



**IEEE Standard for
Local and metropolitan area networks—**

Part 21: Media Independent Handover Services

IEEE Computer Society

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LAN/MAN Standards Committee

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IEEE Standard for Local and metropolitan area networks— Media Independent Handover Services

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Abstract: This standard specifies IEEE 802[®] media access-independent mechanisms that optimize handovers between heterogeneous IEEE 802 systems and between IEEE 802 systems and cellular systems.

Keywords: management, media independent handover, mobile node, mobility, seamless, point of attachment, point of service

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Introduction

This introduction is not part of IEEE Std 802.21-2008, IEEE Standard for Local and Metropolitan Area Networks: Media Independent Handover Services.

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

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**IEEE Standard for
Local and metropolitan area networks—**

Part 21: Media Independent Handover Services

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1. Overview

1.1 Scope

This standard defines extensible IEEE 802[®] media access independent mechanisms that enable the optimization of handover between heterogeneous IEEE 802 networks and facilitates handover between IEEE 802 networks and cellular networks.

1.2 Purpose

The purpose is to improve the user experience of mobile devices by facilitating handover between IEEE 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 are also usable for handovers between IEEE 802 networks and non IEEE 802 networks.

1.3 General

This standard provides link-layer intelligence and other related network information to upper layers to optimize handovers between heterogeneous networks. This includes media types specified by Third Generation (3G) Partnership Project (3GPP), 3G Partnership Project 2 (3GPP2), and both wired and wireless media in the IEEE 802 family of standards. In this standard, unless otherwise noted, *media* refers to the method/mode of accessing a telecommunication system (e.g., cable, radio, satellite), as opposed to sensory aspects of communication (e.g., audio, video).

The following items are not within the scope of this standard:

- Intra-technology handover [except for handovers across extended service sets (ESSs) in case of IEEE 802.11]
- Handover policy
- Security mechanisms
- Enhancements specific to particular link-layer technologies that are required to support this standard (they will be carried out by those respective link-layer technology standards)
- Higher layer (layer 3 and above) enhancements that are required to support this standard

The purpose of this standard is to enhance the experience of mobile users by facilitating handovers between heterogeneous networks. The standard addresses the support of handovers for both mobile and stationary users. For mobile users, handovers can occur when wireless link conditions change due to the users' movement. For the stationary user, handovers become imminent when the surrounding network environment changes, making one network more attractive than another.

This standard supports another important aspect of optimized handover—link adaptation. A user can choose an application that requires a higher data rate than available on the current link, necessitating a link adaptation to provide the higher rate, or necessitating a handover if the higher rate is unavailable on the current link.

In all such cases, service continuity should be maintained to the extent possible during handover. As an example, when making a network transition during a phone call the handover procedures should be executed in such a way that any perceptible interruption to the conversation will be minimized.

This standard supports cooperative use of information available at the mobile node and within the network infrastructure. The mobile node 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 nodes, and higher layer service availability. Both the mobile node and the network make decisions about connectivity. In general, both the mobile node 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 supporting connections on more than one radio interface).

The overall network can include a mixture of cells of drastically different sizes, such as those from IEEE 802.15, IEEE 802.11, IEEE 802.16, 3GPP, and 3GPP2, with overlapping coverage. The handover process can be initiated by measurement reports and triggers supplied by the link layers on the mobile node. The measurement reports can include metrics such as signal quality, synchronization time differences, and transmission error rates. Specifically the standard consists of the following elements:

- a) A framework that enables service continuity while a mobile node (MN) transitions between heterogeneous link-layer technologies. The framework relies on the presence of a mobility management protocol stack within the network elements that support the handover. The framework presents media independent handover (MIH) reference models for different link-layer technologies.
- b) A set of handover-enabling functions within the protocol stacks of the network elements and a new entity created therein called the MIH Function (MIHF).
- c) A media independent handover service access point (called the MIH_SAP) and associated primitives are defined to provide MIH users with access to the services of the MIHF. The MIHF provides the following services:
 - 1) The media independent event service that detects changes in link-layer properties and initiates appropriate events (triggers) from both local and remote interfaces.
 - 2) The media independent command service provides a set of commands for the MIH users to control link properties that are relevant to handover and switch between links if required.

- 3) The media independent information service provides the information about different networks and their services thus enabling more effective handover decision to be made across heterogeneous networks.
- d) The definition of new link-layer service access points (SAPs) and associated primitives for each link-layer technology. The new primitives help the MIHF collect link information and control link behavior during handovers. If applicable, the new SAPs are recommended as amendments to the standards for the respective link-layer technology.

Figure 1 shows the placement of the MIHF within the protocol stack of a multiple interfaced MN or network entity. The MIHF provides services to the MIH users through a single media independent interface (the MIH service access point) and obtains services from the lower layers through a variety of media dependent interfaces (media-specific SAPs).

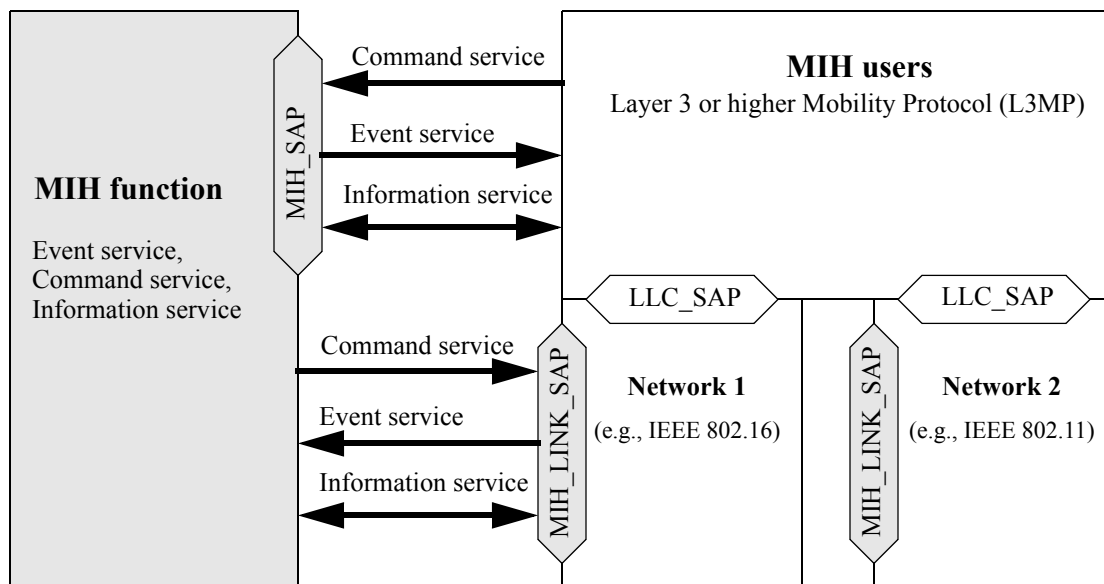


Figure 1—MIH services and their initiation

1.4 Assumptions

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

- a) The MN is capable of supporting multiple link-layer technologies, such as wireless, wired, or mixed.
- b) The MIHF is a logical entity, whose definition is independent of its deployment location on the MN or in the network.
- c) The MIHF, regardless of whether it is located on the MN or in the network, receives and transmits information about the configuration and condition of access networks around the MN. This information originates at different layers of the protocol stack within the MN or at various network elements.
 - 1) When the information originates at a remote network element, the MIHF on the local network element obtains it through MIH message exchanges with a peer MIHF instance that resides in the remote network element.
 - 2) When the information originates at lower layers of the protocol stack within an MN or network entity, the MIHF on that entity obtains it locally through the service primitives of the SAPs that define the interface of the MIHF with the lower layers.

1.5 Media independence

The intent of this standard is to provide generic link-layer intelligence independent of the specifics of mobile nodes or radio networks. As such, this standard 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.

This standard defines 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 this standard. Suitable amendments are required to existing link-layer [medium access control (MAC)/ physical layer (PHY)] standards of different media-specific technologies such as IEEE Std 802.3TM, IEEE Std 802.11TM, IEEE Std 802.16TM, 3GPP, and 3GPP2 to satisfy the requirements of generic link-layer intelligence identified by this standard.¹

¹Information on references can be found in Clause 2.

