command service | R1, R3 |
| 17 | MIH Handover Initiate | Request, Response | Command Service | R1, R3 |
| 18 | MIH Handover Prepare | Request, Response | Command Service | R1, R3, R5 |
| 19 | MIH Handover Commit | Request, Response | Command Service | R1, R3 |
| 20 | MIH Handover Complete | Request, Response | Command Service | R1, R3, R5 |
| 21 | MIH Network Address Information | Request, Response | Command Service | R5 |
| 22 | MIH Get Information | Request, Response | Information service | R1, R3 |
| …. | ….. | | ….. | |
| 23+ | Reserved | | Reserved | |

# Annex A-4

The table below lists the Type identifier values for different individual IEs and also for Type identifiers corresponding to pre-defined Report formats.

**Table 22—Type identifiers for Information Elements**

| No | Type | Identifier | Comments |
|---|---|---|---|
| 1 | TYPE_IE_LIST_OF_NETWORKS | 0x10000001 | |
| 2 | TYPE_IE_NUMBER_OF_OPERATORS | 0x10000002 | |
| 3 | TYPE_IE_LIST_OF_OPERATORS | 0x10000003 | |
| 4 | TYPE_IE_OPERATOR_IDENTIFIER | 0x10000004 | |
| 5 | TYPE_IE_NUMBER_POAS | 0x10000101 | |
| 6 | TYPE_IE_ROAMING_PARTNERS | 0x10000102 | |
| 7 | TYPE_IE_COST | 0x10000103 | |
| 8 | TYPE_IE_NETWORK_SECURITY | 0x10000104 | |
| 9 | TYPE_IE_NETWORK_QOS | 0x10000105 | |
| 10 | TYPE_IE_POA_ADDRESS | 0x10000201 | |
| 10 | TYPE_IE_POA_LOCATION | 0x10000202 | |
| 11 | TYPE_IE_DATA_RATE | 0x10000203 | |
| 12 | TYPE_IE_MAC_TYPE | 0x10000204 | |
| 13 | TYPE_IE_PHY_TYPE | 0x10000205 | |
| 14 | TYPE_IE_CHANNEL_RANGE | 0x10000206 | |
| 16 | TYPE_IE_POA_CAPABILITIES | 0x10000207 | |
| 16 | TYPE_IE_SUBNET_INFORMATION | 0x10000208 | |
| | | | |
| 17 | TYPE_REPORT_GENERAL_INFORMATION | 0x100000FF | |
| 18 | TYPE_REPORT_ACCESS_NETWORK | 0x100001FE | |
| 19 | TYPE_REPORT_ALL_ACCESS_NETWORKS | 0x100001FF | |
| 20 | TYPE_REPORT_POA | 0x100002FF | |
| | | | |

# Annex B (informative)

## B.1 Media Independent Neighbor Graphs (An Example)

Neighbor graph is a network graph that connects a set of vertices (network PoAs) and a set of edges (a path between two PoAs) around a station's (MN) location. It is a way of representing neighborhood information. In case of homogeneous networks, network PoAs are of the same kind while for heterogeneous networks they are different. Media independent neighbor graph (MING) consists of homogeneous and heterogeneous network elements. In that sense media independent neighbor graph is a superset of all media specific neighbor graphs. Stations can obtain media specific neighbor graph information directly from the access networks. However, it is limited by the media the stations are currently attached to. 802.21 media independent neighbor information on the other hand can help obtain a global view of the network neighbor graph consisting of multiple media types.

Thus MING contains a set of different types of neighbors relative to a given PoA. This set can be kept by the MIIS functional entity and can eventually help a MN to identify quickly the potential candidate PoAs for handover. MING may also serve other purposes. For example, if a multi-mode MN knows (via MING) that some modes may not be supported by the neighboring access networks, the MN may like not to power up (for power management) the respective radio interfaces and then scan for neighbor information. A graphical representation of MING is shown in Figure 34 —. The graph contains a set of media independent information elements.

