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IEEE Standard for
Local and metropolitan area networks—

Part 21.1: Media Independent Services

Sponsor

LAN/MAN Standards Committee
of the
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Approved 14 February 2017

IEEE-SA Standards Board

Abstract: Several use cases and services are defined, namely, handover between heterogeneous networks, home energy management system, software-defined radio access networks (SDRANs), radio resource management (RRM), and device-to-device (D2D) communication service that need to be implemented in conjunction with the media independent services (MIS) framework as specified in IEEE Std 802.21™-2017.

Keywords: home energy management system, IEEE 802®, IEEE 802.21™, IEEE 802.21.1™, media independent handover, media independent service, mobile node, mobility, network-assisted device-to-device communication, point of attachment, point of services, radio resource management, seamless, software-defined radio access network, use case

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Introduction

This introduction is not part of IEEE Std 802.21.1-2017, IEEE Standard for Local and metropolitan area networks—Part 21.1: Media Independent Services.

This standard defines several use cases and services, namely, handover between heterogeneous networks, home energy management system (HEMS), software-defined radio access networks (SDRANs), radio resource management (RRM), and device-to-device (D2D) communication service that need to be implemented in conjunction with the media independent services (MIS) framework as specified in IEEE Std 802.21-2017.

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IEEE Standard for
Local and metropolitan area networks—

Part 21.1: Media Independent Services

1. Overview

1.1 Scope

This standard defines several media independent services (MIS); handover, home energy management system (HEMS), software-defined radio access networks (SDRANs), radio resource management (RRM), and device-to-device (D2D) communication that shall be implemented in conjunction with the MIS framework as defined in IEEE Std 802.21™-2017 to optimize the performance of such services.

1.2 Purpose

The purpose of this standard is to describe the media independent use cases and services, and when implemented using the framework described in IEEE Std 802.21-2017, the user experience and management of mobile devices can be greatly improved. The services described in this specification are applicable for interworking between IEEE 802® networks and non IEEE 802 networks (e.g., cellular networks).

1.3 General

This standard describes the following use cases that can be independently implemented using the MIS framework (IEEE Std 802.21-2017), which improves the user experience of mobile devices and management of these devices by operators while mobile devices are either connected or interworking in a heterogeneous networking environment:

— Media independent handover service (Clause 5).
— Media independent service for software-defined radio access networks (SDRANs) (Clause 6).
— Media independent service for home energy management system (HEMS) (Clause 7).
— Media independent service for radio resource management (RRM) (Clause 8).
— Media independent service for device-to-device (D2D) communication (Clause 9).

The handover service use case 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), both wired and wireless media in the IEEE 802 family of standards, and downlink-only (DO) media such as Digital Video

Broadcasting (DVB), Terrestrial Digital Multimedia Broadcasting (T-DMB), and Advanced Television Systems Committee—Mobile/Handheld (ATSC-M/H).[1] The use case addresses the support of handovers for both mobile and stationary users supporting both dual-radio and single-radio mode of operation. 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.

The SDRANs use case describes how the MIS framework is used to support the seamless handover in a software-defined radio access network (SDRAN) environment that includes both fronthaul and backhaul networks. The MIS framework enables operators to provide link-layer intelligence, allocate radio resources, and optimize handovers when a mobile device is switching between heterogeneous networks that are managed by a software-defined networking (SDN) controller.

The HEMS use case describes how MIS framework is used to control the devices in a home networking environment for energy management purpose. This use case leverages the media independent command service (MICS) framework and multicast group management capabilities as defined in IEEE Std 802.21-2017.

The RRM service use case describes how MIS framework is used to support resource management in heterogeneous networks. The MIS framework enables mobile node (MN) to monitor its link status (e.g., signal strength and data rate), communicate it to the network, and provide control to its physical layer and data link layers. Leveraging these capabilities, this use case describes how an operator controls and manages the radio resources (e.g., frequency and power) in a heterogeneous networking environment that uses various communication technologies and various frequency bands.

The D2D communication service use case describes how MIS framework is used to provide D2D communication service between MNs that are in close proximity. Using MIS framework, communication service providers and network operators help an MN to search for and connect to its peer when requested. The MN then discovers other MNs in close proximity and connects them using network assistance. Network operators save network resources by offloading data to D2D communication.

This standard also defines additional primitives and messages that are required to support the preceding use cases, which are not specified in IEEE Std 802.21-2017. The configuration and management parameters for all MIS are defined in a MIB, see Annex I of IEEE Std 802.21-2017.

1.4 Assumptions

The following assumptions apply during a single-radio handover for a device that has two or more radios:

a) In a single-radio scenario, the mobile device transmits on only one radio at a time. The target radio shall not transmit while the source radio is transmitting.

b) While the source radio is receiving, the target radio shall not transmit in a manner causing interference to the source radio receiver.

c) Prior to handover completion, only the source radio link is used to carry data.

1.5 Media independence

This standard, in conjunction with IEEE Std 802.21-2017, is intended to provide a generic interface between higher layer protocol stack and existing media-specific link layers, such as those specified by 3GPP, 3GPP2, the IEEE 802 family of standards, and downlink-only media.

[1] 3GPP is a trademark of The European Telecommunications Standards Institute (ETSI).

The handover use case uses service access points (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 adaptations are required to existing lower layer [medium access control (MAC) layer and physical (PHY) layer] standards of different media-specific technologies such as IEEE Std 802.3™-2015, IEEE Std 802.11™-2012, IEEE Std 802.16™-2012, 3GPP, 3GPP2, and DVB to satisfy the requirements of generic link-layer intelligence identified by this standard.[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.

IEEE Std 802.1Q™-2014, IEEE Standard for Local and metropolitan area networks—Bridges and Bridged Networks.[3, 4]

IEEE Std 802.3™-2015, IEEE Standard for Ethernet.

IEEE Std 802.11™-2012, IEEE 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.

IEEE Std 802.16™-2012, IEEE Standard for Air Interface for Broadband Wireless Access Systems.

IEEE Std 802.21™-2017, IEEE Standard for Standard for Local and metropolitan area networks—Part 21: Media Independent Services Framework.

IETF RFC 3748 (2004-06), Extensible Authentication Protocol (EAP).[5]

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

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.

IETF RFC 5944 (2010-10), IP Mobility Support for IPv4, Revised.

IETF RFC 6275 (2011-07), Mobility Support in IPv6.

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3. Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause. [6]

authentication process: A process to assure that the claimed identity belongs to the entity. It is also called *entity authentication*.

NOTE—In this standard, an access authentication is an entity authentication with the identity used to access a specific network or a media independent service (MIS).[7]

authenticator: A network entity to execute extensible authentication protocol (EAP) with a mobile node (MN) called a *peer*. An authenticator can use a backend server to conduct EAP execution. *Syn:* **EAP authenticator.**

bidirectional network: A general communication network providing bidirectional transmission such as IEEE 802.3, IEEE 802.11, IEEE 802.16, 3GPP, and 3GPP2.

candidate network: A network that is a potential target to the mobile node's (MN's) movement.

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

candidate point of service (PoS): A potential PoS that serves the mobile nodes (MNs) after movement.

certificate authority (CA): A trusted entity that issues and revokes public key certificates.

downlink-only (DO) network: A broadcasting network providing unidirectional transmission from the point of attachment (PoA) to the user device, such as digital video broadcasting (DVB), terrestrial-digital media broadcast (T-DMB), and advanced television system committee mobile handheld (ATSC-M/H).

dual-radio operation: In this mode a dual-radio device is capable of receiving and transmitting simultaneously on both the radios. Since both radios are 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**.

EAP authenticator: *See:* **authenticator**.

EAP peer: The entity that responds to the extensible authentication protocol (EAP) authenticator.

encryption: An algorithm to convert plaintext data to ciphertext to provide confidentiality with a cryptographic key as a parameter.

extensible authentication protocol (EAP): An access authentication framework specified in IETF RFC 3748. It supports different authentication methods, called *EAP methods*.

group manager (GM): A media independent service (MIS) user that manages the group by adding, deleting, and updating the group membership information. It also generates the group key when needed. It is also the entity that issues group manipulation commands.

[6] *IEEE Standards Dictionary Online* is available at: http://dictionary.ieee.org.
[7] Notes in text, tables, and figures of a standard are given for information only and do not contain requirements needed to implement this standard.

group manipulation command: A command, sent to a group of nodes or to an individual node, that instructs the recipient to perform certain operations such as joining and leaving a group, updating group membership, and so on. By group manipulation command, we refer to the following commands:

MIS_Pull_Group_Manipulate

MIS_Push_Group_Manipulate

handover: The process by which a mobile node (MN) obtains facilities and preserves traffic flows upon occurrence of a link switch event. The mechanisms and protocol layers involved in the handover vary with the type of the link switch event [i.e., with the type of the serving and target point of attachment (PoA) 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**.

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

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).

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

horizontal handovers: A handover where a mobile node (MN) moves between points of attachment (PoAs) 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**.

NOTE—UMTS is a trademark of The European Telecommunications Standards Institute (ETSI).

information server: A server providing information about candidate access networks. The information server may be implemented in a media independent information server but may also be implemented with other standards such as the access network discovery and selection function (ANDSF) defined in 3GPP or a server using access network query protocol (ANQP) defined in IEEE Std 802.11-2012.

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

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.

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 switch: The process by which a mobile node (MN) 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 MN.

lower layers: The layers located at OSI Level 2 and below across different link-layer technology standards supported by this standard, IEEE Std 802.21.1-2017. 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 media independent service function (MISF) uses the services provided by these layers.

media independent service function (MISF): A function that realizes MIS services.

media independent service function group identifier (MISF Group ID): An identifier of a group of MISF peer entities.

media independent service (MIS) network entity: Network entity with media independent service function (MISF) capability.

media independent service (MIS) node: A media independent service function (MISF) capable entity [mobile node (MN) or network].

media independent service (MIS) non-PoS: An MIS network entity that directly exchanges MIS messages with other MIS network entities but is not capable of *directly* exchanging MIS messages with any MIS enabled mobile node (MN).

media independent service point of service (MIS PoS): Network-side MISF instance that exchanges MIS messages with a mobile node (MN)-based MISF. The same MIS Network Entity includes an MIS PoS for each MIS-enabled MN with which it exchanges MIS messages. A single MIS PoS is capable of hosting more than one MIS service. The MIS Network Entity that includes multiple MIS PoSs capable of providing different combinations of MIS services to the respective MNs based on subscription or roaming conditions. Note that for a network entity comprising multiple interfaces, the notion of MIS PoS is associated with the network entity itself and not with just one of its interfaces. For MIS service access authentication, a PoS serves as an authenticator. Moreover, when a service access authentication establishes keys for proactive authentication, a PoS provides key distribution service for media specific authenticators.

media independent service (MIS) users: Entities that use the services provided by the MISF. MIS users use the MIS_SAP to interact with the MISF.

MIS security association (SA): A media independent service (MIS) security association is a set of cryptographic attributes established between the peer MIS entities for protecting MIS messages at the MIS protocol layer. An MIS SA is established via transport layer security (TLS) handshake, extensible authentication protocol (EAP) execution, or via group key distribution mechanism using group key block (GKB) where all of the TLS handshake, EAP execution, and group key distribution take place over the MIS protocol. When an MIS SA is established via TLS handshake, the TLS master key and its child keys, TLS random values and the TLS ciphersuite negotiated in the TLS handshake are a part of the MIS SA. When an MIS SA is established via EAP execution, a master session key (MSK) or re-authentication master session key (rMSK) and its child keys, MIS random values and the MIS ciphersuite negotiated between the peer MIS entities are associated with the MIS SA. When an MIS SA is established via group key distribution mechanism using GKB, the master group key and its child keys, and the MIS group ciphersuite indicated to the peer MIS entities are associated with the MIS SA.

MIS service access authentication: An authentication process that authorizes the access to media independent services (MIS).

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

mobile node (MN): Communication node that is capable of changing its point of attachment (PoA) from one link to another.

multimedia program (MMP): An instance of certain content (e.g., voice, data, or video) with some specific attributes, e.g., chapter 2 of a TV series.

multimedia service (MMS): A sequence of multimedia programs (MMPs) under the control of a content aggregator and provider, e.g., TV Channel One, TV Channel Two.

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

network entity: A communication node inside the network.

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

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

network selection: The process by which a mobile node (MN) 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 MN and/or obtained from the network.

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

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.

preregistration: Preparatory handover signaling (possibly including security establishment) that is accomplished before the handover actually occurs.

proactive authentication: A media specific authentication with the candidate network(s) executed prior to a handover to one of the candidate networks.

proxy information server: A server that assists the mobile node (MN) to obtain the required information when a query is made via the source network. To the MN, the proxy information server appears to be an information server of the source network.

proxy point of attachment (PoA): An entity that provides service to a mobile node (MN) and a target PoA via the source network. To the MN, this entity appears to be a PoA in the target network. In some scenarios, it is a non-PoA network entity that is collocated at a media independent service (MIS) point of service (PoS), and it enables such services as preregistration of the MN.

seamless handover: A handover associated with a link switch between points of attachment (PoAs), where the mobile node (MN) 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.

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:* **home subscriber network; visited network**.

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

serving point of service (serving PoS): A media independent service (MIS) PoS that is currently providing the MIS services to the mobile node (MN).

single-radio handover: A handover between (possibly heterogeneous) radio access technologies (RATs) during which a mobile node (MN) transmits over only one radio link at a time.

single-radio handover (SRHO)-capable node: A media independent service function (MISF) capable node that processes single-radio MIS packets.

single-radio MIS packet: A packet that may contain one or more of the following commands—MIS_Prereg_Xfer, MIS_N2N_Prereg_Xfer, MIS_Prereg_Ready, or MIS_CTRL_Transfer—in its payload.

single-radio operation: In this mode, a dual-radio device is capable of receiving and transmitting 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 is 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**.

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 (PoA) to the target PoA. The network allocates transport facilities to the target PoA prior to the occurrence of the link switch event (make-before-break).

source network PoS: The point of service (PoS) in the network of the mobile node's (MN's) current point of attachment (PoA).

source radio: The mobile nodes's (MN's) radio interface that transmits and/or receives over the radio link that the MN currently has established with the source network.

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).

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.

target network PoA: A point of attachment (PoA) in the target network, to which a mobile node (MN) will be attached after a handover has been completed.

target network PoS (TPoS): A point of service (PoS) in the target network of the target point of attachment (PoA) that will serve a mobile node (MN) after a handover has been completed.

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

target radio: The mobile node's (MN's) radio interface that will transmit and/or receive information with the target network over the radio link.

uniform resource identifier (URI): A compact sequence of characters that identifies an abstract or physical resource including video.

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

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. Acronyms and abbreviations

3G	3rd generation
3GPP	3rd Generation Partnership Project
3GPP2	3rd Generation Partnership Project 2
AAA	authentication, authorization, and accounting
AID	action identifier
ANDSF	access network discovery and selection function
ANQP	access network query protocol
AP	access point
ATSC-M/H	advanced television system committee mobile handheld
BS	base station
CA	certificate authority
CN	core network
CRL	certificate revocation list
D2D	device to device
DHCP	dynamic host configuration protocol
DO	downlink only
DVB	digital video broadcasting
EAP	extensible authentication protocol
FA	foreign agent
GKB	group key block
GM	group manager
GPRS	general packet radio service
GSM	global system for mobile communication
HEMS	home energy management system
HGW	home gateway
HPoS	home network point of service (PoS)
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IP	Internet protocol
IPsec	IP security
IPTV	IP television
IS	information service
ITU	International Telecommunications Union
L1	layer 1 (PHY)
L2	layer 2 (MAC and/or LLC)

L3	layer 3
LAN	local area network
LLC	logical link control
LTE	long term evolution
MAC	medium access control
MIAK	media independent authentication key
MIB	management information base
MICS	media independent command services
MIES	media independent event services
MIIS	media independent information service
MIP	mobile IP
MIS	media independent service
MISF	media independent service function
MISK	media independent session key
MLME	MAC layer management entity
MMP	multimedia program
MMS	multimedia service
MN	mobile node
MSK	master session key
MSPMK	media specific pairwise master key
MSRK	media specific root key
N/A	not applicable
NADC	network-assisted D2D communication
NAI	network access identifier
PAC	peer aware communication
PDU	protocol data unit
PHY	physical layer
PMIP	proxy mobile IP
PoA	point of attachment
PoS	point of service
PRF	pseudorandom function
ProSe	proximity services
PV	photovoltaics
QoE	quality of experience
QoS	quality of service
RAN	radio access network
RAT	radio access technology

RDF	resource description framework
RFC	request for comment
RLC	radio link control
rMSK	re-authentication master session key
RP	reference point
RRM	radio resource management
SA	security association
SAP	service access point
SDN	software-defined networking
SDO	standards development organization
SDRAN	software-defined radio access network
SID	service identifier
SINR	signal over interference plus noise ratio
SLA	service level agreement
SP	service provider
SPoS	source network point of service (PoS)
SRHO	single-radio handover
TCP	transmission control protocol
T-DMB	terrestrial-digital media broadcast
TLS	transport layer security
TLV	type length value (a form of encoding, or an item encoded using that coding)
TPoA	target network point of attachment (PoA)
TPoS	target network point of service (PoS)
UDP	user datagram protocol
UMTS	universal mobile telecommunications system
URI	uniform resource identifier
URL	uniform resource locator
WLAN	wireless local area network
WPAN	wireless personal area network
XML	extensible mark-up language

5. Media independent handover service

5.1 Introduction

5.1.1 General

This use case 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 MIS 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 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 Network discovery

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

5.1.4 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 shall be made available to the MIS users to enable effective network selection.

5.1.5 Handover policy

The primary role of the media independent service function (MISF) is to facilitate handovers and provide intelligence to the network selector entity. The MISF 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.

5.1.6 Media independent single-radio handover

In single-radio handover, the opportunities to deliver handover messages are limited. To improve single-radio handover performance, it is important to accomplish as much of the handover signaling (including security establishment) before the handover actually occurs; this preparatory signaling is called *preregistration*. The exact signaling steps included in the preregistration process may depend on the requirements of the target network and is independent of the signaling nature of the source network. As a general rule, preregistration typically involves one or more of the following steps, which are often needed for handovers:

— Proactive authentication—that is, authenticating the MN before it arrives in the target network

— Address allocation—one or more Internet protocol (IP) addresses to be used by the MN after it arrives in the target network

— Data path setup—establishing tunnels and forwarding entries for the MN in the target network

— Context establishment—building all necessary state information such as QoS parameters and access permissions within target network entities

Each of these operations is often time-consuming. If they have to be carried out after the MN moves into the coverage area of the target network radio access, seamless session handover for many applications would be impossible. This is due to the break-before-make dead time before packets could start flowing again via the target network. Moreover, it shall be possible to carry out each of the operations securely to prevent hijacking attempts or mismanagement of target network resources. As long as handovers occur only between access points within the same operator network, it is often possible to guarantee that signaling packets are never exposed to attack. In contrast, for access networks belonging to different operators, the data path between neighboring access points of serving and target access networks are more likely to traverse the Internet, potentially exposing preregistration signaling to attack.

5.1.7 Enabling fast authentication using PoS for single-radio handover

Enabling movement between the networks of roaming partners for single-radio smart phones and Internet-enabled wireless devices can be facilitated by enabling preregistration via the point of service (PoS) and making use of certain functions as developed in 3GPP (TS23.401 [B4]), 3GPP2 (C.S0001-D [B9]), and the WiMAX Forum® [B49].[8, 9] Using the PoS, signaling messages related to security information between roaming partners are exchanged, and as a result low-latency optimized session handover is achievable. Communications between the source and target networks shall be secured. However, authentication has been typically quite time-consuming because of reliance on distant authentication agents. A method is defined to establish a secure communication channel between source and target networks as part of handover preregistration procedures (see 5.5.4.1). Improving the security model and reducing authentication delay enables improvements in handover performance, because single-radio systems are not capable of taking advantage of parallel authentication operations.

[8] WiMAX Forum is a registered trademark of the WiMAX Forum.
[9] The numbers in brackets correspond to those of the bibliography in Annex A.

5.2 General design principles

5.2.1 Single-radio handover MISF design principles

The following are functional requirements that facilitate single-radio handover between possibly heterogeneous radio access technology (RAT) networks:

a) Tunneling mechanism to deliver the preregistration messages

b) Control for preregistration states and delivery for preregistration contexts

5.3 Deployment example and functional model for MIS services

5.3.1 Deployment example for MIS services

A network model including MIS services is shown in Figure 1 to better illustrate the MIS reference points (see 5.4.2 of IEEE Std 802.21-2017). Moving from left to right, the model includes an MIS-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 (CN) (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 1, an access network can also connect to a CN 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 reference point RP1. At any given point in time, the subscriber's serving network can be the home subscriber network or a visited network.

The network providers offer MIS 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 MIS capability or responds to MIS service discovery. Each service provider for these access networks allows access to one or more MIS Points of Service (PoS) node(s). These PoS nodes provide some or all of the MIS services as determined during the MIS capabilities discovery. The PoS location varies based on the operator deployment scenario and the technology-specific MIS architecture.

An MIS 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 1, the MIS entity in the MN communicates with MIS 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 MISF, 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). MIS events originate at both sides of an active RP1 link. The MN is typically the first node to react to these events.

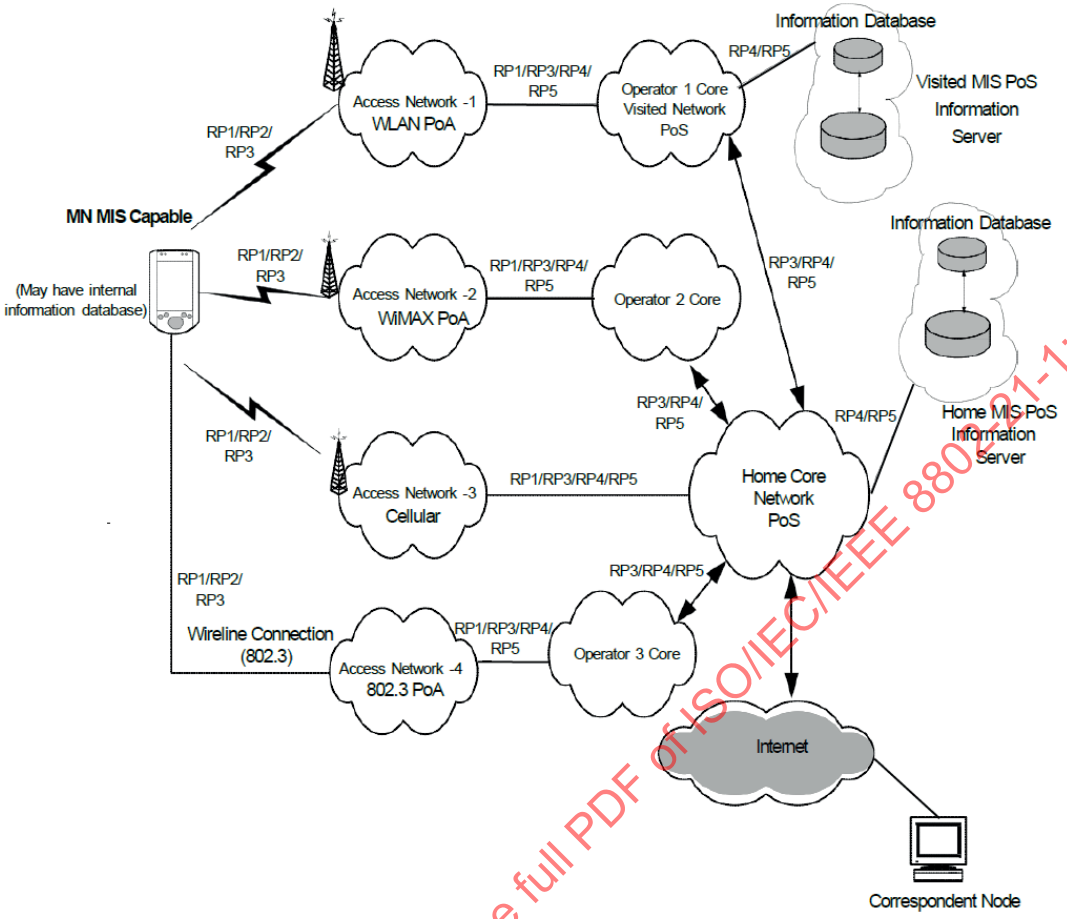


Figure 1—Example of network model with MIS services

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 MIS network entities communicate with each other via RP4 or RP5 reference points. The MIS-capable PoA communicates with other MIS network entities via RP4 and RP5 reference points. The MIS-capable MN have MIS 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 MIS information service, visited providers offer access to their Information Server located in an MIS PoS node (upper far right). The operator provides the media independent information service (MIIS) to MNs 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 MIS 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 MIS entities. As an example, in Figure 1 the home subscriber network accesses its own MIS Information Server or core operator 1 (visited network) MIS Information Server.

5.3.2 Single-radio handover MISF relationship to reference model

To prepare for handover, the MN may exchange link-layer protocol data units (PDUs) with the target network PoA through a communication link that is established between an MN and the target PoA using the active network connection. These PDUs contain the same information as in the PDUs that would be exchanged if the target links were active. There is no guarantee that the target link is accessible during a single-radio handover. A proxy PoA is used to enable the MN and the target PoA to exchange link-layer PDUs.

During a single-radio handover, an L2 frame may be encapsulated in a MIS message, which is then exchanged via an active link between the MISFs of a local and a remote node using MIS protocol over higher layer transport [transmission control protocol (TCP) or user datagram protocol (UDP) over IP].

5.3.3 Single-radio handover functional model and signaling flow

The functional model for single-radio handover is shown in Figure 2.

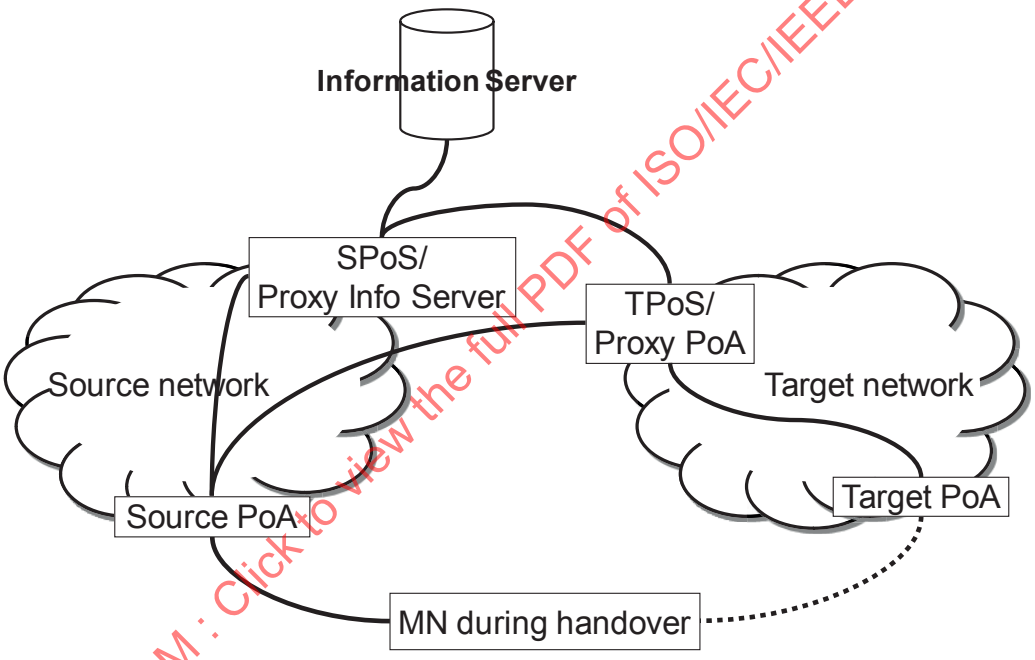


Figure 2—Single-radio handover functional model

In the preceding scenario, the source network PoS (SPoS) is providing the service to the source network users, in which the proxy Information Server (see 5.5) is co-located. Source network users are connected via source PoA. The target network PoS (TPoS) belongs to the target network and provides the service to the target networks users that are connected via target PoA. It is not always necessary that a source PoA and a target PoA need to be served by two different PoSs. A PoS may cover a plurality of networks. In that case, the source PoS and TPoS are collocated and an MN performs handover from the source PoA to the target PoA using the same PoS. This scenario is captured in Figure 1 (5.3.1).

5.4 Single-radio handover procedures

A single-radio handover following the reference model in 5.3.2 consists of various handover procedures and involves different information elements (5.9, 5.10, 5.11, and 5.12) and messages (5.13). Examples of handover are described in Annex B. Figure 3 shows the single-radio handover process consisting of the following five procedures:

a) **Network discovery** enables the MN to determine whether or not there is a candidate target network available for handover. Network discovery may involve the following:

   1) The MN may query the Information Server to discover candidate networks and their handover policies. Such information includes whether candidate networks and MN support single-radio handover (SRHO) or not, and the availability of proxy services on the candidate network. Network discovery also allows the MN to acquire the corresponding system information blocks for candidate points of attachment (candidate PoAs) to perform the radio measurements.

   2) The MN may request that the source network PoS identify one or more candidate target networks.

   3) During idle times when the source radio is not in use, the MN may activate its target radio to scan for one or more reachable TPoAs.

b) The **handover decision** may involve the following:

   1) A handover trigger, which may be a command

   2) Target network selection

   3) Proxy services discovery

   4) Evaluating the handover benefit: the evaluation is made by either the MN or the network, e.g., based on parameters such as signal strength, target quality of experience, cost, and operator policy

c) **Preregistration** includes pro-active authentication and establishing context (user identity, security, resource information) at the target network. With the help of proxy services, the MN performs preregistration procedures with the target network while still retaining its data connection with the source network. Optionally, the preregistration procedure may occur before the handover decision procedure as in the case of WiMAX™ target networks. [10]

b) During **target link preparation,** the MN and target network prepare the establishment of the target link. This procedure ascertains whether the target network has enough resources to accommodate the new link and may include performing resource reservation or admission control as well as confirming that the signal conditions are favorable enough to establish the target link.

c) Finally, during **SRHO execution**, the source link is disconnected, the target radio is activated, and the target link is established. The association of the network layer address to the link-layer address will change from the source link-layer address to the target link-layer address for IP-based mobility management, and future incoming packets are then routed to the target radio.

[10] WiMAX is a trademark of the WiMAX Forum.

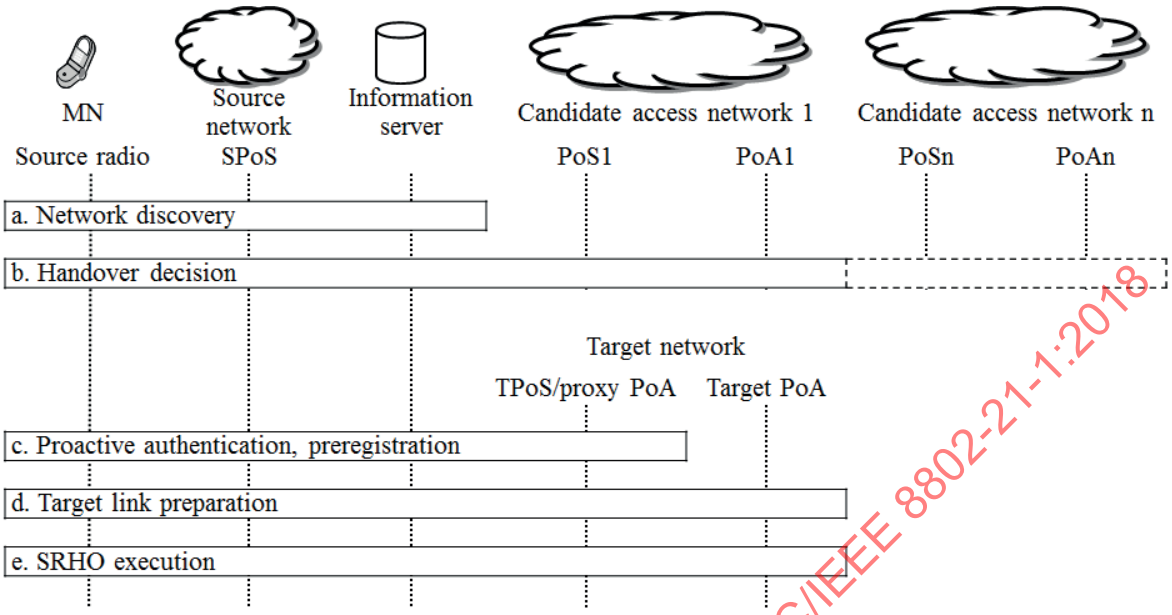


Figure 3—Single-radio handover procedures

5.5 Proxy operations

5.5.1 Introduction

The signaling between the MN and the target network via the source network or between the MN and the Information Server can be accomplished through proxy services. In single-radio handover, the MN sends signal to the proxy PoA as if signaling to the target PoA (TPoA), and the TPoA responds by signaling to the proxy PoA as if signaling to the MN. The MN sends signal to the proxy Information Server as if signaling to the Information Server, and the Information Server responds by signaling to the proxy Information Server as if signaling to the MN.

In a WiMAX network, the proxy services may be implemented as an extension of the Signal Forwarding Function (SFF) (WiMAX Forum [B49]) and may reside at the Access Service Network Gateway (ASN-GW).

In a 3GPP network, the proxy services may be implemented as an extension of the Mobility Management Entity (MME) (3GPP TS23.401 [B4]).

In a 3GPP2 network, the proxy services may be implemented in the High-Rate Packet Data Signal-Forwarding Function (HRPD-SFF) and the existing functions of the Packet Control Function (PCF) (3GPP2 C.S0001-D [B9]).

In a network employing a centralized or distributed mobility management architecture, the proxy services may be collocated within the mobility management anchors (IETF [B24]).

Signaling between the MN and the proxy service may be accomplished in a media independent manner using the functions of the source network PoS and the target network PoS (TPoS) and the signaling messages defined in this specification.

5.5.2 Network discovery using proxy Information Server

The MN may need to communicate with the Information Server to discover a target access network. If the MN directly accesses the Information Server, it discovers its target network by using MIS_Get_Information request and response messages. However, the MN may not always be able to directly access the Information Server, and the MN and the Information Server may be located in different networks and in different administrative domains. For example, the MN may need to query via access network query protocol (ANQP) messages in a Wi-Fi® access network while the information is available in an access network discovery and selection function (ANDSF) server that is located in a cellular provider's network.[11] Network discovery in this scenario is accomplished if the Wi-Fi PoA is SRHO-capable, and an intermediate entity called *proxy Information Server* is available to forward the MN's request to the ANDSF server.

Figure 4 shows an example call flow of the network discovery process using a proxy Information Server. The goal of the MN is to discover the target network. The steps of the discovery process are as follows:

a) The MN requests information about the target network using MIS_CTRL_Transfer request or a non-MIS message such as ANQP query.

b) The SRHO-capable PoA transmits the MIS_CTRL_Transfer request message to the proxy Information Server. If the SRHO-capable PoA received a non-MIS message in step a), the SRHO-capable PoA encapsulates the query message into the MIS_CTRL_Transfer request message and transmits the message to the proxy Information Server (see 5.11.14).

c) The proxy Information Server extracts a non-MIS message (e.g., ANQP query) from the MIS_CTRL_Transfer request message, and then exchanges signaling with the Information Server by using the extracted non-MIS message. Note that signaling (e.g., ANQP and ANDSF) between the proxy Information Server and the Information Server is out of the scope of this specification.

d) The proxy Information Server transmits a MIS_CTRL_Transfer response message to the SRHO-capable PoA by encapsulating the response that is obtained from the functional entity (i.e., MIS user).

e) The SRHO-capable PoA responds to the MN with information about the target network using MIS_CTRL_Transfer request or a non-MIS message such as an ANQP response. In case the MN did not use MIS as the protocol to transmit the original query, the SRHO-capable PoA decapsulates the MIS_CTRL_Transfer response message and forwards the content (e.g., the ANQP response) to the MN. If the MN used the MIS protocol for the initial query, then the SRHO-capable PoA forwards the MIS_CTRL_Transfer response message to the MN.

Use cases of the proxy Information Server are included in Annex M.

[11] Wi-Fi is a registered trademark of theWi-Fi Alliance.

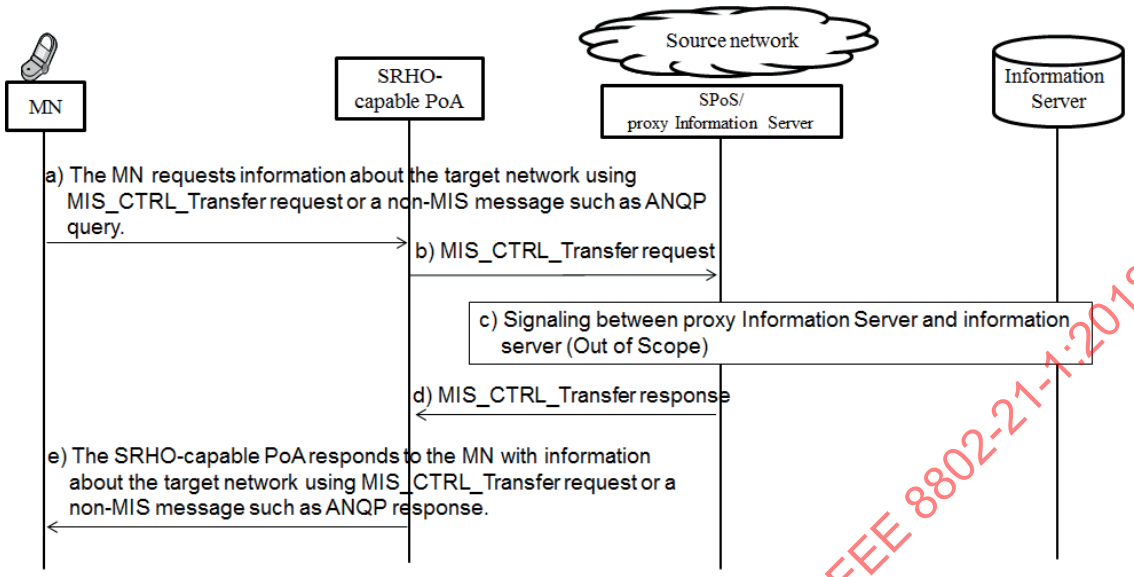


Figure 4—Network discovery using a proxy Information Server

5.5.3 Preregistration using proxy PoA

To prepare for handover, the MN needs to communicate with the target network PoA (TPoA) by performing a network access procedure with the target access network. The first part of this communication is the transport of TCP or UDP/IP packets to the proxy PoA (Figure 5 and Figure 6). The second part of this communication depends on whether the TPoA is SRHO-capable (Figure 5) or whether it is a legacy PoA lacking such capability (Figure 6). If the target PoA is SRHO-capable, the L2 frame is encapsulated into a MIS packet to be forwarded to the target radio.