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

3GPP TS 23.003 (2007-09), Numbering, addressing and identification (Release 7).

3GPP TS 25.008, Digital cellular telecommunication system (Phase 2+); Radio subsystem link control.

3GPP TS 25.215 (2007-11), Physical layer - Measurements (FDD) (Release 7).

3GPP TS 25.401 (2007-09), UTRAN overall description (Release 7).

3GPP TS 25.413 (2007-09), UTRAN Iu interface RANAP signalling (Release 7).

3GPP2 C.S0004-D (2004-02), Signaling Link Access Control (LAC) Standard for cdma2000 Spread Spectrum Systems.

ANSI X3.159-1989: Programming Language C.²

IEEE P802.1aj™/D2.2, (2007-10), Draft Standard for Local and Metropolitan Area Networks—Virtual Bridged Local Area Networks—Amendment 08: Two-Port Media Access Control (MAC) Relay.^{3, 4, 5}

IEEE P802.11u™/D3.0, (2008-05) (this version), Draft Amendment to Standard for Information Technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements; Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Amendment 7: Interworking with External Networks.

IEEE P802.16Rev2/D5.0, (2008-06), 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 802.11™-2007, Information Technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements—Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

IEEE Std 802.11k™-2008, Information Technology—Telecommunications and information exchange between systems—Local and metropolitan area networks—Specific requirements; Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) specifications; Amendment 1: Radio Resource Measurement of Wireless LANs.

IEEE Std 802.16™-2004 [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.

²ANSI publications are available from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

³IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, Piscataway, NJ 08854, USA (<http://standards.ieee.org/>).

⁴The IEEE standards or products referred to in this clause are trademarks of the Institute of Electrical and Electronics Engineers, Inc.

⁵Numbers preceded by P are IEEE authorized standards projects that were not approved by the IEEE-SA Standards Board at the time this publication went to press. For information about obtaining drafts, contact the IEEE.

IEEE Std 802.16e™-2005 [ISO/IEC 8802-16: 2005], 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 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in Licensed Bands and Corrigendum 1.

IEEE Std 802.3™-2005, 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.

IETF RFC 1661 (1994-07), The Point-to-Point Protocol (PPP).⁶

IETF RFC 2865 (2000-06), Remote Authentication Dial In User Service (RADIUS).

IETF RFC 2988 (2000-11), Computing TCP's Retransmission Timer.

IETF RFC 3344 (2002-08), IP Mobility Support for IPv4.

IETF RFC 3588 (2003-09), Diameter Base Protocol.

IETF RFC 3775 (2004-06), Mobility Support in IPv6.

IETF RFC 3825 (2004-07), Dynamic Host Configuration Protocol Option for Coordinate-based Location Configuration Information.

IETF RFC 4119 (2005-12), A Presence-based GEOPRIV Location Object Format.

IETF RFC 4140 (2005-08), Hierarchical Mobile IPv6 Mobility Management (HMIPv6).

IETF RFC 4282 (2005-12), The Network Access Identifier.

IETF RFC 4555 (2006-06), IKEv2 Mobility and Multihoming Protocol (MOBIKE).

IETF RFC 4776 (2006-11), Dynamic Host Configuration Protocol (DHCPv4 and DHCPv6) Option for Civic Addresses Configuration Information.

IETF RFC 4857 (2007-06), Mobile IPv4 Regional Registration.

IETF RFC 4881 (2007-06), Low-Latency Handoffs in Mobile IPv4.

IETF RFC 5268 (2008-06), Mobile IPv6 Fast Handovers.

ISO 3166-1 (1997), Codes for the representation of names of countries and their subdivisions—Part 1: Country codes.⁷

ISO 4217, Codes for the Representation of Names of Countries.

ITU-T Recommendation X.290 (1995), OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications—General concepts.⁸

⁶IETF RFCs are available from the Internet Engineering Task Force website at <http://www.ietf.org/rfc.html>.

⁷ISO publications are available from the ISO Central Secretariat, Case Postale 56, 1 rue de Varembe, CH-1211, Genève 20, Switzerland/Suisse (<http://www.iso.ch/>). ISO publications are also available in the United States from the Sales Department, American National Standards Institute, 11 West 42nd Street, 13th Floor, New York, NY 10036, USA (<http://www.ansi.org/>).

ITU-T Recommendation X.296 (1995), OSI conformance testing methodology and framework for protocol Recommendations for ITU-T applications—Implementation conformance statements.

ITU-T Recommendation Y.1540, Internet protocol data communication service—IP packet transfer and availability performance parameters.

W3C Recommendation, RDF/XML Syntax Specification.⁹

W3C Recommendation, Resource Description Framework (RDF)—Concepts and Abstract Syntax.

W3C Recommendation, SPARQL Query Language for RDF.

⁸ITU-T publications are available from the International Telecommunications Union, Place des Nations, CH-1211, Geneva 20, Switzerland/Suisse (<http://www.itu.int/>).

⁹W3C recommendations are available from <http://www.w3.org>.

3. Definitions

For the purpose of this standard, the following terms and definitions apply. *The Authoritative Dictionary of IEEE Standards Terms* [B17]¹⁰ should be referenced for terms not defined in this clause.

3.1 candidate point of attachment (candidate PoA): A point of attachment (PoA) under evaluation to which the link may be switched.

3.2 dual-radio operation: In this mode a dual radio device can receive and transmit simultaneously on both the radios. Since both radios can be active simultaneously in these types of devices, the target radio connects with the target network to prepare the target network for handover. The source radio maintains connection with the source network during the handover. *See also:* **single-radio operation**.

3.3 handover: The process by which a mobile node obtains facilities and preserves traffic flows upon occurrence of a link switch event. The mechanisms and protocol layers involved in the handover can 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. *See also:* **hard handover; soft handover; seamless handover**.

3.4 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).

3.5 handover policies: A set of rules that contribute to making the handover decision for a mobile node.

3.6 home subscriber network: Network managed by an operator with whom the subscriber has a business relationship (subscription). *See also:* **visited network; serving network**.

3.7 horizontal handovers: A handover where a mobile node moves between point of attachments of the same link type (in terms of coverage, data rate and mobility), such as universal mobile telecommunications systems (UMTS) to UMTS or wireless local area network (WLAN) to WLAN. *Syn:* **intra-technology handovers**.

3.8 inter-technology handovers: *See:* **vertical handovers**.

3.9 intra-technology handovers: *See:* **horizontal handovers**.

3.10 link: A communication channel through which nodes communicate for the exchange of L2 protocol data units. Each link is associated with two endpoints and has a unique identifier.

3.11 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.

3.12 link indication: Link state information provided by the link layer to higher layers.

3.13 link switch: The process by which a mobile node changes the link that connects it to the network. Changing a link implies changing the remote link endpoint and therefore the point of attachment of the mobile node.

¹⁰The numbers in brackets correspond to those of the bibliography in Annex A.

3.14 lower layers: The layers located at OSI Level 2 and below across different link-layer technology standards supported by this standard. For example, the IEEE 802.11 Lower Layers are the MAC sublayer and the PHY, while the 3GPP Lower Layers are L1/MAC/radio link control (RLC)/packet data convergence protocol (PDCP) in the case of wideband code division multiple access (W-CDMA) frequency division duplex (FDD)/time division duplex (TDD), L1/LAPDm in the case of GSM CS, and L1/MAC/RLC in the case of general packet radio service (GPRS)/ Enhanced GPRS (EGPRS), respectively. The term “Lower Layers” also includes Logical Link Control Layers such as IEEE 802.2 Logical Link Control (LLC) or 3GPP Radio Link Control (RLC). The MIHF uses the services provided by these layers.

3.15 media independent handover (MIH) discovery protocol: A protocol for discovering media independent handover (MIH) entities.

3.16 media independent handover (MIH) network entity: Network entity with media independent handover function (MIHF) capability.

3.17 media independent handover point of service (MIH PoS): Network-side MIHF instance that exchanges MIH messages with an MN-based MIHF. The same MIH Network Entity includes an MIH PoS for each MIH-enabled mobile node with which it exchanges MIH messages. A single MIH PoS can host more than one MIH service. The same MIH Network Entity can include multiple MIH Points of Service that can provide different combinations of MIH services to the respective mobile nodes based on subscription or roaming conditions. Note that for a network entity comprising multiple interfaces, the notion of MIH PoS is associated with the network entity itself and not with just one of its interfaces.