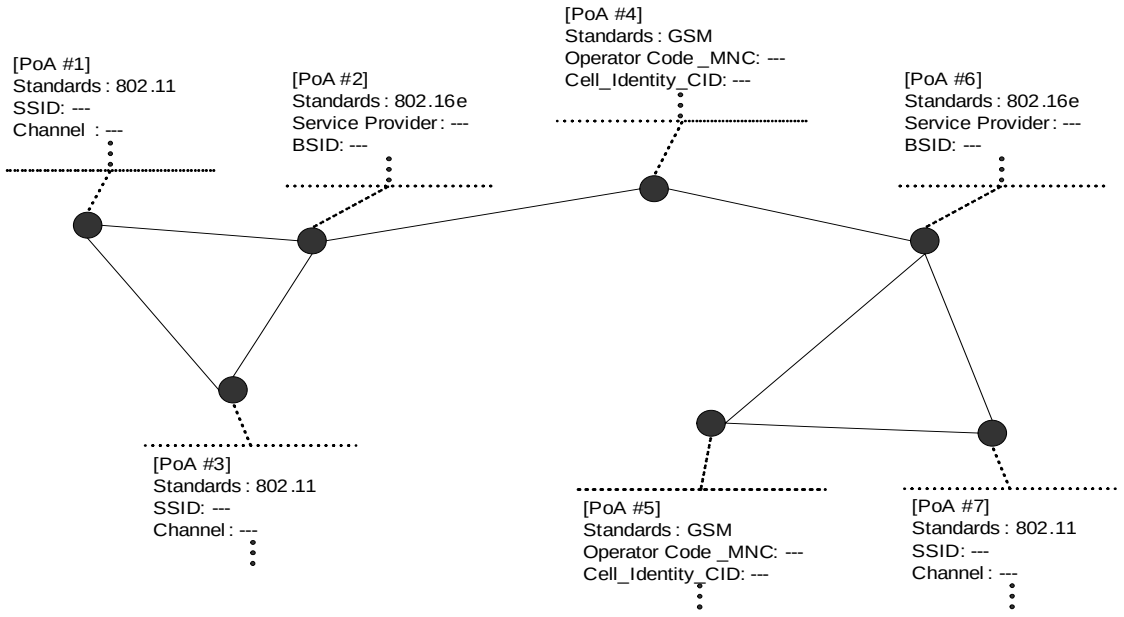



**Figure 34 — An Example Representation of Media Independent Neighbor Graph (MING)**

A MING may be manually configured, e.g., manually listing the neighbors for a given AP, or obtained via the management interface, or other access networks. Rather than incurring such management overhead, the

PoA can learn its neighbors of other media type dynamically through the course of report/response message exchanges. However, how this information is reported and the corresponding responses are outside the scope of the standard. A neighbor information element shall only contain entries of neighboring PoAs that are legitimate neighbors relative to a given PoA satisfying the query. A MING should also prevent the addition of bogus neighbors. The exact form of the implementation of MING is vendor dependent and outside the scope of the standard, however, a dynamic mechanism to construct and maintain MING is described in Appendix 11.2. A MING query may also be performed to obtain the neighbor information. In such cases, neighbor information IE is used in the neighbor information query. The format of the neighbor information map is described in Appendix.

Media Independent Neighbor Graph (MING) is a way to represent the MIIS neighborhood information. MING contains the pertinent information on a set of different types' neighbors that are candidates to which STAs can handover. This MING is compiled by the MIIS entity in the network side and can include information from measurement reports sent by STAs who successfully performed heterogeneous handovers, as well as the information via the management interface.

MING can be defined as a set of MING vertices and a set of MING edges representing a binary relation between MING vertices.

— MING vertex: A PoA with a list of information elements related with the PoA.
— MING edges: The neighboring relationship between two PoAs. Two PoAs i and j are neighbors if there exists a path of motion between i and j such that it is possible for a mobile MN to perform a handover successfully. For example, if a mobile MN can successfully handover from 802.11 AP1 to a cellular BS2, AP1 and BS2 are neighbors and (AP1, BS2) is a MING Edge.

If a MN is anticipating handover, it might request information service from MIIS entity at network side. Whenever receiving such a request, MIIS entity at network side should reply with a partial set of MING. The partial set shall only contain entries of neighboring PoAs with legitimate relationship of the PoA the MN now makes a connection to. If supported, unsolicited advertisement can be used for distributing the partial set as well. Figure 35 — describes the partial set of MING, which can be obtained when a MN requests neighboring information while connecting to PoA #2.

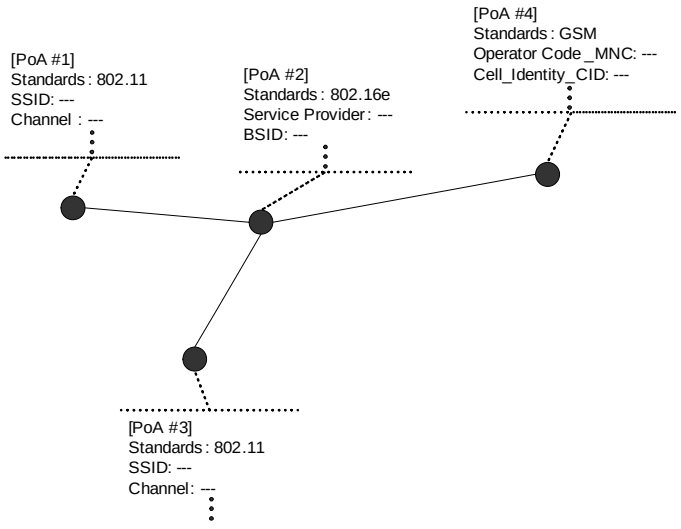



**Figure 35 — Partial Set of MING**

## B.2 Management of Neighboring Network Information

Two PoAs directly connected in MING represents the neighboring relationship. That is to say, a MN can handover between the two PoAs if MING contains a MING edge between the two PoAs. In most cases, this neighboring network information is manually managed by an administrator. Such manual administration is effective if the topology of network is almost fixed and hardly changes. However, some network systems have inherent feature that their topology is a little dynamic. In such network system, the quality of MING can decrease by topology change of existing PoAs. When a PoA is taken away, all the edges to the PoA should be evicted due to their inactivity. If a directional antenna is equipped with a PoA, the change of direction of the antenna may lead the eviction. So, this section describes a dynamic method to construct or manage MING..