Figure 5 shows the transport of the target radio control frame as a payload of a MIS packet between the MN and the proxy PoA via the source radio interface since the target radio link is unavailable. In this figure, the MN has 2 interfaces (1) and (2). It uses the wireless interface (1) with PHY_1 and $L2_1$ to connect to the source network. The MN uses reference point 1 (RP1) (see Figure 3 in 5.4.2 of IEEE Std 802.21-2017) to communicate with TPoS / proxy PoA via network layer transport.

If the target radio were used, the MN would have used the target radio with protocol stack PHY_2 and $L2_2$ to communicate with the TPoA, which also implements the corresponding protocol stack PHY_2 and $L2_2$. Without using the target radio to communicate, the target radio link-layer control frame $L2_2$ is encapsulated into a MIS packet. The TPoS/proxy PoA communicates with the SRHO-capable TPoA using reference point 5 (RP5) (see Figure 3 in 5.4.2 of IEEE Std 802.21-2017) over network layer transport. When the MIS packet arrives at the SRHO-capable TPoA, it is decapsulated to retrieve the target $L2_2$ frame.

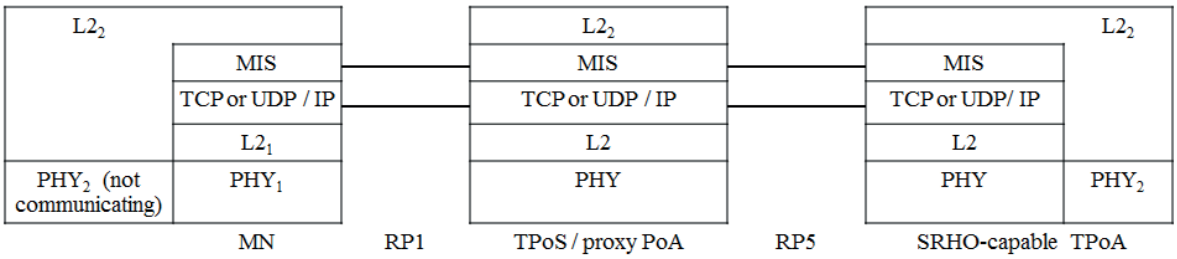


Figure 5—Transport of the L2 frame of the target interface via a MIS using the logical connection at the TPoS to the SRHO-capable TPoA

Figure 6 also shows the transport of the target radio L2 control frame as a payload of a MIS packet between the MN and the proxy PoA via the source radio since the target radio link is unavailable. However, since the TPoA is not SRHO-capable, the MIS user at the proxy PoA has to communicate with the TPoA using other mechanisms that are out of scope of this specification.

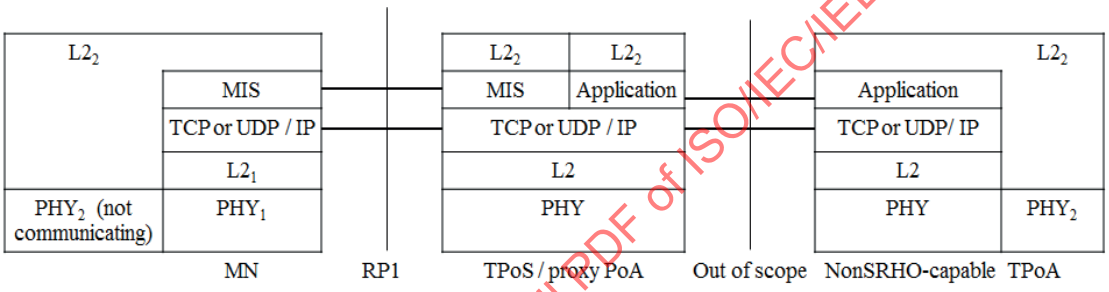


Figure 6—Transport of L2 frame via the proxy PoA to a legacy TPoA that is not SRHO-capable

The procedures of communication between the MN and the TPoA are shown in Figure 7 and are as follows:

a) The MN sends a message to the SPoS or directly to the TPoS/proxy PoA with a payload containing a target network L2 handover frame. If the message is directly sent to the TPoS/proxy PoA, the SPoS is bypassed. If the message is sent to the SPoS, the SPoS will forward the message to the TPoS/proxy PoA.

b) Upon receiving this message from the MN, the TPoS/proxy PoA helps to discover a suitable TPoA if not already known. It will determine whether the target PoA is SRHO-capable. If not, the TPoS / proxy PoA will communicate the link-layer frames to the target PoA using a mechanism that is outside the scope of this specification.

   1) The TPoS or proxy PoA signals with this TPoA using MIS message if the TPoA is a SRHO-capable node (the target PoA supports MIS_Prereg_Xfer messaging).

   2) Otherwise, the proxy PoA signals with the candidate target PoA using other L2-specific protocol messages. SPoS will relay the reply messages to MN, indicating whether the L2 preregistration signaling is successful. Also, the reply will include an indication of the fact that the messages used for the proxy PoA to signal with the TPoA are outside the scope of this document. L2 frames are passed to the target PoA either by way of proxy PoA or by MIS_Prereg_Xfer commands.

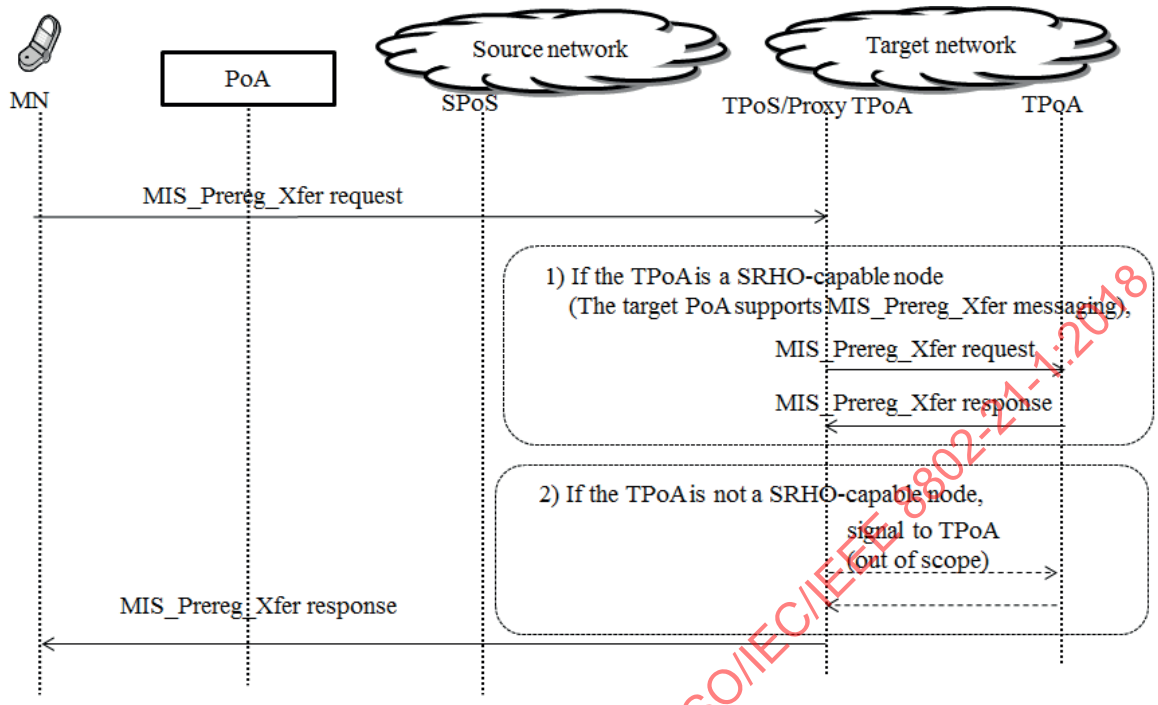


Figure 7—Communication between the MN and the TPoA

As previously shown, the MN and the target network exchange link-layer PDUs without using the target PoA's physical radio channel. The exchanged single-radio control frames are processed by the MISF, which receives them at port 4551, the assigned transport layer protocol's port number (IETF [B26]).

5.5.4 PoS facilitated proactive authentication for single-radio handover service

For single-radio handover, it is desired to conduct proactive authentication for preregistration to reduce the latency brought about by the authentication required to be attached to the target network. The PoS is a convenient and natural place to facilitate such proactive authentication. The security protections are needed between different PoS modules to transmit authentication credentials.

5.5.4.1 Establishing MIS Security Association between roaming partners

It is out of scope for this document to specify exactly how the secure communication channel should be established. The specific method shall be agreed upon as a part of the roaming agreement. For example, the certificate of the trusted certificate authority (CA) shall be configured so that it is established on demand by using IKEv2 (IETF RFC 7296 [B37]). The following overview describes some circumstances enabling dynamic establishment of security association between the SPoS and the TPoS.

MIS_Prereg_Xfer and MIS_N2N_Prereg_Xfer messages exchanged between the SPoS and the TPoS may require security protection. Furthermore, the TPoS may reject these messages from an unauthorized source network PoS. To protect the link between the SPoS and the TPoS, several approaches are possible.

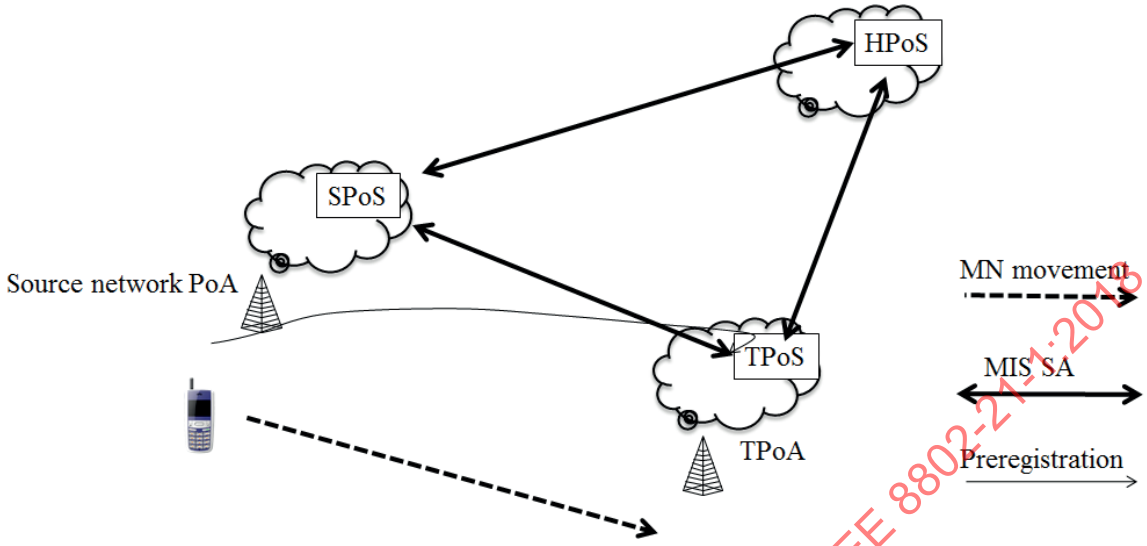


Figure 8—MN handover signaling for preregistration using SPoS

An MIS SA (Security Association) (see 8.4.2 of IEEE Std 802.21-2017) is used for protecting the communications between an SPoS and a TPoS. In this case, the SPoS acts as the initiating end-point of an MIS SA and a TPoS as the other end-point of the MIS SA. The MIS SA is established using (datagram) transport layer security [(D)TLS] over MIS or extensible authentication protocol (EAP) over MIS (see 9.2 of IEEE Std 802.21-2017).

Other mechanisms for providing message integrity and confidentiality, such as IP security (IPsec) and transport layer security (TLS) over TCP, can also be used for protecting the communications between SPoS and TPoS.

Except for the initial network attachment, by the time an MN enters a network, it can also have a security relationship with the PoS in that network by using MIS_Prereg_Xfer commands. For each newly visited network, this security relationship is created on demand, enabled by signaling from another PoS. The PoS creating the visited security relationship can either be the MN's home PoS (HPoS, a PoS in MN's home network) or the PoS in the network previously visited by the MN. When the MN first attaches to one of the partner networks of the roaming partners, it is either the MN's home network or a visited network. If the first attachment is to the MN's home network, the MN is expected to already have a security association with HPoS; otherwise, the MN bootstraps this security association with the assistance of the HPoS.

After initial attachment, there is signaling defined so that at all times the MN has a security association with the PoS in the network at its current PoA, i.e., the SPoS. As the MN moves from one partner network to the next target network, the MN establishes or renews a security association with the PoS in the target network, the TPoS. When handover is completed, the TPoS begins to play the role of the MN's serving PoS, and subsequently when a handover is required the TPoS plays the role of the SPoS.

In order to enable a wider application of handovers and in particular preregistration signaling, security is essential for the control traffic. As previously described, this signaling traffic is mediated by the PoS in each target network, which may be unknown to the MN until the need for handover has been determined. In such cases, for secure signaling, the MN needs to establish a security association with the TPoS. Clause 9 of IEEE Std 802.21-2017 defines methods for an MIS SA to be established through (D)TLS or EAP. The methods specified there shall be used to establish an MIS SA between an MN and a TPoS so that TPoS is capable of providing security service, in particular, facilitating proactive authentication for an MN in a handover event. For single-radio handover, an optimized MIS SA establishment mechanism is introduced to speed up when the home networks of SPoS and TPoS have an existing trust relationship through partnership agreement.

5.5.4.2 Optimized MIS SA establishment for single-radio handover service

This clause specifies one optimized MIS SA establishment for single-radio handover service. It allows a TPoS to obtain a key derivation key *K* from a SPoS or from a higher level entity. The key derivation key *K* is used to derive other keys such as the media independent session key (MISK) as described in 9.2.2 of IEEE Std 802.21-2017 between the MN and the TPoS, enabling further secure preregistration activities. Because of previous protocol operations (e.g., derivation of MIAK upon arrival in the source network), the MN has a current security association with the SPoS. As discussed in 5.5.4.1 the protection mechanisms applied between SPoS and TPoS are out of the scope of this specification. If the key *K* is distributed by SPoS to MN and to TPoS, the key distribution is protected by MIS SA between MN and SPoS and by out-of-scope mechanisms between SPoS and TPoS.

In order to establish an SA between the MN and the TPoS, they need to exchange Nonce-M and Nonce-S through messages MIS_Prereg_Xfer Request, MIS_Prereg_Xfer Response, and MIS_N2N_Prereg_Xfer Request. They also need to agree on a ciphersuite code specified in 9.2.3 of IEEE Std 802.21-2017. With this information, MN and TPoS derive the MISK as specified in 9.2.2 of IEEE Std 802.21-2017.

NOTE 1—The optimized MIS SA establishment is allowed only when a trust relationship has established between the network domains of SPoS and TPoS. It shall fall back to an SA establishment mechanism as specified in IEEE Std 802.21-2017 whenever it is possible, or if any of the MN or TPoS requests so.

NOTE 2—If protocol of establishing SAs between an MN and a TPoS is EAP, the optimized MIS SA establishment applies. In this case, the MN and the TPoS use key derivation key *K* as it is obtained through an EAP or EAP re-authentication protocol (ERP) execution.

NOTE 3—If protocol of establishing SAs between an MN and a TPoS is TLS, then the optimized SA establishment method does not apply, because the MN and the TPoS are not able to use key derivation key *K* in TLS.

NOTE 4—If any SPoS is compromised, the generated key *K* is compromised and so is the remaining of the PoS chains assuming that a TPoS will become a SPoS. To prevent such domino effect, the chain shall be limited. That is, after certain number of executions of the optimized SA establishment, it shall force an SA establishment through the methods specified in IEEE Std 802.21-2017.

5.5.4.3 TPoS selection by the SPoS

It is possible for the SPoS to take a more active role to promote smooth handover. When the MN determines the need for handover, but does not already know the address of the TPoS for the intended target network, the MN starts the preregistration sequence by sending all the known information to the SPoS. If the SPoS has access to information about the MIS PoS in each such surrounding network, the SPoS can make a determination about which target network is best to be able to provide connectivity and service to the MN. This also depends on the SPoS having access to location and configuration information about the MN—for example, which radio access technologies (RATs) are configured for operation on the MN. When the candidate TPoS is in another operator's network, it is also important that the SPoS should have a security relationship with a candidate TPoS in order to avoid interference from malicious nodes. This would typically mean that the operators are also roaming partners.

Subsequently, the SPoS will provide the address of the TPoS to the MN along with *K*, as previously described. The exact nature of the information about TPoS provided by the MN is dependent on the RAT type of the target network and is outside the scope of this document.

5.6 Media independent event service

5.6.1 Link events for handover services

In addition, to link events in 6.3.4 of IEEE Std 802.21-2017, the following handover services related events are defined:

— **Link Handover events:** These events inform upper layers about the occurrence of L2 handovers/link switches if supported by the given media type.[12]

Table 1 defines link events for handover services.

Table 1—Link events for handover services

Link event name	Link event type	Description	Defined in
Link_Handover_Imminent	Link handover	L2 handover is imminent based on changes in link conditions.	5.10.1
Link_Handover_Complete	Link handover	L2 link handover to a new PoA has been completed.	5.10.2

5.6.2 MIS events for handover services

In addition to MIS events in Table 5 of IEEE Std 802.21-2017, Table 2 defines MIS events for handover services. An MIS event is marked as local only (L), remote only (R), or local and remote (L, R), indicating whether it is subscribed by a local MIS user, a remote MIS user, or both, respectively.

Table 2—MIS events for handover services

MIS event name	(L)ocal (R)emote	Description	Defined in
MIS_Link_Handover_Imminent	L, R	L2 handover is imminent based on either the changes in the link conditions or additional information available in the network. For example, the network decides that an application requires a specific QoS that can be best provided by a certain access technology.	5.11.1
MIS_Link_Handover_Complete	L, R	L2 link handover to a new PoA has been completed.	5.11.2

5.7 Media independent command service (MICS)

5.7.1 Link commands for handover services

In addition to link commands in Table 6 of IEEE Std 802.21-2017, Table 3 defines link commands for handover services.

[12] The mechanism that triggers and executes a link-layer handover/switch (also referred as an *L2 handover*) is specified within the corresponding media-specific standard and out of scope of this standard.

Table 3—Link commands for handover services

Link command	Comments	Defined in
Link_Prereg_Ready	Request a preregistration on a target link	5.10.3

5.7.2 MIS commands for handover services

5.7.2.1 General

In addition to MIS commands in Table 7 of IEEE Std 802.21-2017, Table 4 defines MIS commands for handover services. An MIS command is marked as local only (L), remote only (R), or local and remote (L, R), indicating whether it is issued by a local MIS user, a remote MIS user, or both, respectively.

Table 4—MIS commands for handover services

MIS command	(L) ocal, (R) emote	Comments	Defined in
MIS_Net_HO_Candidate_Query	R	Network initiates handover and sends a list of suggested networks and associated points of attachment.	5.11.3
MIS_MN_HO_Candidate_Query	R	Command used by MN to query and obtain handover related information about possible candidate networks.	5.11.4
MIS_N2N_HO_Query_Resources	R	This command is sent by the serving MISF entity to the target MISF entity to allow for resource query.	5.11.5
MIS_MN_HO_Commit	R	Command used by MN to notify the serving net- work of the decided target network information.	5.11.6
MIS_Net_HO_Commit	R	Command used by the network to notify the MN of the decided target network information.	5.11.7
MIS_N2N_HO_Commit	R	Command used by a serving network to inform a target network that an MN is about to move toward that network, initiate context transfer (if applicable), and perform handover preparation.	5.11.8
MIS_MN_HO_Complete	R	Notification from MISF of the MN to the target or source MISF indicating the status of handover completion.	5.11.9
MIS_N2N_HO_Complete	R	Notification from either source or target MISF to the other (i.e., peer) MISF indicating the status of the handover completion.	5.11.10
MIS_Net_HO_Best_Commit	R	Command used by the network to notify the specific group of MNs of the decided target network information.	5.11.11
MIS_Prereg_Xfer	R	Transport parameters and link-layer frames.	5.11.12
MIS_N2N_Prereg_Xfer	R	Transport link-layer frames between the SPoS and the TPoS.	5.12.1
MIS_Prereg_Ready	R	Check readiness of preregistration on a target link.	5.11.13
MIS_CTRL_Transfer	R	Deliver control message encapsulated by the MIS header	5.11.14

5.7.2.2 Naming convention for MIS handover commands

Generally, there are three types of MIS handover command primitives based on the functionality specified for the following scenarios:

a) MN to network
b) Network to MN
c) Network to network

This classification helps to ensure the specification of the proper protocol functionality and the relevant parameters for specific use as determined by the origination and the destination points.

Accordingly, these commands have a naming convention that identifies the origination point in the primitive name, as shown in Table 5. This convention is followed by the MISF to help ensure that these commands are utilized for the intended purpose. The destination point applies for remote commands only.

Table 5—Naming convention for MIS handover command primitives

Primitive name prefix	Originating point	Destination point
MIS_MN_HO_***	MN	Network
MIS_Net_HO_***	Network	MN
MIS_N2N_HO_***	Network	Network

5.7.2.3 Mobile initiated handovers

In this case, the MN initiates the handovers. The network selection policy function in this case resides on the MN. The MN directly uses the set of MIS_MN_HO_*** commands and may indirectly cause some MIS_N2N_HO_*** commands to be used when initiating handovers. The MN uses these commands to query the list of available candidate networks, reserve any required resources at the candidate target network, and indicate the status of handover operation to the MISF in the network.

5.7.2.4 Network initiated handovers

In this case, the network initiates the handovers. The network selection policy function in this case resides on the network. The network uses the set of MIS_Net_HO_*** in conjunction with any MIS_N2N_HO_*** commands for initiating handovers. The network uses these commands to query the list of resources currently being used by the MN, the serving network reserves any required resources at the candidate target network, and the network commands the MN to commit to performing a handover to a specific network.

5.8 Media independent information service

5.8.1 Information elements

Table 6 represents the list of handover-related information elements and their semantics in addition to what has been defined in 6.5.4 of IEEE Std 802.21-2017. Each information element has an abstract data type [see Annex E and also Annex E of IEEE Std 802.21-2017 for detailed definitions]. The binary and resource description framework (RDF) representation of these information elements are described in 6.5.6.2, 6.5.6.3,

and 6.5.7.2 of IEEE Std 802.21-2017, respectively. These information elements shall be used in conjunction with others that are described in IEEE Std 802.21-2017.

Table 6—Information elements

Name of information element	Description	Data type
Access network specific information elements		
IE_NET_MOB_MGMT_PROT	Type of mobility management protocol supported.	IP_MOB_MGMT
IE_NET_MOBILE_NETWORK	Indicator whether the access network itself is mobile.	BOOLEAN
IE_PoS_TUNN_MGMT_PRTO	Type of tunnel management protocol supported.	IP_TUNN_MGMT
IE_PoS_NAI	NAI of the PoS	MISF_ID

5.8.2 IE containers

— **IE_CONTAINER_NETWORKS**—contains the information depicting an access network that are necessary for handover use case in addition to what has been specified in Table 12 of IEEE Std 802.21-2017, as shown in Table 7.

Table 7—IE_CONTAINER_NETWORKS definition

Information element ID = [see Table F.1 of IEEE Std 802.21-2017]	**Length**= *variable*
IE_NET_MOB_MGMT_PROT(optional)	

5.9 Media dependent SAPs

5.9.1 MIS_LINK_SAP

The primitives defined as part of the MIS_LINK_SAP are described in Table 8. These are specific to handover use case and shall be used with others that are defined in 7.3 of IEEE Std 802.21-2017. Annex D contains their mapping to several specific link technologies. IETF RFC 5184 [B33] specifies many of these primitives as L2 abstractions.

Table 8—MIS_LINK_SAP primitives

Primitives	Service category	Description	Defined in
Link_Handover_Imminent	Event	L2 handover is imminent	5.10.1
Link_Handover_Complete	Event	L2 handover has been completed	5.10.2
Link_Prereg_Ready	Command	Used by MISFs at the MN and the PoS to prepare for preregistration	5.10.3
Link_Up	Event	L2 connectivity is established	5.10.4

5.9.2 MIS_NET_SAP

The primitive defined for MIS_NET_SAP is described in Table 9. This is specific to handover use case and shall be used with others that are defined in 7.5 of IEEE Std 802.21-2017.

Table 9—MIS_NET_SAP primitive

Primitive	Service category	Description	Defined in
MIS_N2N_Prereg_Xfer	Command	Used by MISFs at the SPoS and the TPoS for cross-network preregistration operations	5.12.1

5.9.3 Media independent SAP: MIS_SAP

The primitives defined as part of MIS_SAP are described in Table 10. These are specific to handover use case and shall be used with others that are defined in 7.4 of IEEE Std 802.21-2017.

Table 10—MIS_SAP primitives

Primitives	Service category	Description	Defined in
MIS_Link_Handover_Imminent	Event	L2 handover is imminent	5.11.1
MIS_Link_Handover_Complete	Event	L2 handover has been completed	5.11.2
MIS_Net_HO_Candidate_Query	Command	Initiate handover	5.11.3
MIS_MN_HO_Candidate_Query	Command	Initiate MN query request for candidate network	5.11.4
MIS_N2N_HO_Query_Resources	Command	Query available network resources	5.11.5
MIS_MN_HO_Commit	Command	Notify the serving network of the decided target network information	5.11.6
MIS_Net_HO_Commit	Command	Network has committed to handover	5.11.7
MIS_N2N_HO_Commit	Command	Notify target network that the serving network has committed to handover	5.11.8
MIS_MN_HO_Complete	Command	Initiate MN handover complete notification	5.11.9
MIS_N2N_HO_Complete	Command	Handover has been completed	5.11.10
MIS_Net_HO_Bcst_Commit	Command	Command a specific group of MNs to handover from DO network to other networks	5.11.11
MIS_Prereg_Xfer	Command	Used by MISFs at the MN and the PoS for preregistration operations	5.11.12
MIS_Prereg_Ready	Command	Used by MISFs at the MN and the PoS to prepare for preregistration	5.11.13
MIS_CTRL_Transfer	Command	Used by the MISF to deliver control messages	5.11.14
MIS_Capability_Discover	Service management	Discover list of Events and Command supported by MISF	5.11.15
MIS_Link_Up	Event	L2 connection has been established	5.11.16

5.10 MIS_LINK_SAP primitives

5.10.1 Link_Handover_Imminent.indication

5.10.1.1 Function

Link_Handover_Imminent is generated when a native link-layer handover or switch decision has been made and its execution is imminent (as opposed to Link_Going_Down that only indicates that a link is losing connectivity due to a change in a certain link condition such as signal strength, but does not guarantee that a link switch-over has been decided by the link layer itself). It contains information about the

new PoA of the MN (the LinkIdentifier parameter contains information about the new PoA). This is a Link Handover event as discussed in 5.6.1.

5.10.1.2 Semantics of service primitive

Link_Handover_Imminent.indication (
Old Link Identifier,
New Link Identifier,
OldAccessRouter,
NewAccessRouter
)

Parameters:

Name	Data type	Description
OldLinkIdentifier	LINK_TUPLE_ID	Identifier of the old link.
NewLinkIdentifier	LINK_TUPLE_ID	Identifier of the new link.
OldAccessRouter	LINK_ADDR	(Optional) Link address of old Access Router.
NewAccessRouter	LINK_ADDR	(Optional) Link address of new Access Router.

5.10.1.3 When generated

Depending on whether it is the MN or the network, it is generated when a native link-layer handover or switch decision has been made and its execution is imminent.

5.10.1.4 Effect on receipt

The MISF receives this event from the link layer. The MISF then passes this notification to the MIS user(s) that has subscribed for this notification. The MIS user(s) takes necessary actions to minimize the effect of the pending native link-layer handover or switch on user data transfer. This event is also used as an indication to start buffering packets.

5.10.2 Link_Handover_Complete.indication

5.10.2.1 Function

Link_Handover_Complete event is generated whenever a native link-layer handover/switch has just been completed (as opposed to Link_Up that only indicates that a link has been brought up for L2 connectivity, but does not indicate that a native link handover/switch-over has just been completed by the link layer). Notifying the upper layer of this event improves transport, session, and application layer responsiveness to the link changes, which allows them to better adapt their data flows by resuming flows upon receiving this indication. The upper layers also use this event to check whether their IP configuration needs to be updated. This is a link-layer event that exists for intra-technology handovers defined in many media types. This event is applicable for the MN only and is valid only for intra-technology handovers. This is a Link Handover event as discussed in 5.6.1.

5.10.2.2 Semantics of service primitive

Link_Handover_Complete.indication (
OldLinkIdentifier,
NewLinkIdentifier,
OldAccessRouter,
NewAccessRouter,
LinkHandoverStatus
)

Parameters:

Name	Data type	Description
OldLinkIdentifier	LINK_TUPLE_ID	Identifier of the old link.
NewLinkIdentifier	LINK_TUPLE_ID	Identifier of the new link.
OldAccessRouter	LINK_ADDR	(Optional) Link address of old Access Router.
NewAccessRouter	LINK_ADDR	(Optional) Link address of new Access Router.
LinkHandoverStatus	STATUS	Status of the link handover.

5.10.2.3 When generated

This is generated whenever an L2 link-layer handover or switch has just been completed.

5.10.2.4 Effect on receipt

The MISF receives this event from the link layer. The MISF then passes this notification to the MIS user(s) that has subscribed for this notification. Upon reception of this event, an upper layer stops any handover adaptation that it has engaged to cope with the just completed native link-layer handover/switch and resume normal data transfer. This event is also used as an indication that a reverification of the IP parameter should be considered.

5.10.3 Link_Prereg_Ready

5.10.3.1 Link_Prereg_Ready.request

5.10.3.1.1 Function

The primitives defined here are used by MIS functions running on the MN and PoS to prepare for preregistration for MN on a target PoA. See Annex L for examples.

5.10.3.1.2 Semantics of service primitive

Link_Prereg_Ready.request (
ExecutionDelay
)

Parameters:

Name	Data type	Description
ExecutionDelay	UNSIGNED_INT(2)	Time (in ms) to elapse before the action should be taken. A value of 0 indicates that the action is taken immediately. Time elapsed is calculated from the instance the request arrives until the time when the execution of the action is carried out.

5.10.3.1.3 When generated

This primitive is generated by the MISF to prepare preregistration of the target link.

5.10.3.1.4 Effect on receipt

Upon receipt of this primitive, the target link interface prepares preregistration at the time specified by the ExecutionDelay parameter. The L2 messages for preregistration are transmitted to the MISF for preregistration preparation with the target link layer.

5.10.3.2 Link_Prereg_Ready.confirm

5.10.3.2.1 Function

This primitive is used by link-layer technologies to provide an indication of the result of the preregistration preparation on the target link layer.

5.10.3.2.2 Semantics of service primitive

Link_Prereg_Ready.confirm (
Status
)

Parameters:

Name	Data type	Description
Status	STATUS	Status of the operation. Code 3 (Authorization Failure) is not applicable. (See Table E.2 of IEEE Std 802.21-2017.)

5.10.3.2.3 When generated

This primitive is generated in response to a Link_Prereg_Ready.request operation.

5.10.3.2.4 Effect on receipt

Upon reception of this primitive, the MISF knows the status of the preregistration on the target link.

5.10.4 Link_Up.indication

This primitive is defined in 7.3.2 of IEEE Std 802.21-2017. The following additional parameter is needed while using this primitive for handover use:

Use case specific parameters:

Name	Data type	Description
MobilityManagementSupport	IP_MOB_MGMT	(Optional) Indicates the type of Mobility Management Protocol supported by the new PoA.

5.11 MIS_SAP primitive

5.11.1 MIS_Link_Handover_Imminent.indication

5.11.1.1 Function

This primitive is issued by the MISF to report the imminent occurrence of an intra-technology link handover. This MIS event is either local or remote. This indication directly corresponds to the link-layer event Link_Handover_Imminent.indication defined in 5.10.1.

5.11.1.2 Semantics of service primitive

MIS_Link_Handover_Imminent.indication (
SourceIdentifier,
OldLinkIdentifier,
NewLinkIdentifier,
OldAccessRouter,
NewAccessRouter
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker of this primitive, which is either the local MISF or a remote MISF.
OldLinkIdentifier	LINK_TUPLE_ID	Identifier of the old link.
NewLinkIdentifier	LINK_TUPLE_ID	Identifier of the new link.
OldAccessRouter	LINK_ADDR	(Optional) Link address of old Access Router.
NewAccessRouter	LINK_ADDR	(Optional) Link address of new Access Router.

5.11.1.3 When generated

This notification is generated by the MISF when a link-layer intra-technology handover is about to occur. The event could be triggered by the reception of a Link_Handover_Imminent.indication from a link or on receipt of an MIS_Link_Handover_Imminent indication message.

5.11.1.4 Effect on receipt

Upper layer entities take different actions upon notification.

5.11.2 MIS_Link_Handover_Complete.indication

5.11.2.1 Function

This primitive is issued by the MISF to report the completion of an intra-technology link handover. This MIS event is either local or remote. MIS_Link_Handover_Complete indication is a result of a Link_Handover_Complete indication from the link layer.

5.11.2.2 Semantics of service primitive

MIS_Link_Handover_Complete.indication (
SourceIdentifier,
OldLinkIdentifier,
NewLinkIdentifier,
OldAccessRouter,
NewAccessRouter,
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker of this primitive, which is either the local MISF or a remote MISF.
OldLinkIdentifier	LINK_TUPLE_ID	Identifier of the old link.
NewLinkIdentifier	LINK_TUPLE_ID	Identifier of the new link.
OldAccessRouter	LINK_ADDR	(Optional) Link address of old Access Router.
NewAccessRouter	LINK_ADDR	(Optional) Link address of new Access Router.

5.11.2.3 When generated

This notification is generated by the MISF when a link-layer intra-technology handover is completed. The event could be triggered by the reception of a Link_Handover_Complete.indication from a link or on receipt of an MIS_Link_Handover_Complete indication message.

5.11.2.4 Effect on receipt

Upper layer entities take different actions on this notification. An MIS user makes use of this notification to configure other layers (IP, Mobile IP) for various upper layer handovers that are needed. Transport layers (e.g., TCP) also make use of this primitive to fine tune their flow control and flow congestion mechanisms.

5.11.3 MIS_Net_HO_Candidate_Query

5.11.3.1 General

For network initiated handovers, the network controller provides a list of candidate network choices to the MN (via MIS_Net_HO_Candidate_Query request message). The MN indicates resources required on each of these candidate networks in the MIS_Net_HO_Candidate_Query response message. The network controller then queries each of the candidate networks for available resources (using

MIS_N2N_HO_Query_Resources primitive). Once the target network has been selected, the network controller sends an MIS_Net_HO_Commit message. An example of this operation is illustrated in B.2.

5.11.3.2 MIS_Net_HO_Candidate_Query.request

5.11.3.2.1 Function

The primitive is invoked by an MIS user on a network node to communicate to a peer MIS user about its intent of handover initiation.

5.11.3.2.2 Semantics of service primitive

MIS_Net_HO_Candidate_Query.request (
DestinationIdentifier,
SuggestedNewLinkList,
SuggestedCandidateAuthenticatorList,
QueryResourceReportFlag
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This specifies MISF ID of the remote MISF(s) to be configured of this request.
SuggestedNewLinkList	LIST(LINK_POA_LIST)	A list of PoAs for each link, suggesting the new access networks to which handover initiation should be considered. The access networks towards the top of the list are more preferable than those towards the bottom of the list.
SuggestedCandidateAuthenticatorList	LIST(LINK_AUTHENTICATOR_LIST)	List of media specific authenticator's address for the suggested candidate PoAs.
QueryResourceReportFlag	BOOLEAN	Flag to specify if resources need to be reported by MN: TRUE: Required to report resource list FALSE: Not required to report resource list.

5.11.3.2.3 When generated

This primitive is invoked by an MIS user to communicate with a remote MIS user about its intent of handover initiation. Serving PoS requests MN to provide information about resources required to initiate a handover by setting the QueryResourceReportFlag parameter.

5.11.3.3 MIS_NET_HO_Candidate_Query.indication

5.11.3.3.1 Function

This primitive is used by an MISF to indicate to an MIS user that an MIS_Net_HO_Candidate_Query request message was received from a remote MISF.

5.11.3.3.2 Semantics of service primitive

MIS_Net_HO_Candidate_Query.indication (
SourceIdentifier,
SuggestedNewLinkList,
SuggestedCandidateAuthenticatorList,
QueryResourceReportFlag
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker of this primitive, which is a remote MISF.
SuggestedNewLinkList	LIST(LINK_POA_LIST)	A list of PoAs for each link, suggesting the new access networks to which handover initiation should be considered. The access networks towards the top of the list are more preferable than those towards the bottom of the list.
SuggestedCandidateAuthenticatorList	LIST(LINK_AUTHENTICATOR_LIST)	List of media specific authenticator's address for the suggested candidate PoAs.
QueryResourceReportFlag	BOOLEAN	Flag to specify if resources need to be reported by MN: TRUE: Required to report resource list. FALSE: Not required to report resource list.

5.11.3.3.3 When generated

This primitive is generated by an MISF on receiving an MIS_Net_HO_Candidate_Query request message from a peer MISF.

5.11.3.3.4 Effect on receipt

An MIS user receiving this indication shall invoke an MIS_Net_HO_Candidate_Query.response primitive towards the remote MISF indicated by the Source Identifier in the request message.

5.11.3.4 MIS_NET_HO_Candidate_Query.response

5.11.3.4.1 Function

This primitive is used by the MISF on an MN to respond to an MIS_Net_HO_Candidate_Query request message from a remote MISF in the network.