3.18 media independent handover (MIH) node: An media independent handover function (MIHF) capable entity (mobile node or network).

3.19 media independent handover (MIH) non-PoS: An MIH network entity that can directly exchange MIH messages with other MIH network entities but cannot *directly* exchange MIH messages with any MIH enabled mobile node.

3.20 media independent handover (MIH) transport protocol: A protocol for transporting MIH protocol messages between a pair of MIH entities.

3.21 media independent handover (MIH) users: Entities that use the services provided by the MIHF. MIH users use the MIH_SAP to interact with the MIHF.

3.22 media independent handover function (MIHF): A function that realizes MIH services.

3.23 media independent handover function (MIHF) pairing: The communication relationship that exists between different MIHF instances when they exchange MIH messages or MIH information.

3.24 media independent handover function (MIHF) transaction: A combination of an MIH Request message and MIH Response message, MIH Indication, or MIH Response message and any associated MIH Acknowledgement messages.

3.25 mobile-controlled handover: The mobile node has the primary control over the handover process.

3.26 mobile-initiated handover: The mobile node initiates the handover process by indicating to the network that the handover is necessary or desired.

3.27 mobile node (MN): Communication node that can change its point of attachment from one link to another.

3.28 mobile node association: The connectivity state where the mobile node is ready to exchange user data [like transmission control protocol (TCP) / user datagram protocol (UDP) packets] with the network point of attachment.

3.29 network detection: The process by which a mobile node collects information on networks in its locality, identifies the different points of attachment, and ascertains the validity of link-layer configuration.

3.30 network entity: A communication node inside the network.

3.31 network-controlled handover: A handover where the network has the primary control over the handover process.

3.32 network-initiated handover: The network initiates the handover process by indicating to the mobile node that the handover is necessary or desired.

3.33 network neighborhood: The area of interest in which the network discovery and selection entity seeks to determine the available coverage of a wired/wireless network with identical or different link-layer technologies.

3.34 network point of attachment (network PoA, or PoA): The network side endpoint of a layer 2 link that includes a mobile node as the other endpoint. *See also:* **candidate PoA; serving PoA; target PoA.**

3.35 network selection: The process by which a mobile node or a network entity makes a decision to connect to a specific network (possibly out of many available) based on a policy configured in the mobile node and/or obtained from the network.

3.36 network selector: The entity that undertakes the network selection decisions that can lead to a handover.

3.37 operator identifier (operator ID): An identifier of the access or core network provider.

3.38 PICS Proforma: A normative document to express in compact form the static conformance requirements of a specification. As such, it serves as a reference to the static conformance review.

3.39 seamless handover: A handover associated with a link switch between points of attachment, 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.

3.40 serving network: A network that provides services to the user. The serving network can be a home subscriber network or a visited network. *See also:* **visited network; home subscriber network.**

3.41 serving point of attachment (serving PoA): The PoA of the current link being used by the mobile node.

3.42 single-radio operation: In this mode, a dual radio device can receive and transmit on only one radio at a time. This is usually the mode of operation when radio frequencies of the two radios are close to each other (e.g., in IMT 2000 bands). Since only one radio can be active at a time in these types of devices, the source radio uses the back-end connection of the source network with the target network to prepare the target network for handover while maintaining the client side connections. Once the target preparation is complete the device switches from source radio to target radio. Since all the target preparation has been completed a priori, the target radio quickly establishes connectivity with the target network and all the connections are then transferred from source network to target network. *See also:* **dual-radio operation.**

3.43 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).

3.44 static conformance requirement: One of the requirements that specify the limitations on the combinations of implemented capabilities permitted in a real open system, which is claimed to conform to the relevant specification(s).

3.45 static conformance review: A review of the extent to which the static conformance requirements are claimed to be supported by the system under test, by comparing the answers in the implementation conformance statement(s) and the system conformance statement with the static conformance requirements expressed in the relevant specifications.

3.46 target point of attachment (target PoA): A candidate PoA that has been selected to become the new serving PoA.

3.47 vertical handovers: A handover where the mobile node moves between point of attachments of different link types, such as from universal mobile telecommunications system (UMTS) to wireless area network (WLAN). *Syn:* **inter-technology handovers.**

3.48 visited network: A network managed by an operator other than the subscriber's home operator and in which the subscriber is receiving service. *See also:* **home subscriber network; serving network.**

4. Abbreviations and acronyms

The following abbreviations and acronyms are used in this standard:

3G	3rd generation
3GPP	3rd Generation Partnership Project
3GPP2	3rd Generation Partnership Project 2
AAA	authentication, authorization, and accounting
ACK	acknowledgement
AID	action identifier
AP	access point
AR	access router
BCE	binding cache entry
BS	base station
BTS	base transceiver station
CoA	care-of address
CoS	class of service
CS	convergence sublayer / command service
DCD	downlink channel descriptor
DHCP	dynamic host configuration protocol
ES	event service
ESS	extended service set
FA	foreign agent
GPRS	general packet radio service
GSM	global system for mobile communication
HESSID	homogenous extended service set ID
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	internet protocol
IS	information service
ITU	International Telecommunications Union
L1	layer 1 (PHY)
L2	layer 2 (MAC and/or LLC)
LAN	local area network
LbyR	location by reference
LCP	location configuration protocol
LLC	logical link control
LMA	local mobility anchor
LSAP	logical link control service access point
LTE	long term evolution
MAC	medium access control
MAG	mobile access gateway
MICS	media independent command services
MIES	media independent event services
MIH	media independent handover
MIHF	media independent handover function
MIIS	media independent information service
MIP	mobile IP
MLME	MAC layer management entity
MN	mobile node
MPLS	multi-protocol label switching
MS	mobile station
MSB	most significant bit
MSDU	medium access control (MAC) service data unit

MSGCF	MAC state generic convergence function
N/A	not applicable
NAI	network access identifier
NAS	network access server
NCMS	network control and management system
OUI	organizationally unique identifier
PDU	protocol data unit
PHY	physical layer
PLME	physical layer management entity
PLMN	public land mobile network
PoA	point of attachment
PoS	point of service
PPP	point-to-point protocol
PSAP	public safety answering point
QoS	quality of service
RAT	radio access technology
RDF	resource description framework
RFC	request for comment
RLC	radio link control
RNC	radio network controller
RSNA	robust security network association
RSSI	received signal strength indication
SAP	service access point
SCTP	stream control transmission protocol
SDO	standards development organization
SDU	service data unit
SIB	system information block
SID	service identifier
SINR	signal over interference plus noise ratio
SIP	session initiation protocol
SLA	service level agreement
SM	session management
SME	station management entity
SNR	signal-to-noise ratio
SS	subscriber station
STA	station
TCP	transmission control protocol
TLV	type-length-value
UDP	user datagram protocol
UE	user equipment
UIR	unauthenticated information request
UMTS	universal mobile telecommunications system
URL	uniform resource locator
WLAN	wireless local area network
XML	extensible mark-up language

5. General architecture

5.1 Introduction

5.1.1 General

This standard supports different 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 MN and the network.

Handover decision making involves cooperative use of both MN and network infrastructure. Handover control, handover policies, and other algorithms involved in handover decision making are generally handled by communication system elements that do not fall within the scope of this standard. However, it is beneficial to describe certain aspects of the overall handover procedure so that the role and purpose of the MIH services in the handover process are clear. The following subclauses give an overview of how the different factors that affect handovers are addressed within this standard.

5.1.2 Service continuity

Service continuity is defined as the continuation of the service during and after the handover while minimizing aspects such as data loss and duration of loss of connectivity during the handover without requiring any user intervention. The change of access network need not be noticeable to the end user. However, irrespective of that, there should be no need for the user to re-establish the service. There can 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 quality of service (QoS) supported by the new access network is unacceptable, higher layer entities can decide not to handover or terminate the current session after the handover based on applicable policies. This standard specifies essential elements that enable service continuity.

5.1.3 Application class

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

5.1.4 Quality of service

The quality of the service (QoS) experienced by an application depends on the accuracy, speed, and availability of the information transfer in the communication channel. This standard provides support for fulfilling application QoS requirements during handover.