Each MING vertex or edge might be managed based on a given timer. Whenever getting a report about a PoA's existence or a neighboring relation from STAs, MIIS entity at network side should add a MING vertex (or edge) or refresh the existing one. If no MN reports the same MING vertex (or edge) during a given time, the corresponding one is deleted. The information elements of the deleted MING vertex can be stored in a temporal storage to re-use them when the corresponding MING vertex is again added.

A 802.21-compatible MN is recommended to send a report message to MIIS entity at network side. This can occur after any successful handover. This implies that MING vertex (or edge) is created only if roaming agreement is satisfied, when MN handovers between two PoAs within a managed operator's network. If supported, the report message can be required by the network. Whatever mechanisms, such a report message itself should be verified.

The following section defines the primitives for supporting the dynamic management of neighboring network information

## B.3 MING POA Report

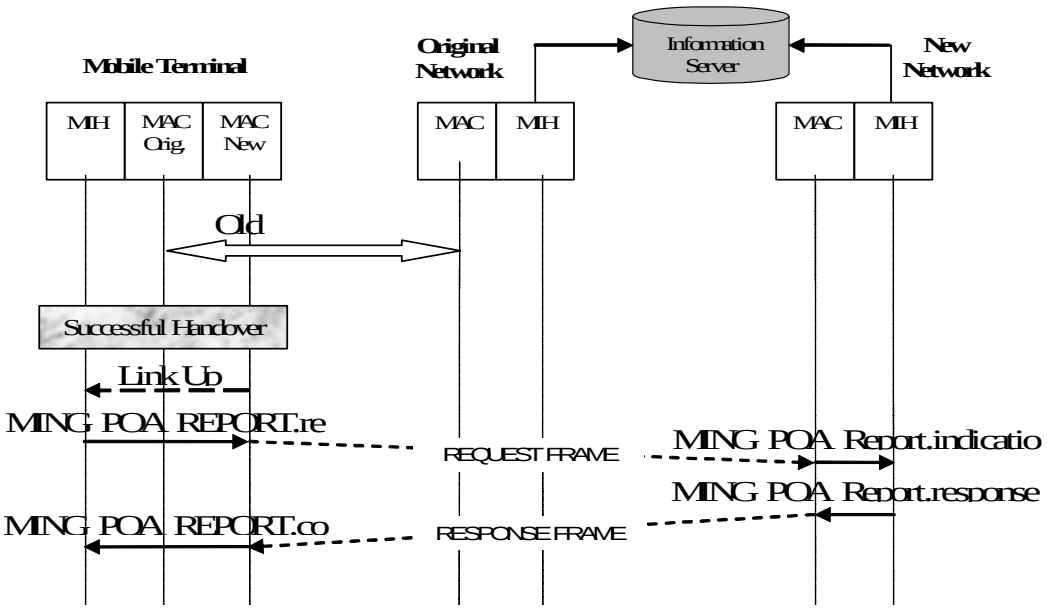



**Figure 36 — MING POA Report**

## B.4.1 MING_POA_Report.request

### B.4.1.1 Function

This primitive is used by MN's MIH to report the discovered PoAs to MIIS entity at network side. This primitive requests that a MING_POA_REPORT be sent to the MIIS with which the MN is associated.

### B.4.1.2 Semantics of service primitive

MING_POA_Report.request
(
Current PoA,
MING_POA_REPORT,
Neighbor Status,
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| Current PoA | | N/A | Current PoA the sending MN makes a connection with |
| MING_POA_REPORT | | N/A | Discovered PoAs and the related ANI, LLI, and HLSI found. |
| Neighbor Status | Yes / Don't know yet | N/A | For the PoA known after successful handover, the Neighbor Status is "Yes"<br><br>For the PoA discovered anyhow at any time (except handover), the Neighbor Status is "Don't know yet" |

[Note: MING_POA_REPORT is not yet clear.]

### B.4.1.3 When generated

This primitive is generated by MN's MIH to report the discovered PoAs to MIIS entity at the network side.

### B.4.1.4 Effect on receipt

On receipt of this primitive, the management entity constructs a MING POA Report Request message. The MN then attempts to transmit this to the MIIS entity with which it is associated at the network side.

## B.4.2 MING_POA_Report.confirm

### B.4.2.1 Function

This primitive reports the result of a MING_POA_REPORT.

### B.4.2.2 Semantics of service primitive

MING_POA_Report.confirm
(
ResultCode,
MING Vertex Set,
)

### B.4.2.3 When generated

| Name | Type | Valid Range | Description |
|---|---|---|---|
| ResultCode | Enumeration | SUCCESS,<br>INVALID_PAMAMETERS,<br>REFUSED,<br>TIMEOUT,<br>TRANSMISSION_FALIURE,<br>UNSPECIFIED_FALILURE | Indicates the result of the corresponding MING_POA_Report.request |
| MING Vertex Set | | N/A | A set of MING Vertexes being reported. Only present if ResultCode = SUCCESS |

This primitive is generated by MN's management entity as a result of an MING_POA_Report.request and indicates the result of the request.

### B.4.2.4 Effect on receipt

On receipt of this primitive, the ResultCode may be evaluated and the reported data may be used.

## B.4.3 MING_POA_Report.indication

### B.4.3.1 Function

This primitive indicates that an MING_POA_Report was received from a MN. It is valid only at an MIH capable AP.