5.11.3.4.2 Semantics of service primitive

MIS_Net_HO_Candidate_Query.response (
DestinationIdentifier,
Status,
SourceLinkIdentifier,
HandoverStatus,
PreferredLinkList,
PreferredCandidateAuthenticatorList
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies a remote MISF that shall be the destination of this response.
Status	STATUS	Status of operation.
SourceLinkIdentifier	LINK_TUPLE_ID	This identifies the current link.
HandoverStatus[a]	HO_STATUS	Lists the acceptance status (permit/decline) of the handover request.
PreferredLinkList[b]	LIST(RQ_RESULT)	A list of RQ_RESULT suggesting new access networks to which handover initiation should be considered. This can be different than the networks that were suggested in the handover request. The list is sorted from most preferred first to least preferred last.
PreferredCandidate-AuthenticatorList	LIST (LINK_AUTHENTICATOR_LIST)	List of corresponding media specific authenticator's addresses for the preferred candidate PoAs.

[a] This parameter is not included if Status does not indicate "Success."
[b] This parameter is not included if Status does not indicate "Success" or Handover Status indicates "decline."

5.11.3.4.3 When generated

This primitive is generated by the MISF on receiving an MIS_Net_HO_Candidate_Query response message from a peer MISF.

5.11.3.4.4 Effect on receipt

On receiving the primitive, the entity that originally initiated the handover request decides to carry out the handover or abort it based on the primitive. However, if Status does not indicate "Success," the recipient ignores any other returned values and, instead, performs appropriate error handling.

5.11.3.5 MIS_NET_HO_Candidate_Query.confirm

5.11.3.5.1 Function

The primitive is used by the MISF to confirm that an MIS_Net_HO_Candidate_Query response message was received from a peer MISF.

5.11.3.5.2 Semantics of service primitive

MIS_Net_HO_Candidate_Query.confirm (
SourceIdentifier,
Status,
SourceLinkIdentifier,
HandoverStatus,
PreferredLinkList,
PreferredCandidateAuthenticatorList
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	Contains the MISF ID of the MN that sent the MIS_Net_HO_Candidate_Query response message.
Status	STATUS	Status of operation.
SourceLinkIdentifier	LINK_TUPLE_ID	This identifies the current link.
HandoverStatus[a]	HO_STATUS	Lists the acceptance status (permit/decline) of the handover request.
PreferredLinkList[b]	LIST(RQ_RESULT)	A list of RQ_RESULT suggesting new access networks to which handover initiation should be considered. This can be different than the networks that were suggested in the handover request. The list is sorted from most preferred first to least preferred last.
PreferredCandidate-AuthenticatorList	LIST (LINK_AUTHENTICATOR_LIST)	List of the corresponding media specific authenticator's address for the preferred candidate PoAs.

[a] This parameter is not included if Status does not indicate "Success."
[b] This parameter is not included if Status does not indicate "Success" or Handover Status indicates "decline."

5.11.3.5.3 When generated

This primitive is generated by the MISF on receiving an MIS_Net_HO_Candidate_Query response message from a peer MISF.

5.11.3.5.4 Effect on receipt

On receiving the primitive, the entity that originally initiated the handover request decides to carry out the handover or abort it based on the primitive. However, if Status does not indicate "Success," the recipient ignores any other returned values and, instead, performs appropriate error handling.

5.11.4 MIS_MN_HO_Candidate_Query

5.11.4.1 MIS_MN_HO_Candidate_Query.request

5.11.4.1.1 Function

This primitive is used by MIS users on an MN to inform MISF to query candidates for possible handover initiation. The request includes queries on QoS resources and/or whether IP address configuration method of the ongoing data sessions is supported in the candidate network. This primitive also includes the current IP configuration server address [e.g., DHCP server, foreign agent (FA) IP address, access router (AR) IP address] when the current IP configuration method is included.

5.11.4.1.2 Semantics of service primitive

MIS_MN_HO_Candidate_Query.request (
DestinationIdentifier,
SourceLinkIdentifier,
CandidateLinkList,
QoSResourceRequirements,
IPConfigurationMethods,
DHCPServerAddress,
FAAddress,
AccessRouterAddress,
CandidateAuthenticatorList
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies a remote MISF that shall be the destination of this request.
SourceLinkIdentifier	LINK_TUPLE_ID	This identifies the source link for handover.
CandidateLinkList	LIST(LINK_POA_LIST)	A list of PoAs, identifying candidate networks to which handover needs to be initiated. The list is sorted from most preferred first to least preferred last.
QoSResourceRequirements	QOS_LIST	Minimal QoS resources required at the candidate network.
IPConfigurationMethods	IP_CFG_MTHDS	(Optional) Current IP configuration methods.
DHCPServerAddress	IP_ADDR	(Optional) IP address of current DHCP Server. It is only included when MN is using dynamic address configuration.
FAAddress	IP_ADDR	(Optional) IP address of current Foreign Agent. It is only included when MN is using Mobile IPv4.
AccessRouterAddress	IP_ADDR	(Optional) IP address of current Access Router. It is only included when MN is using Ipv6.
CandidateAuthenticatorList	LIST (LINK_ AUTHENTICATOR_ LIST)	List of the corresponding media specific authenticator's addresses for the candidate PoAs.

5.11.4.1.3 When generated

This primitive is generated by an MIS user in the MN that wants to query other candidate networks for a possible handover. MN uses the QueryResourceList parameter to notify the serving PoS of the minimal

resource requirement at the candidate networks in order for the handover to be successful. An MIS user on MN generates this primitive when it wants to query IP address related information from the candidate networks before handover.

5.11.4.1.4 Effect on receipt

Upon receipt of this primitive, the local MISF generates and sends an MIS_MN_HO_Candidate_Query request message to the remote MISF identified by the Destination Identifier.

5.11.4.2 MIS_MN_HO_Candidate_Query.indication

5.11.4.2.1 Function

This primitive is used by MISF to indicate the receipt of MIS_MN_HO_Candidate_Query request message from an MN.

5.11.4.2.2 Semantics of service primitive

MIS_MN_HO_Candidate_Query.indication (
SourceIdentifier,
SourceLinkIdentifier,
CandidateLinkList,
QoSResourceRequirements,
IPConfigurationMethods,
DHCPServerAddress,
FAAddress,
AccessRouterAddress,
CandidateAuthenticatorList
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker of this primitive, which is a remote MISF.
SourceLinkIdentifier	LINK_TUPLE_ID	This identifies the source link for handover.
CandidateLinkList	LIST(LINK_POA_LIST)	A list of PoAs, identifying candidate networks to which handover needs to be initiated. The list is sorted from most preferred first to least preferred last.
QoSResourceRequirements	QOS_LIST	Minimal QoS resources required at the candidatenetwork.
IPConfigurationMethods	IP_CFG_MTHDS	(Optional) Current IP configuration methods.
DHCPServerAddress	IP_ADDR	(Optional) IP address of current DHCP Server. It is only included when MN is using dynamic address configuration.
FAAddress	IP_ADDR	(Optional) IP address of current Foreign Agent. It is only included when MN is using Mobile IPv4.
AccessRouterAddress	IP_ADDR	(Optional) IP address of current Access Router. It is only included when MN is using IPv6.
CandidateAuthenticatorList	LIST(LINK_ AUTHENTICATOR_ LIST)	List of the corresponding media specific authenticator's addresses for the candidate PoAs.

5.11.4.2.3 When generated

This primitive is generated by MISF on receiving MIS_MN_HO_Candidate_Query request message from a peer MISF in an MN.

5.11.4.2.4 Effect on receipt

The MIS user invokes MIS_N2N_HO_Query_Resources.request primitive to exchange MIS_N2N_HO_Query_Resource messages with MISF in one or more candidate networks under consideration before invoking the MIS_MN_HO_Candidate_Query.response primitive.

5.11.4.3 MIS_MN_HO_Candidate_Query.response

5.11.4.3.1 Function

The primitive is used by MIS users to inform MISF of the result of the candidate query request.

5.11.4.3.2 Semantics of service primitive

MIS_MN_HO_Candidate_Query.response (
DestinationIdentifier,
Status,
SourceLinkIdentifier,
PreferredCandidateLinkList,
PreferredCandidateAuthenticatorList
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies a remote MISF that shall be the destination of this response.
Status	STATUS	Status of operation.
SourceLinkIdentifier	LINK_TUPLE_ID	This identifies the source link.
PreferredCandidateLinkList[a]	LIST(RQ_RESULT)	A list of RQ_RESULT suggesting new access networks to which handover initiation should be considered. This can be different than the networks that were suggested in the handover request. The list is sorted from most preferred first to least preferred last.
PreferredCandidate-AuthenticatorList	LIST(LINK_AUTHENTICATOR_LIST	List of the corresponding media specific authenticator's address for the preferred candidate PoAs.

[a] This parameter is not included if Status does not indicate "Success."

5.11.4.3.3 When generated

The MIS user invokes this primitive in response to an MIS_MN_HO_Candidate_Query request message from a peer MISF entity in MN and possibly after the exchange of MIS_N2N_HO_Query_Resources messages with the MISF in the candidate networks.

5.11.4.3.4 Effect on receipt

Upon receipt of this primitive, MISF send a response message to the destination.

5.11.4.4 MIS_MN_HO_Candidate_Query.confirm

5.11.4.4.1 Function

This primitive is used by MISF to inform MIS users of the receipt of candidate query and IP address related information response.

5.11.4.4.2 Semantics of service primitive

MIS_MN_HO_Candidate_Query.confirm (
SourceIdentifier,
Status,
SourceLinkIdentifier,
PreferredCandidateLinkList,
PreferredCandidateAuthenticatorList
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker of this primitive, which is a remote MISF.
Status	STATUS	Status of operation.
SourceLinkIdentifier	LINK_TUPLE_ID	This identifies the source link.
PreferredCandidateLinkList[a]	LIST(RQ_RESULT)	A list of RQ_RESULT suggesting new access networks to which handover initiation should be considered. This can be different than the networks that were suggested in the handover request. The list is sorted from most preferred first to least preferred last.
PreferredCandidateAuthenticator List	LIST(LINK_ AUTHENTICATOR_ LIST)	List of the corresponding media specific authenticator's address for the preferred candidate PoAs.

[a] This parameter is not included if Status does not indicate "Success."

5.11.4.4.3 When generated

This primitive is generated by MISF on receiving MIS_MN_HO_Candidate_Query response message from a peer MISF in the network.

5.11.4.4.4 Effect on receipt

On receiving the primitive, the MIS user entity that originally initiated the candidate query request decides to choose the candidate network for handover or abort it based on the list of PoA, available resources, and the IP address related information. However, if Status does not indicate "Success," the recipient ignores any other returned values and, instead, performs appropriate error handling.

5.11.5 MIS_N2N_HO_Query_Resources

5.11.5.1 MIS_N2N_HO_Query_Resources.request

5.11.5.1.1 Function

This primitive is used by an MISF on the serving network to communicate with its peer MISF on the candidate network. This is used to query the available link resource and IP address related information of the candidate network.

5.11.5.1.2 Semantics of service primitive

MIS_N2N_HO_Query_Resources.request (
DestinationIdentifier,
QoSResourceRequirements,
IPConfigurationMethods,
DHCPServerAddress,
FAAddress,
AccessRouterAddress,
CandidateLinkList
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This specifies MISF ID of the remote MISF(s) to be configured.
QoSResourceRequirements	QOS_LIST	Minimal QoS resources required at the candidate network.
IPConfigurationMethods	IP_CFG_MTHDS	(Optional) Current IP configuration methods.
DHCPServerAddress	IP_ADDR	(Optional) IP address of current DHCP Server. It is only included when MN is using dynamic address configuration.
FAAddress	IP_ADDR	(Optional) IP address of current Foreign Agent. It is only included when MN is using Mobile IPv4.
AccessRouterAddress	IP_ADDR	(Optional) IP address of current Access Router. It is only included when MN is using IPv6.
CandidateLinkList	LIST(LINK_ID)	(Optional) A list of candidate links [i.e., access points (APs) or base stations (BSs)] on a specific candidate network. In this list, each link is indicated by its link type and a PoA link address.

5.11.5.1.3 When generated

In the case of mobile-initiated handover, this primitive is generated after receiving the MIS_MN_HO_Candidate_Query request message from the MISF on the MN. In the case of network-initiated handover, this primitive is generated after receiving the MIS_Net_HO_Candidate_Query response message from the MN.

5.11.5.1.4 Effect on receipt

Upon receipt of this primitive, MISF shall send an MIS_N2N_HO_Query_Resources request message to the destination.

5.11.5.2 MIS_N2N_HO_Query_Resources.indication

5.11.5.2.1 Function

The MISF on the candidate network indicates that an MIS_N2N_HO_Query_Resources request message is received from a remote MISF on the serving network. This information allows the upper layer entity to identify the link resource usage and to provide IP address related information for the impending handover.

5.11.5.2.2 Semantics of service primitive

MIS_N2N_HO_Query_Resources.indication (
SourceIdentifier,
QoSResourceRequirements,
IPConfigurationMethods,
DHCPServerAddress,
FAAddress,
AccessRouterAddress,
CandidateLinkList
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies a remote MISF that shall be the destination of this request.
QoSResourceRequirements	QOS_LIST	Minimal QoS resources required at the candidate network.
IPConfigurationMethods	IP_CFG_MTHDS	(Optional) Current IP configuration methods.
DHCPServerAddress	IP_ADDR	(Optional) IP address of current DHCP Server. It is only included when MN is using dynamic address configuration.
FAAddress	IP_ADDR	(Optional) IP address of current Foreign Agent. It is only included when MN is using Mobile IPv4.
AccessRouterAddress	IP_ADDR	(Optional) IP address of current Access Router. It is only included when MN is using IPv6.
CandidateLinkList	LIST(LINK_ID)	(Optional) A list of candidate links (i.e., APs or BSs) on a specific candidate network. In this list, each link is indicated by its link type and a PoA link address.

5.11.5.2.3 When generated

In the case of mobile-initiated handover, this primitive is generated after receiving the MIS_MN_HO_Candidate_Query request message from the MISF on the MN. In the case of network-initiated handover, this primitive is generated after receiving the MIS_Net_HO_Candidate_Query response message from the MN.

5.11.5.2.4 Effect on receipt

Upon receipt of this primitive, MISF shall send an MIS_N2N_HO_Query_Resources request message to the destination.

5.11.5.3 MIS_N2N_HO_Query_Resources.response

5.11.5.3.1 Function

This primitive is used by an MISF on the candidate network to communicate with its peer MISF on the serving network that sent out an MIS_N2N_HO_Query_Resources request message. This is used to notify the MISF on the serving network of the link resource status of the candidate network. It is also used to provide IP address related information of the candidate networks.

5.11.5.3.2 Semantics of service primitive

MIS_N2N_HO_Query_Resources.response (
DestinationIdentifier,
Status,
ResourceStatus,
CandidateLinkList
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	Specifies the MISF ID of the node that sent the MIS_N2N_HO_Query_Resources request message.
Status	STATUS	Status of operation.
ResourceStatus[a]	LINK_RES_STATUS	Specifies whether requested resources are available or not at the new PoA.
CandidateLinkList[b]	LIST(RQ_RESULT)	A list of RQ_RESULT of the candidate links (i.e., APs or BSs).

[a] This parameter is not included if Status does not indicate "Success."
[b] This parameter is not included if Status does not indicate "Success" or Resource Status indicates "Not Available."

5.11.5.3.3 When generated

The MISF on the candidate network invokes this primitive in response to an MIS_N2N_HO_Query_Resources request message from a peer MISF entity on the serving network.

5.11.5.4 MIS_N2N_HO_Query_Resources.confirm

5.11.5.4.1 Function

This primitive is used by the MISF on the serving network to respond with the result of any resource preparation for the impending handover and to notify the link resource status of the candidate network. It also carries IP address related information on the candidate networks to MIS users on the serving network.

5.11.5.4.2 Semantics of service primitive

MIS_N2N_HO_Query_Resources.confirm (
SourceIdentifier,
Status,
ResourceStatus,
CandidateLinkList
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	Specifies the MISF ID of the node that sent the MIS_N2N_HO_Candidate_Query response message.
Status	STATUS	Status of operation.
ResourceStatus[a]	LINK_RES_STATUS	Specifies whether requested resources are available or not at the new PoA.
CandidateLinkList[b]	LIST(RQ_RESULT)	A list of RQ_RESULT of the candidate links (i.e., APs or BSs).

[a] This parameter is not included if Status does not indicate "Success."
[b] This parameter is not included if Status does not indicate "Success" or Resource Status indicates "Not Available."

5.11.5.4.3 When generated

This primitive is generated by the MISF when the MISF on the serving network receives an MIS_N2N_HO_Query_Resources response message from a peer MISF on the candidate network.

5.11.5.4.4 Effect on receipt

In the case when the MIS_N2N_HO_Query_Resources.request primitive was initiated by receiving an MIS_MN_HO_Candidate_Query.indication, the MIS user sends an MIS_MN_HO_Candidate_Query.response primitive with the information obtained from this primitive. However, if Status does not indicate "Success," the recipient ignores any other returned values and, instead, performs appropriate error handling.

5.11.6 MIS_MN_HO_Commit

5.11.6.1 MIS_MN_HO_Commit.request

5.11.6.1.1 Function

This primitive is used by MIS users on an MN to notify the serving network of the decided target network information.

5.11.6.1.2 Semantics of service primitive

MIS_MN_HO_Commit.request (
DestinationIdentifier,
LinkType,
TargetNetworkInfo
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This specifies the MISF ID of the serving network that is the target of this primitive.
LinkType	LINK_TYPE	This contains the target link type.
TargetNetworkInfo	TGT_NET_INFO	This contains the target network information.

5.11.6.1.3 When generated

The MIS user generates this primitive to notify the serving network of the target network information.

5.11.6.1.4 Effect on receipt

Upon receipt of this primitive, MISF on the MN sends the corresponding MIS_MN_HO_Commit request message to the serving network.

5.11.6.2 MIS_MN_HO_Commit.indication

5.11.6.2.1 Function

This primitive is generated by an MISF on the serving network to indicate that an MIS_MN_HO_Commit request message has been received from a peer MISF on the MN.

5.11.6.2.2 Semantics of service primitive

MIS_MN_HO_Commit.indication (
SourceIdentifier,
LinkType,
TargetNetworkInfo
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This specifies the MISF ID of the MN that sent the MIS_MN_HO_Commit request message.
LinkType	LINK_TYPE	This contains the target link type.
TargetNetworkInfo	TGT_NET_INFO	This contains the target network information.

5.11.6.2.3 When generated

This primitive is generated by an MISF on the serving network when receiving an MIS_MN_HO_Commit request message from a peer MISF on the mobile node.

5.11.6.2.4 Effect on receipt

Upon receipt of this primitive, an MIS user on the serving network replies with an MIS_MN_HO_Commit.response primitive. MIS user may invoke the MIS_N2N_HO_Commit.request primitive to reserve the resource at the target network.

5.11.6.3 MIS_MN_HO_Commit.response

5.11.6.3.1 Function

This primitive is used by an MIS user on the serving network to communicate with a peer MIS user on the MN from which an MIS_MN_HO_Commit request message is received.

MIS_MN_HO_Commit.response (
DestinationIdentifier,
Status,
LinkType,
TargetNetworkInfo
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This specifies the MISF ID of the MN that sent the MIS_MN_HO_Commit request message.
Status	STATUS	Status of operation.
LinkType	LINK_TYPE	This contains the target link type.
TargetNetworkInfo	TGT_NET_INFO	This contains the target network information.

5.11.6.3.2 When generated

This primitive is generated in response to an MIS_MN_HO_Commit.indication primitive.

5.11.6.3.3 Effect on receipt

When receiving this primitive from the MIS user, the MISF on the Serving PoS sends the corresponding MIS_MN_HO_Commit response message to its peer MISF on the MN.

5.11.6.4 MIS_MN_HO_Commit.confirm

5.11.6.4.1 Function

This primitive is generated by the MISF on the MN to confirm that an MIS_MN_HO_Commit response message is received from a peer MISF on the serving network.

MIS_MN_HO_Commit.confirm (
SourceIdentifier,
Status,
LinkType,
TargetNetworkInfo
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This specifies the MISF ID of the Serving PoS that sent the MIS_MN_HO_Commit response message.
Status	STATUS	Status of operation.
LinkType	LINK_TYPE	This contains the target link type.
TargetNetworkInfo	TGT_NET_INFO	This contains the target network information.

5.11.6.4.2 When generated

This primitive is generated by the MISF on the MN when it receives an MIS_MN_HO_Commit response message from a peer MISF on the serving network.

5.11.6.4.3 Effect on receipt

Upon receipt, the MIS user on the MN is informed about the status of the previously issued target notification request.

5.11.7 MIS_Net_HO_Commit

5.11.7.1 MIS_Net_HO_Commit.request

5.11.7.1.1 Function

This primitive is used by an MIS user on the network to communicate with the remote MIS user on the MN. The primitive is used to request the peer MIS user the commitment to perform a network-controlled or network-assisted link handover based on selected choices for candidate networks and PoA.

5.11.7.1.2 Semantics of service primitive

MIS_Net_HO_Commit.request (
DestinationIdentifier,
ResponseFlag,
LinkType,
TargetNetworkInfoList,
AssignedResourceSet,
LinkActionExecutionDelay,
LinkActionsList,
GroupLinkActionsList
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This specifies MISF ID of the remote MISF(s) to be configured.
ResponseFlag[a]	RESPONSE_FLAG	(Optional) Flag that represents whether or not a response is needed.
LinkType	LINK_TYPE	Contains target link type.
TargetNetworkInfoList	LIST(TGT_NET_INFO)	This list contains target network information for assisting the MN to perform a handover.
AssignedResourceSet	ASGN_RES_SET	This includes the set of resource parameters assigned to the MN for performing the handover.
LinkActionExecutionDelay	UNSIGNED_INT(2)	(Optional) Time (in ms) to elapse before an action needs to be taken. A value of 0 indicates that the action is taken immediately. Time elapsed is calculated from the instance the command arrives until the time when the execution of the action is carried out. This parameter shall be used for non-group operations.
LinkActionsList	LIST(LINK_ACTION_REQ)	(Optional) A list of network controlled handover actions for the links. This parameter shall be used if and only if DestinationIdentifier is an MISF ID.
GroupLinkActionsList	LIST(MULTICAST_ ACTION_REQ)	(Optional) Specifies the suggested actions for a group of links. This parameter shall be used if and only if DestinationIdentifier is an MISF Group ID.

[a] If the ResponseFlag parameter is not present, the MISF shall generate a request message, otherwise the MISF generates either a request or an indication message, based on the ResponseFlag parameter.

5.11.7.1.3 When generated

The MIS user generates this primitive to order specific handover actions on one or more links.

5.11.7.1.4 Effect on receipt

Upon receipt of this primitive, an MISF shall send an MIS_NET_HO_Commit request or indication message to the destination, based on the ResponseFlag parameter.

5.11.7.2 MIS_Net_HO_Commit.indication

5.11.7.2.1 Function

This primitive is used by an MISF to indicate that an MIS_Net_HO_Commit request message has been received from a peer MISF.

5.11.7.2.2 Semantics of service primitive

MIS_Net_HO_Commit.indication (
SourceIdentifier,
ResponseFlag,
LinkType,
TargetNetworkInfoList,
AssignedResourceSet,
LinkActionExecutionDelay,
LinkActionsList,
GroupLinkActionsList
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	Specifies the MISF ID of the remote MISF(s) that sent the MIS_Net_HO_Commit request message.
ResponseFlag [a]	RESPONSE_FLAG	(Optional) Flag that represents whether or not a response is needed.
LinkType	LINK_TYPE	Contains target link type.
TargetNetworkInfoList	LIST(TGT_NET_INFO)	This list contains target network information for assisting the MN to perform a handover.
AssignedResourceSet	ASGN_RES_SET	This includes the set of resource parameters assigned to the MN for performing the handover.
LinkActionExecutionDelay	UNSIGNED_INT(2)	(Optional) Time (in ms) to elapse before an action needs to be taken. A value of 0 indicates that the action is taken immediately. Time elapsed is calculated from the instance the command arrives until the time when the execution of the action is carried out. This parameter shall be used for non-group operation.

LinkActionsList	LIST(LINK_ACTION_REQ)	(Optional) A list of network controlled handover actions for the links. This parameter shall be used if and only if DestinationIdentifier is an MISF ID.
GroupLinkActionsList	LIST(MULTICAST_ACTION_REQ)	(Optional) Specifies the suggested actions for a group of links. This parameter shall be used if and only if DestinationIdentifier is an MISF Group ID.

[a] If the ResponseFlag parameter is not present, the MISF shall generate a response message, otherwise the MISF may generate a response message or no response message, based on the ResponseFlag parameter.

5.11.7.2.3 When generated

This primitive is generated by an MISF on receiving an MIS_Net_HO_Commit request message from a peer MISF.

5.11.7.2.4 Effect on receipt

The MIS user receiving this primitive replies with an MIS_Net_HO_Commit response primitive. Only the applicable actions in the Link Actions List are executed. The non-applicable link actions indicate failed actions when preparing the response.

5.11.7.3 MIS_Net_HO_Commit.response

5.11.7.3.1 Function

This primitive is used by an MISF to communicate with a peer MISF from which an MIS_Net_HO_Commit request message is received. The primitive is used to communicate the response of a handover commit request.

5.11.7.3.2 Semantics of service primitive

MIS_Net_HO_Commit.response (
DestinationIdentifier,
Status,
LinkType,
TargetNetworkInfo,
LinkActionsResultList
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	Specifies the MISF ID of the node that sent the MIS_Net_HO_Commit request message.
Status	STATUS	Status of operation.
LinkType[a]	LINK_TYPE	Contains target link type.
TargetNetworkInfo[a]	TGT_NET_INFO	Contains target network information for handover.
LinkActionsResultList[a]	LIST(LINK_ACTION_RSP)	(Optional) A list of link actions result. This parameter is present if and only if LinkActionsList parameter is present in MIS_NET_HO_Committ.indication

[a] This parameter is not included if Status does not indicate "Success."

5.11.7.3.3 When generated

This primitive is generated in response to an MIS_Net_HO_Commit.indication primitive.

5.11.7.3.4 Effect on receipt

Upon receipt of this primitive, MISF shall send an MIS_Net_HO_Commit response message to the destination.

5.11.7.4 MIS_Net_HO_Commit.confirm

5.11.7.4.1 Function

This primitive is used by the MISF to confirm that an MIS_Net_HO_Commit response message is received from a peer MISF.

5.11.7.4.2 Semantics of service primitive

MIS_Net_HO_Commit.confirm (
SourceIdentifier,
Status,
LinkType,
TargetNetworkInfo,
LinkActionsResultList
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	Specifies the MISF ID of the node that sent the MIS_Net_HO_Commit response message.
Status	STATUS	Status of operation.
LinkType[a]	LINK_TYPE	Contains target link type.
TargetNetworkInfo[a]	TGT_NET_INFO	Contains target network information for handover.
LinkActionsResultList[a]	LIST(LINK_ACTION_RSP)	(Optional) A list of link actions result. This parameter is present if and only if LinkActionsList parameter was present in MIS_Net_HO_Commit.request.

[a] This parameter is not included if Status does not indicate "Success."

5.11.7.4.3 When generated

This primitive is generated by the MISF on receiving an MIS_Net_HO_Commit response message from a peer MISF.

5.11.7.4.4 Effect on receipt

Upon receipt, the old serving PoS is informed about the status of the previously issued command request.

Since the MIS_Net_HO_Commit request message contains actions to effect the handover, the link between the old PoS and the MN may not be accessible (e.g., break before make) for the old PoS to receive the

MIS_Net_HO_Commit response message from the MN. In this case the MIS_Net_HO_Commit response message will not be received by the old PoS, unless the MN knows the old PoS L3 address and sends the message after establishing L3 connectivity.

5.11.8 MIS_N2N_HO_Commit

5.11.8.1 MIS_N2N_HO_Commit.request

5.11.8.1.1 Function

This primitive is used by an MIS user on the serving network to inform a selected target network that an MN is about to move to the target network.

5.11.8.1.2 Semantics of service primitive

The parameters of the primitive are as follows:

MIS_N2N_HO_Commit.request (
DestinationIdentifier,
MNIdentifier,
TargetMNLinkIdentifier,
TargetPoA,
RequestedResourceSet
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies a remote MISF that shall be the destination of this request.
MNIdentifier	MISF_ID	This identifies the MISF of the MN that commits to perform handover action.
TargetMNLinkIdentifier	LINK_ID	This is the identifier of the MN's target link for which resources are requested.
TargetPoA	LINK_ADDR	This is the link address of the target PoA (AP/BS).
RequestedResourceSet	REQ_RES_SET	This includes the set of parameters required for performing MN admission control and resource reservation at the target network.

5.11.8.1.3 When generated

The MIS user on the serving network invokes this primitive when a single target network has been decided.

5.11.8.1.4 Effect on receipt

Upon receipt of this primitive, the local MISF generates and sends an MIS_N2N_HO_Commit request message to the remote MISF on the selected target network identified by the Destination Identifier.

5.11.8.2 MIS_N2N_HO_Commit.indication

5.11.8.2.1 Function

This primitive is used by an MISF to indicate that an MIS_N2N_HO_Commit request message has been received from a peer MISF on the serving network.

5.11.8.2.2 Semantics of service primitive

The parameters of the primitive are as follows:

MIS_N2N_HO_Commit.indication (
SourceIdentifier,
MNIdentifier,
TargetMNLinkIdentifier,
TargetPoA,
RequestedResourceSet
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker of this primitive, which is a remote MISF.
MNIdentifier	MISF_ID	This identifies the MISF of the MN that commits to perform handover action.
TargetMNLinkIdentifier	LINK_ID	This is the identifier of the MN's target link for which resources are requested.
TargetPoA	LINK_ADDR	This is the link address of the target PoA (AP/BS).
RequestedResourceSet	REQ_RES_SET	This includes the set of parameters required for performing MN admission control and resource reservation at the target network.

5.11.8.2.3 When generated

This primitive is generated by an MISF on receiving an MIS_N2N_HO_Commit request message from a peer MISF on the serving network.

5.11.8.2.4 Effect on receipt

Upon receipt of this primitive, MIS user generates an MIS_N2N_HO_Commit.response primitive.

5.11.8.3 MIS_N2N_HO_Commit.response

5.11.8.3.1 Function

This primitive is used by an MIS user to respond to an MIS_N2N_HO_Commit.indication primitive.

5.11.8.3.2 Semantics of service primitive

The parameters of the primitive are as follows:

MIS_N2N_HO_Commit.response (
DestinationIdentifier,
Status,
MNIdentifier,
TargetLinkIdentifier,
AssignedResourceSet
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies a remote MISF that shall be the destination of this request.
Status	STATUS	Status of operation.
MNIdentifier	MISF_ID	This identifies the MISF of the MN that commits to perform handover action.
TargetLinkIdentifier[a]	LINK_TUPLE_ID	This contains the identifier of the target PoA (AP/ BS) for the MN.
AssignedResourceSet[a]	ASGN_RES_SET	This includes the set of resource parameters assigned by the target network to the MN.

[a] This parameter is not included if Status does not indicate "Success."

5.11.8.3.3 When generated

This primitive is generated by an MISF user in response to a received MIS_N2N_HO_Commit.indication primitive.

5.11.8.3.4 Effect on receipt

Upon receipt, the MISF generates and sends an MIS_N2N_HO_Commit response message to the peer MISF on the serving network that sent an MIS_N2N_HO_Commit request message.

5.11.8.4 MIS_N2N_HO_Commit.confirm

5.11.8.4.1 Function

This primitive is used by the MISF to confirm that an MIS_N2N_HO_Commit response message is received from a peer MISF on the selected target network.

5.11.8.4.2 Semantics of service primitive

The parameters of the primitive are as follows:

MIS_N2N_HO_Commit.confirm (
SourceIdentifier,
Status,
MNIdentifier,

TargetLinkIdentifier,
AssignedResourceSet
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	Specifies the MISF ID of the node that sent the MIS_N2N_HO_Commit response message.
Status	STATUS	Status of operation.
MNIdentifier	MISF_ID	This identifies the MISF of the MN that commits to perform handover action.
TargetLinkIdentifier[a]	LINK_TUPLE_ID	This contains the identifier of the target PoA (AP/ BS) for the MN.
AssignedResourceSet[a]	ASGN_RES_SET	This includes the set of resource parameters assigned by the target network to the MN.

[a] This parameter is not included if Status does not indicate "Success."

5.11.8.4.3 When generated

This primitive is generated by the MISF on receiving an MIS_N2N_HO_Commit response message from a peer MISF on the selected target network.

5.11.8.4.4 Effect on receipt

Upon receipt, the serving network is informed about the status of the previously issued command request so that it can react accordingly. For instance, the serving network determines that the handover procedure is acknowledged by the target network and it notifies the MN to perform handover. However, if Status does not indicate "Success," the recipient ignores any other returned values and, instead, performs appropriate error handling.

5.11.9 MIS_MN_HO_Complete

5.11.9.1 MIS_MN_HO_Complete.request

5.11.9.1.1 Function

This primitive is optionally used by MIS users to indicate the completion of MIS level handover aiding procedure.

5.11.9.1.2 Semantics of service primitive

MIS_MN_HO_Complete.request (
DestinationIdentifier,
SourceLinkIdentifier,
TargetLinkIdentifier,
HandoverResult
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies a remote MISF that shall be the destination of this request.
SourceLinkIdentifier	LINK_TUPLE_ID	This identifies the source link of the handover.
TargetLinkIdentifier	LINK_TUPLE_ID	This identifies the target link.
HandoverResult	HO_RESULT	Handover result.

5.11.9.1.3 When generated

This primitive is generated when MIS level handover procedure is complete.

5.11.9.1.4 Effect on receipt

Upon receipt of this primitive, the local MISF generates and sends an MIS_MN_HO_Complete request message to the remote MISF identified by the Destination Identifier.

5.11.9.2 MIS_MN_HO_Complete.indication

5.11.9.2.1 Function

This primitive is used by MISF to inform MIS users locally that an MIS_MN_HO_Complete request message is received.

5.11.9.2.2 Semantics of service primitive

MIS_MN_HO_Complete.indication (
SourceIdentifier,
SourceLinkIdentifier,
TargetLinkIdentifier,
HandoverResult
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	Specifies the MISF ID of the node that sent the MIS_MN_HO_Complete request message.
SourceLinkIdentifier	LINK_TUPLE_ID	This identifies the source link of the handover.
TargetLinkIdentifier	LINK_TUPLE_ID	This identifies the target link.
HandoverResult	HO_RESULT	Handover result.

5.11.9.2.3 When generated

This primitive is generated when an MIS_MN_HO_Complete request message is received.

5.11.9.2.4 Effect on receipt

This indicates the completion of the handover. A corresponding response is generated.

5.11.9.3 MIS_MN_HO_Complete.response

5.11.9.3.1 Function

This primitive is used by MIS users to send a response to the MIS_MN_HO_Complete request.

5.11.9.3.2 Semantics of service primitive

MIS_MN_HO_Complete.response (
DestinationIdentifier,
Status,
SourceLinkIdentifier,
TargetLinkIdentifier
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	Specifies the MISF ID of the node that sent the MIS_MN_HO_Complete request message.
Status	STATUS	Status of operation.
SourceLinkIdentifier	LINK_TUPLE_ID	This identifies the source link of the handover.
TargetLinkIdentifier	LINK_TUPLE_ID	This identifies the target link.

5.11.9.3.3 When generated

This primitive is generated when the MIS user wants to respond to the MIS_MN_HO_Complete.indication.

5.11.9.3.4 Effect on receipt

This indicates the completion of the MIS level handover aiding procedure.

5.11.9.4 MIS_MN_HO_Complete.confirm

5.11.9.4.1 Function

This primitive is used by MISF to inform MIS users locally that an MIS_MN_HO_Complete response message is received.

5.11.9.4.2 Semantics of service primitive

MIS_MN_HO_Complete.confirm (
SourceIdentifier,
Status,

SourceLinkIdentifier,
TargetLinkIdentifier
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	Specifies the MISF ID of the node that sent the MIS_MN_HO_Complete response message.
Status	STATUS	Status of operation.
SourceLinkIdentifier	LINK_TUPLE_ID	This identifies the source link of the handover.
TargetLinkIdentifier	LINK_TUPLE_ID	This identifies the target link.

5.11.9.4.3 When generated

MISF generates this primitive when an MIS_MN_HO_Complete response message is received.

5.11.9.4.4 Effect on receipt

This indicates the completion of the MIS level handover aiding procedure.

5.11.10 MIS_N2N_HO_Complete

5.11.10.1 MIS_N2N_HO_Complete.request

5.11.10.1.1 Function

This primitive is used by an MIS user in the network to communicate with a peer network MIS entity about the completion of handover operation.

5.11.10.1.2 Semantics of service primitive

MIS_N2N_HO_Complete.request (
DestinationIdentifier,
MNIdentifier,
SourceLinkIdentifier,
TargetLinkIdentifier,
HandoverResult
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	Identify the MISF ID of the destination node.
MNIdentifier	MISF_ID	This identifies the MISF on MN.
SourceLinkIdentifier	LINK_TUPLE_ID	Specifies the source link of the handover.
TargetLinkIdentifier	LINK_TUPLE_ID	Specifies the target link of the handover.
HandoverResult	HO_RESULT	Handover result.

5.11.10.1.3 When generated

The MIS user invokes this primitive when handover operations have been completed.

5.11.10.1.4 Effect on receipt

Upon receipt of this primitive, the local MISF generates and sends an MIS_N2N_HO_Complete request message to the remote MISF identified by the Destination Identifier.

5.11.10.2 MIS_N2N_HO_Complete.indication

5.11.10.2.1 Function

This primitive is used by the MISF to indicate the status of the handover operation.

5.11.10.2.2 Semantics of service primitive

MIS_N2N_HO_Complete.indication (
SourceIdentifier,
MNIdentifier,
SourceLinkIdentifier,
TargetLinkIdentifier,
HandoverResult
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	Specifies the MISF ID of the node that sent the MIS_N2N_HO_Complete request message.
MNIdentifier	MISF_ID	This identifies the MISF on MN.
SourceLinkIdentifier	LINK_TUPLE_ID	Specifies the source link of the handover.
TargetLinkIdentifier	LINK_TUPLE_ID	Specifies the target link of the handover.
HandoverResult	HO_RESULT	Handover result.

5.11.10.2.3 When generated

This primitive is generated by the MISF on receiving an MIS_N2N_HO_Complete request message from a peer MISF.

5.11.10.2.4 Effect on receipt

The MIS user receiving this primitive replies with an MIS_N2N_HO_Complete.response primitive.

5.11.10.3 MIS_N2N_HO_Complete.response

5.11.10.3.1 Function

This primitive is used to send a response to a handover complete request.