There are two aspects of QoS to consider in the context of IEEE 802.21. First, there is the QoS experienced by an application during a handover. Secondly, there is the QoS considered as part of a handover decision. This standard includes mechanisms that support both aspects of QoS towards enabling seamless mobility; however the MIHF alone cannot guarantee seamless mobility. Depending on the QoS requirements of the end-to-end application, seamless mobility implies minimizing the handover latency and packet loss so as to minimize the end-to-end delay and the loss of transmitted information. Seamless mobility also implies the timely assessment of network conditions, such as the monitoring of packet loss on the current link and signal strength from both current and target networks, in order to optimize the handover decision and its execution.

The MIH QoS model (see Annex B) defines parameters that are used to set the requirements and assess the performance of packet transfers between a source and its destinations. When used in threshold-setting commands (such as MIH_Link_Configure_Thresholds), these parameters describe the QoS requirements of the MIH user. On the other hand, when used in parameter-reporting events (such as MIH_Link_Parameters_Report) and parameter-extraction commands (such as MIH_Link_Get_Parameters), they characterize current network conditions. Therefore, depending on their usage these parameters can represent either static QoS requirements or dynamic network measurements.

5.1.5 Network discovery

This standard defines the information that helps in network discovery and specifies the means by which such information can be obtained and be made available to the MIH users. The network information includes information about link type, link identifier, link availability, link quality, etc.

5.1.6 Network selection

Network selection is the process by which an MN or a network entity selects a network (possibly out of many available) to establish network-layer connectivity. The selection is based on various criteria such as required QoS, cost, user preferences, or the network operator's policies. This standard specifies means by which such information can be made available to the MIH users to enable effective network selection.

5.1.7 Power management

This standard allows the MN to discover different types of wireless networks (e.g., IEEE 802.11, IEEE 802.16, and 3GPP networks), avoiding powering-up of multiple radios and/or excessive scanning at the radios. Thus, this standard minimizes power consumed by mobile devices in the discovery of potential handover candidates. Specific power management mechanisms deployed are dependent on individual link-layer technologies and the potential power management benefits from this standard only extend to the discovery of wireless networks.

5.1.8 Handover policy

The primary role of the MIHF is to facilitate handovers and provide intelligence to the network selector entity. The MIHF aids the network selector entity with the help of the event service, command service, and information service. The network selector entity and the handover policies that control handovers are outside the scope of this standard.

5.2 General design principles

5.2.1 MIHF design principles

This standard is based on the following general design principles:

- a) MIHF is a logical entity that facilitates handover decision making. MIH users make handover decisions based on inputs from the MIHF.
- b) MIHF provides abstracted services to higher layers. The service primitives defined by this interface are based on the technology-specific protocol entities of the different access networks. The MIHF communicates with the lower layers of the mobility-management protocol stack through technology-specific interfaces.
- c) Higher layer mobility management protocols specify handover signaling mechanisms for vertical handovers. Additionally, different access network technologies have defined handover signaling mechanisms to facilitate horizontal handover. The definition of such handover signaling mechanisms is outside the scope of this standard except in the case of handovers across ESSs in

IEEE Std 802.11. The role of this standard (IEEE Std 802.21) is to serve as a handover facilitating service and to maximize the efficiency of such handovers by providing appropriate link-layer intelligence and network information.

- d) The standard provides support for remote events. Events are advisory in nature. The decision whether to cause a handover or not based on these events is outside the scope of this standard.
- e) The standard supports transparent operation with legacy equipment. IEEE 802.21 standard compatible equipment should be able to co-exist with legacy equipment.

5.2.2 QoS design principles

In the context of this standard it is assumed that applications communicate via a communication channel that is considered to be composed of several connected segments, each under a possibly different but cooperative administrative authority. Examples of such channels [e.g., for internet protocol (IP) traffic] have been detailed in ITU-T Recommendation Y.1540.

It is generally accepted that, based on the required accuracy of information transfer, applications can be grouped into a small number of behavioral sets (ITU-T Recommendation Y.1540) called *class of service* (CoS). Support for differentiation via CoS is pervasive in many of the IEEE 802 based standards (IEEE Std 802.11, IEEE Std 802.1qTM, IEEE Std 802.16, etc.).

It is assumed that the classes of service definitions used within this standard conform to ITU-T Recommendation Y.1540.

5.3 MIHF service overview

5.3.1 General

This standard defines services that comprise the MIHF service; these services facilitate handovers between heterogeneous access links.

- a) A media independent event service (MIES) that provides event classification, event filtering and event reporting corresponding to dynamic changes in link characteristics, link status, and link quality.
- b) A media independent command service (MICS) that enables MIH users to manage and control link behavior relevant to handovers and mobility.
- c) A media independent information service (MIIS) that provides details on the characteristics and services provided by the serving and neighboring networks. The information enables effective system access and effective handover decisions.

The MIHF 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 MIH users use the event service, command service, and information service provided by MIHF to manage, determine, and control the state of the underlying interfaces.

These services provided by MIHF help the MIH users in maintaining service continuity, service adaptation to varying quality of service, battery life conservation, network discovery, and link selection. In a system containing heterogeneous network interfaces of IEEE 802 types and cellular (3GPP, 3GPP2) types, the MIHF helps the MIH users to implement effective procedures to couple services across heterogeneous network interfaces. MIH users utilize services provided by the MIHF across different entities to query resources required for a handover operation between heterogeneous networks.

MIH Services in mobile nodes facilitate seamless handovers between heterogeneous networks. MIH Services are used by MIH users such as a mobility management protocol (e.g., Mobile IP). Other mobility management protocols (in addition to Mobile IP) and even other MIH users are not precluded from making use of MIH Services.

5.3.2 Media independent event service

5.3.2.1 General

Events indicate changes in state and transmission behavior of the physical, data link and logical link layers, or predict state changes of these layers. The event service is also used to indicate management actions or command status on the part of the network or some management entity.

5.3.2.2 Event origination

Events originate from the MIHF (MIH Events) or any lower layer (Link Events) within the protocol stack of an MN or network node, as shown in Figure 12.

5.3.2.3 Event destination

The destination of an event is the MIHF or any upper layer entity. The recipient of the event is located within the node that originated the event or within a remote node. The destination of an event is established with a subscription mechanism that enables an MN or network node to subscribe its interest in particular event types.

5.3.2.4 Event service flow

In the case of local events, messages often propagate from the lower layers (e.g., PHY, MAC) to the MIHF and from MIHF to any upper layer. In case of remote events, messages propagate from the MIHF in one protocol stack to the MIHF in the peer protocol stack. One of the protocol stacks can be present in an MN while the other can be present in a fixed network entity. This network entity is the point of attachment or any node not directly connected to the other protocol stack.

5.3.2.5 Event service use cases and functions

The event service is used to detect the need for handovers. For example, an indication that the link will cease to carry MAC service data units (SDUs) at some point in the near future is used by MIH users 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 needed to handover between attachment points.

Events carry additional context data such as a layer 2 (MAC and/or LLC) (L2) identifier or L3 identifier. A Link_Up event can also carry a new IP address acquisition indication that informs the upper layers of the need to initiate a layer 3 handover.

5.3.3 Media independent command service

5.3.3.1 General

The command service enables higher layers to control the physical, data link, and logical link layers (also known as “lower layers”). The higher layers control the reconfiguration or selection of an appropriate link through a set of handover commands. If an MIHF supports the command service, all MIH commands are mandatory in nature. When an MIHF receives a command, it is always expected to execute the command.

5.3.3.2 Command origination

Commands are invoked by MIH users (MIH Commands), as well as by the MIHF itself (Link Commands), as shown in Figure 15.

5.3.3.3 Command destination

The destination of a command is the MIHF or any lower layer. The recipient of a command is located within the protocol stack that originated the command, or within a remote protocol stack.

5.3.3.4 Command service flow

In the case of local commands, messages often propagate from the MIH users (e.g., policy engine) to the MIHF and then from MIHF to lower layers. In the case of remote commands, messages propagate from MIH users via MIHF in one protocol stack to the MIHF in a peer protocol stack (with the use of the MIH Protocol). One of the protocol stacks can be present in an MN while the other can be present in a fixed network entity. This network entity is either a point of attachment or any node not directly connected to the other protocol stack.