### B.4.3.2 Semantics of service primitive

MING_POA_Report.indication
(
PeerSTAAddress,
Neighbor Status,
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| PeerSTAAddress | MACAddress | Any valid individual MAC Address | The address of the MN from which a MING_POA_Report was received. |
| Neighbor Status | Yes /<br>Don't know yet | N/A | For the PoA known after successful handover, the Neighbor Status is "Yes"<br><br>For the PoA discovered anyhow at any time (except handover), the Neighbor Status is "Don't know yet" |

### B.4.3.3 When generated

This primitive is generated when a valid PoA report is received at the network side.

### B.4.3.4 Effect on receipt

On receipt of this primitive, MIIS entity at network side tries to update its MING. If Neighbor Status is "Yes", it should also update the neighboring relationship between the Current PoA and the reported PoA.

## B.4.4 MING_POA_Report.response

### B.4.4.1 Effect on receipt

This primitive is generated in response to an MING_POA_Report.indication reporting the result of an MING POA REPORT to the peer-MN.

#### 20.0.0.1 Semantics of service primitive

### B.4.4.2 Semantics of service primitive

(
PeerSTAAddress,
ResultCode,
MING Vertex Set,
)

| Name | Type | Valid Range | Description |
|---|---|---|---|
| PeerSTAAddress | MACAddress | Any valid individual MAC Address | The address of the MN from which a MING_POA_Report was received. |

| | | | |
|---|---|---|---|
| ResultCode | Enumeration | SUCCESS, INVALID_PAMAMETERS, REFUSED, TIMEOUT, TRANSMISSION_FALIURE, UNSPECIFIED_FALILURE | Indicates the result of the corresponding MING_POA_Report.indication |
| MING Vertex Set | | N/A | A set of MING Vertexes being reported. Only present if ResultCode = SUCCESS |

#### B.4.4.3 When generated

This primitive is generated by the network in response to an MING_POA_Report.indication. If the returned ResultCode is SUCCESS, the primitive contains the vertexes to be sent to the MN.

#### B.4.4.4 Effect on receipt

On receipt of this primitive, the MIH constructs a MING POA Report Response message. The MN then attempts to transmit this to the MN indicated by the PeerSTAAddress parameter.

## B.4.5 Media Independent Neighbor Graph (MING) Query

Information service primitives as defined in Section 8.5 are sufficient for query and response of neighbor information. However the following new filter type is needed in addition to the filters that are defined earlier.

— FILTER_INFO_NEIGHBOR_INFO

InfoQueryParameters while using the above filter includes 802.21neighbor information IE containing a PoA. The format of such neighbor information IE is discussed in section 11.5.1. On the other hand, MIH_REPORT in query response contains the list of neighbor information IEs along around the POA.

More flexible query with detailed search conditions as well as query for obtaining higher layer information is better performed using the RDF/XML based query as described below.

## B.4.6 Neighbor Information IE

A neighbor information IE is a variable-length IE that carries the identification of a particular POA along with the information that is associated with the particular point of attachment.

| | |
|---|---|
| Length (1 byte) | Zero, One or More Neighbor Information Entry (Variable) |

— Length: Length specifies the length of the fields after the length field.

— Neighbor Information Entry : Neighbor information entry contains all the information relevant to a particular neighbor and is defined below

| Link Type (1byte) | POA ID Length (1 byte) | POA ID (Variable ) | Link Information Length (1 byte) | Link Information (Variable) |
|---|---|---|---|---|

— Link Type : 1--802.3 , 2 --- 802.11, 3--802.16 ,4--GSM , 5--GPRS ,6--CDMA2000, 7--- WCDMA
— POA ID length: POA ID length is the length of the POA ID field
— POA ID: POA ID is the identification of the point of attachment of a specific link type. For example, POA ID can be MAC address of the AP, BS or Ethernet switch.
— Link Information length: Link information length specifies the length of the link information
— Link Information: Link information contains the information related to that particular link