5.11.10.3.2 Semantics of service primitive

MIS_N2N_HO_Complete.response (
DestinationIdentifier,
Status,
MNIdentifier,
SourceLinkIdentifier,
TargetLinkIdentifier,
ResourceRetentionStatus
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	Specifies the MISF ID of the node that sent the MIS_N2N_HO_Complete request message.
Status	STATUS	Status of operation.
MNIdentifier	MISF_ID	This identifies the MISF of MN.
SourceLinkIdentifier	LINK_TUPLE_ID	Specifies the source link of the handover.
TargetLinkIdentifier	LINK_TUPLE_ID	Specifies the target link of the handover.
ResourceRetention-Status[a]	BOOLEAN	Status of local resource at the invoker of this primitive, which is either the source network or the target network depending on the handover flow. TRUE: Retain resource. FALSE: Release resource.

[a] This parameter is not included if Status does not indicate "Success."

5.11.10.3.3 When generated

The MIS user responds with this primitive after processing the handover complete request.

5.11.10.3.4 Effect on receipt

Upon receipt, the local MISF sends an MIS_N2N_HO_Complete response message to the destination MISF.

5.11.10.4 MIS_N2N_HO_Complete.confirm

5.11.10.4.1 Function

This primitive is used by the MISF to confirm that an MIS_N2N_HO_Complete response message is received from a peer MISF.

5.11.10.4.2 Semantics of service primitive

MIS_N2N_HO_Complete.confirm (
SourceIdentifier,
Status,
MNIdentifier
SourceLinkIdentifier,
TargetLinkIdentifier,

ResourceRetentionStatus
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	Specifies the MISF ID of the node that sent the MIS_N2N_HO_Complete response message.
Status	STATUS	Status of operation.
MNIdentifier	MISF_ID	This identifies the MISF of MN.
SourceLinkIdentifier	LINK_TUPLE_ID	Specifies the source link of the handover.
TargetLinkIdentifier	LINK_TUPLE_ID	Specifies the target link of the handover.
ResourceRetention-Status[a]	BOOLEAN	Status of local resource at the invoker of MIS_N2N_HO_Complete.resonse primitive, which is either the source network or the target network depending on the handover flow. TRUE: Retain resource. FALSE: Release resource.

[a] This parameter is not included if Status does not indicate "Success."

5.11.10.4.3 When generated

This primitive is generated by MISF on receiving MIS_N2N_HO_Complete response message from a peer MISF.

5.11.10.4.4 Effect on receipt

Upon receipt, the MIS user determines that the handover complete request was processed successfully. However, if Status does not indicate "Success," the recipient ignores any other returned values and, instead, performs appropriate error handling.

5.11.11 MIS_Net_HO_Bcst_Commit

5.11.11.1 MIS_Net_HO_Bcst_Commit.request

5.11.11.1.1 Function

This primitive is used by MIS users on the network to inform the remote MIS users belonging to a specific group of MNs of possible network initiated handovers. This primitive is used to recommend a handover from either a downlink-only (DO) network or a bidirectional network to another network based on the selected choices for candidate networks and PoAs. This primitive includes multimedia service (MMS) or multimedia program (MMP) information to identify a group of MNs to which the DO network recommends the handover. Network initiated handovers from the bidirectional network to the DO network for a single MN would be invoked by using MIS_Net_HO_Commit.

5.11.11.1.2 Semantics of service primitives

MIS_Net_HO_Bcst_Commit.request (
DestinationIdentifier,
TargetMNGroupInfo,
LinkType,
TargetNetworksInfoList,
LinkActionExecutionDelay,
LinkActionsList
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This specifies MISF ID of the remote MISF(s) to be configured.
TargetMNGroupInfo	GROUP_INFO	MMS or MMP information to identify the group of MNs to which the networks recommend a handover.
LinkType	LINK_TYPE	Contains target link type.
TargetNetworksInfoList	LIST(TGT_NET_INFO)	This list contains information of recommended target networks of type LinkType for assisting the MN to perform handover.
LinkActionExecutionDelay	UNSIGNED_INT(2)	Time (in ms) to elapse before an action needs to be taken. A value of 0 indicates that the action is taken immediately. Time elapsed is calculated from the instance the command arrives until the time when the execution of the action is carried out.
LinkActionsList	LIST(LINK_ACTION_REQ)	A list of network initiated handover actions for the links.

5.11.11.1.3 When generated

The MIS user on the network generates this primitive to recommend a handover action when a specific MMP or MMS will no longer be available on the DO network.

5.11.11.1.4 Effect on receipt

Upon receipt of this primitive, the local MISF generates and sends an MIS_Net_HO_Bcst_Commit indication message to the remote MISF. The remote MISF forwards the indication as an indication to the remote MIS users.

5.11.11.2 MIS_Net_HO_Bcst_Commit.indication

5.11.11.2.1 Function

This primitive is used by an MISF for MIS users to perform a network initiated handover. This primitive is the result of the receipt of an MIS_Net_HO_Bcst_Commit indication message from a remote MISF.

5.11.11.2.2 Semantics of service primitives

MIS_Net_HO_Bcst_Commit.indication (
SourceIdentifier,
TargetMNGroupInfo,
LinkType,
TargetNetworksInfoList,

LinkActionExecutionDelay,
LinkActionsList
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	The remote MISF(s) that sent the MIS_Net_HO_Bcst_Commit indication message.
TargetMNGroupInfo	GROUP_INFO	MMS or MMP information to identify the group of MNs to which the networks recommend a handover.
LinkType	LINK_TYPE	Contains target link type.
TargetNetworksInfoList	LIST(TGT_NET_INFO)	This list contains information of recommended target networks of type LinkType for assisting the MN to perform handover.
LinkActionExecutionDelay	UNSIGNED_INT(2)	Time (in ms) to elapse before an action needs to be taken. A value of 0 indicates that the action is taken immediately. Time elapsed is calculated from the instance the command arrives until the time when the execution of the action is carried out.
LinkActionsList	LIST(LINK_ACTION_REQ)	A list of network initiated handover actions for the links.

5.11.11.2.3 When generated

This primitive is generated by an MISF upon receiving an MIS_Net_HO_Bcst_Commit indication message.

5.11.11.2.4 Effect on receipt

The MIS user receiving this primitive generates no response primitive. Only the applicable actions in the Link Actions List are executed.

5.11.12 MIS_Prereg_Xfer

The primitives defined in this subclause are used by MIS users running on the MN and SPoS during preregistration for MN at a target PoA. See Annex I for examples. For many handovers, the MN and the TPoS may need to exchange layer-2 information in the same way as they would exchange layer-2 information during a handover not mediated by the MISF. Such layer-2 signaling messages are provided by the MN or by the TPoS within the LLInformation parameter carried by MIS_Prereg_Xfer messages.

5.11.12.1 MIS_Prereg_Xfer.request

5.11.12.1.1 Function

This primitive is used to transport parameters and link-layer frames from the MN's MIS user to the MISF running on the MN's serving the PoS (i.e., the SPoS) for preregistration signaling, including the establishment of a secure tunnel, between the MN and a TPoS in an appropriate target network.

5.11.12.1.2 Semantics of service primitive

MIS_Prereg_Xfer.request (
DestinationIdentifier,
TargetLinkIdentifier,
LLInformation,
TPoSIdentifier,
CandidateLinkList,
CiphersuiteCode,
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	Identifies an MISF as the destination of this request.
TargetLinkIdentifier	LINK_TUPLE_ID	(Optional: may be included if the target link is known) Identifies the remote PoA as the corresponding peer of the L2 exchange.[a]
LLInformation	LL_FRAMES	(Optional: included if the target link is known) Carries link-layer frames.
TPoSIdentifier	MISF_ID	(Optional) This identifies the TPoS that shall be the destination of the link-layer frames.
CandidateLinkList	LIST (LINK_PoA_LIST)	(Optional) A list of PoAs, identifying candidate networks to which handover should be initiated. The list is sorted from most preferred first to least preferred last. The link information can include values of IEs from Table E.10, Table E.11, Table E.14, and Table F.1 of IEEE Std 802.21-2017, and Table F.1
CiphersuiteCode	Octet(1)	(Optional) CiphersuiteCode (see Table 25 in 9.2.3 of IEEE Std 802.21-2017) is included when MN wishes to request use of a particular algorithm during the establishment of a security association with TPoS for the purposes of preregistration in the target network.

[a] Note that LINK_TUPLE_ID includes the LINK_ID of both sides of the link, the MN, and the PoA.

5.11.12.1.3 When generated

This primitive is generated by an MIS user on MN to preregister with a TPoS. The MN sends this primitive to instruct its serving PoS (i.e., the SPoS) to generate a Security Association with an appropriate TPoS when the SPoS and the TPoS reside on different nodes.

5.11.12.1.4 Effect on receipt

If the TargetLinkIdentifier is not included, the SPoS shall use the CandidateLinkList (if included) to identify the appropriate TPoS that initiates preregistration activities with an appropriate TPoA. In the absence of other information, the SPoS uses available link-type information and location information for the MN to identify an appropriate TPoS. After reception of this primitive, the SPoS's MISF shall generate an MIS_Prereg_Xfer.indication primitive destined to the SPoS's MIS user.

5.11.12.2 MIS_Prereg_Xfer.indication

5.11.12.2.1 Function

This primitive is used by the SPoS's MISF to notify the SPoS's MIS user about the reception of an MIS_Prereg_Xfer request message.

5.11.12.2.2 Semantics of service primitive

MIS_Prereg_Xfer.indication (
SourceIdentifier,
TargetLinkIdentifier,
LLInformation,
TPoSIdentifier,
CandidateLinkList,
CiphersuiteCode
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	Identifies the invoker, an MN in the same network as the SPoS.
TargetLinkIdentifier	LINK_TUPLE_ID	(Optional: may be included if the target link is known) Identifies the remote PoA as the corresponding peer of the L2 exchange.[a]
LLInformation	LL_FRAMES	(Optional) This carries link-layer frames. This attribute may be included if the target link is known.
TPoSIdentifier	MISF_ID	(Optional) This identifies the TPoS.
CandidateLinkList	LIST(LINK_PoA_LIST)	(Optional) A list of PoAs, identifying candidate networks to which handover should be initiated. The list is sorted from most preferred first to least preferred last. The link information can include values and IEs from Table E.10, Table E.11, Table E.14, and Table F.1 of IEEE Std 802.21-2017, and Table F.1.
CiphersuiteCode	Octet(1)	(Optional) CiphersuiteCode (see Table 25 in 9.2.3 of IEEE Std 802.21-2017) is included when the MN wishes to request use of a particular algorithm during the establishment of a security association with the TPoS for the purposes of preregistration in the target network.

[a] Note that LINK_TUPLE_ID includes the LINK_ID of both sides of the link, the MN, and the PoA.

5.11.12.2.3 When generated

This primitive is generated by an MISF after receiving an MIS_Prereg_Xfer request message.

5.11.12.2.4 Effect on receipt

If TPoS Identifier is not provided, the MIS user on the SPoS uses CandidateLinkList provided by the MN to identify an appropriate TPoS. If the TPoS is hosted remotely (e.g., in a separate target network), the MIS user on the SPoS shall generate an MIS_N2N_Prereg_Xfer.request primitive for the TPoS. Otherwise, the MIS user shall generate an MIS_Prereg_Xfer.response primitive and transmit that response to the MISF specified by the SourceIdentifier.

5.11.12.3 MIS_Prereg_Xfer.response

5.11.12.3.1 Function

The SPoS's MIS user uses this primitive to relay preregistration frames to the MN via the SPoS's local MISF.

5.11.12.3.2 Semantics of service primitive

MIS_Prereg_Xfer.response (
DestinationIdentifier,
TargetLinkIdentifier,
LLInformation,
MN_NAI,
TPoSIdentifier,
SALifeTime,
Status
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies an MISF that shall be the destination of this response.
TargetLinkIdentifier	LINK_TUPLE_ID	(Optional: may be included if the target link is known) Identifies the remote PoA as the corresponding peer of the L2 exchange.[a]
LLInformation	LL_FRAMES	(Optional) Carries link-layer frames; included if and only if the corresponding MIS_Prereg_Xfer.indication contained LLInformation.
MN_NAI	MISF_ID	(Optional) Carries the MN's Network Access Identifier in the case optimized pull key distribution is used.
TPoSIdentifier	MISF_ID	(Optional) This identifies the TPoS.
SALifeTime	LIFETIME	(Optional) Lifetime of the Security Association [b]
Status	STATUS	Status of the preregistration transfer with TPoS. Code 3 (Authorization Failure) is not applicable. (See Table E.2 of IEEE Std 802.21-2017.)

[a] Note that LINK_TUPLE_ID includes the LINK_ID of both sides of the link, the MN, and the PoA.

[b] When (D)TLS is not used to establish the MIS security association between the MN and the TPoS, the default SALifeTime for MISK and derived keys is 65 536 s (slightly over 18 h). This value may be overridden by passing a preferred value as the SALifeTime parameter in relevant MIS primitives.

5.11.12.3.3 When generated

This primitive is generated by the MIS user on SPoS either: a) after receiving an MIS_Prereg_Xfer.indication primitive if the MIS user that received the corresponding MIS_Prereg_Xfer.request primitive did not invoke an MIS_N2N_Prereg_Xfer.request primitive, or b) after receiving a MIS_N2N_Prereg_Xfer.confirm primitive. If the SPoS has received a positive confirmation that the TPoS has accepted the Security Association, this will enable the MN to complete the establishment of the secure tunnel.

5.11.12.3.4 Effect on receipt

The local MISF generates an MIS_Prereg_Xfer response message in order to provide the MN with the information previously requested in MIS_N2N_Prereg_Xfer request.

5.11.12.4 MIS_Prereg_Xfer.confirm

5.11.12.4.1 Function

This primitive is used to notify the MN's MIS user about the reception of an MIS_Prereg_Xfer response message.

5.11.12.4.2 Semantics of service primitive

MIS_Prereg_Xfer.confirm (
SourceIdentifier,
TargetLinkIdentifier,
LLInformation,
MN_NAI,
TPoSIdentifier,
SALifeTime,
Status
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker, which is an MISF.
TargetLinkIdentifier	LINK_TUPLE_ID	This identifies the remote PoA that is the corresponding peer of the L2 exchange.[a]
LLInformation	LL_FRAMES	(Optional) Carries link-layer frames.
MN_NAI	MISF_ID	(Optional) Carries the Network Access Identifier assigned for use by the MN after movement to the target network.
TPoSIdentifier	MISF_ID	(Optional) Identifies the TPoS.
SALifeTime	LIFETIME	(Optional) Lifetime of the Security Association.
Status	STATUS	Status of the preregistration transfer with the TPoS. Code 3 (Authorization Failure) is not applicable. (See Table E.2 of IEEE Std 802.21-2017.)

[a] Note that LINK_TUPLE_ID includes the LINK_ID of both sides of the link, the MN, and the PoA.

5.11.12.4.3 When generated

The MN's MISF generates this primitive after receiving an MIS_Prereg_Xfer response protocol message. If the MN included CiphersuiteCode with the MIS_Prereg_Xfer request message, the optional KeyDerivationKey will be included in the MIS_Prereg_Xfer response message so that the MN's MISF computes the keys necessary for communication with the TPoS and the TPoA according to 9.2.2 of IEEE Std 802.21-2017.

5.11.12.4.4 Effect on receipt

The MIS user on the MN may generate another MIS_Prereg_Xfer.request primitive—for example, if preregistration procedures are not completed.

5.11.13 MIS_Prereg_Ready

The primitives defined in this subclause are used by the MISF at the MN to select a target network interface for preregistration. After the target network interface receives the MIS_Prereg_Ready.request, the target network interface responds with MIS_Prereg_Ready.confirm. See Annex L for examples.

5.11.13.1 MIS_Prereg_Ready.request

5.11.13.1.1 Function

This primitive is used by an MIS application of the MN MISF to request preparation for preregistration on a target link interface of the MN.

5.11.13.1.2 Semantics of service primitive

MIS_Prereg_Ready.request (
DestinationIdentifier,
LinkIdentifier
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies the MISF that shall be the destination of this request.
LinkIdentifier	LINK_ID	Identifier of the link to prepare preregistration.

5.11.13.1.3 When generated

This primitive is generated by the MISF user to prepare preregistration of the target link.

5.11.13.1.4 Effect on receipt

If the Destination Identifier is the MISF-ID of the local MISF, the local MISF invokes a MIS_Prereg_Ready.request primitive to the specified lower layer link. Otherwise, the local MISF generates and sends an MIS_Prereg_Ready request message to the remote MISF identified by the Destination Identifier. The remote MISF issues a Link_Prereg_Ready.request to the specified lower layer link.

5.11.13.2 MIS_Prereg_Ready.confirm

5.11.13.2.1 Function

This primitive is used by the MISF to confirm that the target link is ready for preregistration signaling.

5.11.13.2.2 Semantics of service primitive

MIS_Prereg_Ready.confirm (
SourceIdentifier,
Status,
LinkIdentifier
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the MISF invoking of this primitive.
Status	STATUS	Status of the preregistration transfer with the TPoS. Code 3 (Authorization Failure) is not applicable. (See Table E.2 of IEEE Std 802.21-2017.)
LinkIdentifier	LINK_ID	Identifier of the link to prepare preregistration.

5.11.13.2.3 When generated

This primitive is generated by the MISF upon receiving an MIS_Prereg_Ready response message from a peer MISF.

5.11.13.2.4 Effect on receipt

Upon receipt of this primitive, the MISF user gets the status indication of preregistration preparation on the target link. If Status does not indicate “Success,” the recipient performs appropriate error handling.

5.11.14 MIS_CTRL_Transfer

The primitives defined in this subclause are used by the MISF of MN or PoS to transfer control messages encapsulated by MIS header. See 5.5.2 for the use of MIS_CTRL_Transfer message. See Annex M for examples.

5.11.14.1 MIS_CTRL_Transfer.request

5.11.14.1.1 Function

This primitive delivers control messages encapsulated by the MIS header. The control messages are not only MIS specific control messages but may include other messages, such as ANQP and ANDSF control messages.

5.11.14.1.2 Semantics of service primitive

MIS_CTRL_Transfer.request (
DestinationIdentifier,
CTRLmessage
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	Identifies an MISF as the destination of this request.
CTRLmessage	CTRL_PROT_MSGS	Delivers control messages.

5.11.14.1.3 When generated

This primitive is generated by an MIS application to deliver control messages such as ANQP and ANDSF messages.

5.11.14.1.4 Effect on receipt

After receipt of this primitive, the MISF of the MN at the PoS shall generate an MIS_CTRL_Transfer request message destined to the MISF of the proxy Information Server.

5.11.14.2 MIS_CTRL_Transfer.indication

5.11.14.2.1 Function

This primitive is used by the MISF to notify the local MIS application about the reception of a MIS_CTRL_Transfer request message.

5.11.14.2.2 Semantics of service primitive

MIS_CTRL_Transfer.indication (
SourceIdentifier,
CTRLmessage
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	Identifies the invoker, typically a remote MISF.
CTRLmessage	CTRL_PROT_MSGS	This delivers control messages.

5.11.14.2.3 When generated

This primitive is generated by an MISF after receiving an MIS_CTRL_Transfer request message.

5.11.14.2.4 Effect on receipt

The MIS application shall generate an MIS_CTRL_Transfer.response primitive.

5.11.14.3 MIS_CTRL_Transfer.response

5.11.14.3.1 Function

This primitive is used by an MIS application to provide control messages to the local MISF.

5.11.14.3.2 Semantics of service primitive

MIS_CTRL_Transfer.response (
DestinationIdentifier,
CTRLmessage,
Status
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies a remote MISF that shall be the destination of this response.
CTRLmessage	CTRL_PROT_MSGS	Delivers control messages.
Status	STATUS	Status of the preregistration transfer with the TPoS. Code 3 (Authorization Failure) is not applicable. (See Table E.2 of IEEE Std 802.21-2017.)

5.11.14.3.3 When generated

This primitive is generated by the local MISF after receiving an MIS_CTRL_Transfer.indication primitive.

5.11.14.3.4 Effect on receipt

The local MISF generates an MIS_CTRL_Transfer response message.

5.11.14.4 MIS_CTRL_Transfer.confirm

5.11.14.4.1 Function

This primitive is used to notify the local MIS application about the reception of an MIS_CTRL_Transfer response message.

5.11.14.4.2 Semantics of service primitive

MIS_CTRL_Transfer.confirm (
SourceIdentifier,
CTRLmessage,
Status
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker, which is a remote MISF.
CTRLmessage	CTRL_PROT_MSGS	Delivers control messages.
Status	STATUS	Status of the preregistration transfer with the TPoS. Code 3 (Authorization Failure) is not applicable. (See Table E.2 of IEEE Std 802.21-2017.)

5.11.14.4.3 When generated

This primitive is generated by the local MISF after receiving an MIS_CTRL_Transfer response message.

5.11.14.4.4 Effect on receipt

The MIS application on the MN generates an MIS_CTRL_Transfer.request primitive.

5.11.15 MIS_Capability_Discover

MIS_Capability_Discover.request, MIS_Capability_Discover.indication, MIS_Capability_Discover.response, and MIS_Capability_Discover.confirm are defined in 7.4.1 of IEEE Std 802.21-2017. The following additional parameter is needed while using these primitives for handover use:

Use case specific parameters

Name	Data type	Description
MBBHandoverSupport	LIST(MBB_HO_SUPP)	(Optional) This is used to indicate if a make before break handover is supported on the remote MISF. Break before make handover is always supported.

MBBHandoverSupport parameter needs to be added to MIS_Capability_Discover.request, MIS_Capability_Discover.indication, MIS_Capability_Discover.response, and MIS_Capability_Discover.confirm that are specified in 7.4.1 of IEEE Std 802.21-2017.

5.11.16 MIS_Link_Up.indication

This primitive is defined in 7.4.7 of IEEE Std 802.21-2017. The following additional parameter is needed while using this primitive for handover use:

Use case specific parameters

Name	Data type	Description
MobilityManagementSupport	IP_MOB_MGMT	(Optional) Indicates the type of Mobility Management Protocol supported by the new PoA.

5.12 MIS_NET_SAP primitive

5.12.1 MIS_N2N_Prereg_Xfer

The primitives defined in this subclause are used by MIS functions running on the SPoS and the TPoS to enable preregistration for MN on a target PoA. See Annex I for examples. The primitives provide the ability to transport link-layer frames for the target link over the MIS protocol between the source network PoS and the TPoS. Preregistration is conducted between the MN and the target PoA. As part of preregistration, media-specific authentication may be conducted with an authenticator deployed in the target PoA.

5.12.1.1 MIS_N2N_Prereg_Xfer.request

5.12.1.1.1 Function

The SPoS generates this primitive to deliver link-layer frames to the TPoS.

5.12.1.1.2 Semantics of Service Primitive

MIS_N2N_Prereg_Xfer.request (
DestinationIdentifier,
TargetLinkIdentifier,
LLInformation,
MNID,
CandidateLinkList,
CiphersuiteCode
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies a remote MISF that shall be the destination of this request.
TargetLinkIdentifier	LINK_TUPLE_ID	(Optional) Identifies the remote PoA as the corresponding peer of the L2 exchange; shall be included if the target link is known. [a]
LLInformation	LL_FRAMES	(Optional) Carries link-layer frames; shall be included if the target link is known.
MNID	MISF_ID	(Optional) MISF_ID of the MN to identify the MN's Media Independent Root Key to be transferred to the TPoS.
CandidateLinkList	LIST (LINK_PoA_LIST)	(Optional) A list of PoAs, identifying candidate networks to which handover should be initiated. The list is sorted from most preferred first to least preferred last. This attribute shall not be included if the target link is known.
CiphersuiteCode	Octet(1)	(Optional) CiphersuiteCode (see Table 25 in 9.2.3 of IEEE Std 802.21-2017) is included when the MN wishes to request use of a particular algorithm during the establishment of a security association with the TPoS for the purposes of preregistration in the target network.

[a] Note that LINK_TUPLE_ID includes the LINK_ID of both sides of the link, the MN, and the PoA.

5.12.1.1.3 When generated

The MIS user on SPoS generates this primitive after receiving an MIS_Prereg_Xfer.indication primitive, to relay preregistration signaling to the TPoS. The SPoS relays link-layer frames; alternatively, the SPoS

establishes a security association derived from KeyDerivationKey. In order to establish a SA between the TPoS and the MN, the MISF of the SPoS produces KeyDerivationKey and Nonce-S. Then SPoS's MISF encrypts the service specific TLVs including KeyDerivationKey, Nonce-S, and Nonce-M using the mechanism specified in Clause 9 of IEEE Std 802.21-2017, and transmits the result to the TPoS, where Nonce-M is the value received from the MN in the MIS_Prereg_Xfer request message.

5.12.1.1.4 Effect on receipt

The local MISF shall generate a MIS_N2N_Prereg_Xfer request message to the remote MISF.

5.12.1.2 MIS_N2N_Prereg_Xfer.indication

5.12.1.2.1 Function

This primitive is used by the MISF of the TPoS to notify its MIS user of the reception of an MIS_N2N_Prereg_Xfer request message.

5.12.1.2.2 Semantics of service primitive

```
MIS_N2N_Prereg_Xfer.indication (
                                SourceIdentifier,
                                TargetLinkIdentifier,
                                LLInformation,
                                MNID,
                                KeyDerivationKey
                                )
```

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker, which is a remote MISF.
TargetLinkIdentifier	LINK_TUPLE_ID	(Optional)This identifies the remote PoA that is the corresponding peer of the L2 exchange.[a] This attribute shall be included if the target link is known.
LLInformation	LL_FRAMES	(Optional) carries link-layer frames. This attribute shall be included only if the target link is known.
MNID	MISF_ID	ID of the MN, used to index and compute the MN's Media Independent Root Key to be established by the TPoS.
KeyDerivationKey	OCTET(16)	A key derivation key.

[a] Note that LINK_TUPLE_ID includes the LINK_ID of both sides of the link, the MN and the PoA.

5.12.1.2.3 When generated

TPoS's MISF generates this primitive upon receiving an MIS_N2N_Prereg_Xfer request message. If the MIS_N2N_Prereg_Xfer request message includes KeyDerivationKey *K,* Nonce-S, and Nonce-M, the MISF derives the key hierarchy from KeyDerivationKey *K*, Nonce-S, and Nonce-M as described in 9.2.2 of IEEE Std 802.21-2017, installing keys as necessary in the authentication, authorization, and accounting (AAA) used by the target network.

5.12.1.2.4 Effect on receipt

The TPoS shall generate appropriate messages to install a media-specific pair-wise master key (MSPMK, defined in 10.2.1.2 of IEEE Std 802.21-2017) to the TPoA that is derived from KeyDerivationKey *K* and other parameters (note that this message is not specified in this specification).

The MIS user shall generate an MN_NAI associated with the MNID provided; the two IDs are allowed to be the same.

The MIS user shall subsequently generate an MIS_N2N_Prereg_Xfer.response primitive and include MN_NAI.

5.12.1.3 MIS_N2N_Prereg_Xfer.response

5.12.1.3.1 Function

This primitive is used by the TPoS's MIS user to supply preregistration frames to the TPoS's MISF.

5.12.1.3.2 Semantics of service primitive

MIS_N2N_Prereg_Xfer.response (
DestinationIdentifier,
TargetLinkIdentifier,
LLInformation,
MN_NAI,
SALifeTime,
Status
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies a remote MISF that shall be the destination of this response.
TargetLinkIdentifier	LINK_TUPLE_ID	This identifies the remote PoA that is the corresponding peer of the L2 exchange. [a]
LLInformation	LL_FRAMES	(Optional) Carries link-layer frames.
MN_NAI	MISF_ID	(Optional) Carries the MN's temporary Network Access Identifier assigned by the target network.
SALifeTime	Lifetime TLV	(Optional) Lifetime of the Security Association. [b]
Status	STATUS	Status of the preregistration transfer with the TPoS. Code 3 (Authorization Failure) is not applicable. (See Table E.2 of IEEE Std 802.21-2017.)

[a] Note that LINK_TUPLE_ID includes the LINK_ID of both sides of the link, the MN, and the PoA.

[b] When (D)TLS is not used to establish the MIS security association between the MN and the TPoS, the default SALifeTime for MISK and derived keys is 65 536 s (slightly over 18 h). This value may be overridden by passing a preferred value as the SALifeTime parameter in relevant MIS primitives.

5.12.1.3.3 When generated

This primitive is generated after receiving an MIS_N2N_Prereg_Xfer.indication primitive.

5.12.1.3.4 Effect on receipt

The MISF at the TPoS shall generate an MIS_N2N_Prereg_Xfer response message in order to provide the required information until the authentication is finished.

5.12.1.4 MIS_N2N_Prereg_Xfer.confirm

5.12.1.4.1 Function

This primitive is used to notify the SPoS's MIS user about the reception of an MIS_N2N_Prereg_Xfer response message.

5.12.1.4.2 Semantics of service primitive

MIS_N2N_Prereg_Xfer.confirm (
SourceIdentifier,
TargetLinkIdentifier,
LLInformation,
MN_NAI,
SALifeTime,
Status
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker, which is a remote MISF.
TargetLinkIdentifier	LINK_TUPLE_ID	This identifies the remote PoA that is the corresponding peer of the L2 exchange.[a]
LLInformation	LL_FRAMES	(Optional) This carries link-layer frames.
MN_NAI	MISF_ID	(Optional) This carries the MN's Network Access Identifier
SALifeTime	Lifetime TLV	(Optional) Lifetime of the Security Association[b]
Status	STATUS	Status of the preregistration transfer with the TPoS. Code 3 (Authorization Failure) is not applicable. Code 6 (the TPoS is identical to the SPoS), is not applicable. (See Table E.2 of IEEE Std 802.21-2017.)

[a] Note that LINK_TUPLE_ID includes the LINK_ID of both sides of the link, the MN, and the PoA.

[b] When (D)TLS is not used to establish the MIS security association between the MN and the TPoS, the default SALifeTime for MISK and derived keys is 65 536 s (slightly over 18 h). This value may be overridden by passing a preferred value as the SALifeTime parameter in relevant MIS primitives.

5.12.1.4.3 When generated

This primitive is generated by the remote MIS user after receiving a MIS_N2N_Prereg_Xfer response message.

5.12.1.4.4 Effect on receipt

The SPoS's MIS user generates an MIS_Prereg_Xfer.response primitive with the information obtained from this primitive. The MISF on SPoS retrieves its stored values for KeyDerivationKey and Nonce-S that had previously been sent to the TPoS's MISF. The SPoS also encrypts any service specific TLVs including

KeyDerivationKey and Nonce-S using the SA between SPoS and MN as described in Clause 9 of IEEE Std 802.21-2017.

5.13 MIS protocol messages

The following messages are specific to handover use case and shall be used with others that are defined in IEEE Std 802.21-2017.

The following MIS messages may use an MISF Group ID including MISF Broadcast ID as their destination identifier. The only allowed multicast transmission is when the message is sent by a PoS, although a message can be sent by a PoS and MN. The message with multicast transmission is called *group addressed message.*

- MIS Messages for Command Service:
  - MIS_Net_HO_Candidate_Query request
  - MIS_N2N_HO_Query_Resources request
  - MIS_Net_HO_Commit request/indication
  - MIS_Net_HO_Bcst_Commit indication

The MISF ID is of type MISF_ID (see 8.3.1 of IEEE Std 802.21-2017). Other MIS messages that may use an MISF Group ID as their destination identifier are specified in 8.3.2 of IEEE Std 802.21-2017.

5.13.1 Messages for service management

5.13.1.1 MIS_Capability_Discover

MBB Handover Support TLV needs to be added to MIS_Capability_Discover request and MIS_Capability_Discover response that are specified in 8.6.1 of IEEE Std 802.21-2017.

Use case specific TLVs:

MBBHandoverSupport (optional) (MBB handover support TLV)

5.13.2 MIS messages for event services

5.13.2.1 MIS_Link_Handover_Imminent indication

The corresponding MIS primitive of this message is defined in 5.10.1.

This message indicates that a link-layer handover decision has been made and its execution is imminent.

MIS Header Fields (SID=2, Opcode=3, AID=7)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
OldLinkIdentifier (Link identifier TLV)
NewLinkIdentifier (New link identifier TLV)
OldAccessRouter (optional) (Old access router TLV)
NewAccessRouter (optional) (New access router TLV)

5.13.2.2 MIS_Link_Handover_Complete indication

The corresponding MIS primitive of this message is defined in 5.10.2.

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

MIS Header Fields (SID=2, Opcode=3, AID=8)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
OldLinkIdentifier (Link identifier TLV)
NewLinkIdentifier (New link identifier TLV)
OldAccessRouter (optional) (Old access router TLV)
NewAccessRouter (optional) (New access router TLV)
LinkHandoverStatus (Status TLV)

5.13.2.3 MIS_Link_Up

Mobility management support TLV needs to be added to MIS_Link_Up indication specified in 8.6.2.2 of IEEE Std 802.21-2017.

Use case specific TLV:

MobilityManagementSupport (optional) (Mobility management support TLV)

5.13.3 MIS messages for command service

5.13.3.1 MIS_NET_HO_Candidate_Query request

The corresponding MIS primitive of this message is defined in 5.11.3.2.

This message is used for communication between the MISF on an MN and the MISF on a network. The function is used to communicate an intent of network initiated handover.

MIS Header Fields (SID=3, Opcode=1, AID=4)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
SuggestedNewLinkList (List of link PoA list TLV)
SuggestedCandidateAuthenticatorList (the list is empty if no authenticator is suggested.) (Authenticator List TLV)
QueryResourceReportFlag (Query resource report flag TLV)

5.13.3.2 MIS_Net_HO_Candidate_Query response

The corresponding MIS primitive of this message is defined in 5.11.3.4.

This message is used for communication between the MISF on an MN and the MISF on a network. The function is used to respond to an intent of network initiated handover.

MIS Header Fields (SID=3, Opcode=2, AID=4)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Status (Status TLV)
SourceLinkIdentifier (Link identifier TLV)
HandoverStatus (not included if Status does not indicate “Success”) (Handover status TLV)
PreferredLinkList (not included if Status does not indicate “Success”) (Preferred link list TLV)
PreferredCandidateAuthenticatorList (not included if Status does not indicate “Success”) (Authenticator List TLV)

5.13.3.3 MIS_MN_HO_Candidate_Query request

The corresponding MIS primitive of this message is defined in 5.11.4.1.

This message is used by an MISF on the MN to communicate to a network MISF, an intent to initiate a handover.

MIS Header Fields (SID=3, Opcode=1, AID=5)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
SourceLinkIdentifier (Link identifier TLV)
CandidateLinkList (List of link PoA list TLV)
QoSResourceRequirements (Handover resource query list TLV)
IPConfigurationMethods (optional) (IP address configuration methods TLV)
DHCPServerAddress (optional) (DHCP server address TLV)
FAAddress (optional) (FA address TLV)
AccessRouterAddress (optional) (Access router address TLV)

5.13.3.4 MIS_MN_HO_Candidate_Query response

The corresponding MIS primitive of this message is defined in 5.11.4.3.

This message is used by an MISF in the network to respond to an MIS_MN_HO_Candidate_Query request message from a remote MISF on the MN.

MIS Header Fields (SID=3, Opcode=2, AID=5)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Status (Status TLV)
SourceLinkIdentifier (Link identifier TLV)
PreferredCandidateLinkList (not included if Status does not indicate “Success”) (Preferred link list TLV)
PreferredCandidateAuthenticatorList (Authenticator List TLV)

5.13.3.5 MIS_N2N_HO_Query_Resources request

The corresponding MIS primitive of this message is defined in 5.11.5.1.

This message is used by an MISF on the serving network to communicate to an MISF on the candidate network an intent to initiate a handover. This message is also used to retrieve IP address related information from the candidate network.

MIS Header Fields (SID=3, Opcode=1, AID=6)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
QoSResourceRequirements (Handover resource query list TLV)
IPConfigurationMethods (optional) (IP address configuration methods TLV)
DHCPServerAddress (optional) (DHCP server address TLV)
FAAddress (optional) (FA address TLV)
AccessRouterAddress (optional) (Access router address TLV)
CandidateLinkList (optional) (Link identifier list TLV)

5.13.3.6 MIS_N2N_HO_Query_Resources response

The corresponding MIS primitive of this message is defined in 5.11.5.3.

This message is used by an MISF in the candidate network to respond to an MIS_N2N_HO_Query_Resources request message from an MISF on the serving network. This is used to return the result of resource preparation of the impending handover and to notify the MISF on the serving network of the link resource status and IP address related information of the candidate network.

MIS Header Fields (SID=3, Opcode=2, AID=6)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Status (Status TLV)
ResourceStatus (not included if Status does not indicate “Success”) (Resource status TLV)
CandidateLinkList (optional) (not included if Status does not indicate “Success”) (Preferred link list TLV)

5.13.3.7 MIS_MN_HO_Commit request

The corresponding MIS primitive of this message is defined in 5.11.6.1.

This message is used by the MISF on the MN to notify the Serving PoS of the decided target network information.

MIS Header Fields (SID=3, Opcode=1, AID=7)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
LinkType (Link type TLV)
TargetNetworkInfo (Target network info TLV)

5.13.3.8 MIS_MN_HO_Commit response

The corresponding MIS primitive of this message is defined in 5.11.6.3.

This message is used by the MISF on the Serving PoS to respond to an MIS_MN_HO_Commit request message.

MIS Header Fields (SID=3, Opcode=2, AID=7)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Status (Status TLV)
LinkType (Link type TLV)
TargetNetworkInfo (Target network info TLV)

5.13.3.9 MIS_Net_HO_Commit request

The corresponding MIS primitive of this message is defined in 5.11.7.1.

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

MIS Header Fields (SID=3, Opcode=1, AID=8)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
LinkType (Link type TLV)
TargetNetworkInfoList (List of target network info TLV)
AssignedResourceSet (Assigned resource set TLV)
Link Action Execution Delay (Time interval TLV)
LinkActionsList (Optional) (Link actions list TLV)
GroupLinkActionsList (Optional) (Group Link Actions List TLV)

5.13.3.10 MIS_Net_HO_Commit response

The corresponding MIS primitive of this message is defined in 5.11.7.3.

This message is used by the MISF to respond to a request to commit to a handover request to a specific link and PoA.