5.3.3.5 Command service use cases and functions

The commands generally carry the upper layer decisions to the lower layers on the local device entity or at the remote entity. For example the command service can be used by the policy engine of an entity in the network to request an MN to switch between links (remote command to lower layers on MN protocol stack).

This standard facilitates both mobile-initiated and network-initiated handovers. Handovers are initiated by changes in the wireless environment that leads to the selection of a network that supports a different access technology other than the serving network.

During network selection, the MN and the network need to exchange information about available candidate networks and select the best network. The network selection policy engine can select a different network than the current one, which can necessitate an inter-technology handover. Network selection and handover initiation are outside the scope of mobility management protocols such as mobile IP (MIP) and session initiation protocol (SIP). Once a new network has been selected and handover has been initiated, mobility management protocols handle packet routing aspects such as address update and transfer of packet delivery to the new network.

This standard supports a set of media independent commands that help with network selection under different conditions. These commands allow both the MN and the network to initiate handovers and exchange information about available networks and negotiate the best available network under different conditions. Please refer to the flow diagrams in Annex C for more information. These commands do not affect packet routing aspects and can be used in conjunction with other mobility management protocols such as MIP and SIP to perform inter-technology handovers.

5.3.4 Media independent information service

The media independent information service (MIIS) provides a framework and corresponding mechanisms by which an MIHF entity can discover and obtain network information existing within a geographical area to facilitate the handovers.

The neighboring network information discovered and obtained by this framework and mechanisms can also be used in conjunction with user and network operator policies for optimum initial network selection and access (attachment), or network re-selection in idle mode.

MIIS primarily provides a set of information elements (IEs), the information structure and its representation, and a query/response type of mechanism (pull mode) for information transfer. The information can also include inter-technology handover policies. The definition of such policies is outside the scope of this standard. MIIS also supports a push mode wherein the information can be pushed to the MN by the operator. The information can be present in an information server from where the MIHF in the MN accesses it. The definition of the information server is outside the scope of this standard. In other cases information can be present locally in the MN, and can be learned by the MN or pre-provisioned, or both. The definition of and indexing of such a local database, as well as the regime for maintaining it or accessing it, are outside the scope of this standard.

The information is made available via both lower and higher layers. Information is made available at L2 through both a secure and a non-secure port. Information available through the non-secure port allows a network selection decision to be made before incurring the overhead of authentication and the establishment of a secure L2 connection with the network.

In certain scenarios information cannot be accessed at L2, or the information available at L2 is not sufficient to make an intelligent handover decision. In such cases information can be accessed via higher layers. Hence this standard enables both L2 and L3 transport options for information access. The selected transport option is expected to provide security, such as data integrity and data confidentiality, for the information access.

MIIS typically provides static link-layer parameters such as channel information, the MAC address and security information of a point of attachment (PoA). Information about available higher layer services in a network can also help in more effective handover decision making before the MN actually attaches to any particular network.

The information provided by MIIS conforms to the structure and semantics specified within this standard. MIIS specifies a common (or media independent) way of representing this information across different technologies by using a standardized format such as extensible mark-up language (XML) or binary encoding. A structure of information is defined as a schema.

MIIS provides the ability to access information about all networks in a geographical area from any single L2 network, depending on how the IEEE 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 network is outside the scope of the standard. Typically, in a heterogeneous network composed of multiple media types, the network selector 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. Some IEEE standards define similar means and support MNs 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. MIIS defines a unified mechanism to the higher layer entities to provide handover candidate information in a heterogeneous network environment by a given geographical location. However, the algorithm for deciding what information to provide is out of scope. In the larger view, the objective is to help the higher layer mobility protocol to acquire a global view of the heterogeneous networks to effect seamless handover across these networks.

5.4 Media independent handover reference framework

5.4.1 General

The following subclause describes the key points with regards to communication between different MIHF entities in the MN and the network. The reference points in this subclause (5.4) are for illustration only. This subclause does not define any specific deployed network system architecture.

5.4.2 MIHF communication model

MIH Functions communicate with each other for various purposes. The MN exchanges MIH information with its MIH point of service (PoS). The MIHF in any Network Entity becomes an MIH PoS when it communicates directly with an MN-based MIHF. When an MIHF in a Network Entity does not have a direct connection to the MN, it does not act as an MIH PoS for that particular MN. However the same MIH Network Entity can still act as MIH PoS for a different MN.

An MN can have multiple L2 interfaces. However, MIHF communication need not take place on all L2 interfaces of an MIH-capable MN. As an example, on an MIH-capable MN with three L2 interfaces, namely IEEE 802.11, IEEE 802.16, and IEEE 802.3, the IEEE 802.3 interface might be used only for system administration and maintenance operations, while the IEEE 802.11 and IEEE 802.16 interfaces might engage in the provisioning of MIHF services. The MN can use L2 transport for exchanging MIH information with an MIH PoS that resides in the same Network Entity as its Network PoA. The MN can use L3 transport for exchanging MIH information with an MIH PoS that does not reside in the same Network Entity as its Network PoA. The framework supports use of either L2 or L3 mechanisms for communication among MIH network entities.

Figure 2 shows the MIHF communication model. The model shows MIHFs in different roles and the communication relationships among them. The communication relationship shown in Figure 2 applies only to MIHFs. It is important to note that each of the communication relationships in the communication model does not imply a particular transport mechanism. Rather, a communication relationship only intends to show that passing MIHF-related information is possible between the two different MIHFs. Moreover, each communication relationship shown in the diagram encompasses different types of interfaces, different transport mechanisms used (e.g., L2, L3), and different MIHF service related content being passed (e.g., MIIS, MICS, or MIES).

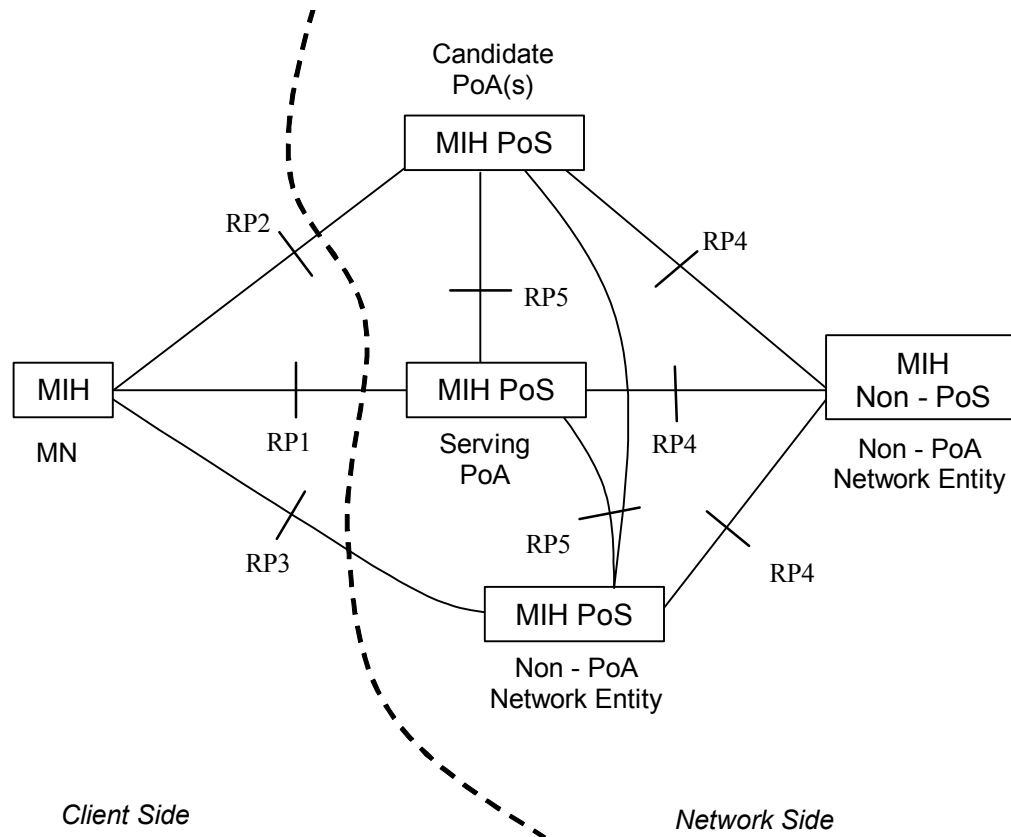


Figure 2—MIHF communication model

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

- a) MIHF on the MN
- b) MIH PoS on the Network Entity that includes the serving PoA of the MN
- c) MIH PoS on the Network Entity that includes a candidate PoA for the MN
- d) MIH PoS on a Network Entity that does not include a PoA for the MN
- e) MIH non-PoS on a Network Entity that does not include a PoA for the MN

The communication model also identifies the following reference points between different instances of MIHFs (see Table 1).