# Annex C

# Schema Representation

## C.1 BasicSchema representation in RDF/XML : (normative)

```
<?xml version="1.0"?>
<!DOCTYPE rdf:RDF [
 <!ENTITY rdf "http://www.w3.org/1999/02/22-rdf-syntax-ns#">
 <!ENTITY rdfs "http://www.w3.org/2000/01/rdf-schema#">
 <!ENTITY mihbase "URL_TO_BE_ASSIGNED">
 <!ENTITY owl "http://www.w3.org/2002/07/owl#">
 <!ENTITY xsd "http://www.w3.org/2001/XMLSchema#">
]>

<rdf:RDF xmlns:rdf="&rdf;" xmlns:rdfs="&rdfs;" xmlns:mihbase="&mihbase;"
 xml:base="&mihbase;" xmlns:owl="&owl;" xmlns:xsd="&xsd;">

<owl:Ontology rdf:about="">
 <rdfs:comment></rdfs:comment>
 <rdfs:label>Basic Schema for IEEE 802.21 Information Service</rdfs:label>
</owl:Ontology>

<owl:Class rdf:ID="PoA">
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#data-rate"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#phy-type"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#phy-type"/>
   <owl:maxCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#mac-type"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#mac-type"/>
   <owl:maxCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxCardinality>
  </owl:Restriction>
```

```
</rdfs:subClassOf>
<rdfs:subClassOf>
 <owl:Restriction>
  <owl:onProperty rdf:resource="#channel-range"/>
  <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
 </owl:Restriction>
</rdfs:subClassOf>
<rdfs:subClassOf>
 <owl:Restriction>
  <owl:onProperty rdf:resource="#channel-range"/>
  <owl:maxCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxCardinality>
 </owl:Restriction>
</rdfs:subClassOf>
<rdfs:subClassOf>
 <owl:Restriction>
  <owl:onProperty rdf:resource="#qos"/>
  <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
 </owl:Restriction>
</rdfs:subClassOf>
<rdfs:subClassOf>
 <owl:Restriction>
  <owl:onProperty rdf:resource="#security"/>
  <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
 </owl:Restriction>
</rdfs:subClassOf>
<rdfs:subClassOf>
 <owl:Restriction>
  <owl:onProperty rdf:resource="#neighboring-poa"/>
  <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
 </owl:Restriction>
</rdfs:subClassOf>
<rdfs:subClassOf>
 <owl:Restriction>
  <owl:onProperty rdf:resource="#poa-location"/>
  <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
 </owl:Restriction>
</rdfs:subClassOf>
<rdfs:subClassOf>
 <owl:Restriction>
  <owl:onProperty rdf:resource="#poa-location"/>
  <owl:maxCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxCardinality>
 </owl:Restriction>
</rdfs:subClassOf>
<rdfs:subClassOf>
 <owl:Restriction>
  <owl:onProperty rdf:resource="#operator-identifier"/>
  <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
 </owl:Restriction>
</rdfs:subClassOf>
<rdfs:subClassOf>
 <owl:Restriction>
  <owl:onProperty rdf:resource="#operator-identifier"/>
  <owl:maxCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxCardinality>
 </owl:Restriction>
```

```
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#cost"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#cost"/>
   <owl:maxCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#poa-capabilities"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#poa-capabilities"/>
   <owl:maxCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#roaming-partner"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#poa-subnet-info"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
   <owl:Restriction>
     <owl:onProperty rdf:resource="#poa-address"/>
     <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
   </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
   <owl:Restriction>
     <owl:onProperty rdf:resource="#link-type"/>
     <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
   </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:comment>
  A distinct instance of this class must be assigned for each point of attachment.
 </rdfs:comment>
</owl:Class>
```

```
<owl:DatatypeProperty rdf:ID="data-rate">
 <rdfs:label>Data Rate</rdfs:label>
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="&xsd;unsignedInt"/>
 <rdfs:comment>
  The data-rate property contains a maximum data rate of the link layer of the PoA in unit of Kbps.
 </rdfs:comment>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="phy-type">
 <rdfs:label>PHY Type</rdfs:label>
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="&xsd;string"/>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="mac-type">
 <rdfs:label>MAC Type</rdfs:label>
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="&xsd;string"/>
</owl:DatatypeProperty>

<owl:Class rdf:ID="Channel-Range">
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#low-channel-range"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#high-channel-range"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
</owl:Class>

<owl:ObjectProperty rdf:ID="channel-range">
 <rdfs:label>Channel Range</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="#Channel-Range"/>
</owl:ObjectProperty>

<owl:DatatypeProperty rdf:ID="low-channel-range">
 <rdfs:label>Low Channel Range</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#Channel-Range"/>
 <rdfs:range rdf:resource="&xsd;unsignedInt"/>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="high-channel-range">
 <rdfs:label>High Channel Range</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#Channel-Range"/>
```

```
 <rdfs:range rdf:resource="&xsd;unsignedInt"/>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="security">
 <rdfs:label>Security</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="&xsd;boolean"/>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="uam">