MIS Header Fields (SID=3, Opcode=2, AID=8)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Status (Status TLV)
LinkType (not included if Status does not indicate “Success”) (Link type TLV)
TargetNetworkInfo (not included if Status does not indicate “Success”) (Target network info TLV)
LinkActionsResultList (Optional) (not included if Status does not indicate “Success”) (Link actions result list TLV)

5.13.3.11 MIS_NET_HO_Commit indication

The corresponding MIS primitive of this message is defined in 5.11.7.2.

This message is used by the MISF to indicate that an MIS_NET_Net_HO_Commit request message has been received from a peer MISF.

MIS Header Fields (SID=3, Opcode=3, AID=8)
Source Identifier = sending MISF ID (Authenticator List TLV) (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
LinkType (Link type TLV)
TargetNetworkInfoList (List of target network info TLV)
AssignedResourceSet (Optional) (Assigned resource set TLV)
LinkActionExecutionDelay (Optional) (Time interval TLV)
LinkActionsList (Optional) (Link actions list TLV)
GroupLinkActionsList (Optional) (Group Link Actions List TLV)

5.13.3.12 MIS_N2N_HO_Commit request

The corresponding MIS primitive of this message is defined in 5.11.8.1.

This message is used by the MISF on the serving network to communicate with its peer MISF on the selected target network. This is used to request the target network to allocate resources to an MN that is about to attach to that network link and PoA.

MIS Header Fields (SID=3, Opcode=1, AID=9)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
MNIdentifier (MN MISF ID TLV)
TargetMobileNodeLinkIdentifier (MN link ID TLV)
TargetPoA (PoA TLV)
RequestedResourceSet (Requested resource set TLV)

5.13.3.13 MIS_N2N_HO_Commit response

The corresponding MIS primitive of this message is defined in 5.11.8.3.

This message is used by the MISF on the selected target network to communicate with its peer MISF on the serving network. This is used to respond to the MIS_N2N_HO_Commit request message.

MIS Header Fields (SID=3, Opcode=2, AID=9)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Status (Status TLV)
MNIdentifier (MN MISF ID TLV)
TargetLinkIdentifier (not included if Status does not indicate “Success”) (Link identifier TLV)
AssignedResourceSet (not included if Status does not indicate “Success”) (Assigned resource set TLV)

5.13.3.14 MIS_MN_HO_Complete request

The corresponding MIS primitive of this message is defined in 5.11.9.1.

This message is used by the MISF on the MN to communicate the status of handover operation to the MISF on the target network.

MIS Header Fields (SID=3, Opcode=1, AID=10)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
SourceLinkIdentifier (Link identifier TLV)
TargetLinkIdentifier (New link identifier TLV)
HandoverResult (Handover result TLV)

5.13.3.15 MIS_MN_HO_Complete response

The corresponding MIS primitive of this message is defined in 5.11.9.3.

This message is used by the MISF on the target network to communicate the response following the completion of handover operation to the MN.

MIS Header Fields (SID=3, Opcode=2, AID=10)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Status (Status TLV)
SourceLinkIdentifier (Link identifier TLV)
TargetLinkIdentifier (New link identifier TLV)

5.13.3.16 MIS_N2N_HO_Complete request

The corresponding MIS primitive of this message is defined in 5.11.10.1.

This message is used by the MISF to communicate the status of handover operation.

MIS Header Fields (SID=3, Opcode=1, AID=11)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
MNIdentifier (MN-MISF ID TLV)
SourceLinkIdentifier (Link identifier TLV)
TargetLinkIdentifier (New link identifier TLV)
HandoverResult (Handover result TLV)

5.13.3.17 MIS_N2N_HO_Complete response

The corresponding MIS primitive of this message is defined in 5.11.10.3.

This message is used by the MISF to communicate the response following the completion of the handover operation. The message is used to communicate the preferred action to be taken with respect to resources associated with the previous connection. If the handover is successful, the resources are released.

MIS Header Fields (SID=3, Opcode=2, AID=11)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Status (Status TLV)
MNIdentifier (MN MISF ID TLV)
SourceLinkIdentifier (Link identifier TLV)
TargetLinkIdentifier (New link identifier TLV)
ResourceRetention Status (not included if Status does not indicate “Success”) (Resource retention status TLV)

5.13.3.18 MIS_Net_HO_Bcst_Commit indication

The corresponding MIS primitive of this message is defined in 5.11.11.2.

This message is used by the MISF on the network to recommend a handover from the DO network or a bidirectional network to a specific link and PoA of another network.

The requesting MISF entity shall use a zero length MISF ID to send this message.

MIS Header Fixed Fields (SID=3, Opcode=3, AID=12)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
TargetMNGroupInfo (Target MN group info TLV)
LinkType (Link type TLV)
TargetNetworksInfoList (List of target network info TLV)
LinkActionExecutionDelay (Time interval TLV)
LinkActionsList (Link actions list TLV)

5.13.3.19 MIS_Prereg_Xfer Request

The MN’s MISF sends this message so that the SPoS transmits link-layer frames to expedite preregistration with an appropriate TPoS, particularly to initiate proactive authentication for the establishment of a security

association. The corresponding primitive is defined in 5.11.12.1. Nonce-M is included if the MN is requesting the SPoS to establish a security association with the TPoS. CandidateLinkList is included if the MN has information available about the desired target link. Nonce-M is generated by MN's MISF.

MIS Header Fields (SID=3, Opcode=1, AID=13)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
TargetLinkIdentifier (optional) (Link Identifier TLV)
LLInformation (optional) (Link-layer Information TLV)
TPoSIdentifier (optional) (TPoS Identifier TLV)
CandidateLinkList (optional) (Link identifier list TLV)
CiphersuiteCode (optional) (Ciphersuite Code TLV)
Nonce-M (optional) (Nonce TLV)

5.13.3.20 MIS_Prereg_Xfer Response

This message is used by the MISF running on the SPoS to complete the establishment of a security association between an MN and an appropriate TPoS. The corresponding primitive is defined in 5.11.12.3. SALifetime, KeyDerivationKey, and Nonce-S are not sent unless the MN sent Nonce-M in the MIS_Prereg_Xfer request and the SPoS and the MN have a security association. When SALifetime and KeyDerivationKey are sent, the service specific TLVs shall be encrypted by the security association between the SPoS and the MN described in Clause 9 of IEEE Std 802.21-2017.

MIS Header Fields (SID=3, Opcode=2, AID=13)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
TargetLinkIdentifier (optional) (Link Identifier TLV)
LLInformation (optional) (Link-layer Information TLV)
MN_NAI (optional) (Network Access Identifier TLV)
TPoSIdentifier (optional) (TPoS Identifier TLV)
KeyDerivationKey (optional) (Key TLV)
Nonce-S (optional) (Nonce TLV)
SALifeTime (optional) (KeyLifeTime TLV)
Status (Status TLV)

5.13.3.21 MIS_N2N_Prereg_Xfer Request

An MISF sends this message to relay link-layer frames during preregistration. The corresponding primitive is defined in 5.12.1.1. Nonce-S, Nonce-M, and the KeyDerivationKey shall all be absent when the MISF and a remote MISF do not have a security association. When Nonce-S, Nonce-M, and the KeyDerivationKey are present, the service specific TLVs shall be encrypted by the security association between the MISF and the remote MISF as described in Clause 9 of IEEE Std 802.21-2017.

MIS Header Fields (SID=3, Opcode=1, AID=14)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
TargetLinkIdentifier (optional) (Link Identifier TLV)
LLInformation (optional) (Link-layer Information TLV)
MNID (optional) (MN MISF ID TLV)
CiphersuiteCode (optional) (Ciphersuite Code TLV)
KeyDerivationKey (optional) (Key TLV)
Nonce-S (optional) (Nonce TLV)
Nonce-M (optional) (Nonce TLV)
SALifeTime (optional) (KeyLifeTime TLV)

5.13.3.22 MIS_N2N_Prereg_Xfer Response

An MISF sends this message to complete the establishment of a security association between itself and the preregistering MN or to accomplish other layer-2 signaling. The corresponding primitive is defined in 5.12.1.3. The SALifeTime is included if specified by the TPoS for the requested security association. The TPoS also includes the MN_NAI parameter if the MNID parameter of the MIS_N2N_Prereg_Xfer request message is not appropriate for use in the target network.

MIS Header Fields (SID=3, Opcode=2, AID=14)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
TargetLinkIdentifier (Link Identifier TLV)
LLInformation (optional) (Link-layer Information TLV)
MN_NAI (optional) (Network Access Identifier TLV)
SALifeTime (optional) (KeyLifeTime TLV)
Status (Status TLV)

5.13.3.23 MIS_Prereg_Ready request

The corresponding MIS primitive of this message is defined in 5.11.13.1.

This message is transmitted to the MISF to perform preparation of preregistration.

MIS Header Fields (SID=3, Opcode=1, AID=15)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
LinkIdentifier (Link identifier TLV)

5.13.3.24 MIS_Prereg_Ready response

The corresponding MIS primitive of this message is defined in 5.11.13.2.

This message returns the result of a MIS_Prereg_Ready request.

MIS Header Fields (SID=3, Opcode=2, AID=15)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Status (Status TLV)
LinkIdentifier (Link identifier TLV)

5.13.3.25 MIS_CTRL_Transfer request

This message is used to deliver control messages such as ANQP and ANDSF messages. The delivery of control messages is described in 5.5.2. The corresponding MIS primitive of this message is defined in 5.11.14.1.

MIS Header Fields (SID=3, Opcode=1, AID=16)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
CTRLmessage (Control Information TLV)

5.13.3.26 MIS_CTRL_Transfer response

This message is used to respond to the MIS_CTRL_Transfer request message. Moreover, this message delivers control messages such as ANQP and ANDSF messages. The delivery of control messages is described in 5.5.2. The corresponding MIS primitive of this message is defined in 5.11.14.3.

MIS Header Fields (SID=3, Opcode=2, AID=16)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
CTRLmessage (optional) (Control Information TLV)

6. Media independent service for software-defined radio access networks

6.1 Introduction

A radio access network (RAN) is part of a mobile network that is implemented with a radio access technology (RAT). Conceptually, it resides between mobile devices and core network (CN). RANs differ from CNs in that they mostly deal with L1/L2 functions, such as interference, cell ID, neighbor lists, and handover threshold. A RAN is divided into two parts: one is the fronthaul and the other is backhaul. The fronthaul is the connection between a baseband controller and remote standalone radio heads at cell sites. The backhaul is the connection between the baseband controller and the mobile network back to the wired CN.

This clause provides a general overview of the MIS use case for software-defined radio access networks (SDRANs) in a centralized way. To support the mobility and radio resource management (RRM) functionalities over SDRAN, media independent service (MIS) framework of IEEE 802.21 can be used without any modification to it.

The SDRAN is the RAN including fronthaul and backhaul, where the centralized controller enables both seamless handover and dynamic resource allocation by a clear separation from the data forwarding plane in a heterogeneous RAN environment. Here, software-defined networking (SDN) is responsible for providing an abstraction of network resources through well-defined application programming interfaces. This abstraction enables SDRAN to simplify network operation (e.g., mobility management entity) across heterogeneous access network technologies. The centralized controller enabled by SDN allows for achieving flexible resource management of RAN across heterogeneous environments. This trend also introduces new challenges in seamless mobility because RANs require the shared nature of radio spectrum for mobile users in small cell environments.

The SDRAN enables RRM in a centralized controller, in which the SDRAN separates RRM from the data forwarding functions to evolve independently. This functional split introduces more degrees of flexibility in the actual execution of RRM. The centralized control and management framework enables a flexible and software-defined coordination of all radio resource. The centralized controller allows for an efficient software solution for RRM on commodity servers. The SDRAN paradigm also improves adaptability to the diversity of service scenarios that will arise from the deployment of a centralized controller in small-cell or multi-radio access technologies.

This use case reuses the radio resource coordination of MIS framework for handover in SDRAN environment where MNs from one access network are re-assigned to neighboring access networks with available resources. MIS primitives and messages are used to transfer radio resource configuration information for seamless handover. The SDN provides interfaces for exchange of primitives between network entity (e.g., point of attachment) and the centralized controller (e.g., PoA controller). Thus, MIS framework is appropriate for handover resource allocation and mobility management in SDRANs that use various heterogeneous switches managed by SDN controller(s).

6.1.1 MIS framework architecture

In SDRAN, handover occurs when wireless link conditions change due to the users' movement. In this case, service continuity should be maintained to minimize any perceptible interruption to the conversation. The MIS provides a framework and corresponding mechanisms, in which an MISF entity discovers and obtains radio resource information existing within SDRAN to facilitate the handovers. The MIS framework is assumed to be operated by a single operator or by cooperating service providers. It is based on the principal concepts of IEEE 802.21 for context information gathering and optimized handover decision making.

Figure 9 presents the MIS framework architecture for SDRAN, which consists of MN, PoS, PoA, PoA controller, SDN controller, and Information Server. PoS is an MIS network entity that exchanges MIS messages with the MN. PoA is the endpoint of a L2 link as it may exchange message with the MN. PoA controller is an MIS PoS that manages both handover control and resource control of PoAs. PoA controller is responsible for decision of the data traffic flow about where traffic is sent to, from the underlying PoA that forwards traffic to the selected destination. Information Server is related to the controlling flow of new incoming MN. Software-define networking (SDN) controller is a forwarding controller for access switches. It is responsible for data forwarding decision where traffic is sent to/from the underlying PoA that forwards traffic to the selected destination, in a way that is related to the data flow.

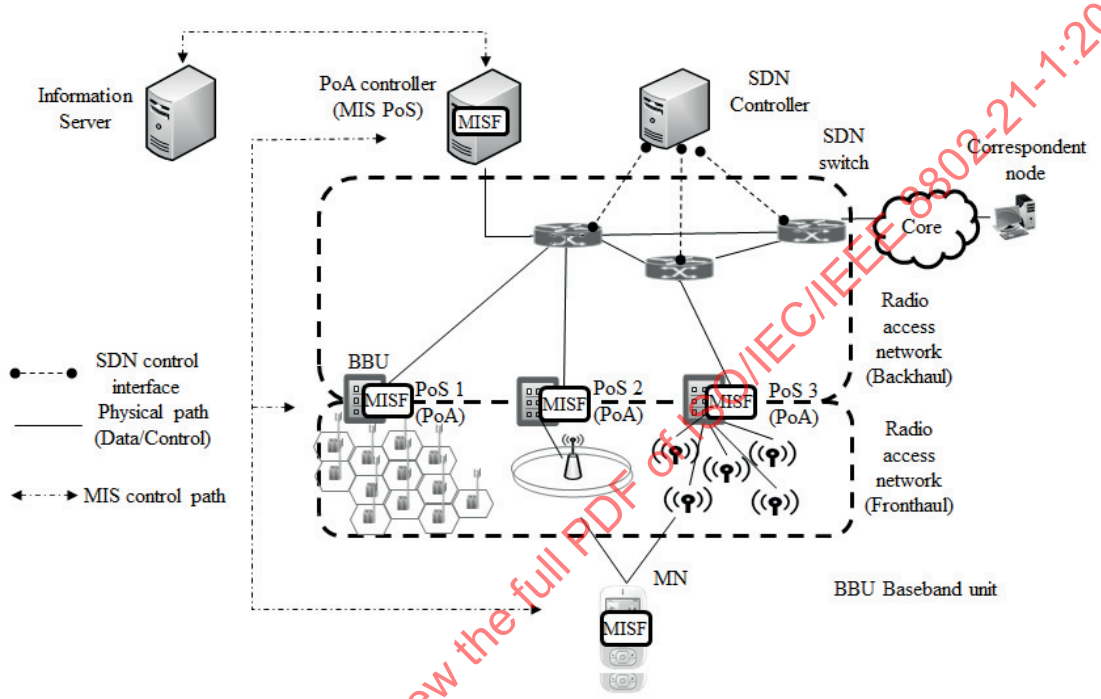


Figure 9—MIS framework architecture for SDRANs

6.1.2 MIS communication model

Figure 10 illustrates the MIS communication model for SDRAN. This model includes five reference points (RPs) defined in IEEE Std 802.21-2017. The MN uses L2 transport to exchange MIS information with an MIS PoS that resides in its PoA through RP1. When an MISF in a PoA does not have a direct connection to the MN, it does not act as an MIS PoA for that particular MN. Then, the MN exchanges MIS information with the PoA controller through the RP3.

Figure 10 also shows the MISF communication model. The model shows MISFs in different roles and the communication relationships among them. The communication relationship only intends to show that passing MIS-related information is possible between the two different Network Entities. Moreover, each communication relationship shown in the diagram encompasses different types of interfaces, different transport mechanisms used (e.g., L2, L3), and different service related content being passed (e.g., MIIS, MICS, or MIES).

This 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.

6.1.3 MIS SAPs

Figure 11 shows an MIS protocol stack and the interaction of the MISF with other elements for handover control in SDRAN. PoA controller rearranges resources of PoS(PoA)s for handover control by using MIS protocol. PoS(PoA)s use different communication technologies and share their link status by using service primitives. All exchanges between the MISF and other functional entities occur through service primitives specified in IEEE Std 802.21-2017. The service primitives grouped in service access points (SAPs) specify the interaction between the service user and provider.

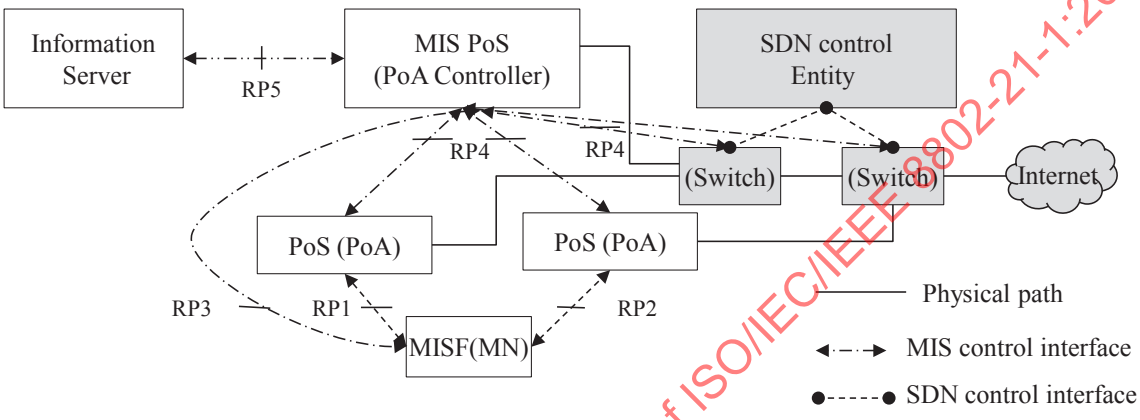


Figure 10—MIS communication model for SDRAN

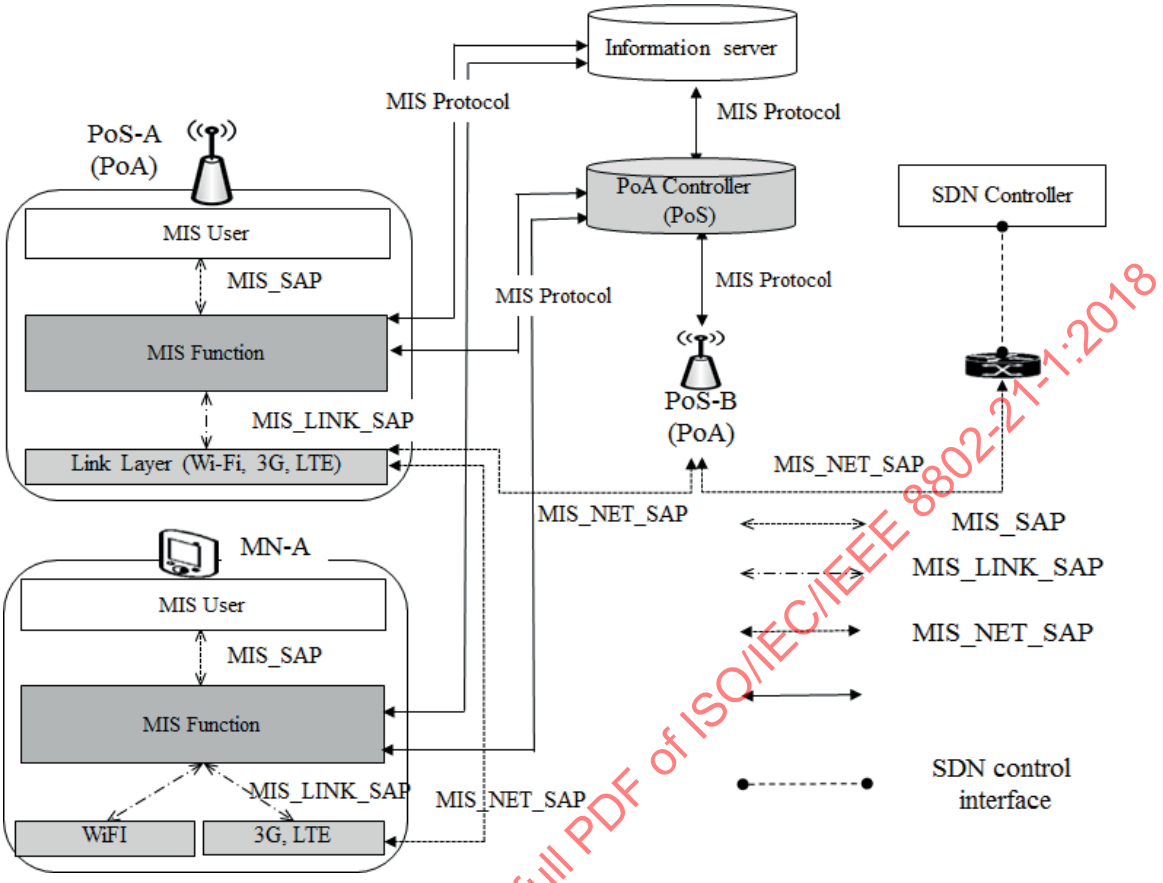


Figure 11—Relationship between different MIS SAPs

6.2 Service scenarios and signaling flows

6.2.1 Stages for handover procedure

To prepare for handover, the MN may exchange link-layer PDUs with the target network PoA through a communication link that is established between an MN and the target PoA using the MIS protocol.

During the handover procedure, PoA controller controls resources of PoAs that use various communication technologies [e.g., wireless local area network (WLAN) and LTE™] by using MIS protocol message.[13] PoAs directly configure radio resources (e.g., frequency, time, and power) according to MIS message. The MIS protocol message is forwarded to PoA controller via SDN switches.

In SDRANs, handover refers to the ability of transferring an ongoing call or data session from one RAT to another, without any interruption, to the ongoing services. Radio resource allocation for handover procedure comprises the following four stages as shown in Figure 12.

1. In the first stage, the MN queries the Information Server to discover candidate networks and their handover policies by starting handover initiation. This handover initiation enables the MN to

[13] LTE is a trademark of The European Telecommunications Standards Institute (ETSI).

determine whether or not there is a candidate target network available for handover. It consists of a set of steps of collection of information about neighboring networks, and exchange of information about QoS offered by these networks.

2. In the second stage, handover preparation starts from the link corruption detection until the request for preparation handover. The MN queries the PoA controller to discover candidate PoAs and their resource availability. Such information includes whether candidate networks and MN support RRM or not, and the availability of MIS service on the SDN controller. The handover preparation consists of all steps of link measurements, collection of information about neighboring PoAs, and exchange of information about resource availabilities by these PoAs.

3. In the third stage, handover decision is the procedure to decide whether the connection to be switched to a new PoA based on parameters collected in the handover preparation phase. The evaluation is made by the MN or the network based on parameters such as signal strength, target QoS, cost, resource availability, and operator policy. After that, radio resource allocation will be prepared by PoA controller or via SDN controller based on PoA's link status or radio resource allocation of neighboring PoAs.

4. In the last stage, PoA's radio resources (e.g., frequency, time, interface mode, and power) are configured by PoA or PoA controller. MN prepares to connect to RAN with newly allocated radio resources as an action of handover execution. After that, PoA reports its allocated radio resources to Information Server, PoA controller (or SDN controller), and neighboring PoAs.

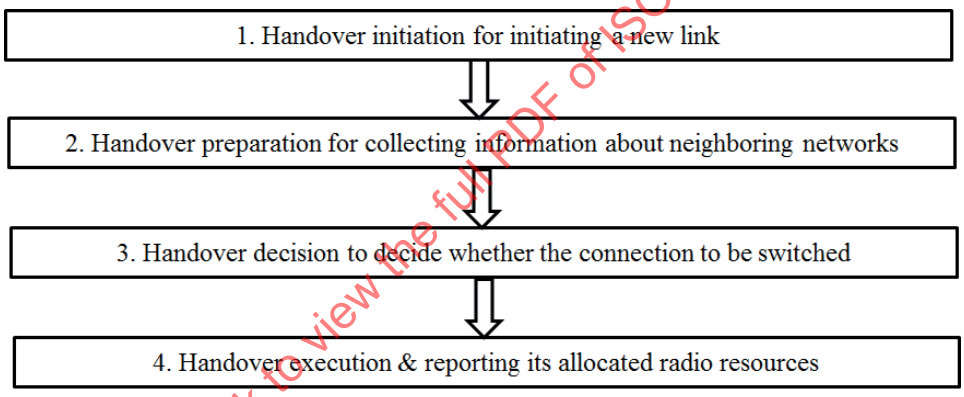


Figure 12—Stages for seamless handover in SDRANs

6.2.2 Signaling flows

Over the SDRANs, handover triggers generated by the link layer are exploited by the MISF incorporated in the PoA controller to make easy vertical handover. This procedure has the four phases described in 6.2.1 (handover initiation, handover preparation, handover decision, and handover execution). The solid lines in Figure 13, Figure 14, Figure 15, and Figure 16 show the MIS signaling flows of the MIS protocol. All the primitives and messages required for this use case are described in 6.3 and 6.4. Note that the SDRAN should handle the part of configuring the path or the RRM to support handover in SDRAN. However, Figure 13, Figure 14, Figure 15, and Figure 16 only describe IEEE 802.21 related signaling flows on the handover in SDRAN.

6.2.2.1 Stage 1: handover initiation

The handover initiation phase starts when the MN is connected to the serving network via the current PoA (PoS 1). The MN queries information about neighboring networks by sending an MIS_Get_Information request message [see b) in Figure 13] to the Information Server. The Information Server responds with an

MIS_Get_Information response message [see c) in Figure 13]. This information is attempted as soon as the MN is first attached to the PoS 1 and it has access to the MIS Information Server. Figure 13 shows an example signaling flow for handover initiation.

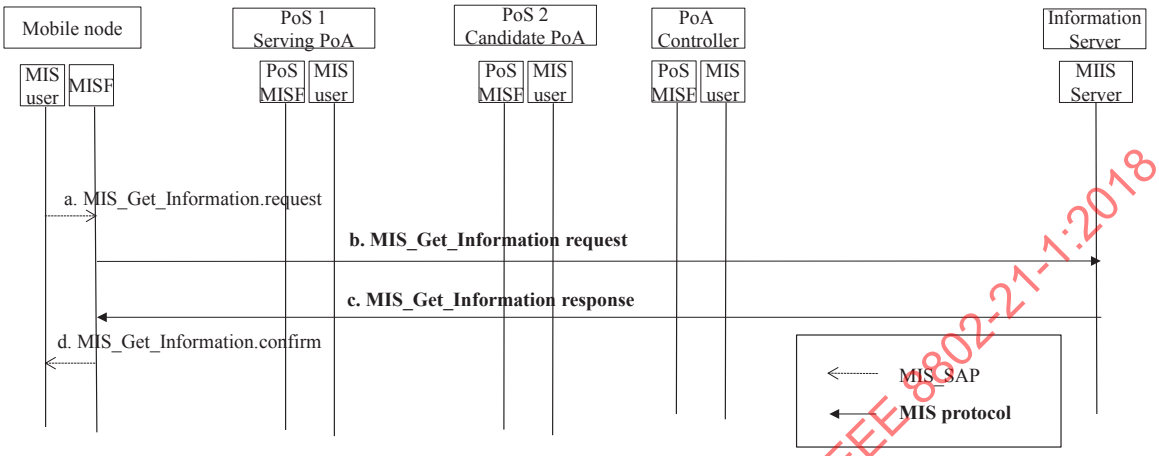


Figure 13—Signaling flows for handover initiation procedure

6.2.2.2 Stage 2: handover preparation

Figure 14 shows an example of signaling flow for handover preparation. When detecting a new link, the MN triggers a mobile-initiated handover by sending an MIS_MN_HO_Candidate_Query request message to the PoA controller [see d) in Figure 14]. This request contains the information of potential candidate networks. The PoA controller extracts context information of both attached users and neighboring RANs. The PoA controller queries the availability of resources at the candidate PoAs by sending an MIS_N2N_HO_Query_Resources request message to one or multiple Candidate PoAs [see g) in Figure 14]. The Candidate PoAs respond with an MIS_N2N_HO_Query_Resources response message [see j) in Figure 14] and the PoA controller notifies the MN of the resulting resource availability at the candidate PoAs through an MIS_MN_HO_Candidate_Query response message [see m) in Figure 14]. Thus, the MN has enough information about the neighboring networks to make a handover decision based on policies and multi-criteria of decision in either MN or network centric approach.

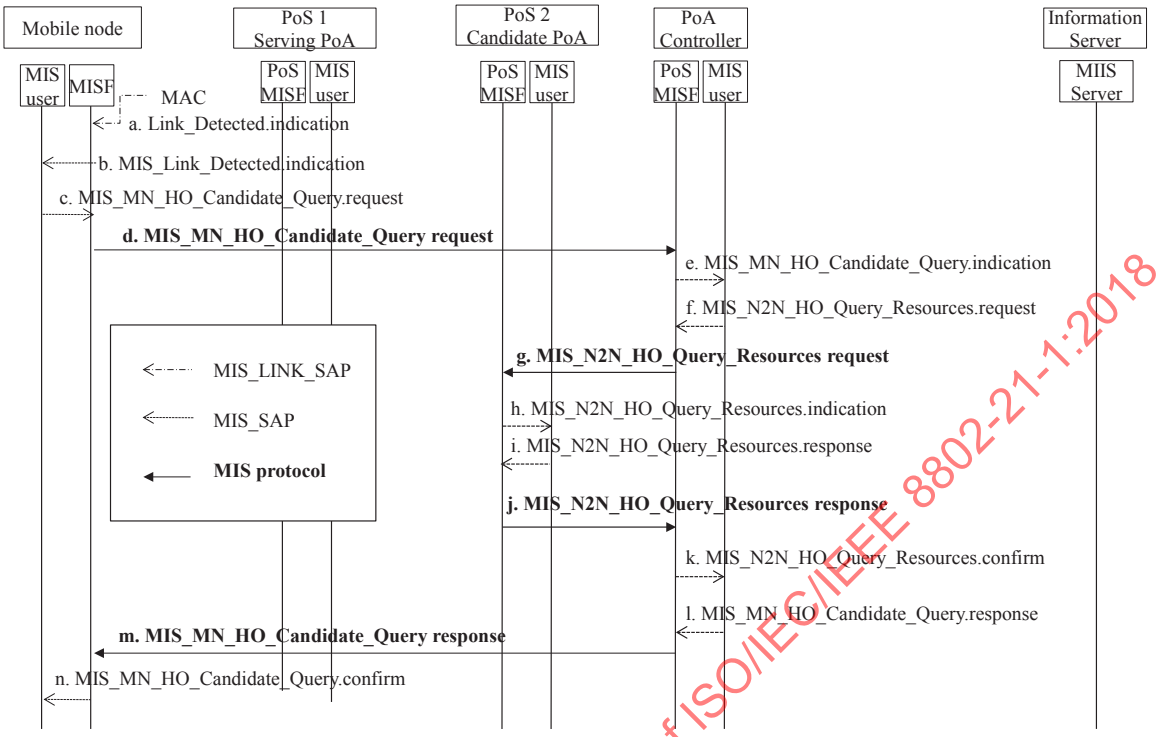


Figure 14—Signaling flows for handover preparation procedure

6.2.2.3 Stage 3: handover decision

After executing the selection mechanism and determining the preferred candidate target RAN, the MN decides on the target of the handover and notifies the PoA controller of the decided target network information by sending the MIS_MN_HO_Commit request message [see b) in Figure 15]. The MIS_MN_HO_Commit request message includes information on MN's newly allocated radio resources (e.g., frequency band and transmit power). The PoA controller sends the MIS_N2N_HO_Commit request message [see e) in Figure 15] to the Target PoA (PoS 2) to request resource preparation at the target network. The Target PoA (PoS 2) responds with the result of the resource preparation by an MIS_N2N_HO_Commit response message [see h) in Figure 15]. The target PoA (PoS 2) replies to the PoA controller (MIS PoS) by sending MIS_N2N_HO_Commit response message [see h) in Figure 15] to prepare connection with newly allocated resources. The PoA controller (MIS PoS) responds to MN by sending MIS_MN_HO_Commit response message [see k) in Figure 15] to prepare connection with newly allocated resources and MN allocates its own radio resources.

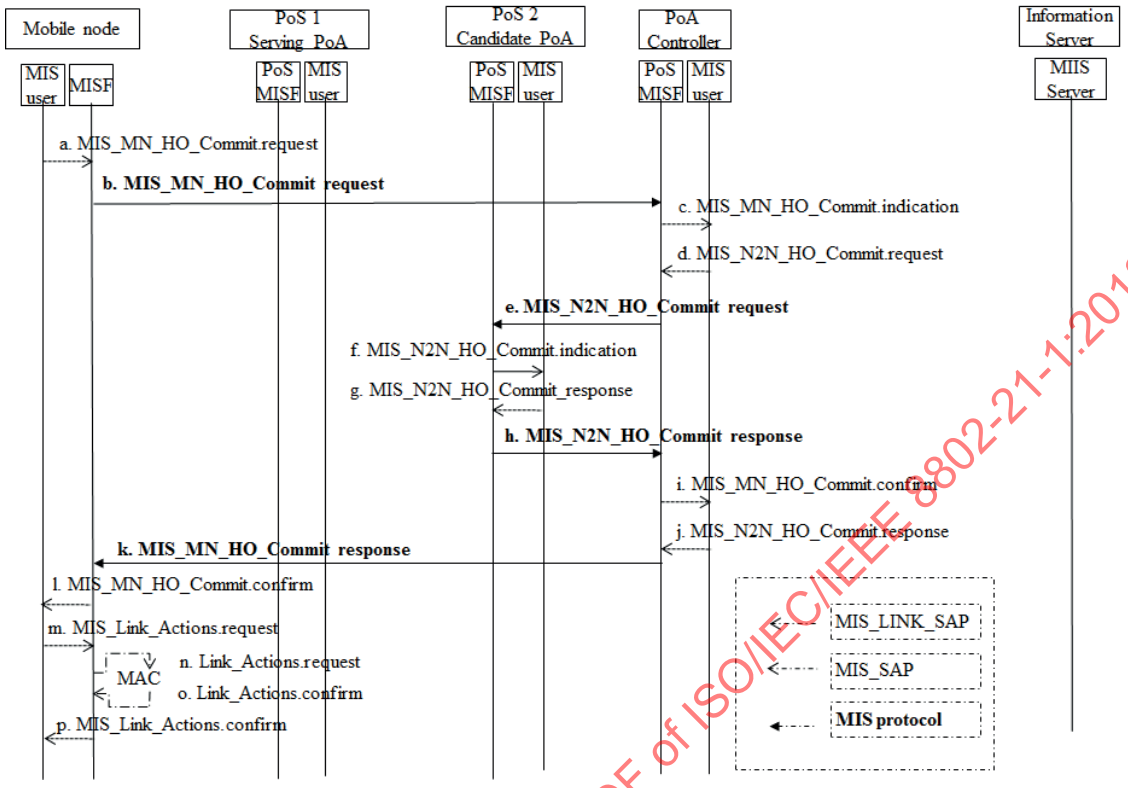


Figure 15—Signaling flows for handover decision procedure

6.2.2.4 Stage 4: handover execution

When the MN moves its attachment from a previous PoA (PoS 1) to a new PoA (PoS 2), certain handover execution procedures are carried out between the MN and the PoA controller as follows: After radio link has been activated, the MN establishes the new layer 2 connection and sends an MIS_MN_HO_Complete request message to the PoA controller [see d) in Figure 16]. After finishing handover, the PoA controller sends an MIS_N2N_HO_Complete request message to the previous Serving PoA (PoS 1) to release resource [see g) in Figure 16], which was allocated to the MN. After identifying that the resource is successfully released upon receiving (j) MIS_N2N_HO_Complete response message, the PoA controller sends an (m) MIS_MN_HO_Complete response message to the MN. The handover procedure is completed when MN receives the (m) MIS_MN_HO_Complete response message from PoA controller.

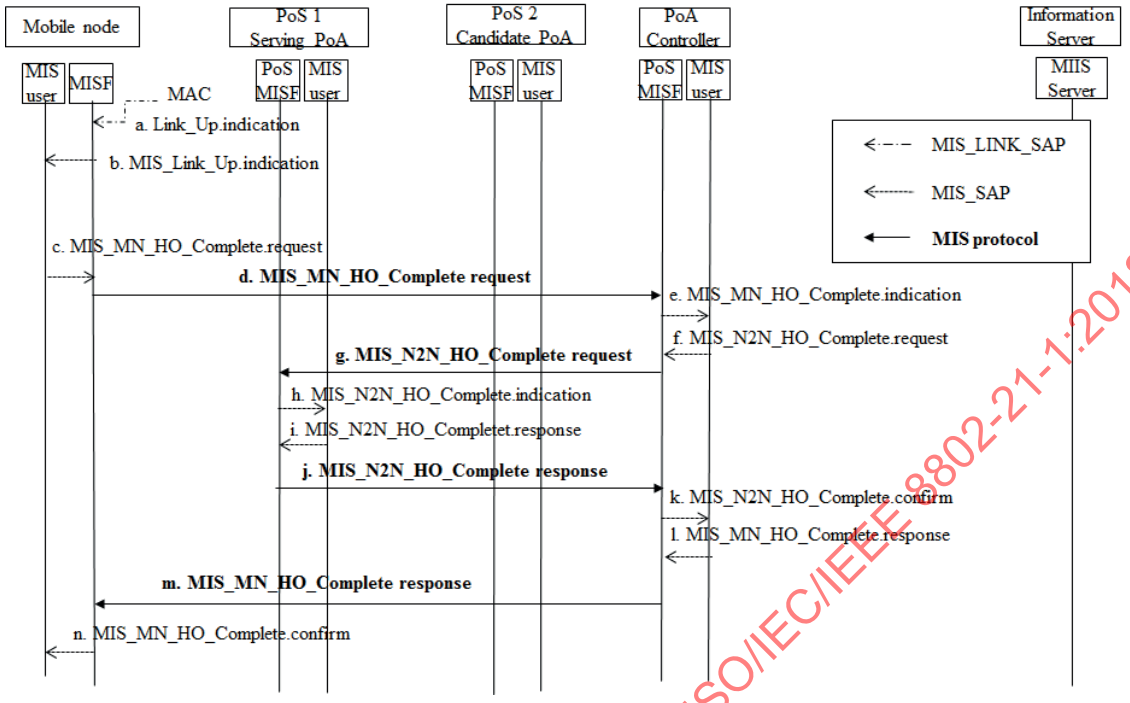


Figure 16—Signaling flows for handover execution procedure

6.3 Service access points (SAPs) and primitives

This use case requires the following primitives defined in Clause 5 of this standard and Clause 7 of IEEE Std 802.21-2017.