- **Reference point RP1:** Reference point RP1 refers to MIHF procedures between the MIHF on the MN and the MIH PoS on the Network Entity of its serving PoA. RP1 encompasses communication interfaces over both L2 and L3 and above. MIHF content passed over RP1 are related to MIIS, MIES, or MICS.
- **Reference point RP2:** Reference point RP2 refers to MIHF procedures between the MIHF on the MN and the MIH PoS on the Network Entity of a candidate PoA. RP2 encompasses communication interfaces over both L2 and L3 and above. MIHF content passed over RP2 are related to MIIS, MIES, or MICS.
- **Reference point RP3:** Reference point RP3 refers to MIHF procedures between the MIHF on the MN and the MIH PoS on a non-PoA Network Entity. RP3 encompasses communication interfaces

- over L3 and above and possibly L2 transport protocols like Ethernet bridging, or multi-protocol label switching (MPLS). MIHF content passed over RP3 are related to MIIS, MIES, or MICS.
- **Reference point RP4:** Reference point RP4 refers to MIHF procedures between an MIH PoS in a Network Entity and an MIH non-PoS instance in another Network Entity. RP4 encompasses communication interfaces over L3 and above. MIHF content passed over RP4 are related to MIIS, MIES, or MICS.
 - **Reference point RP5:** Reference point RP5 refers to MIHF procedures between two MIH PoS instances in different Network Entities. RP5 encompasses communication interfaces over L3 and above. MIHF content passed over RP5 are related to MIIS, MIES, or MICS.

Table 1—Summary of reference points

Reference point	Description
RP1	Between the MIHF on an MN and an MIH PoS on the Network Entity of the serving PoA.
RP2	Between the MIHF on an MN and an MIH PoS on the Network Entity of the candidate PoA.
RP3	Between the MIHF on an MN and an MIH PoS on a non-PoA network entity.
RP4	Between an MIHF PoS and an MIH non-PoS instance in different Network Entities.
RP5	Between two MIH PoS instances in different Network Entities.

All reference point definitions are within the scope of this standard. Annex D provides a mapping of various MIH messages to the reference points.

5.4.3 A deployment example for the MIH services

A network model including MIH services is shown in Figure 3 to better illustrate the MIH Reference Points. Moving from left to right, the model includes an MIH-capable mobile node (MN, far left) that supports multiple wired and wireless access technologies. The model assumes that the serving network either operates multiple link-layer technologies or allows its user to roam into other networks when a service level agreement (SLA) in support of inter-working has been established.

The model illustrates access networks that are connected in some loose, serial way to a given core network (i.e., Core Operator 1, 2, or 3). Also depicted is an access network that is more tightly coupled (Access Network-3). Not depicted in Figure 3, an access network can also connect to a core network via the Internet. Each Core Operator network (1, 2, or 3) might represent a service provider, corporate intranet provider, or just another part of the visited or home access. In this depicted model, the provisioning provider is operating Access Network-3, which couples the terminal to the core (labeled Home Core Network) via RP1. At any given point in time, the subscriber's serving network can be the home subscriber network or a visited network.

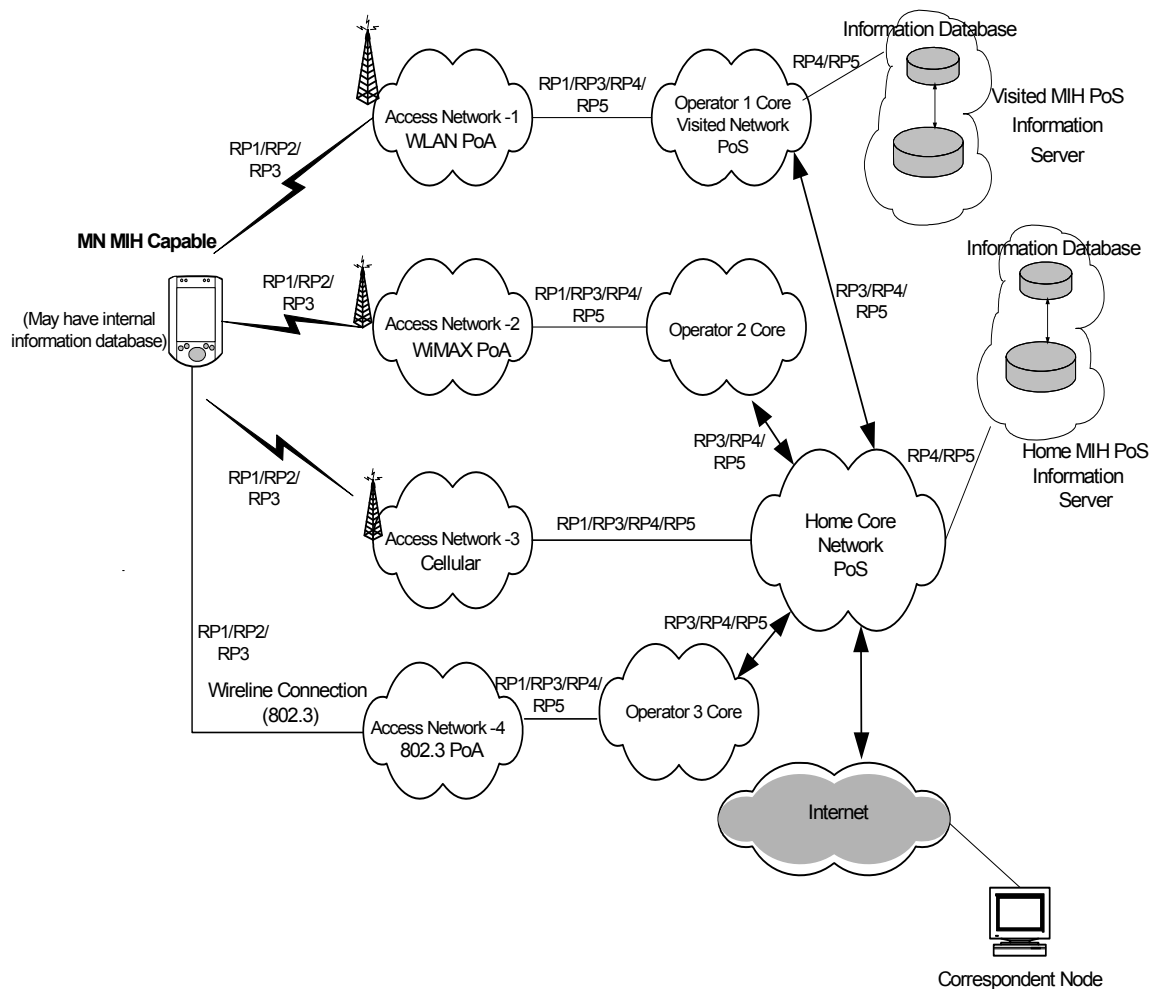


Figure 3—Example of network model with MIH services

The network providers offer MIH services in their access networks (Access Network 1 to 4) in order to facilitate heterogeneous handovers into their networks. Each access technology either advertises its MIH capability or responds to MIH service discovery. Each service provider for these access networks allows access to one or more MIH Points of Service (PoS) node(s). These PoS nodes provide some or all of the MIH services as determined during the MIH capabilities discovery. The PoS location varies based on the operator deployment scenario and the technology-specific MIH architecture.