 <rdfs:label>UAM</rdfs:label>
 <rdfs:subPropertyOf rdf:resource="#security"/>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="pana">
 <rdfs:label>PANA</rdfs:label>
 <rdfs:subPropertyOf rdf:resource="#security"/>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="qos">
 <rdfs:label>QoS</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="&xsd;boolean"/>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="diffserv">
 <rdfs:label>Diffserv</rdfs:label>
 <rdfs:subPropertyOf rdf:resource="#qos"/>
</owl:DatatypeProperty>

<owl:ObjectProperty rdf:ID="neighboring-poa">
 <rdfs:label>Neighboring PoAs</rdfs:label>
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="#PoA"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="poa-location">
 <rdfs:label>PoA Location</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="#PoA-Location"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="operator-identifier">
 <rdfs:label>Operator Identifier</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="#Operator-Identifier"/>
</owl:ObjectProperty>

<owl:ObjectProperty rdf:ID="roaming-partner">
 <rdfs:label>Roaming Partner</rdfs:label>
```

```
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="#Operator-Identifier"/>
</owl:ObjectProperty>

<owl:DatatypeProperty rdf:ID="cost">
 <rdfs:label>Cost</rdfs:label>
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="&xsd;string"/>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="poa-capabilities">
 <rdfs:label>PoA Capabilities</rdfs:label>
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="&xsd;unsignedInt"/>
 <rdfs:comment>
 PoA Capability bitmap
 Bit 0:Security
 Bit 1:QoS
 Bit 2:Internet Access
 Bit 3:IP Version 4
 Bit 4:IP Version 6
 Bit 5:Emergency Services
 Bit 6:-31:Reserved
 </rdfs:comment>
</owl:DatatypeProperty>

<owl:ObjectProperty rdf:ID="poa-subnet-info">
 <rdfs:label>PoA subnet info</rdfs:label>
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="#Subnet-Information"/>
</owl:ObjectProperty>

<owl:Class rdf:ID="Subnet-Information">
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#subnet-address"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#prefix-length"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
</owl:Class>

<owl:ObjectProperty rdf:ID="subnet-address">
 <rdfs:label>Subnet Address</rdfs:label>
 <rdfs:domain rdf:resource="#Subnet-Information"/>
 <rdfs:range rdf:resource="#Address"/>
</owl:ObjectProperty>

<owl:DatatypeProperty rdf:ID="prefix-length">
```

```
 <rdfs:label>Prefix Length</rdfs:label>
 <rdfs:domain rdf:resource="#Subnet-Information"/>
 <rdfs:range rdf:resource="&xsd;unsignedByte"/>
</owl:DatatypeProperty>

<owl:Class rdf:ID="PoA-Location">
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#geospatial-location-information"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#geospatial-location-information"/>
   <owl:maxCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#civic-location-information"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#civic-location-information"/>
   <owl:maxCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#method"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#method"/>
   <owl:maxCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:comment>
  This class has properties that indicate a location of PoA.
  The properties include geospatial-location-information, civic-location-information and method.
Any property can be added to this class in an extended schema.
 </rdfs:comment>
</owl:Class>

<owl:ObjectProperty rdf:ID="geospatial-location-information">
 <rdfs:label>Geospatial Locaiton Information</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty" />
 <rdfs:domain rdf:resource="#PoA-Location"/>
 <rdfs:range rdf:resource="#Geospatial-Location-Information"/>
```

```
</owl:ObjectProperty>

<owl:Class rdf:ID="Geospatial-Location-Information">
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#latitude-resolution"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#latitude"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#longtitude-resolution"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#longitude"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#altitude-type"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#altitude-resolution"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#altitude"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#datum"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:comment>
  This class has properties that represent geographic coordinate.
  The format is based on the Location Configuration Information (LCI) defined in RFC 3825.
```

```
 </rdfs:comment>
</owl:Class>

<owl:DatatypeProperty rdf:ID="latitude-resolution">
 <rdfs:label>Latitude Resolution</rdfs:label>
 <rdfs:domain rdf:resource="#Geospatial-Location-Information"/>
 <rdfs:range rdf:parseType="Resource">
  <xsd:integer.minInclusive rdf:datatype="&xsd;integer">0</xsd:integer.minInclusive>
  <xsd:integer.maxInclusive rdf:datatype="&xsd;integer">34</xsd:integer.maxInclusive>
  <rdfs:subClassOf rdf:resource="&xsd;integer"/>
 </rdfs:range>
 <rdfs:comment>
  This property contains the latitude resolution.
 </rdfs:comment>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="latitude">
 <rdfs:label>Latitude</rdfs:label>
 <rdfs:domain rdf:resource="#Geospatial-Location-Information"/>
 <rdfs:range rdf:parseType="Resource">
  <xsd:hexBinary.minInclusive rdf:datatype="&xsd;hexBinary">0</xsd:hexBinary.minInclusive>
sive<xsd:hexBinary.maxInclusive  rdf:datatype="&xsd;hexBinary">3FFFFFFF</xsd:hexBinary.maxInclu-