6.3.1 MIS_LINK_SAP primitives

Primitives	Defined in
Link_Detected	7.3.1 of IEEE Std 802.21-2017
Link_Up	7.3.2 of IEEE Std 802.21-2017
Link_Action	7.3.12 of IEEE Std 802.21-2017

6.3.2 MIS_SAP primitives

Primitives	Defined in
MIS_Link_Detected	7.4.6 of IEEE Std 802.21-2017
MIS_Link_Up	7.4.7 of IEEE Std 802.21-2017
MIS_MN_HO_Candidate_Query	5.11.4
MIS_N2N_HO_Query_Resources	5.11.5
MIS_MN_HO_Commit	5.11.6
MIS_N2N_HO_Commit	5.11.8

MIS_MN_HO_Complete	5.11.9
MIS_N2N_HO_Complete	5.11.10
MIS_Get_Information	7.4.15 of IEEE Std 802.21-2017

6.4 MIS protocol messages

This use case requires the following messages defined in Clause 5 of this standard and Clause 8 of IEEE Std 802.21-2017.

6.4.1 MIS messages for command service

Messages	Defined in
MIS_MN_HO_Candidate_Query	5.13.3.3, 5.13.3.4
MIS_N2N_HO_Query_Resources	5.13.3.5, 5.13.3.6
MIS_MN_HO_Commit	5.13.3.7, 5.13.3.8
MIS_N2N_HO_Commit	5.13.3.12, 5.13.3.13
MIS_MN_HO_Complete	5.13.3.14, 5.13.3.15
MIS_N2N_HO_Complete	5.13.3.16, 5.13.3.17

6.4.2 MIS messages for information service

Messages	Defined in
MIS_Get_Information	8.6.4 of IEEE Std 802.21-2017

7. Media independent service for home energy management system

7.1 Introduction

This subclause explains a general overview of the home energy management system (HEMS) use case.

HEMS is a system to manage the energy usage in a home. HEMS with connecting devices (i.e., home appliances or equipment) realize the “visualization” of electricity or gas consumption and the “auto control” of devices.

HEMS typically includes a home gateway (HGW) and the following various devices:

— Air conditioning system
— Lighting
— Smart meter
— Photovoltaics (PV)
— Home security

HGW and devices are connected in the home by a wired or wireless network. HGW controls home appliances and collects usage information through the network.

For example, the user operates HGW, and HGW executes the collective lightings power off and the centralized control of the air conditioning system. Moreover, devices send the usage state of electricity to HGW, and HGW displays the amounts of electric energy in the home.

Figure 17 shows a structure example of HEMS. HGW connects to devices such as PV, air conditioning system, and lighting devices by home area network. In this example, HGW and terminal devices are connected via the cloud server, and the user controls HGW by using the terminal device. HGW collectively sends a control message to the devices using a multicast transport, and the devices sends usage information to HGW in response to the control message. In this use case, the media independent service (MIS) framework of IEEE 802.21 specifications is applied to the interface between the HGW and the devices. HEMS performs the collective control of the devices and the acquisition of usage information. The controlling system of HGW by using the terminal devices via cloud server (dotted line in Figure 17) is out of scope of this use case.

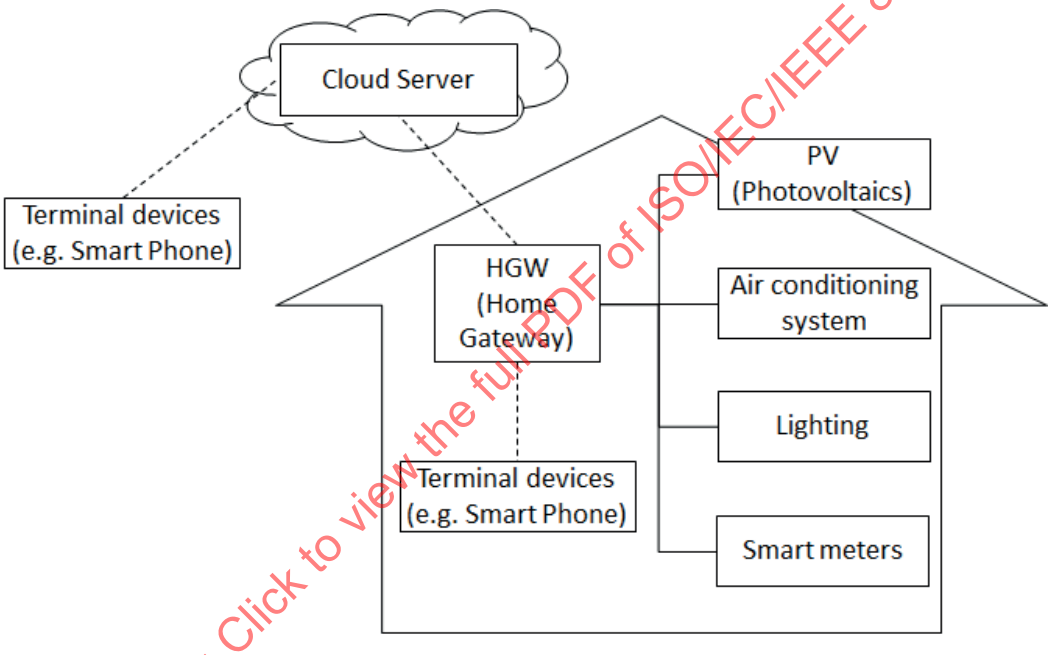


Figure 17—Structure example of HEMS

7.2 Service scenarios and signaling flows

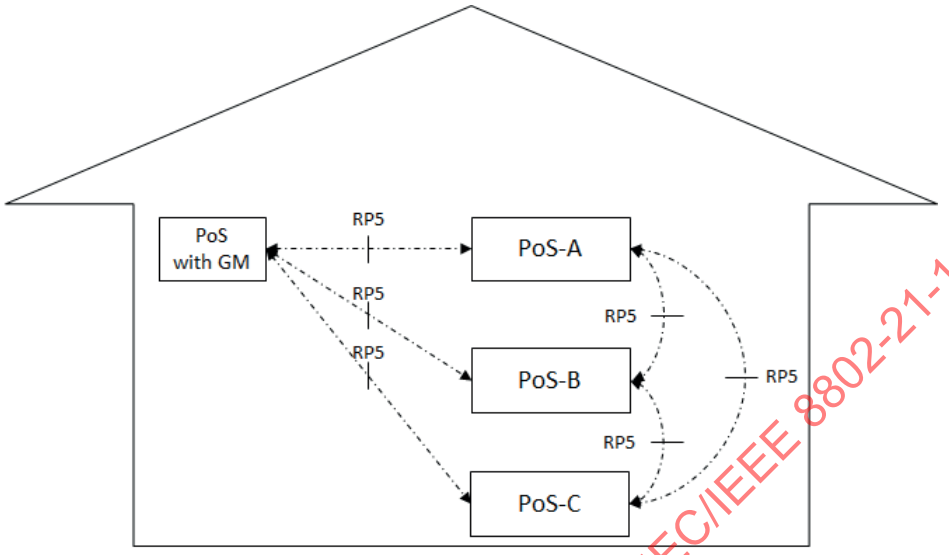
This subclause describes the service scenario and IEEE 802.21 signaling flows.

Figure 18 shows the MIS reference model corresponding to the HEMS structure, and Figure 19, Figure 20, and Figure 21 show the command flows corresponding to the different types of communication.

In this case, HGW as "PoS with GM" operates the connecting devices as "PoS." HGW controls the power switch or settings of devices and collects their state. HGW operates Multicast Group Management described in IEEE Std 802.21-2017 as PoS with GM.

PoS with GM transmits control commands to PoSs and controls them. When the PoS with GM collectively controls PoSs, it sends the control command by a multicast transport. PoS sends usage information

regularly to the PoS with GM. And PoS, when receiving the acquisition command of the usage information from the PoS with GM, sends the usage information of the device to the PoS with GM.



- PoS with GM: Home Gateway which controls and manages devices in the home
- PoS-A,B,C: Devices controlled and managed by Home Gateway

Figure 18—MIS reference model for HEMS use case

Table 11 shows the list of Service management primitives used to realize the HEMS use case. MIS_LINK_SAPs used in Link layer are not required, since the control command transmission and the usage information acquisition in HEMS are independent of the media. PoS with GM manages all the group membership in the system. When PoS needs to update its group membership, PoS sends MIS_Pull_Group_Manipulate to PoS with GM, and PoS with GM updates the membership according to the request. On the other hand, PoS with GM decides to update the membership of PoS, and sends MIS_Push_Group_Manipulate to PoS.

Table 11—Service management primitives for HEMS use case

Service management primitive	Comments	Defined in
MIS_Configuration_Update	This command is sent by a PoS to a group of other PoS(s) to update their configuration. In the use case of HEMS, PoS sends the HEMS control command and the usage information.	7.4.19 of IEEE Std 802.21-2017
MIS_Pull_Group_Manipulate	This command is sent by a PoS to another PoS to create, delete or update the group membership.	7.4.20 of IEEE Std 802.21-2017
MIS_Push_Group_Manipulate	This command is sent by a PoS to a group of other PoS(s) to create, delete or update a group membership.	7.4.21 of IEEE Std 802.21-2017
MIS_Push_Certificate	This command is sent by a PoS to another PoS or an MN and it is used for sending of a certificate.	7.4.23 of IEEE Std 802.21-2017
MIS_Revoke_Certificate	This command is sent by a PoS to a group of PoS(s) and/or an MN to revoke a certificate previously issued by the PoS.	7.4.24 of IEEE Std 802.21-2017

Figure 19 shows the control command flow from PoS with GM to each PoS. When the connecting device (i.e., PoS) in the home is operated remotely, home gateway (i.e., PoS with GM) uses MIS_Configuration_Update to send command flow to each connecting device (i.e., PoS).

PoS with GM sends control commands to each PoS using MIS_Configuration_Update indication message. This multicast control message is protected using MIS protocol protection mechanism described in 8.4.2.4 of IEEE Std 802.21-2017.

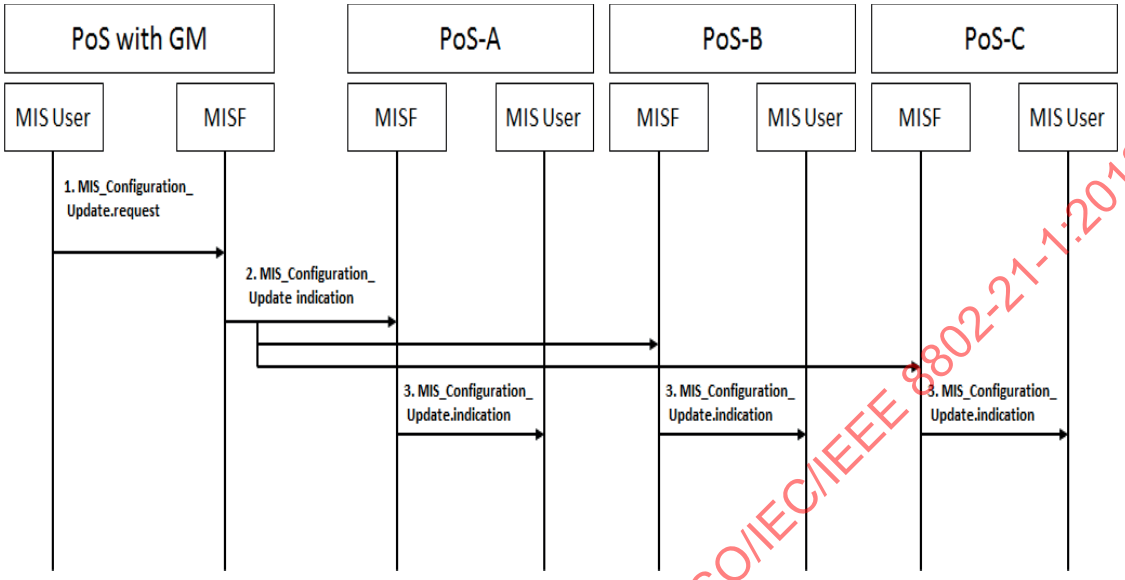


Figure 19—Transmission of the control command

1. MIS user of PoS with GM generates the HEMS control commands for PoS, and sends it to the local MISF using the MIS_Configuration_Update.request primitive.
2. MISF of PoS with GM sends the HEMS control commands for PoS using the MIS_Configuration_Update indication message.
3. MISF of PoS receives the MIS_Configuration_Update indication message, and sends it to the MIS user using the MIS_Configuration_Update.indication primitive.
4. MIS user of PoS receives the MIS_Configuration_Update.indication primitive, and runs the control command.

Figure 20 shows the notification command flow from each PoS to PoS with GM. This command flow is used periodically when the connecting devices (i.e., PoS) notify their usage state information to the home gateway (i.e., PoS with GM).

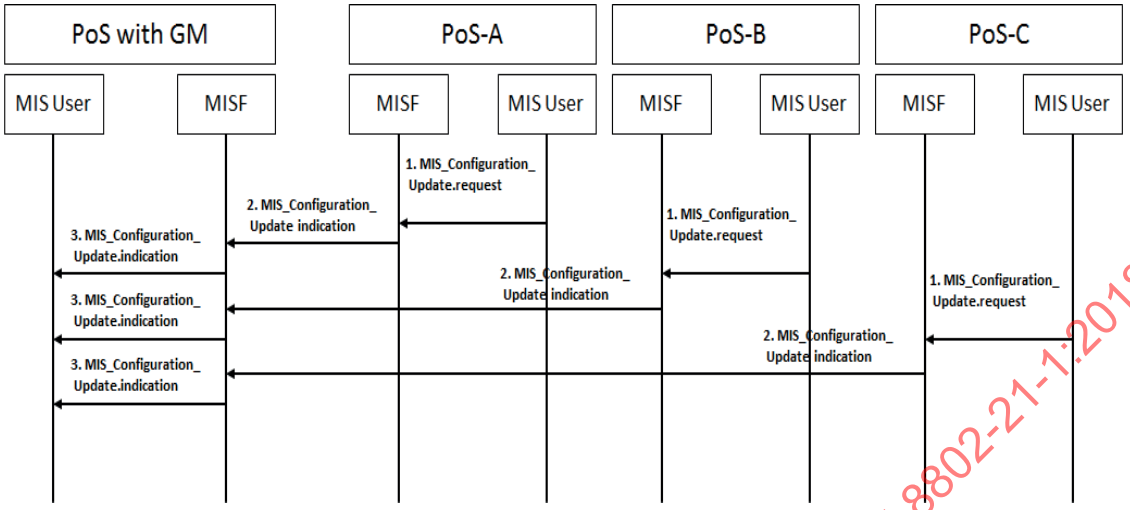


Figure 20—Transmission of the usage information

1. MIS user of PoS generates the usage information, and sends it to the local MISF using the MIS_Configuration_Update.request primitive.
2. MISF of PoS sends the usage information to the PoS with GM using MIS_Configuration_Update indication message.
3. MISF of PoS with GM receives the MIS_Configuration_Update indication message, and sends it to the MIS user of PoS with GM using the MIS_Configuration_Update.indication primitive.
4. MIS user of PoS with GM receives MIS_Configuration_Update.indication primitive, and collects the usage information.

Figure 21 shows the command flow of updating the group membership triggered by the connecting device. In this figure, the connecting device (i.e., PoS) uses MIS_Pull_Group Manipulate to request the updated membership to the home gateway (i.e., PoS with GM), and then, to receive the updated membership.

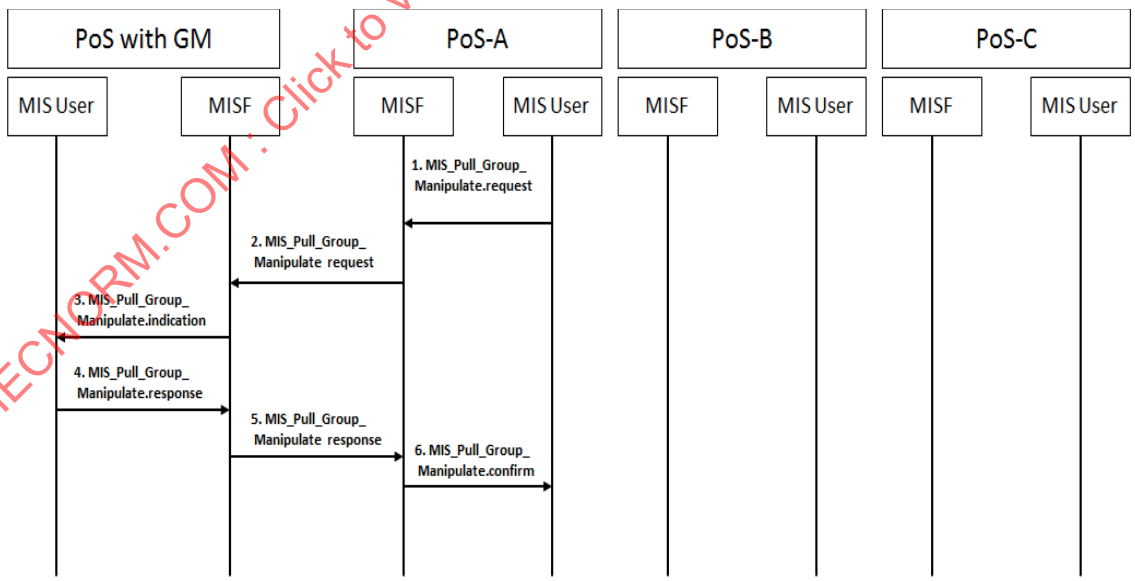


Figure 21—Group membership update triggered by connecting device

1. MIS user of PoS generates group membership for PoS with GM, and sends it to the local MISF using the MIS_Pull_Group_Manipulate.request primitive.
2. MISF of PoS sends group membership for PoS with GM using the MIS_Pull_Group_Manipulate request message.
3. MISF of PoS with GM receives the MIS_Pull_Group_Manipulate request message, and sends it to the MIS user using the MIS_Pull_Group_Manipulate.indication primitive.
4. MIS user of PoS with GM receives the MIS_Pull_Group_Manipulate.indication primitive, and generates the acknowledge receipt, and sends it the local MISF using the MIS_Pull_Group_Manipulate.response primitive.
5. MISF of PoS with GM sends the acknowledge receipt to the PoS using MIS_Pull_Group_Manipulate response message.
6. MISF of PoS receives the MIS_Pull_Group_Manipulate response message, and sends it to the MIS user of PoS using the MIS_Pull_Group_Manipulate.confirm primitive.

Figure 22 shows the command flow of updating the group membership triggered by the home gateway. In this figure, the home gateway (i.e., PoS with GM) uses MIS_Push_Group_Manipulate to send the updated the membership to each connecting device (i.e., PoS).

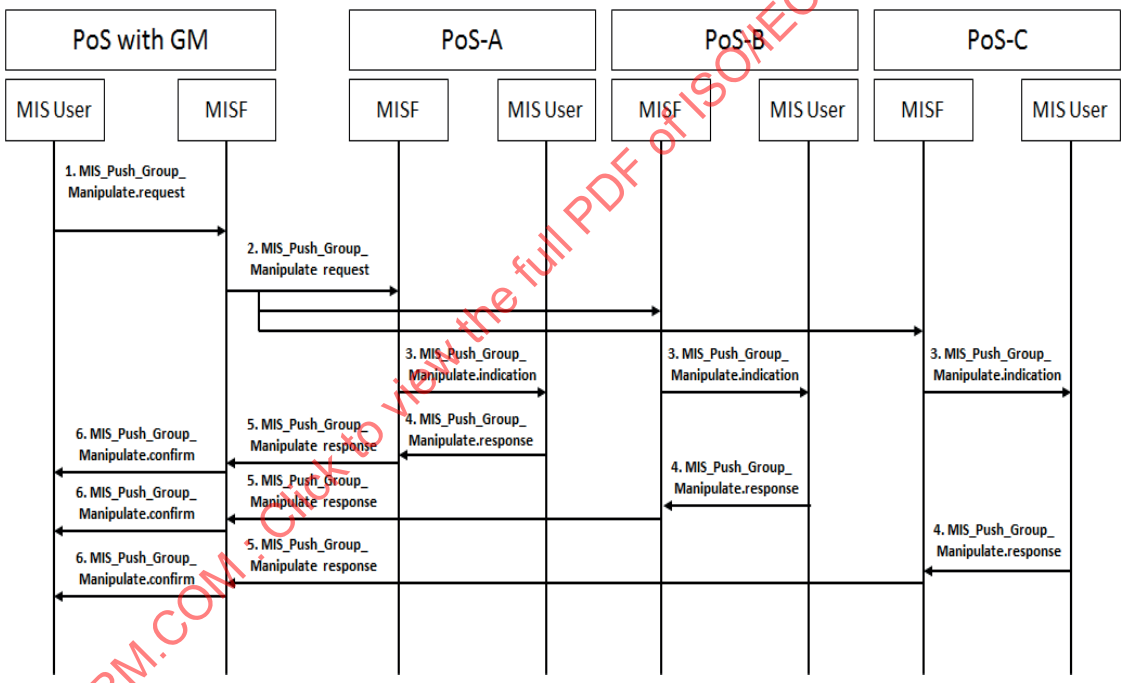


Figure 22—Group membership update triggered by home gateway

1. MIS user of PoS with GM generates group membership for PoS, and sends it to the local MISF using the MIS_Push_Group_Manipulate.request primitive.
2. MISF of PoS with GM sends group membership for PoS using the MIS_Push_Group_Manipulate request message.
3. MISF of PoS receives the MIS_Push_Group_Manipulate request message, and sends it to the MIS user using the MIS_Push_Group_Manipulate.indication primitive.
4. MIS user of PoS receives the MIS_Push_Group_Manipulate.indication primitive, and generates the acknowledge receipt, and sends it the local MISF using the MIS_Push_Group_Manipulate.response primitive.

5. MISF of PoS sends the acknowledge receipt to the PoS with GM using MIS_Push_Group_Manipulate response message.
6. MISF of PoS with GM receives the MIS_Push_Group_Manipulate response message, and sends it to the MIS user of PoS with GM using the MIS_Push_Group_Manipulate.confirm primitive.

Figure 23 shows the command flow of sending the certificate from the home gateway to each connecting device. In this figure, the home gateway (i.e., PoS with GM) uses MIS_Push_Certificate to send the certificate to each connecting devices (i.e., PoS).

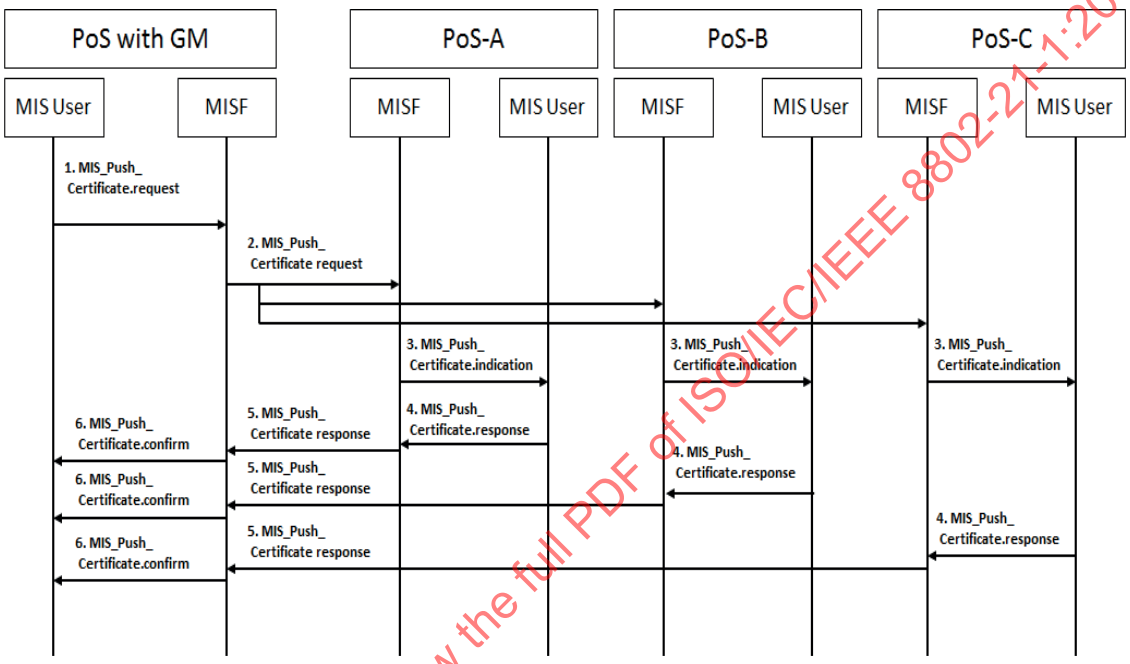


Figure 23—Transmission of certificate

1. MIS user of PoS with GM shares the certificate, and sends it to the local MISF using the MIS_Push_Certificate.request primitive.
2. MISF of PoS with GM sends the certificate the MIS_Push_Certificate request message.
3. MISF of PoS receives the MIS_Push_Certificate request message, and sends it to the MIS user using the MIS_Push_Certificate.indication primitive.
4. MIS user of PoS receives the MIS_Push_Certificate.indication primitive, and generates the acknowledge receipt, and sends it the local MISF using the MIS_Push_Certificate.response primitive.
5. MISF of PoS sends the acknowledge receipt to the PoS with GM using MIS_Push_Certificate response message.
6. MISF of PoS with GM receives the MIS_Push_Certificate response message, and sends it to the MIS user of PoS with GM using the MIS_Push_Certificate.confirm primitive.

Figure 24 describes certificate revocation list (CRL) sharing in home area network. In this example, PoS-A having the latest CRL directly sends it with other PoS and PoS with GM under the same home area network.

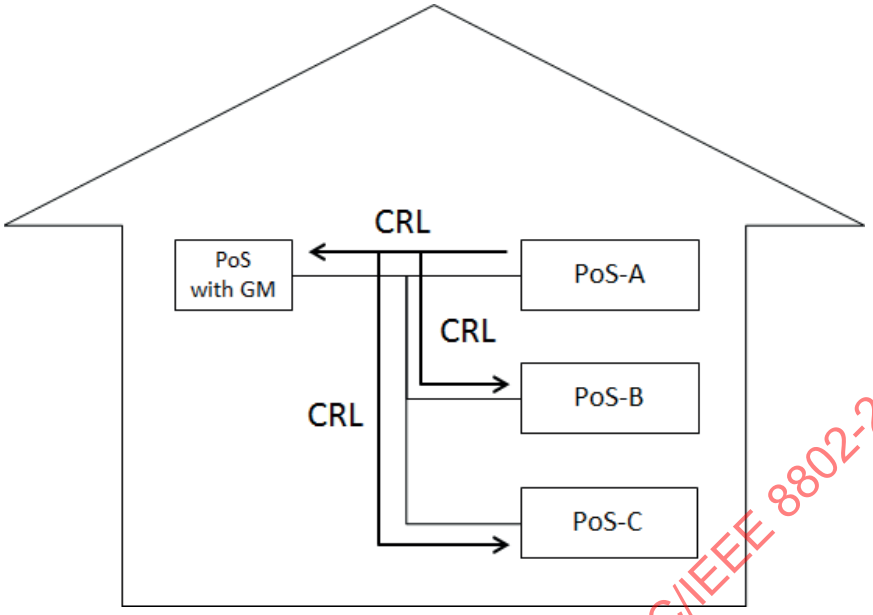


Figure 24—CRL sharing in home area network

Figure 25 shows the command flow described in Figure 24.

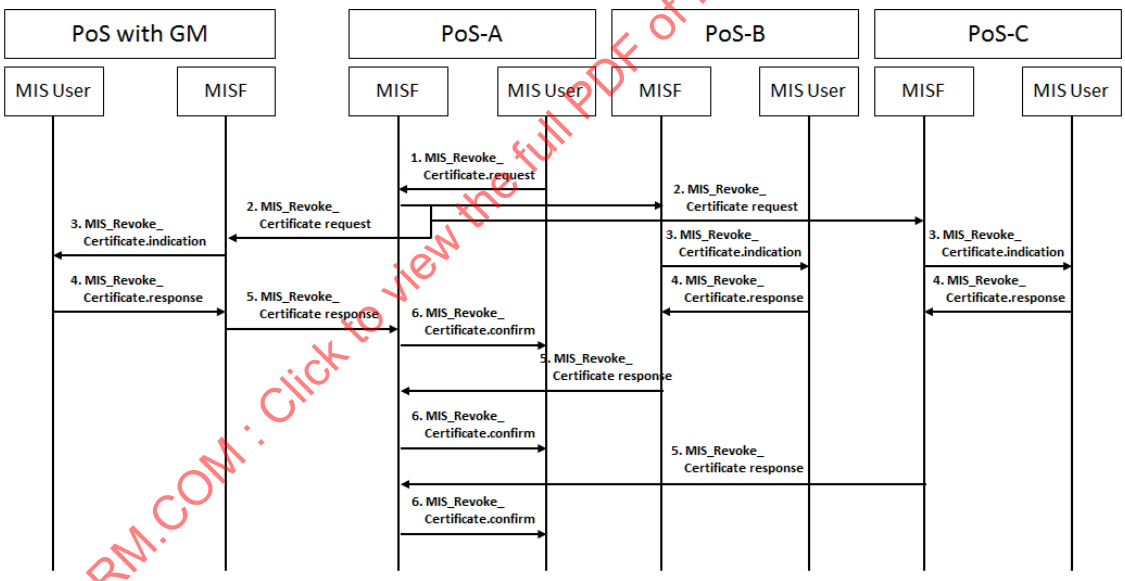


Figure 25—Transmission of CRL

1. If MIS user of PoS shares the CRL, and sends it to the local MISF using the MIS_Revoke_Certificate.request primitive.
2. MISF of PoS sends the CRL to the other PoS using MIS_Revoke_Certificate request message.
3. MISF of PoS receives the MIS_Revoke_Certificate request message, and sends it to the MIS user of PoS using the MIS_Revoke_Certificate.indication primitive.
4. MIS user of PoS receives MIS_Revoke_Certificate.indication primitive, and generates the acknowledge receipt, and sends it the local MISF using the MIS_Revoke_Certificate.response primitive.

5. MISF of PoS sends the acknowledge receipt to the PoS using MIS_Revoke_Certificate response message.
6. MISF of PoS receives the MIS_Revoke_Certificate response message, and sends it to the MIS user of PoS using the MIS_Revoke_Certificate.confirm primitive.

CRL operational guidelines for HEMS use case are described in Annex N.

8. Media independent service for radio resource management

8.1 Introduction

In recent days, networks with various communication technologies have appeared, interferences between wireless access networks have increased, and thus resource management in heterogeneous networks is needed. For example, the 2.4 GHz band is used by WLAN devices and wireless personal area network (WPAN) devices such as Bluetooth® devices, and the 5 GHz band is used by WLAN devices and cordless phones.[14] Moreover, the 5 GHz band is considered for the use of long term evolution (LTE) technology, and therefore interference in the 5 GHz band is expected to increase.

Media independent service (MIS) framework is utilized to support resource management in heterogeneous networks. MIS framework supports seamless handover in heterogeneous networks by using media independent event service (MIES), media independent command service (MICS), and media independent information service (MIIS). MIES primitives and messages help MN to monitor link status (e.g., signal strength and data rate), and MICS primitives and messages helps MN to control its link layers (physical layer and data link layer) for seamless handover in heterogeneous networks. It is possible to expect that MIS framework enables MN to monitor link status and control radio resources (e.g., frequency and power) for radio resource management (RRM). MIIS primitives and messages are used to transfer network configuration information for handover and also for radio resource allocations in heterogeneous networks. Thus, MIS framework is appropriate for resource management in heterogeneous networks that use various communication technologies and various frequency bands.

8.2 Service scenarios and signaling flows

8.2.1 Signaling architecture

Figure 26 shows the MIS framework for resource management in heterogeneous networks. Point of attachment (PoA) controller [i.e., access point (AP) controller] controls resources of PoS(PoA)s that use various communication technologies (e.g., WLAN, Wi-Fi Direct®, Bluetooth, and LTE) by using MICS message.[15] PoS(PoA)s use different communication technologies and share their link status by using MIES message. PoA controller can be implemented as MIS point of service (PoS).

The following entities are equipped with MIS function (MISF):

a) MN-A: a user device, such as a smart phone, which equips radio interfaces of multiple radio access technologies.

b) PoS(PoA)-A: a PoS with PoA, such as base station (BS) in cellular networks or access point (AP) in WLAN, which is a network entity that establishes link connection with the MN.

[14] Bluetooth is a registered trademark of the Bluetooth SIG.
[15] Wi-Fi Direct is a registered trademark of theWi-Fi Alliance.

c) PoS(PoA)-B: PoS(PoA)-A's neighboring PoS(PoA) that interferes with MN or PoS(PoA)-A.

d) PoA controller: a network entity that manages radio resources of PoS(PoA)-A.

e) Information Server: a server that manages configuration information on PoS(PoA)s' radio resource allocations.

PoS(PoA)-A is able to trigger RRM of its own link based on monitored link status by MN, itself, or PoS(PoA)-B. In other words, PoS(PoA)-A manages its own radio resources based on the following:

1) Its own link status.

2) Link status of MN.

3) Link status or resource allocations of PoS(PoA)-B.

4) Configuration information from Information Server.

PoA controller is also able to trigger RRM of PoS(PoA)-A's link. In other words, PoA controller requests RRM of PoS(PoA)-A based on the following:

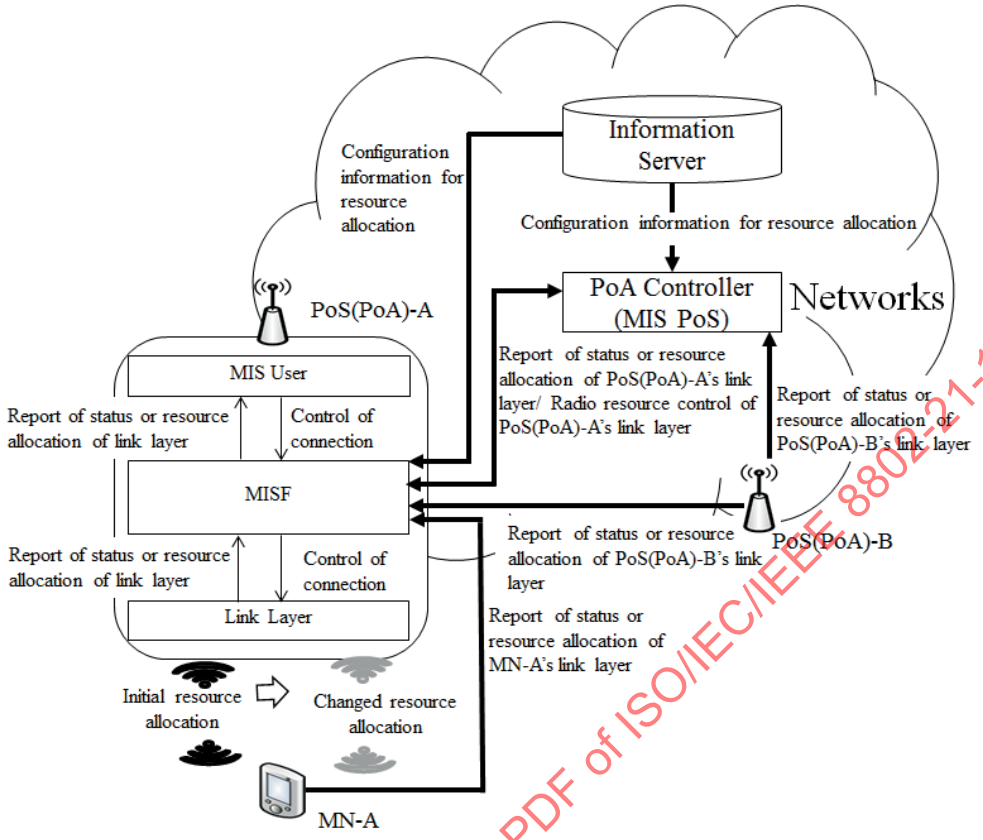
— Link status or resource allocations of PoS(PoA)s (e.g., PoS(PoA)-A and PoS(PoA)-B) that are managed by PoA controller.

— Configuration information from Information Server.

8.2.2 Stages for radio resource allocations

Radio resource allocation of RAN comprises the following four stages, as shown in Figure 27:

1. In the first stage, PoS(PoA)'s radio resource allocation is decided by PoS(PoA) or PoA controller based on PoA's link status or radio resource allocation of PoS(PoA)'s neighboring RANs.
2. In the second stage, MN prepares to connect to RAN with newly allocated radio resources.
3. In the third stage, PoS(PoA)'s radio resources (e.g., frequency and power) are allocated by PoS(PoA) or PoA controller.
4. In the last stage, PoS(PoA) reports its allocated radio resources to Information Server, PoA controller, and neighboring PoS(PoA)s.