An MIH PoS resides next to, or is co-located with, the point of attachment (PoA) node in the access network (e.g., Access Network 1, 2, 4). Alternatively the PoS can reside deeper inside the access or core networks (e.g., Access Network 3). As shown in Figure 3, the MIH entity in the MN can communicate with MIH network entities using reference points RP1, RP2, or RP3 over any of the available access networks. If the PoA in the serving access network has a co-located MIHF, the RP1 reference point terminates at the PoA that is also the PoS (MN to Access Network 1, 2, 4 of the model can all be RP1). In that case, an RP3 reference point would be terminated at any non-PoA (illustrated by MN connectivity to Access Networks 1, 2, 4). MIH events originate at both sides of an active RP1 link. The MN is typically the first node to react to these events.

The interaction of visited and home subscriber networks 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

subscriber network allows the MN to access the public Internet directly through a visited network. As illustrated, two MIH network entities communicate with each other via RP4 or RP5 reference points. The MIH-capable PoA communicate with other MIH network entities via RP4 and RP5 reference points. The MIH-capable MN have MIH communication with other PoA in the candidate access networks via the RP2 reference point to obtain Information Services about the candidate network.

With regard to the MIH Information Service, visited providers can offer access to their information server located in an MIH PoS node (upper far right). The operator provides the MIIS to mobile nodes so they can obtain pertinent information including, but not limited to, new roaming lists, costs, provider identification information, provider services, priorities, and any other information that would enable the selection and utilization of these services. As illustrated, it is possible for the MN to be pre-provisioned with MIIS data by its provider. It is also possible for the MN to obtain MIH Information Services from any access network of its service provider or from visited networks that maintain SLA agreements with the MN's service provider. MIIS can also be available from another overlapping or nearby visited network, using that network's MIIS point of service. The serving network utilizes RP4 and RP5 interfaces to access other MIH entities. As an example, in Figure 3 the home subscriber network accesses its own MIH information server or core operator 1 (visited network) MIH information server.

5.5 MIHF reference models for link-layer technologies

The MIHF provides asynchronous and synchronous services through well-defined service access points for MIH users. The following subclauses (5.5.1 through 5.5.7) describe the reference models for various link-layer technologies with MIH functionality.

5.5.1 IEEE 802 architectural considerations

The MIH reference models for different IEEE 802 technologies and the general MIH framework is designed to be consistent with the IEEE 802 Architecture for different link-layer technologies. The MIH Function is a management entity that obtains link-layer information from lower layers of different protocol stacks and also from other remote nodes. The MIH Function coordinates handover decision making with other peer MIH Functions in the network.

The MIH Protocol provides the capability for transferring MIH messages between peer MIH Function entities at L2 or at L3. These messages transfer information about different available networks and also provide network switching and handover capability across different networks. The MIH protocol encompasses IEEE 802 technologies such as IEEE 802.11 and IEEE 802.16 and also other non-IEEE 802 technologies such as those specified by 3GPP and 3GPP2 standards. In this sense, the MIH Protocol has different scope and functionality than the Link Layer Discovery Protocol (LLDP) as specified by IEEE Std 802.1AB™ [B18].

5.5.2 General MIHF reference model and SAPs

Figure 4 illustrates the position of the MIHF in a protocol stack and the interaction of the MIHF with other elements of the system. All exchanges between the MIHF and other functional entities occur through service primitives, grouped in service access points (SAPs).

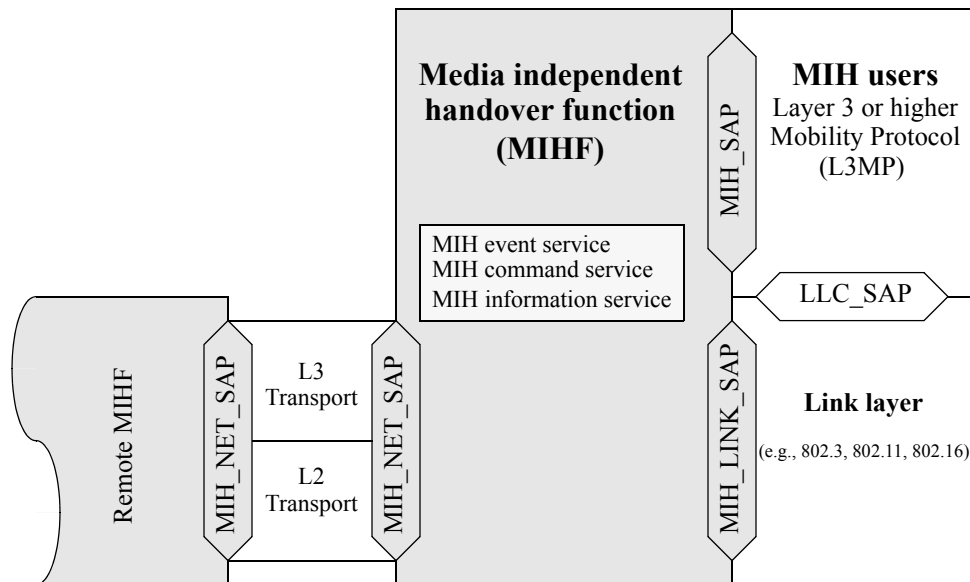


Figure 4—General MIHF reference model and SAPs

The media agnostic general MIH reference model includes the following SAPs:

- MIH_SAP: Media independent interface of MIHF with the upper layers of the protocol stack.
- MIH_LINK_SAP: Abstract media dependent interface of MIHF with the lower layers of the media-specific protocol stacks.
- MIH_NET_SAP: Abstract media dependent interface of MIHF that provides transport services over the data plane on the local node, supporting the exchange of MIH information and messages with the remote MIHF. For all transport services over L2, the MIH_NET_SAP uses the primitives specified by the MIH_LINK_SAP.

In the media-specific reference models, the media independent SAP (MIH_SAP) always maintains the same name and same set of primitives. The media dependent SAP (which is a technology-specific instantiation of the MIH_LINK_SAP), assumes media-specific names and sets of primitives, often reusing names and primitives that already exist in the respective media-specific existing lower-layer SAPs. Primitives defined in MIH_LINK_SAP result in amendments to media-specific SAPs due to additional functionality being defined for interfacing with the MIHF. All communications of the MIHF with the lower layers of media-specific protocol stacks take place through media-specific instantiations of MIH_LINK_SAP.

The message exchanges between peer MIHF instances, in particular the type of transport that they use, are sensitive to several factors, such as the nature of the network nodes that contain the peer MIHF instances (whether or not one of the two is an MN or a PoA), the nature of the access network (whether IEEE 802 or 3G cellular), and the availability of MIH capabilities at the PoA.

Figure 5 presents a summary of the types of relationships that can exist between the MIHF and other functional components in the same network node.