  <rdfs:subClassOf rdf:resource="&xsd;hexBinary"/>
 </rdfs:range>
 <rdfs:comment>
  This property contains the integer part of latitude of the location.
 </rdfs:comment>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="longitude-resolution">
 <rdfs:label>Longitude Resolution</rdfs:label>
 <rdfs:domain rdf:resource="#Geospatial-Location-Information"/>
 <rdfs:range rdf:parseType="Resource">
  <xsd:integer.minInclusive rdf:datatype="&xsd;integer">0</xsd:integer.minInclusive>
  <xsd:integer.maxInclusive rdf:datatype="&xsd;integer">34</xsd:integer.maxInclusive>
  <rdfs:subClassOf rdf:resource="&xsd;integer"/>
 </rdfs:range>
 <rdfs:comment>
  This property contains the longitude resolution.
 </rdfs:comment>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="longitude">
 <rdfs:label>Longitide</rdfs:label>
 <rdfs:domain rdf:resource="#Geospatial-Location-Information"/>
 <rdfs:range rdf:parseType="Resource">
  <xsd:hexBinary.minInclusive rdf:datatype="&xsd;hexBinary">0</xsd:hexBinary.minInclusive>
sive<xsd:hexBinary.maxInclusive  rdf:datatype="&xsd;hexBinary">3FFFFFFF</xsd:hexBinary.maxInclu-
  <rdfs:subClassOf rdf:resource="&xsd;hexBinary"/>
 </rdfs:range>
 <rdfs:comment>
  This property contains the longitude of the location.
 </rdfs:comment>
</owl:DatatypeProperty>
```

```
<owl:DatatypeProperty rdf:ID="altitude-type">
 <rdfs:label>Altitude Type</rdfs:label>
 <rdfs:domain rdf:resource="#Geospatial-Location-Information"/>
 <rdfs:range rdf:parseType="Resource">
  <xsd:integer.minInclusive rdf:datatype="&xsd;integer">0</xsd:integer.minInclusive>
  <xsd:integer.maxInclusive rdf:datatype="&xsd;integer">2</xsd:integer.maxInclusive>
  <rdfs:subClassOf rdf:resource="&xsd;integer"/>
 </rdfs:range>
 <rdfs:comment>
  This property contains the altitude type.
 </rdfs:comment>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="altitude-resolution">
 <rdfs:label>Altitude Resolution</rdfs:label>
 <rdfs:domain rdf:resource="#Geospatial-Location-Information"/>
 <rdfs:range rdf:parseType="Resource">
  <xsd:integer.minInclusive rdf:datatype="&xsd;integer">0</xsd:integer.minInclusive>
  <xsd:integer.maxInclusive rdf:datatype="&xsd;integer">30</xsd:integer.maxInclusive>
  <rdfs:subClassOf rdf:resource="&xsd;integer"/>
 </rdfs:range>
 <rdfs:comment>
  This property contains the altitude resolution.
 </rdfs:comment>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="altitude">
 <rdfs:label>Altitude</rdfs:label>
 <rdfs:domain rdf:resource="#Geospatial-Location-Information"/>
 <rdfs:range rdf:parseType="Resource">
  <xsd:hexBinary.minInclusive rdf:datatype="&xsd;hexBinary">0</xsd:hexBinary.minInclusive>
sive≍xsd:hexBinary.maxInclusive   rdf:datatype="&xsd;hexBinary">3FFFFFFF</xsd:hexBinary.maxInclu-
  <rdfs:subClassOf rdf:resource="&xsd;hexBinary"/>
 </rdfs:range>
 <rdfs:comment>
  This property contains the altitude of the location.
 </rdfs:comment>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="datum">
 <rdfs:label>Datum</rdfs:label>
 <rdfs:domain rdf:resource="#Geospatial-Location-Information"/>
 <rdfs:range rdf:parseType="Resource">
  <xsd:integer.minInclusive rdf:datatype="&xsd;integer">1</xsd:integer.minInclusive>
  <xsd:integer.maxInclusive rdf:datatype="&xsd;integer">2</xsd:integer.maxInclusive>
  <rdfs:subClassOf rdf:resource="&xsd;integer"/>
 </rdfs:range>
 <rdfs:comment>
  This property contains the datum type.
 </rdfs:comment>
</owl:DatatypeProperty>

<owl:ObjectProperty rdf:ID="civic-location-information">
```

```
 <rdfs:label>Civic Location Information</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty" />
 <rdfs:domain rdf:resource="#PoA-Location"/>
 <rdfs:range rdf:resource="#Civic-Location-Information"/>
</owl:ObjectProperty>

<owl:Class rdf:ID="Civic-Location-Information">
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#country-code"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#country-address-elements"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:comment>
  This class has properties that represent civic address.
  The format is defined in draft-ietf-geopriv-radius-lo-04.txt.
 </rdfs:comment>
</owl:Class>

<owl:DatatypeProperty rdf:ID="country-code">
 <rdfs:label>Country Code</rdfs:label>
 <rdfs:domain rdf:resource="#Civic-Location-Information"/>
 <rdfs:range rdf:parseType="Resource">
  <xsd:string.length rdf:datatype="&xsd;integer">2</xsd:string.length>
  <rdfs:subClassOf rdf:resource="&xsd;string"/>
 </rdfs:range>
 <rdfs:comment>
  This property contains the two-letter ISO 3166 country code in capital ASCII letters.
 </rdfs:comment>
</owl:DatatypeProperty>

<owl:ObjectProperty rdf:ID="country-address-elements">
 <rdfs:label>Country Address Elements</rdfs:label>
 <rdfs:domain rdf:resource="#Civic-Location-Information"/>
 <rdfs:range rdf:resource="#Country-Address-Elements"/>
 <rdfs:comment>
This property contains the location information element.The format of the civic address elements is
described in Section 3.3 of draft-ietf-geopriv-dhcp-civil-08.txt with a TLV pair
(whereby the Type and Length fields are one octet long).
 </rdfs:comment>
</owl:ObjectProperty>

<owl:Class rdf:ID="Country-Address-Elements">
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#country-address-element"/>
   <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
  </owl:Restriction>
```

```
 </rdfs:subClassOf>
</owl:Class>

<owl:ObjectProperty rdf:ID="country-address-element">
 <rdfs:label>Country Address Element</rdfs:label>
 <rdfs:domain rdf:resource="#Country-Address-Elements"/>