- PoS(PoA)-A: Access point (AP) or base station (BS) that can control its own radio resources
- MN-A: MN that connects to PoS(PoA)-A
- PoS(PoA)-B: Neighboring AP or BS of PoS(PoA)-A
- PoA Controller: Network entity that can control PoS(PoA)-A's radio resources and MN-A's connection to radio access networks
- Information Server: Server that manages information on PoS(PoA)-A's radio resource allocation

Figure 26—Media independent service framework for resource management in heterogeneous networks

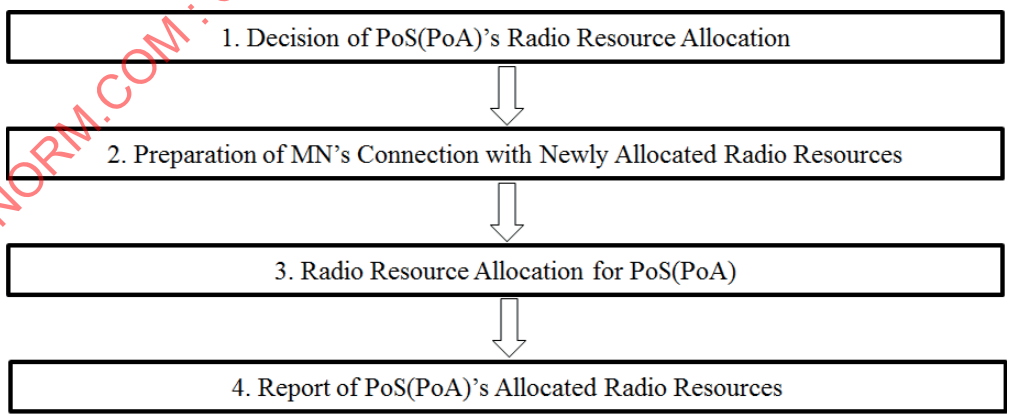


Figure 27—Stages for radio resource allocation of radio access network

8.2.3 Signaling flows

8.2.3.1 Stage 1: Decision of PoS(PoA)'s radio resource allocation

PoS(PoA) itself decides allocation of its own radio resources. Otherwise, PoA controller decides radio resource allocations for PoS(PoA) on behalf of PoS(PoA). For this stage, Link_Resource_Report and MIS_Resource_Report primitives/messages are used as use case specific primitives and messages.

8.2.3.1.1 Decision by PoS(PoA) based on link status of PoS(PoA)

PoS(PoA) (e.g., PoS(PoA)-A) decides its radio resources based on its link status, as shown in Figure 28. For this case Link_Parameter_Report and MIS_Link_Parameter_Report primitives and messages in IEEE Std 802.21-2017 can be used.

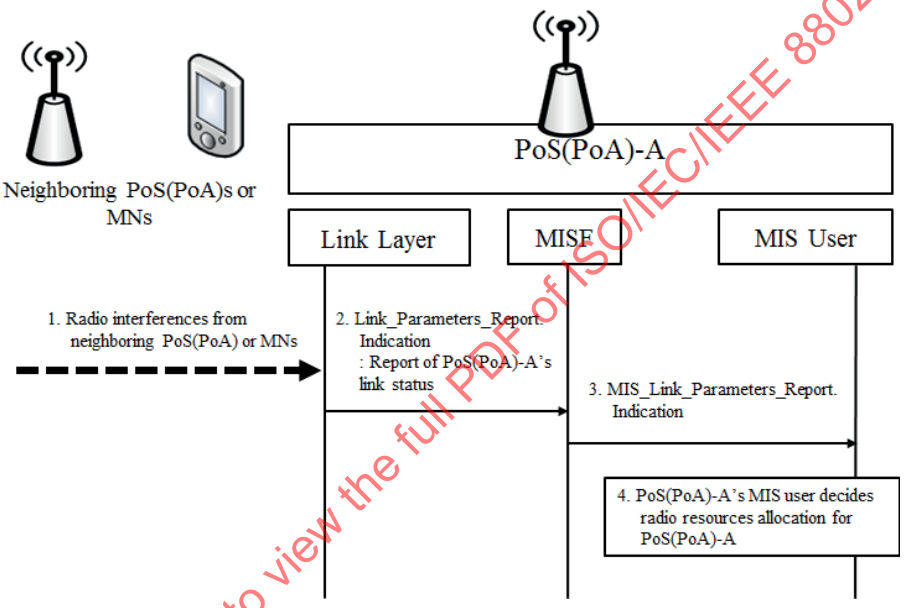


Figure 28—PoS(PoA)-A decides its radio resource allocation based on its link status

The following steps illustrate how PoS(PoA) [e.g., PoS(PoA)-A] decides its radio resources based on its link status:

1. Neighboring PoS(PoA)s or MNs interferes with PoS(PoA)-A.
2. PoS(PoA)-A's link layer informs PoS(PoA)-A's MISF (Media Independent Services Function) of bad link status (e.g., low data rate) by using Link_Paramters_Report.indication primitive.
3. PoS(PoA)-A's MISF informs PoS(PoA)-A's MIS user of bad link status by using MIS_Link_Parameters_Report.indication primitive.
4. Based on link status, PoS(PoA)-A's MIS user determines radio resource allocation for PoS(PoA)-A.

The primitives used in Figure 28 are described in Table 12 and Table 13.

Table 12—Link events for reporting link parameters

Link event name	Link event type	Description	Defined in
Link_Parameters_Report	Link parameters	Link parameters have crossed pre-specified thresholds.	7.3.4 of IEEE Std 802.21-2017

Table 13—MIS events for reporting link parameters

MIS event name	(L) ocal (R) emote	Description	Defined in
MIS_Link_Parameters_Report	L, R	Link parameters have crossed a specified threshold and need to be reported.	7.4.9 of IEEE Std 802.21-2017

8.2.3.1.2 Decision by PoS(PoA) based on link status of MN

PoS(PoA) (e.g., PoS(PoA)-A) decides its radio resource allocation based on link status of MN. MN may experience a bad link status due to some reasons (e.g., radio interference) as shown in Figure 29. In this case, if MN (e.g., MN-A) reports its link status to PoS(PoA) by using Link_Parameter_Report and MIS_Link_Parameter_Report primitives/messages in IEEE Std 802.21-2017, PoS(PoA) allocates appropriate radio resources for MN.

The following steps illustrate how PoS(PoA) (e.g., PoS(PoA)-A) decides its radio resource allocation based on link status of MN:

1. MN-A is an MN connecting to PoS(PoA)-A that needs to allocate appropriate radio resources. MN-A's link layer sends Link_Parameters_Report.indication primitive to MN-A's MISF.
2. MN-A's MISF sends MIS_Link_Parameters_Report indication message to PoS(PoA)-A's MISF.
3. PoS(PoA)-A's MISF informs PoS(PoA)-A's MIS user of MN's link status by using MIS_Link_Parameters_Report.indication primitive.
4. PoS(PoA)-A's MIS user decides its radio resource allocation based on link status of MN-A.

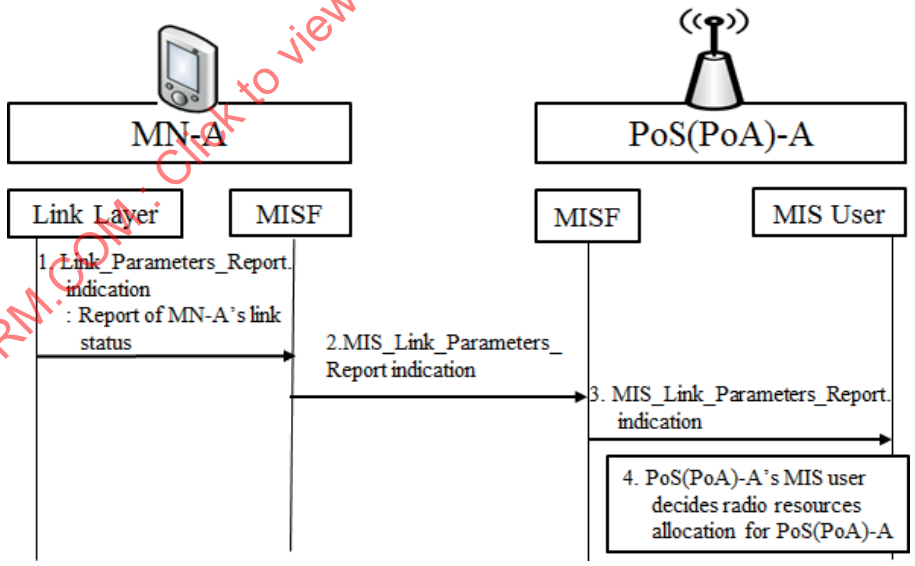


Figure 29—PoS(PoA)-A decides its radio resource allocation based on link status of MN

8.2.3.1.3 Decision by PoS(PoA) based on reports from neighboring PoS(PoA)

PoS(PoA) decides its radio resource allocations based on reports from neighboring PoS(PoA) as shown in Figure 30 and Figure 31. If PoS(PoA) (e.g., PoS(PoA)-A) and neighboring PoS(PoA) [e.g., PoS(PoA)-B] use the same radio resources, they interfere with each other and need to reallocate their radio resources for improving their link status. The PoS(PoA)-B is neighboring PoS(PoA) of PoS(PoA)-A that needs to allocate appropriate radio resources. PoS(PoA)-B reports its link status and radio resource allocation. To report PoS(PoA)-B's link status, Link_Parameters_Report and MIS_Link_Parameters_Report primitives/messages in IEEE Std 802.21-2017 are used as shown in Figure 30.

The following steps illustrate how PoS(PoA) (e.g., PoS(PoA)-A) decides its radio resource allocation based on link status reports of PoS(PoA)-B:

1. PoS(PoA)-B's link layer sends Link_Parameters_Report.indication primitive to PoS(PoA)-B's MISF to report link status of PoS(PoA)-B.
2. PoS(PoA)-B's MISF sends MIS_Link_Parameters_Report indication message to PoS(PoA)-A's MISF.
3. PoS(PoA)-A's MISF informs PoS(PoA)-A's MIS user of PoS(PoA)-B's link status by using MIS_Link_Parameters_Report.indication primitive.
4. PoS(PoA)-A's MIS user decides radio resource allocation for PoS(PoA)-A.

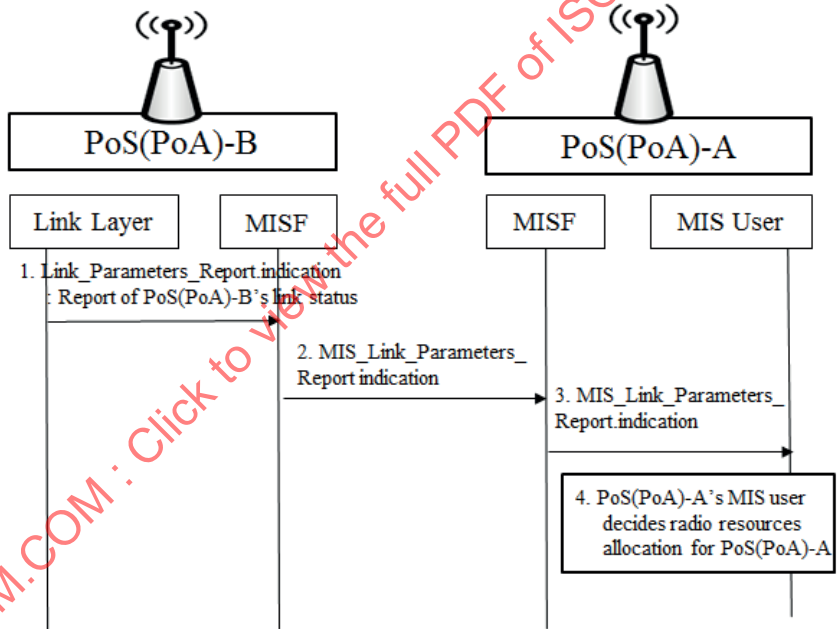


Figure 30—PoS(PoA)-A decides its radio resource allocation based on link status reports of PoS(PoA)-B

To report information on PoS(PoA)-B's allocated radio resources (e.g., frequency bands and transmit power), MIS_Resource_Report primitive/message is used as a use case specific primitive/message. PoS(PoA)-A decides its radio resource allocation based on radio resource allocation reports of PoS(PoA)-B as shown in Figure 30.

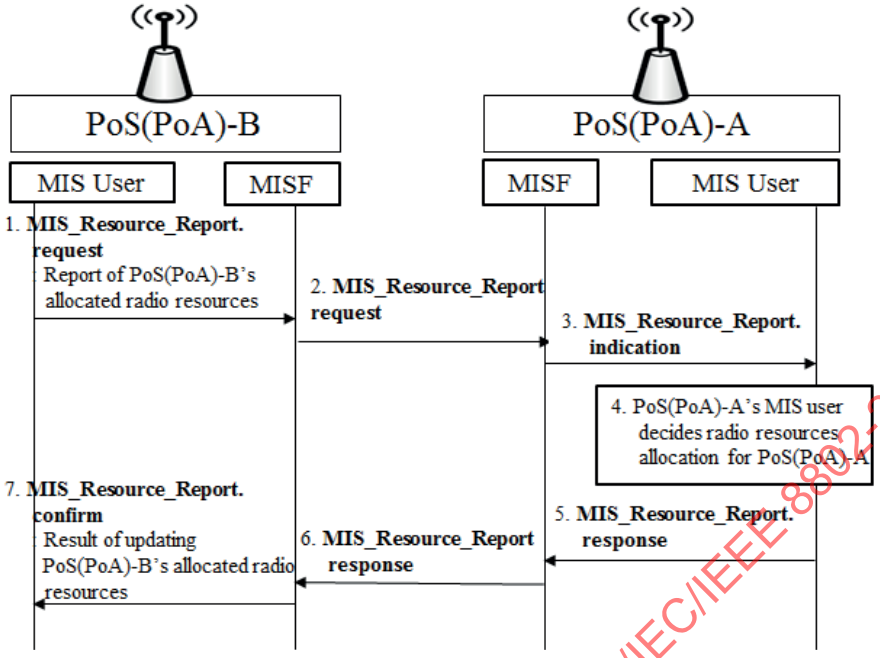


Figure 31—PoS(PoA)-A decides its radio resource allocation based on radio resource allocation reports of PoS(PoA)-B

The following steps illustrate how PoS(PoA) (e.g., PoS(PoA)-A) decides its radio resource allocation based on radio resource allocation reports of PoS(PoA)-B:

1. PoS(PoA)-B's MIS user sends MIS_Resource_Report.request to PoS(PoA)-B's MISF to report allocated radio resources of PoS(PoA)-B.
2. PoS(PoA)-B's MISF sends MIS_Resource_Report request message to PoS(PoA)-A's MISF.
3. PoS(PoA)-A's MISF informs PoS(PoA)-A's MIS user of PoS(PoA)-B's allocated radio resources by using MIS_Resource_Report.indication primitive.
4. PoS(PoA)-A's MIS user decides radio resource allocation for PoS(PoA)-A.
5. PoS(PoA)-A's MIS user sends MIS_Resource_Report.response to PoS(PoA)-A's MISF.
6. PoS(PoA)-A's MISF sends MIS_Resource_Report response message to PoS(PoA)-B's MISF.
7. PoS(PoA)-B's MIS user receives result of PoS(PoA)-A's updating on allocated radio resources of PoS(PoA)-B by MIS_Resource_Report.confirm.

The use case specific commands and primitives/messages are defined in Table 14 and Table 15, respectively.

Table 14—MIS commands for reporting allocated radio resources

MIS command	(L) ocal, (R) emote	Description	Defined in
MIS_Resource_Report	L, R	Command to indicate allocated radio resources (e.g., frequency and transmit power)	8.4.2

Table 15—MIS_SAP primitives for reporting allocated radio resources

Primitives/Messages	Service category	Description	Defined in
MIS_Resource_Report	Command	This primitive/message is to indicate allocated radio resources (e.g., frequency and transmit power)	8.4.2

8.2.3.1.4 Decision by PoS(PoA) based on configuration information from Information Server

PoS(PoA) queries configuration information to the Information Server, and then allocates its own radio resources based on the configuration information as shown in Figure 32. PoS(PoA) requests configuration information such as network type [e.g., IEEE 802.11 and code division multiple access (CDMA)], frequency bands, and location information of neighboring PoS(PoA)s to Information Server. Based on configuration information from Information Server, PoS(PoA) allocates its own radio resources. To query configuration information, MIS_Get_Information primitives/messages that are primitives/messages in IEEE Std 802.21-2017 are used.

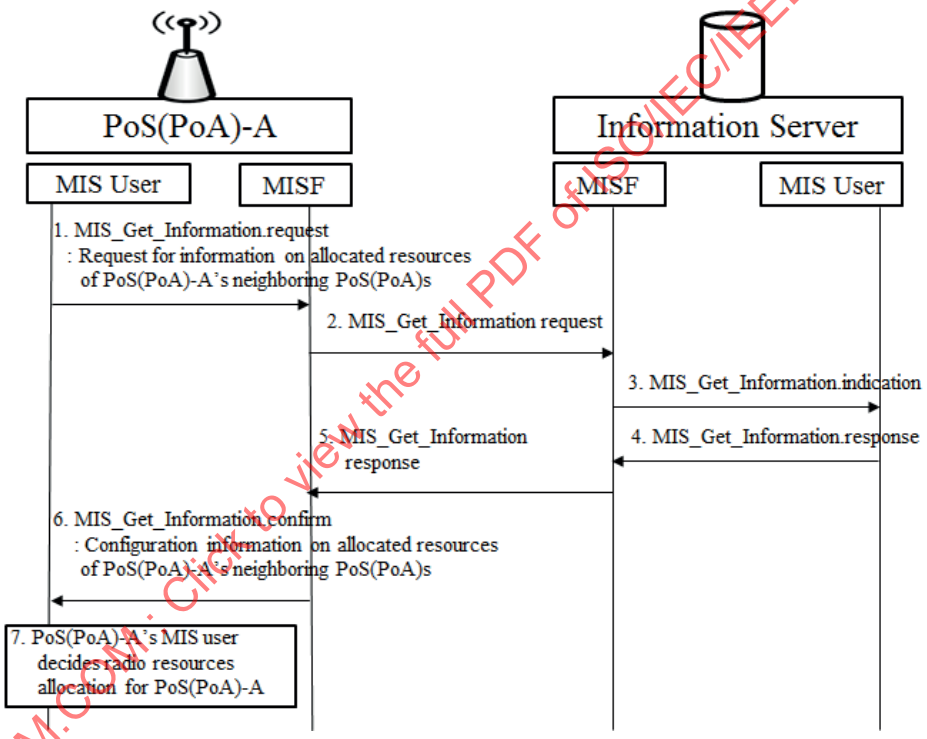


Figure 32—PoS(PoA)-A decides its radio resource allocation based on configuration information from Information Server

The following steps illustrate how PoS(PoA) (e.g., PoS(PoA)-A) decides its radio resource allocation based on configuration information from Information Server:

1. PoS(PoA)-A's MIS user sends MIS_Get_Information.request primitive to PoS(PoA)-A's MISF for requesting information on allocated resources of PoS(PoA)-A's neighboring PoS(PoA)s.
2. PoS(PoA)-A's MISF sends MIS_Get_Information request message to MISF of Information Server.

3. MIS user of Information Server recognizes that PoS(PoA)-A requests configuration information of PoS(PoA)s in neighborhood with PoS(PoA)-A by receiving MIS_Get_Information.indication primitive.
4. MIS user of Information Server sends MIS_Get_Information.response primitive to MISF of Information Server.
5. MISF of Information Server sends MIS_Get_Information response message to PoS(PoA)-A's MISF.
6. PoS(PoA)-A's MIS user receives configuration information of PoS(PoA)-A's neighboring PoS(PoA)s by MIS_Get_Information.confirm primitive.
7. PoS(PoA)-A's MIS user decides radio resource allocation for PoS(PoA)-A.

The primitives/messages used in Figure 32 are described in Table 16.

Table 16—MIS_SAP primitives for requesting information on allocated resources

Primitives/Messages	Service category	Description	Defined in
MIS_Get_Information	Information	Request to get information from repository	7.4.15 of IEEE Std 802.21-2017

8.2.3.1.5 Decision by PoA controller based on reports from PoS(PoA)s

PoA controller also decides radio resource allocation for PoS(PoA) based on reports about link status or radio resource allocation of PoS(PoA)s controlled by PoA controller, as shown in Figure 33 and Figure 34. The PoS(PoA)-B is PoS(PoA) controlled by PoA controller. PoS(PoA)-B reports its link status and radio resource allocation to PoA controller, and then PoA controller allocates radio resources for PoS(PoA)-A. To report PoS(PoA)-B's link status, Link_Parameters_Report and MIS_Link_Parameters_Report primitives/messages in IEEE Std 802.21-2017 are used as shown in Figure 33.

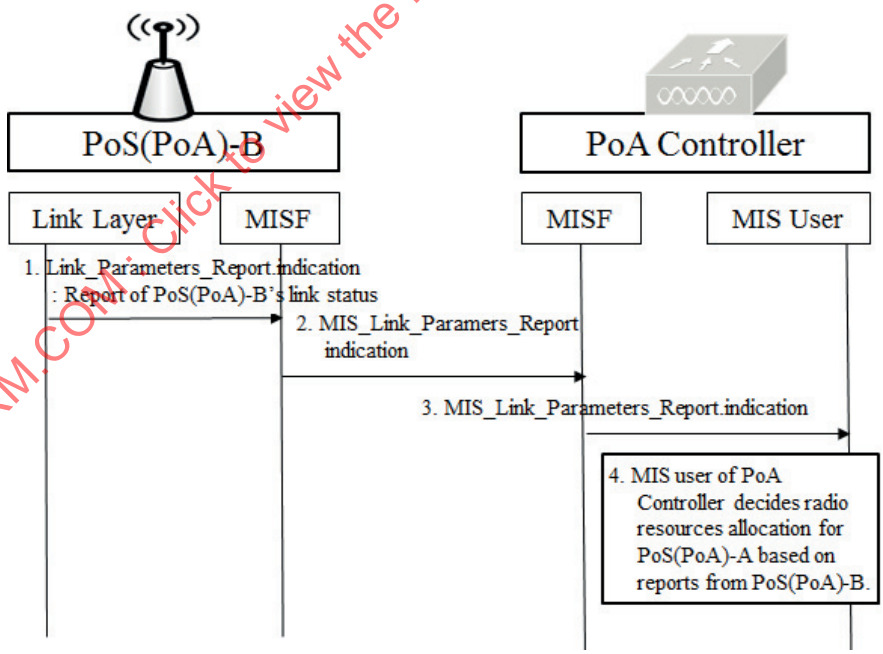


Figure 33—PoA controller decides PoS(PoA)-A's radio resource allocation based on link status reports of PoS(PoA)-B

The following steps illustrate how PoA controller decides PoS(PoA)-A's radio resource allocation based on link status reports of PoS(PoA)-B:

1. PoS(PoA)-B's link layer sends Link_Parameters_Report.indication primitive to PoA-B's MISF for reporting link status of PoS(PoA)-B.
2. PoS(PoA)-B's MISF sends MIS_Link_Parameters_Report indication message to MISF of PoA controller.
3. PoA controller's MISF informs PoA controller's MIS user of PoS(PoA)-B's link status by using MIS_Link_Parameters_Report.indication primitive.
4. MIS user of PoA controller decides PoS(PoA)-A's radio resource allocation based on link status of PoS(PoA)-B.

To report information on PoS(PoA)-B's allocated radio resources (e.g., frequency bands and transmit power), MIS_Resource_Report primitive/message is used as a use case specific primitive/message. PoA controller decides PoS(PoA)-A's radio resource allocation based on radio resource allocation reports of PoS(PoA)-B as shown in Figure 34.

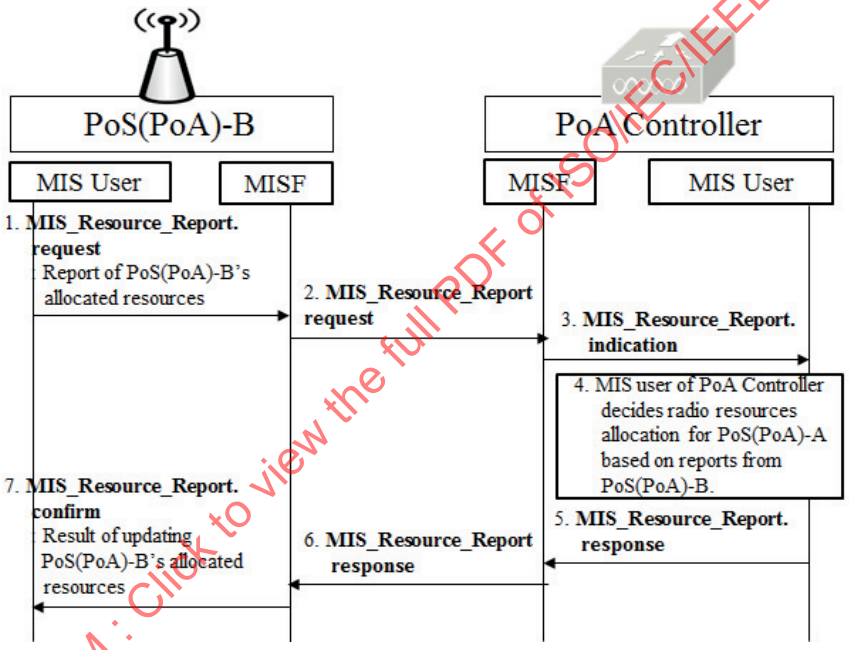


Figure 34—PoA controller decides PoS(PoA)-A's radio resource allocation based on radio resource allocation reports of PoS(PoA)-B

The following steps illustrate how PoA controller decides PoS(PoA)-A's radio resource allocation based on radio resource allocation reports of PoS(PoA)-B:

1. PoS(PoA)-B's MIS user sends MIS_Resource_Report.request to PoS(PoA)-B's MISF to report allocated radio resources of PoS(PoA)-B.
2. PoS(PoA)-B's MISF sends MIS_Resource_Report request message to MISF of PoA controller.
3. PoA controller's MISF informs PoA controller's MIS user of PoS(PoA)-B's allocated radio resources by using MIS_Resource_Report.indication primitive.
4. PoA controller's MIS user decides radio resource allocation for PoS(PoA)-A.
5. PoA controller's MIS user sends MIS_Resource_Report.response to PoA controller's MISF.

6. PoA controller's MISF sends MIS_Resource_Report response message to PoS(PoA)-B's MISF.
7. PoS(PoA)-B's MIS user receives result of PoA controller's updating on allocated radio resources of PoS(PoA)-B by MIS_Resource_Report.confirm.

8.2.3.1.6 Decision by PoA controller based on configuration information from Information Server

PoA controller queries configuration information to Information Server, and then allocate radio resources for PoS(PoA) as shown in Figure 35. PoA controller requests configuration information such as network type, frequency bands, and location information of PoS(PoA)s controlled by PoA controller to Information Server. Based on configuration information from Information Server, PoA controller allocates appropriate radio resources of PoS(PoA). To query configuration information, MIS_Get_Information primitives/messages that are primitives/messages in IEEE Std 802.21-2017 are used.

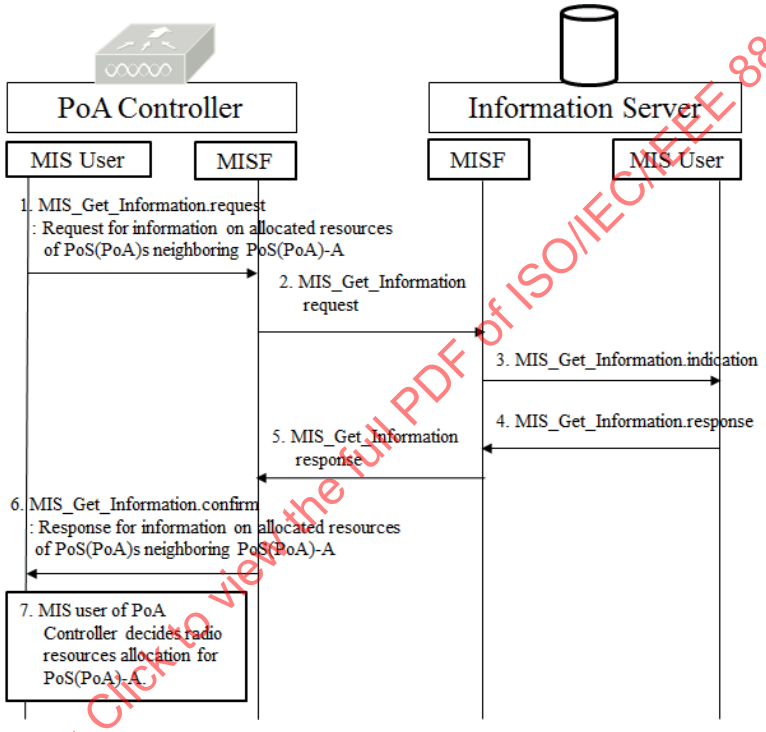


Figure 35—PoA controller decides PoS(PoA)-A's radio resource allocation based on configuration information from Information Server

The following steps illustrate how PoA controller decides PoS(PoA)-A's radio resource allocation based on configuration information from Information Server:

1. MIS user of PoA controller sends MIS_Get_Information.request primitive to MISF of PoA controller.
2. MISF of PoA controller sends MIS_Get_Information request message to MISF of Information Server.
3. MIS user of Information Server recognizes that PoA controller requests configuration information of PoS(PoA)s controlled by PoA controller with MIS_Get_Information.indication primitive.
4. MIS user of Information Server sends MIS_Get_Information.response primitive to MISF of Information Server.

5. MISF of Information Server sends MIS_Get_Information response message to MISF of PoA controller.
6. MIS user of PoA controller receives configuration information of PoS(PoA)s controlled by PoA controller with MIS_Get_Information.confirm primitive.
7. MIS user of PoA controller decides radio resource allocation for PoS(PoA)-A.

8.2.3.2 Stage 2: Preparation of MN's connection with newly allocated radio resources

Before PoS(PoA) allocates new radio resources, MN needs to prepare to change its connection with newly allocated radio resources of PoS(PoA) that MN connects to. MN receives information on new radio resources from PoA controller or PoS(PoA) that MN connects to before performing radio resource allocation. For this stage, MIS_Link_Preparation primitive/message is used as use case specific primitive and message.

8.2.3.2.1 Request for preparation of MN's connection from PoS(PoA)

PoS(PoA) requests MN to prepare connection with newly allocated radio resources by using MIS_Link_Preparation primitive/message that is use case specific one, as shown in Figure 36. The primitive and message of MIS_Link_Preparation include information on PoS(PoA)'s newly allocated radio resources (e.g., frequency band and transmit power). The MN-A connects to PoS(PoA)-A, and thus MN-A is requested to prepare connection with new radio resources by PoS(PoA)-A.

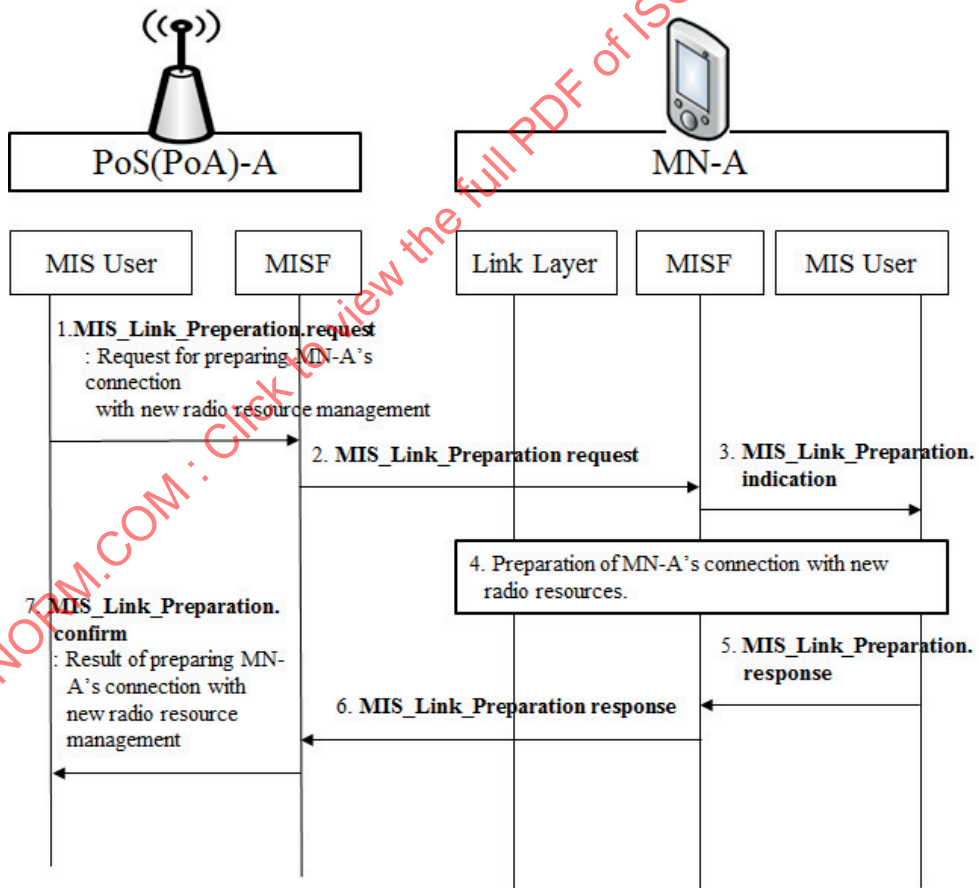


Figure 36—PoS(PoA)-A requests MN-A to prepare connection with newly allocated radio resources

The following steps illustrate how PoS(PoA)-A requests MN-A to prepare connection with newly allocated radio resources:

1. PoS(PoA)-A's MIS user sends MIS_Link_Preperation.request primitive to PoS(PoA)-A's MISF.
2. PoS(PoA)-A's MISF sends MIS_Link_Preparation request message to MN-A's MISF.
3. MN-A's MIS user is informed of new radio resources to prepare MN's connection by MIS_Link_Preparation.indication primitive.
4. MN-A prepares the connection with new radio resources.
5. MN-A's MIS user sends MIS_Link_Preparation.response to MN-A's MISF.
6. MN-A's MISF sends MIS_Link_Preparation response message to PoS(PoA)-A's MISF.
7. PoS(PoA)-A's MIS user receives result of preparing MN-A's connection with new radio resources by MIS_Link_Preparation.confirm.

Table 17 and Table 18 describe the RRM specific MIS commands and primitives/messages used in Figure 36.

Table 17—MIS commands for requesting link preparation

MIS command	(L) ocal, (R) emote	Description	Defined in
MIS_Link_Preparation	L, R	Command to request MN to prepare connection with newly allocated radio resources	8.4.3

Table 18—MIS_SAP primitives for requesting link preparation

Primitives/Messages	Service category	Description	Defined in
MIS_Link_Preparation	Command	This primitive/message is to request MN to prepare connection with newly allocated radio resources	8.4.3

8.2.3.2.2 Request for preparation of MN's connection from PoA controller

PoA controller requests MN to prepare connection with newly allocated resources by using MIS_Link_Preparation primitive/message that is the use case specific one, as shown in Figure 37.

The following steps illustrate how PoA controller requests MN-A to prepare connection with newly allocated radio resources:

1. MIS user of PoA controller sends MIS_Link_Preperation.request primitive to MISF of PoA controller.
2. MISF of PoA controller sends MIS_Link_Preparation request message to MN-A's MISF.
3. MN-A's MIS user is informed of new radio resources to prepare MN's connection by MIS_Link_Preparation.indication primitive.
4. MN-A prepares the connection with new radio resources.
5. MN-A's MIS user sends MIS_Link_Preparation.response to MN-A's MISF.
6. MN-A's MISF sends MIS_Link_Preparation response message to MISF of PoA controller.
7. MIS user of PoA controller receives result of preparing MN-A's connection with new radio resources by MIS_Link_Preparation.confirm.

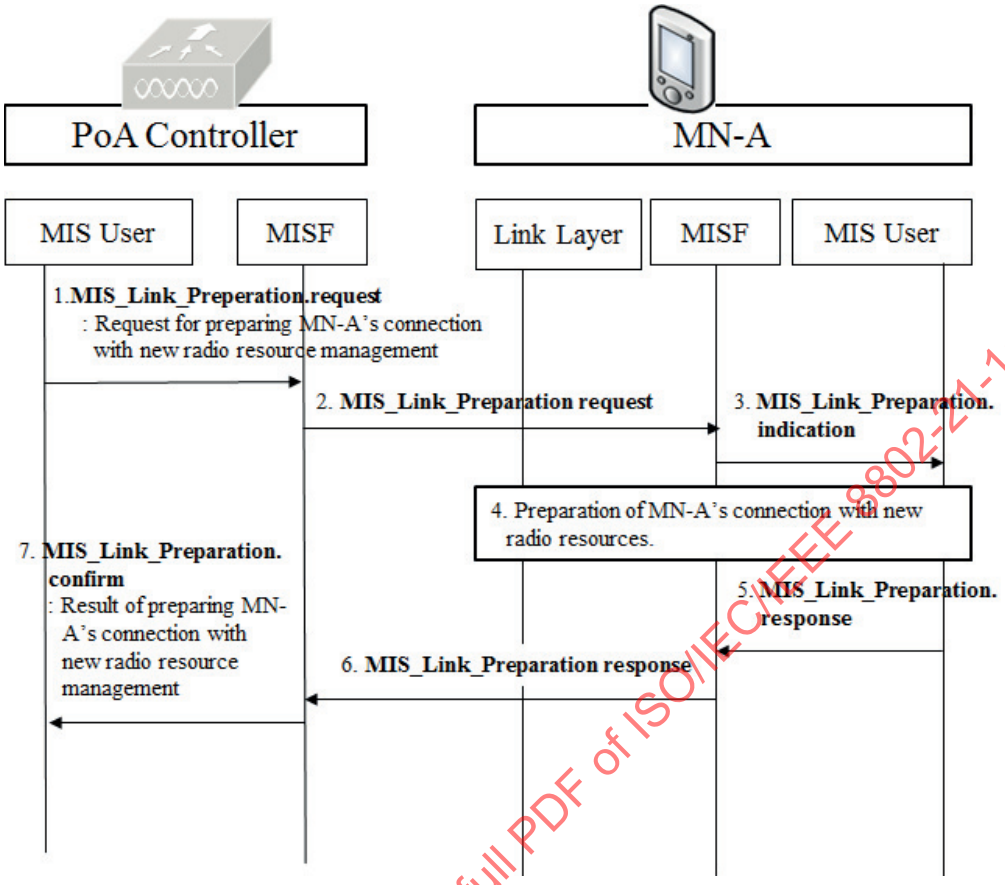


Figure 37—PoA controller requests MN-A to prepare connection with newly allocated radio resources

8.2.3.3 Stage 3: Allocation of PoS(PoA)'s Radio Resources

In this stage, PoS(PoA)'s radio resources are allocated by PoS(PoA) or PoA controller. For this stage, MIS_Resource_Allocation and Link_Resource_Allocation primitives/messages are used for allocating radio resources of PoS(PoA).