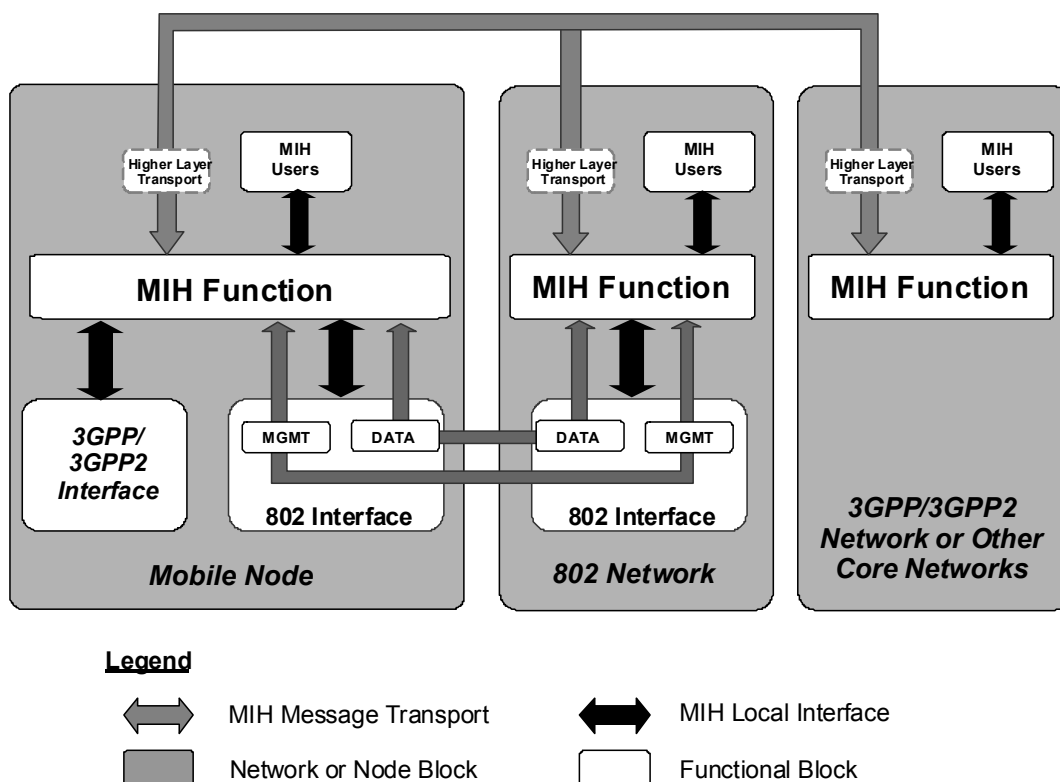


Figure 5—Types of MIHF relationship

The general MIH reference model in Figure 4 enables a simple representation of the broad variety of MIHF relationships shown in Figure 5. In the model, a mobility-management protocol stack is logically identified within each network node that includes an MIHF instance. The provided abstraction makes it easy to isolate and represent the MIH relationships with all pre-existing functional entities within the same network node. Such relationships are both internal (with functional entities that, just like the MIHF, share the logical inclusion in the mobility-management protocol) and external (with functional entities that belong to other planes).

Figure 5 shows how an MIH-enabled MN communicates with an MIH-enabled network. The gray arrows show the MIH signaling over the network, whereas the black arrows show local interactions between the MIHF and lower and higher layers in the same network or node block. For a more detailed view of local interactions, please refer to technology-specific reference models and service access point in 5.5.3 through 5.5.7.

When connected to an IEEE 802 network, an MN directly uses L2 for exchanging MIH signaling, as the peer MIHF can be embedded in a PoA. The MN does this for certain IEEE 802 networks even before being authenticated with the network. However, the MN can also use L3 for exchanging MIH signaling, for example in cases where the peer MIHF is not located in the PoA, but deeper in the network.

When connected to a 3GPP or 3GPP2 network, an MN uses L3 transport to conduct MIH signaling.

5.5.3 MIHF reference model for IEEE 802.3

The MIHF reference model for IEEE 802.3 is illustrated in Figure 6. The transport of MIHF services is supported over the data plane by use of existing primitives defined by the logical link control service access point (LSAP). There are no amendments specified in IEEE Std 802.3 to support any link services defined over the MIH_LINK_SAP in this specification.

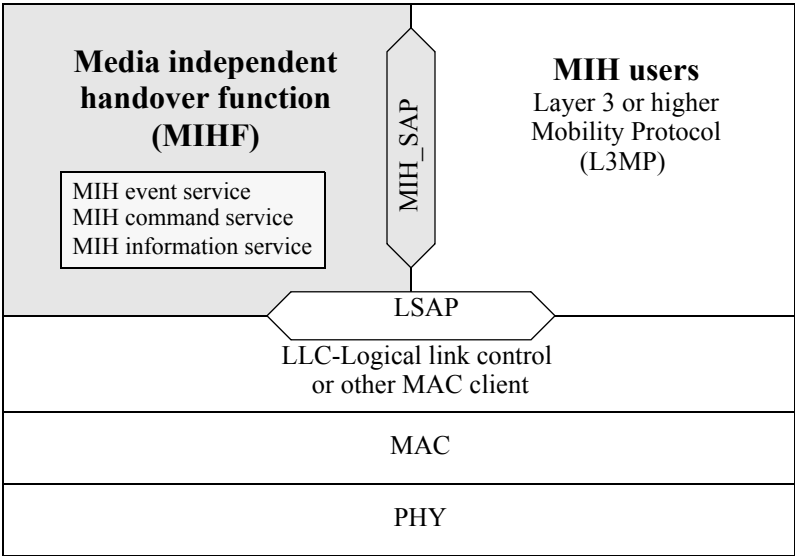


Figure 6—MIHF reference model for IEEE 802.3

5.5.4 MIHF reference model for IEEE 802.11

Figure 7 shows the MIHF reference model for IEEE 802.11. The payload of MIHF services over IEEE 802.11 is carried either in the data frames by using existing primitives defined by the LSAP or by using primitives defined by the MAC State Generic Convergence Function (MSGCF) service access point (SAP) (MSGCF_SAP). The MSGCF has access to all management primitives and provides services to higher layers.

It should be noted that sending MIHF payload over the LSAP is allowed only after successful authentication and association of the station to the access point (AP). Moreover, before the station has authenticated and associated with the AP, only MIH Information Service and MIH capability discovery messages can be transported over the MSGCF_SAP.

The MIH_SAP specifies the interface of the MIHF with MIH users.

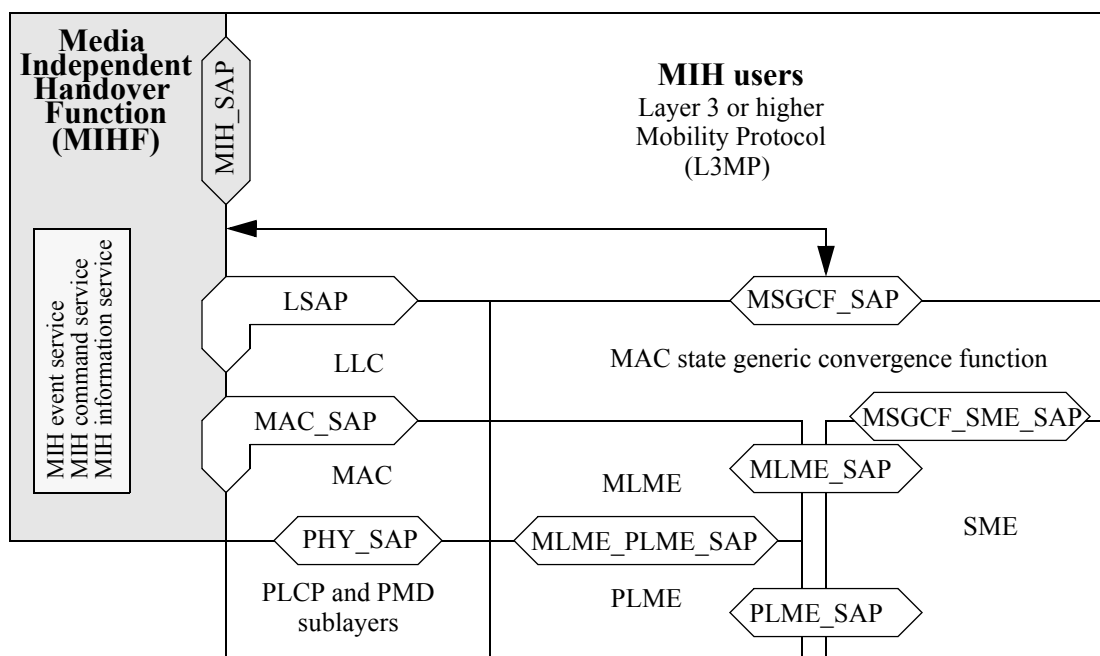


Figure 7—MIH reference model for IEEE 802.11

5.5.5 MIHF reference model for IEEE 802.16

Figure 8 shows the MIHF for IEEE 802.16 based systems. The Management SAP (M_SAP) and Control SAP (C_SAP) are common between the MIHF and Network Control and Management System (NCMS).

The M_SAP specifies the interface between the MIHF and the management plane and allows MIHF payload to be encapsulated in management messages (such as MOB_MIH-MSG defined in IEEE P802.16g [B21]). The primitives specified by M_SAP are used by an MN to transfer packets to a base station (BS), both before and after it has completed the network entry procedures. The C_SAP specifies the interface between the MIHF and control plane. M_SAP and C_SAP also transport MIH messages to peer MIHF entities. The Convergence Sublayer SAP (CS_SAP) is used to transfer packets from higher layer protocol entities after appropriate connections have been established with the network.

The MIH_SAP specifies the interface of the MIHF with other higher layer entities such as transport layer, handover policy engine, and layer 3 mobility protocol.