 <rdfs:range rdf:resource="#Country-Address-Element"/>
 <rdfs:comment>
This property contains the country address elements.The format of the civic address elements is described
in Section 3.4 of draft-ietf-geopriv-dhcp-civil-08.txt with a TLV pair (whereby the Type and Length fields
are one octet long).
 </rdfs:comment>
</owl:ObjectProperty>

<owl:Class rdf:ID="Country-Address-Element">
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#catype"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#cavalue"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
</owl:Class>

<owl:DatatypeProperty rdf:ID="catype">
 <rdfs:label>CAtype</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#Country-Address-Element"/>
 <rdfs:range rdf:resource="&xsd;unsignedByte"/>
 <rdfs:comment>
  A one-octet descriptor of the data civic address value.
 </rdfs:comment>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="cavalue">
 <rdfs:label>CAvalue</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#Country-Address-Element"/>
 <rdfs:range rdf:resource="&xsd;string"/>
 <rdfs:comment>
  The civic address value.
 </rdfs:comment>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="method">
 <rdfs:label>Method</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty" />
 <rdfs:domain rdf:resource="#PoA-Location"/>
 <rdfs:range rdf:resource="&xsd;unsignedByte"/>
```

```
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="link-type">
 <rdfs:label>Link Type</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="&xsd;unsignedInt"/>
 <rdfs:comment>
  This property contains a RADIUS NAS-Port-Type attribute value defined in
  http://www.iana.org/assignments/radius-types.
 </rdfs:comment>
</owl:DatatypeProperty>

<owl:ObjectProperty rdf:ID="poa-address">
 <rdfs:label>PoA Address</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#PoA"/>
 <rdfs:range rdf:resource="#Address"/>
 <rdfs:comment>
  This property contains a link-specific identifier of PoA.
 </rdfs:comment>
</owl:ObjectProperty>

<owl:Class rdf:ID="Address">
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#address-type"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
 <rdfs:subClassOf>
  <owl:Restriction>
   <owl:onProperty rdf:resource="#address"/>
   <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
  </owl:Restriction>
 </rdfs:subClassOf>
</owl:Class>

<owl:DatatypeProperty rdf:ID="address-type">
 <rdfs:label>Address Type</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#Address"/>
 <rdfs:range rdf:resource="&xsd;unsignedShort"/>
</owl:DatatypeProperty>

<owl:DatatypeProperty rdf:ID="address">
 <rdfs:label>Address</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#Address"/>
 <rdfs:range rdf:resource="&xsd;hexBinary"/>
</owl:DatatypeProperty>

<owl:Class rdf:ID="Operator-Identifier">
 <rdfs:subClassOf>
```

```
 <owl:Restriction>
  <owl:onProperty rdf:resource="#operator-namespace"/>
  <owl:minCardinality rdf:datatype="&xsd;nonNegativeInteger">0</owl:minCardinality>
 </owl:Restriction>
</rdfs:subClassOf>
<rdfs:subClassOf>
 <owl:Restriction>
  <owl:onProperty rdf:resource="#operator-namespace"/>
  <owl:maxCardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:maxCardinality>
 </owl:Restriction>
</rdfs:subClassOf>
<rdfs:subClassOf>
 <owl:Restriction>
  <owl:onProperty rdf:resource="#operator-name"/>
  <owl:cardinality rdf:datatype="&xsd;nonNegativeInteger">1</owl:cardinality>
 </owl:Restriction>
</rdfs:subClassOf>
<rdfs:comment>
 This class has properties that represent an operator.
 The properties are operator-namespace and operator-name.
</rdfs:comment>
</owl:Class>

<owl:DatatypeProperty rdf:ID="operator-namespace">
 <rdfs:label>Operator Namespace</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#Operator-Identifier"/>
 <rdfs:range rdf:parseType="Resource">
  <xsd:string.minLength rdf:datatype="&xsd;integer">1</xsd:string.minLength>
  <xsd:string.maxLength rdf:datatype="&xsd;integer">253</xsd:string.maxLength>
  <rdfs:subClassOf rdf:resource="&xsd;string"/>
 </rdfs:range>
</owl:DatatypeProperty>
<owl:DatatypeProperty rdf:ID="operator-name">
 <rdfs:label>Operator Name</rdfs:label>
 <rdf:type rdf:resource="&owl;FunctionalProperty"/>
 <rdfs:domain rdf:resource="#Operator-Identifier"/>
 <rdfs:range rdf:parseType="Resource">
  <xsd:string.minLength rdf:datatype="&xsd;integer">1</xsd:string.minLength>
  <xsd:string.maxLength rdf:datatype="&xsd;integer">253</xsd:string.maxLength>
  <rdfs:subClassOf rdf:resource="&xsd;string"/>
 </rdfs:range>
 <rdfs:comment>
  This property contains the name of the operator.
 </rdfs:comment>
</owl:DatatypeProperty>
</rdf:RDF>
```

# Annex D

(informative)

# Media Specific Enhancements

## D.1. 802.3 MAC/PHY Amendments

A new *ethertype* value must be defined for proper accommodation of MIH PDUs in IEEE 802.3 data frames.

## D.2. 802.11 MAC/PHY Amendments

Please refer to document 21-05-0350-xx-0000-Req_Amendments_802_11 for further details regrading specific requirements and suggested amendements for 802.11 media.

## D.3. 802.16 MAC/PHY Amendments

Please refer to document 21-05-0335-xx-0000-Req_Amendments_802_16 for further details regrading specific requirements and suggested amendements for 802.16 media.

## D.4. Cellular specific Amendments

Please refer to document 21-05-0300-xx-0000-Adhoc3GPPLiasionPackage for further details regrading specific requirements and suggested amendements for 3GPP specific media.

Please refer to document 21-05-0396-xx-0000-Adhoc3GPP2LiasionPackage for further details regrading specific requirements and suggested amendements for 3GPP2 specific media.