8.2.3.3.1 PoS(PoA)'s radio resource allocation by PoS(PoA)

PoS(PoA) itself allocates its radio resources, as shown in Figure 38. MIS_Resource_Allocation.request and Link_Resource_Allocation.request primitives are use case specific primitives for allocating radio resources and include parameters that represent radio resources (e.g., frequency band and transmit power).

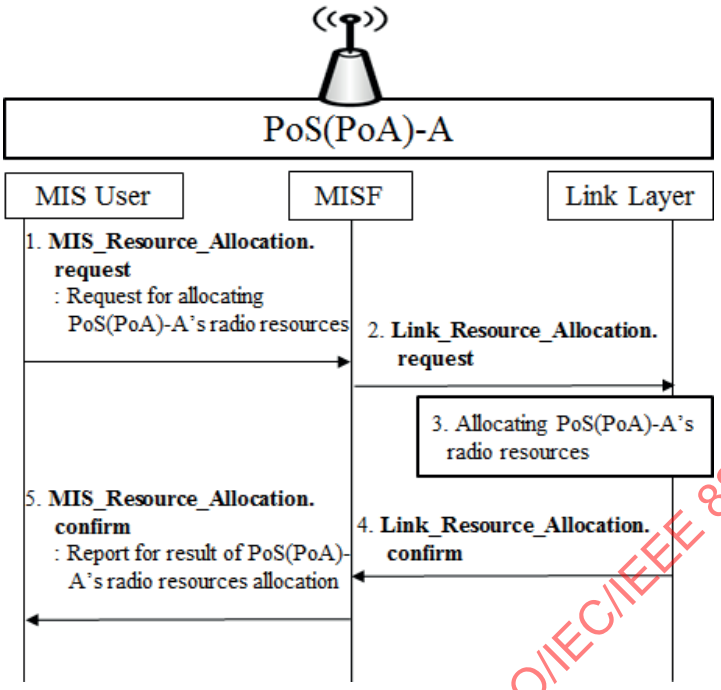


Figure 38—PoS(PoA) allocates its own radio resources

The following steps illustrate how PoS(PoA) allocates its own radio resources:

1. PoS(PoA)'s MIS user sends MIS_Resource_Allocation.request primitive to PoS(PoA)'s MISF.
2. PoS(PoA)'s link layer receives information on radio resources for allocation by Link_Resource_Allocation.request primitive.
3. PoS(PoA)'s link layer allocates its own radio resources.
4. After PoS(PoA)'s link layer allocates radio resources, PoS(PoA)'s link layer sends Link_Resource_Allocation.confirm primitive to PoS(PoA)'s MISF.
5. Result of radio resource allocation is reported to PoS(PoA)'s MIS user by MIS_Resource_Allocation.confirm primitive.

Link_Resource_Allocation.confirm and MIS_Resource_Allocation.confirm should include a parameter to present result (e.g., success or fail) of radio resource allocation. RRM specific commands and primitives/messages used in Figure 38 are described in Table 19, Table 20, Table 21, and Table 22.

Table 19—Link commands for allocating radio resources

Link command	Description	Defined in
Link_Resource_Allocation	Command to request for allocating radio resources (e.g., frequency and transmit power)	8.3.1

Table 20—MIS commands for allocating radio resources

MIS command	(L) ocal, (R) emote	Description	Defined in
MIS_Resource_Allocation	L, R	Command to request for allocating radio resources (e.g., frequency and transmit power)	8.4.1

Table 21—MIS_LINK_SAP primitives for allocating radio resources

Primitives	Service category	Description	Defined in
Link_Resource_Allocation	Command	Request for allocating radio resources (e.g., frequency and transmit power)	8.3.1

Table 22—MIS_SAP primitives for allocating radio resources

Primitives/Messages	Service category	Description	Defined in
MIS_Resource_Allocation	Command	This primitive/message is to request for allocating radio resources (e.g., frequency and transmit power)	8.4.1

8.2.3.3.2 PoS(PoA)'s radio resource allocation by PoA controller

MIS user of PoA controller requests PoS(PoA)'s link layer to allocate radio resources as shown in Figure 39. MIS_Resource_Allocation.request and Link_Resource_Allocation.request primitives are use case specific primitives for PoS(PoA) controller to allocate radio resources of PoS(PoA).

The following steps illustrate how PoA controller allocates radio resources for PoS(PoA):

1. MIS user of PoA controller sends MIS_Resource_Allocation.request primitive to MISF of PoA controller.
2. MISF of PoA controller sends MIS_Resource_Allocation request message to PoS(PoA)'s MISF.
3. PoS(PoA)'s link layer receives information on radio resources for allocation by Link_Resource_Allocation.
4. PoS(PoA)'s link layer allocates its own radio resources.
5. PoS(PoA)'s link layer sends Link_Resource_Allocation.confirm to PoS(PoA)'s MISF.
6. PoS(PoA)'s MISF sends MIS_Response_Allocation response message to MISF of PoA controller.
7. MIS user of PoA controller receives report on the result of PoS(PoA)'s radio resource allocation.

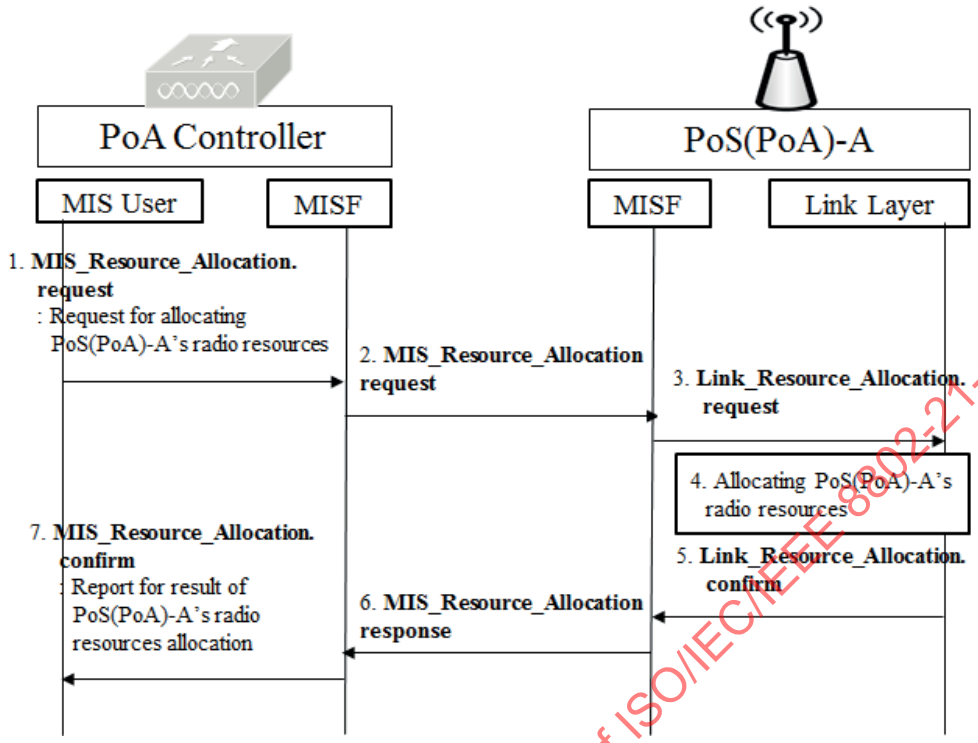


Figure 39—PoA controller allocates radio resources for PoS(PoA)

8.2.3.4 Stage 4: Report of PoS(PoA)'s allocated radio resources

After radio resource allocation of PoS(PoA), PoS(PoA) should report its updated radio resources to other network entities such as neighboring PoS(PoA), PoA controller, and Information Server, as shown in Figure 40. MIS_Resource_Report is use-case specific primitive/message for reporting PoS(PoA)'s updated radio resource allocation. This includes parameters that represent updated radio resources of PoS(PoA).

The following steps illustrate how PoS(PoA) reports its updated radio resources to other network entities:

1. PoS(PoA)'s MIS user sends MIS_Resource_Report.request primitive to PoS(PoA)'s MISF.
2. PoS(PoA)'s MISF sends MIS_Resource_Report request message to MISF of other network entities [e.g., neighboring PoS(PoA), PoA controller, and Information Server].
3. MIS user of other network entities updates information on PoS(PoA)'s radio resource allocation by MIS_Resource_Report.indication primitive.
4. As response to update report, MIS user of other network entities sends MIS_Resource_Report.response to MISF of other network entities.
5. MISF of other network entities sends MIS_Resource_Report response message to PoS(PoA)'s MISF.
6. PoS(PoA)'s MIS user is informed by MIS_Resource_Report.confirm primitive whether other network entities update PoS(PoA)'s radio resource allocation or not.

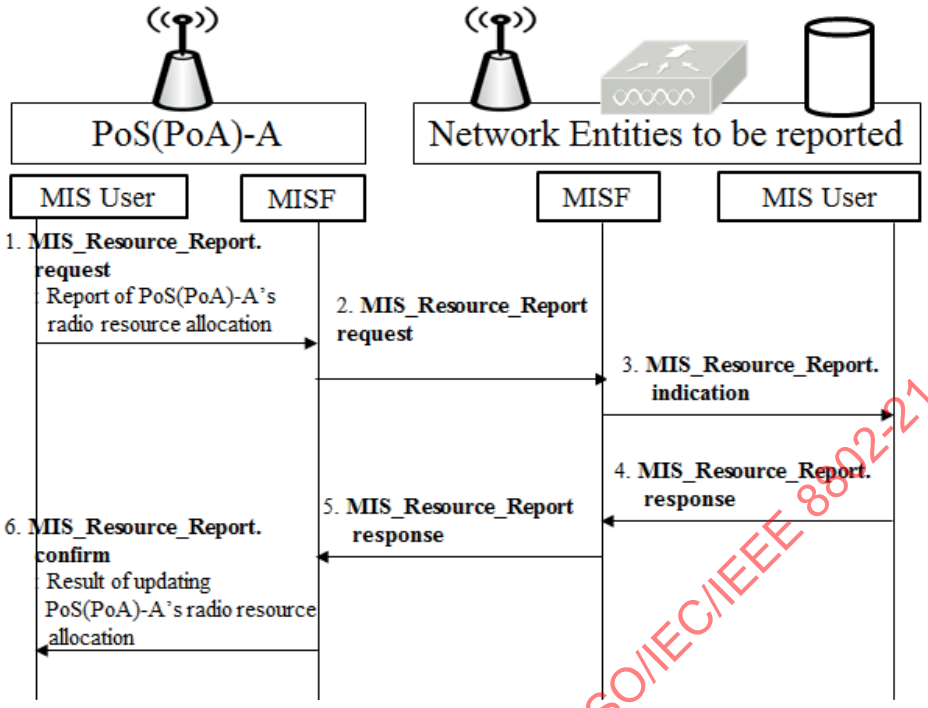


Figure 40—PoS(PoA) reports its updated radio resources to other network entities

8.3 RRM service specific MIS_LINK_SAP primitives

The following primitives are specific to RRM use case and shall be used with others that are defined in IEEE Std 802.21-2017.

8.3.1 Link_Resource_Allocation

8.3.1.1 Link_Resource_Allocation.request

8.3.1.1.1 Function

This primitive is used by the MISF to request the link layer to allocate radio resources (e.g., frequency and transmit power).

8.3.1.1.2 Semantics of service primitive

Link_Resource_Allocation.request (
Resource_Config
)

Parameters:

Name	Data type	Description
Resource_Config	SEQUENCE(LINK_TUPLE_ID, FREQ_BAND_ID, TXPWR_ID)	Configuration information for allocating radio resources (e.g., frequency and transmit power)

8.3.1.1.3 When generated

The MISF generates this primitive upon request from the MIS user to perform allocation of radio resources (e.g., frequency and transmit power).

8.3.1.1.4 Effect on receipt

Upon receipt of this primitive, the link-layer technology performs allocation of radio resources in accordance with the procedures specified by the relevant standards organization.

8.3.1.2 Link_Resource_Allocation.confirm

8.3.1.2.1 Function

This primitive is used by link-layer technologies to provide an indication of the result of the allocation of radio resources.

8.3.1.2.2 Semantics of service primitive

Link_Resource_Allocation.confirm (
Status
)

Parameters:

Name	Data type	Description
Status	STATUS	Status of the operation.

8.3.1.2.3 When generated

The link-layer technology generates this primitive to communicate the result of the allocation of radio resources.

8.3.1.2.4 Effect on receipt

Upon receipt of this primitive, the MISF generates MIS_Resource_Allocation.response primitive to send an indication of the result of allocation of radio resources to an MIS user.

8.4 RRM service specific MIS_SAP primitives

The following primitives are specific to RRM use case and shall be used with others that are defined in IEEE Std 802.21-2017.

8.4.1 MIS_Resource_Allocation

8.4.1.1 MIS_Resource_Allocation.request

8.4.1.1.1 Function

MIS_Resource_Allocation.request is used for an MIS user to request an MISF to allocate radio resources (e.g., frequency and transmit power).

8.4.1.1.2 Semantics of service primitive

MIS_Resource_Allocation.request (
DestinationIdentifier,
Resource_Config_List
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies PoS(PoA) to allocated radio resources.
Resource_Config_List	LIST(SEQUENCE(LINK_TUPLE_ID, FREQ_BAND_ID, TXPWR_ID))	Configuration information list for allocating radio resources (e.g., frequency and transmit power).

8.4.1.1.3 When generated

This primitive is invoked by MIS user when it needs to allocate radio resources (e.g., frequency and transmit power).

8.4.1.1.4 Effect on receipt

On receipt, the local MISF sends an MIS_Resource_Allocation request message to the destination MISF, or the local MISF sends a Link_Resource_Allocation.request primitive to the local link layer.

8.4.1.2 MIS_Resource_Allocation.indication

8.4.1.2.1 Function

This primitive is used by an MISF to notify an MIS user that an MIS_Resource_Allocation request message has been received.

8.4.1.2.2 Semantics of service primitive

MIS_Resource_Allocation.indication (
SourceIdentifier,
Resource_Config_List
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker of this primitive, which is a remote MISF.
Resource_Config_List	LIST(SEQUENCE(LINK_TUPLE_ID, FREQ_BAND_ID, TXPWR_ID))	Configuration information list for allocating radio resources (e.g., frequency and transmit power).

8.4.1.2.3 When generated

This primitive is generated by the remote MISF when an MIS_Resource_Allocation request message is received

8.4.1.2.4 Effect on receipt

The remote MIS user performs necessary actions to process the radio resource allocation request and respond with an MIS_Resource_Allocation.response.

8.4.1.3 MIS_Resource_Allocation.response

8.4.1.3.1 Function

This primitive is used by an MIS user to send the processing status of a received resource allocation request.

8.4.1.3.2 Semantics of service primitive

MIS_Resource_Allocation.response (
DestinationIdentifier,
Status
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies a remote MISF, which shall be the destination of this response.
Status	STATUS	Status of operation

8.4.1.3.3 When generated

This primitive is invoked by the MIS user to report back the result after completing the processing of a resource allocation request.

8.4.1.3.4 Effect on receipt

Upon receipt, the local MISF sends an MIS_Resource_Allocation response message to the destination MISF.

8.4.1.4 MIS_Resource_Allocation.confirm

8.4.1.4.1 Function

This primitive is used by the local MISF to convey the result of a resource allocation request to an MIS user.

8.4.1.4.2 Semantics of service primitive

```
MIS_Resource_Allocation.confirm (
                                SourceIdentifier,
                                Status
                                )
```

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker of this primitive, which is a remote MISF.
Status	STATUS	Status of operation

8.4.1.4.3 When generated

This primitive is used by an MISF to notify an MIS user the result of an MIS_Resource_Allocation.request.

8.4.1.4.4 Effect on receipt

Upon receipt, the MIS user determines the result of resource allocation request.

8.4.2 MIS_Resource_Report

8.4.2.1 MIS_Resource_Report.request

8.4.2.1.1 Function

MIS_Resource_Report.request indicates information on allocated radio resources of a PoS(PoA).

8.4.2.1.2 Semantics of service primitive

```
MIS_Resource_Report.request     (
                                DestinationIdentifier,
                                Resource_Info
                                )
```

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies the remote MISF to receive information on allocated radio resources.
Resource_Info	SEQUENCE(LINK_TUPLE_ID, FREQ_BAND_ID, TXPWR_ID)	Information on allocated radio resources (e.g., frequency and transmit power).

8.4.2.1.3 When generated

This primitive is invoked by an MIS user when it needs to report information on allocated radio resources.

8.4.2.1.4 Effect on receipt

On receipt, the local MISF sends an MIS_Resource_Report request message to the destination MISF.

8.4.2.2 MIS_Resource_Report.indication

8.4.2.2.1 Function

MIS_Resource_Report.indication is sent by the local MISF to a local MIS user to report information on radio resource allocation of PoS(PoA).

8.4.2.2.2 Semantics of service primitive

MIS_Resource_Report.indication (
SourceIdentifier,
Resource_Config
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker of this primitive, which is a remote MISF.
Resource_Info	SEQUENCE(LINK_TUPLE_ID, FREQ_BAND_ID, TXPWR_ID)	Information on allocated radio resources (e.g., frequency and transmit power).

8.4.2.2.3 When generated

This primitive is generated by the remote MISF when an MIS_Resource_Report request message is received

8.4.2.2.4 Effect on receipt

The remote MIS user performs necessary actions to process the resource report request and respond with an MIS_Resource_Report.response.

8.4.2.3 MIS_Resource_Report.response

8.4.2.3.1 Function

This primitive is used by an MIS user to send the processing status of received request.

8.4.2.3.2 Semantics of service primitive

MIS_Resource_Report.response (
DestinationIdentifier,
Status
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies a remote MISF, which shall be the destination of this response.
Status	STATUS	Status of operation

8.4.2.3.3 When generated

This primitive is invoked by the MIS user to report back the result after completing the processing of a report request.

8.4.2.3.4 Effect on receipt

Upon receipt, the local MISF sends an MIS_Resource_Report response message to the destination MISF.

8.4.2.4 MIS_Resource_Report.confirm

8.4.2.4.1 Function

This primitive is used by the local MISF to convey the result of a resource report request to an MIS user.

8.4.2.4.2 Semantics of service primitive

MIS_Resource_Report.confirm (
SourceIdentifier,
Status
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker of this primitive, which is a remote MISF.
Status	STATUS	Status of operation

8.4.2.4.3 When generated

This primitive is used by an MISF to notify an MIS user the result of an MIS_Resource_Report.request.

8.4.2.4.4 Effect on receipt

Upon receipt, the MIS user determines the result of resource report request.

8.4.3 MIS_Link_Preparation

8.4.3.1 MIS_Link_Preparation.request

8.4.3.1.1 Function

MIS_Link_Preparation.request is used for MIS user of PoS(PoA) or PoA controller to request MN to prepare connection with newly allocated radio resources.

8.4.3.1.2 Semantics of service primitive

MIS_Link_Preparation.request (
DestinationIdentifier,
Resource_Config_List
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies PoS(PoA) to allocated radio resources.
Resource_Config_List	LIST(SEQUENCE(LINK_TUPLE_ID, FREQ_BAND_ID, TXPWR_ID))	Configuration information list for allocating radio resources (e.g., frequency and transmit power).

8.4.3.1.3 When generated

This primitive is invoked by MIS user when it needs to request MN to prepare connection with newly allocated radio resources.

8.4.3.1.4 Effect on receipt

On receipt, the local MISF sends an MIS_Link_Preparation request message to the destination MISF.

8.4.3.2 MIS_Link_Preparation.indication

8.4.3.2.1 Function

This primitive is used by an MISF to notify an MIS user that an MIS_Link_Preparation request message has been received.

8.4.3.2.2 Semantics of service primitive

MIS_Link_Preparation.indication (
SourceIdentifier,
Resource_Config_List
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker of this primitive, which is a remote MISF.
Resource_Config_List	LIST(SEQUENCE(LINK_TUPLE_ID, FREQ_BAND_ID, TXPWR_ID))	Configuration information list for allocating radio resources (e.g., frequency and transmit power).

8.4.3.2.3 When generated

This primitive is generated by the remote MISF when an MIS_Link_Preparation request message is received.

8.4.3.2.4 Effect on receipt

The remote MIS user performs necessary actions to process the link preparation request and respond with an MIS_Link_Preparation.response.

8.4.3.3 MIS_Link_Preparation.response

8.4.3.3.1 Function

This primitive is used by an MIS user to send the processing status of a received request.

8.4.3.3.2 Semantics of service primitive

MIS_Link_Preperation.response (
DestinationIdentifier,
Status
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies a remote MISF, which shall be the destination of this response.
Status	STATUS	Status of operation

8.4.3.3.3 When generated

This primitive is invoked by the MIS user to report back the result after completing the processing of a link preparation request.

8.4.3.3.4 Effect on receipt

Upon receipt, the local MISF sends an MIS_Link_Preparation response message to the destination MISF.

8.4.3.4 MIS_Link_Preparation.confirm

8.4.3.4.1 Function

This primitive is used by the local MISF to convey the result of a link preparation request to an MIS user.

8.4.3.4.2 Semantics of service primitive

MIS_Link_Preparation.confirm (
SourceIdentifier,
Status
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker of this primitive, which is a remote MISF.
Status	STATUS	Status of operation.

8.4.3.4.3 When generated

This primitive is used by an MISF to notify an MIS user the result of an MIS_Link_Preparation request.

8.4.3.4.4 Effect on receipt

Upon receipt, the MIS user determines the result of link preparation request.

8.5 RRM service specific MIS protocol messages for command service

The following messages are specific to RRM use case and shall be used with others that are defined in IEEE Std 802.21-2017.

8.5.1 MIS_Resource_Allocation

8.5.1.1 MIS_Resource_Allocation request

The corresponding MIS primitive of this message is defined in 8.4.1.1. An MISF sends this message to request the allocation of radio resources.

MIS Header Fields (SID=3, Opcode=1, AID=17)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Resource_Config_List (Configuration information list for allocating radio resources TLV)

8.5.1.2 MIS_Resource_Allocation response

The corresponding MIS primitive of this message is defined in 8.4.1.3. This message returns the result of MIS_Resource_Allocation request.

MIS Header Fields (SID=3, Opcode=2, AID=17)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Status (Status TLV)

8.5.2 MIS_Resource_Report

8.5.2.1 MIS_Resource_Report request

The corresponding MIS primitive of this message is defined in 8.4.2.1. An MISF sends this message to report information on allocated radio resources of a PoS(PoA).

MIS Header Fields (SID=3, Opcode=1, AID=18)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Resource_Info (Information on allocated radio resources TLV)

8.5.2.2 MIS_Resource_Report response

The corresponding MIS primitive of this message is defined in 8.4.2.3. This message returns the result of MIS_Resource_Report request.

MIS Header Fields (SID=3, Opcode=2, AID=18)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Status (Status TLV)

8.5.3 MIS_Link_Preparation

8.5.3.1 MIS_Link_Preparation request

The corresponding MIS primitive of this message is defined in 8.4.3.1. An MISF sends this message to request MN to prepare connection with newly allocated radio resources.

MIS Header Fields (SID=3, Opcode=1, AID=19)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Resource_Config_List (Configuration information list for allocating radio resources TLV)

8.5.3.2 MIS_Link_Preparation response

The corresponding MIS primitive of this message is defined in 8.4.3.3. This message returns the result of MIS_Link_Preparation request.

MIS Header Fields (SID=3, Opcode=2, AID=19)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Status (Status TLV)

9. Media independent service for D2D communication

9.1 Introduction

Device-to-device (D2D) communication is a direct data communication between mobile nodes (MNs), and it has been recently attracted attention due to the proliferation of proximity-based services. Applications of D2D communications are, for example, social networking, advertisement, public safety, data sharing, and data offload.

For D2D communication, the media independent service (MIS) framework of IEEE Std 802.21-2017 is able to help an MN search for and connect to its peer. The MIS framework of IEEE Std 802.21-2017 is a platform to support interworking between networks using IEEE 802 and non-IEEE 802 technologies. This MIS framework can be easily extended to support D2D communications and interworking with other standards such as IEEE 802.15.8™ peer aware communication (PAC), Wi-Fi Direct, and 3GPP proximity service (ProSe) (see 3GPP TR 23.703 [B8], TS 23.303 [B3]). To interwork with 3GPP operator's networks and Wi-Fi service provider's networks, network assistance from these operators is required.

The MIS framework can be applied to D2D communication with or without assistance of network entities such as a base station or an access point. For D2D communication with network assistance, network entities with an MIS framework provide configuration information for an MN to discover its peer and control D2D connections of MNs. For D2D communication without network assistance, MNs with an MIS framework are capable of finding and selecting the most appropriate D2D technology that can offer the best quality of service (QoS) or quality of experience (QoE).

This clause introduces discovery and connection for D2D communication based on MIS, and includes methods and signaling for supporting discovery and connection for D2D communication based on MIS.

9.2 Service scenarios and signaling flows

9.2.1 D2D communication with network assistance

Communication service providers and network operators have interest in D2D communication because D2D communication provides communication between MNs in close proximity with a small amount of network resource. By using D2D communication, MNs in close proximity share data such as video clips or local information. Service providers of D2D communication are able to distribute local advertisement information or emergency information such as location of emergency shelters. Network operators save network resources by offloading data to D2D communication. For making a connection for D2D communication, it is difficult for an MN to discover its peer that is able to offer communication services (e.g., data sharing, local advertisement and emergency information) that the MN wants to receive.

Communication service providers and network operators help an MN to search for and connect to its peer by assistance of network infrastructures. The D2D communication with network assistance is called *network-assisted D2D communication* (NADC).

MIS framework as defined in IEEE Std 802.21-2017 provides network configuration information for MN and controls MN's connection to access network by using a point of service (PoS) and an Information Server. With minor modification of Information Server and PoS, MIS framework is capable of serving as the control plane for NADC.

9.2.1.1 Service flows

a) Service flows of MN-initiated D2D communication

   1) MN requests information to connect with its peer to Information Server.

   2) Information Server responds to the MN with configuration information to connect with a candidate peer of the MN. The configuration information is, for example, D2D communication technology such as Wi-Fi Direct and PAC, identifier (e.g., MAC address and IP address) of the candidate peer, and frequency information.

   3) Based on configuration information from Information Server, the MN searches for and connects to its peer node.

b) Service flows of NADC PoS-initiated D2D communication

   1) NADC PoS that controls and manages D2D communications of MNs requests information for a peer node of MN to Information Server.

   2) Information Server responds to the MN with configuration information to connect with a candidate peer of the MN. The configuration information are, for example, D2D communication technology such as Wi-Fi Direct and PAC, identifier (e.g., MAC address and IP address) of the candidate peer, and frequency information.

   3) The NADC PoS sends the configuration information of a candidate peer to the MN.

   4) The MN decides whether to use D2D communication. If the MN decides to use D2D communication, the MN tries to search for and connect to its peer node by using the configuration information from NADC PoS.

9.2.1.2 Signaling architecture

Figure 41 shows control signaling for NADC by using MIS messages. Information Server provides configuration information for an MN's peer. The configuration information of Information Server is requested by MNs and PoS. PoS controls MNs' connection of D2D communication by requesting MN to select D2D communication and assigning radio resources for D2D communication. NADC provider operates its own PoS, and NADC PoS communicates with other PoSs. MN and its peer, NADC PoS, and Information Server are equipped with MIS function (MISF) and the following assumptions apply to Figure 41:

a) MN's peer provides communication service that the MN wants to receive.

b) MN and its peer communicate by using the same D2D communication technology.

c) Information Server knows proximity between MNs.

d) Information Server derives proximity between MNs by using MNs' location information (e.g., GPS information).

e) Information Server knows communication services (e.g., local information service, file transmission, and voice call) that MNs provide.

f) Information Server knows D2D communication technologies that MNs uses.

g) NADC PoS controls MNs' D2D connection and control MNs' radio resource for D2D communication.

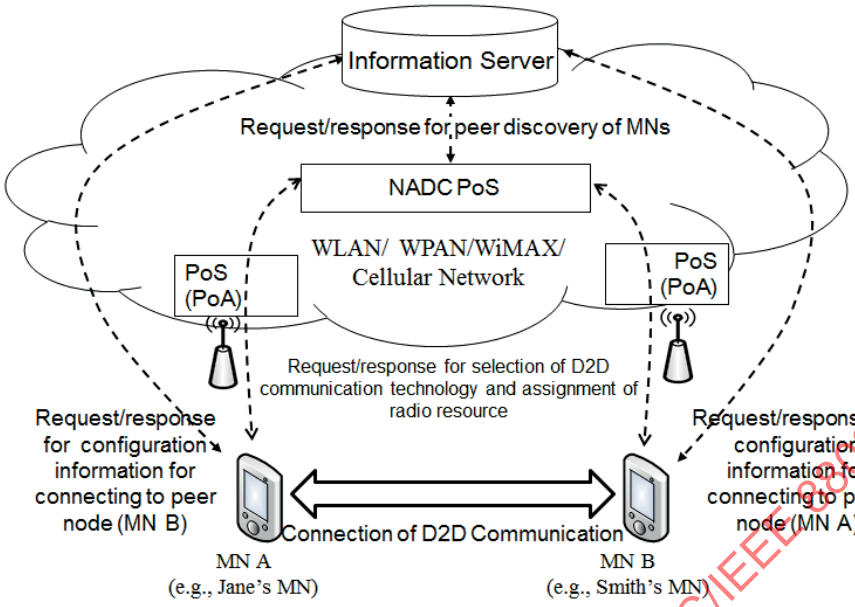


Figure 41—Control signaling of NADC

9.2.1.3 Stages for NADC based on MIS Framework

NADC based on MIS framework comprises three stages as in Figure 42.

1. In the first stage, D2D devices register to Information Server with their configuration information for D2D communications. The configuration information, for example, is D2D technology types such as Wi-Fi Direct and 3GPP ProSe.
2. In the second stage, NADC PoS discovers pairs for D2D communications.
3. In the third stage, NADC PoS orders D2D devices to make D2D communications.

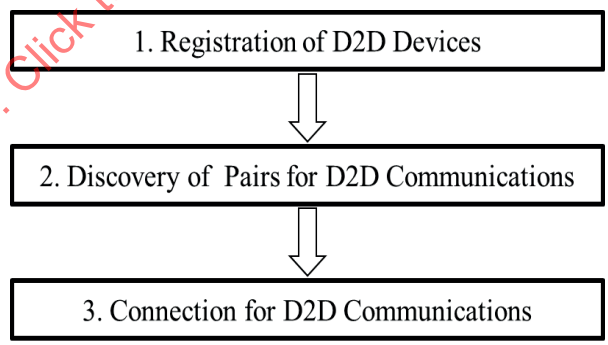


Figure 42—Stages for NADC based on MIS framework

9.2.1.4 Signaling flows and primitives/messages

9.2.1.4.1 Stage 1: Registration of D2D devices

Information Server collects configuration information, which includes list of D2D communication technologies used by MN, for MNs' registrations to Information Server. Signaling flows shown in Figure 43 are as follows:

1. MN's MIS user sends MIS_Register.request primitive to MN's MISF.
2. MN's MISF requests registration to Information Server by sending MIS_Register request message with its configuration information including its available D2D communication technologies (i.e., D2D_Techlist).
3. Information Server's MISF sends MIS_Register.indication primitive to MIS user for registering MN as a D2D device.
4. After Information Server's MIS user registers the MN as a D2D device, the Information Server's MIS user sends MIS_Register.response to Information Server's MISF for responding the registration request.
5. Information Server's MISF responds with MIS_Register response message.
6. MN's MISF reports that the MN is registered to Information Server as a D2D device by sending MIS_Register.confirm primitive to MN's MIS user.

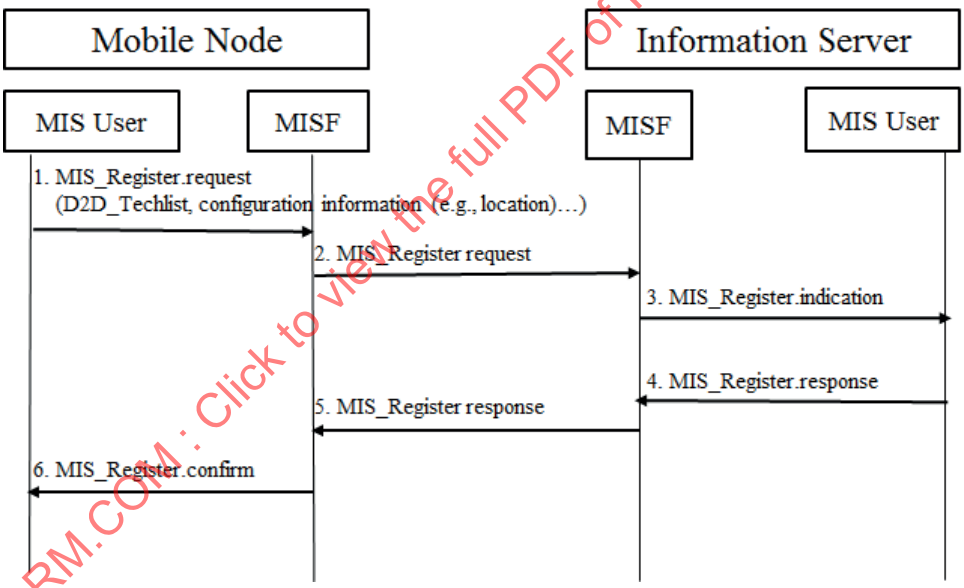


Figure 43—Registration of D2D devices with list of D2D technologies

The primitives used for registration of D2D devices are described in Table 23.

Table 23—MIS_SAP primitives for registration of D2D devices

Primitives	Service category	Description	Defined in
MIS_Register	Service management	Register the local MISF with a remote MISF	7.4.2 of IEEE Std 802.21-2017

The following parameters specific for D2D registration need to be added to MIS_Register primitive defined in 7.4.2 of IEEE Std 802.21-2017:

Parameter	Data type	Description
D2D_Techlist	LIST(D2D_TECH)	List of available D2D technologies that is used by an MN.
Config_Info	LIST(LOCATION, FREQ_ID)	Configuration information for making a D2D connection that includes location information and network connection information (e.g., radio frequency and network identification) of communication devices.

9.2.1.4.2 Stage 2: Discovery of pairs for D2D communications

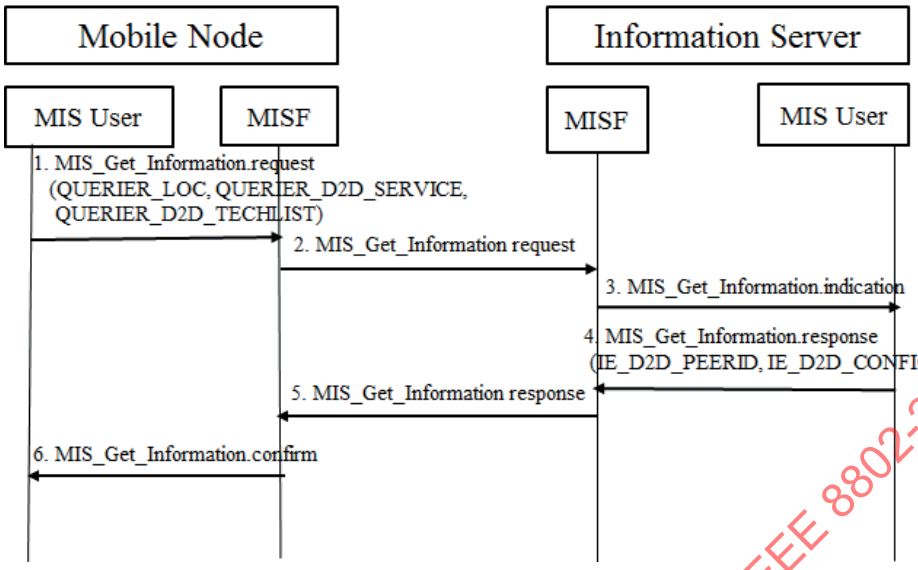
Information Server provides configuration information that helps MN to discover its peer. Signaling flows shown in part (a) and part (b) of Figure 44 are as follows.

Part (a) MN-initiated D2D communication

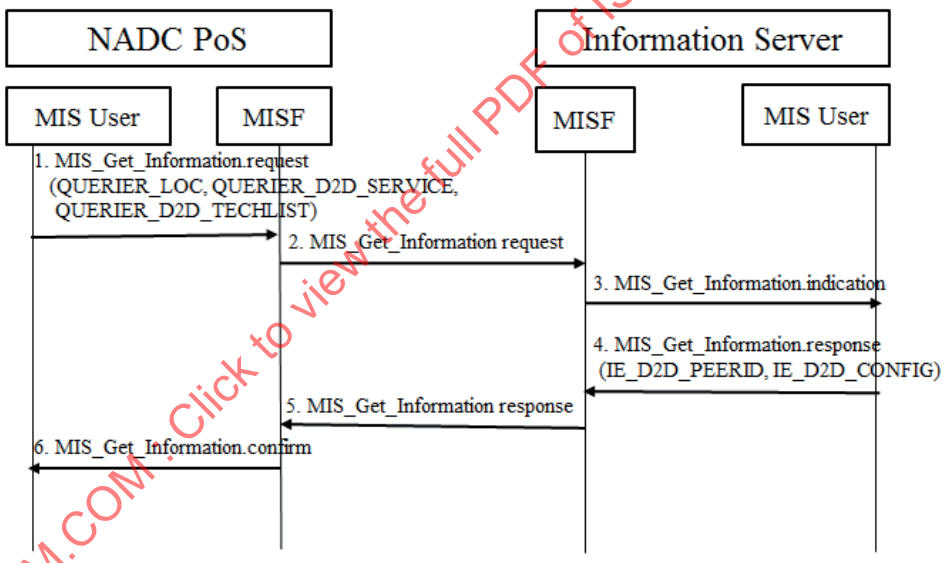
1. MN's MIS user sends MIS_Get_Information.request primitive to MN's MISF with its location (QUERIER_LOC), communication service (QUERIER_D2D_SERVICE), and available D2D service communication (QUERIE_D2D_TECHLIST) and requests information of candidate peer for D2D communication.
2. MN informs Information Server by sending MIS_Get_Information request message.
3. Information Server's MISF sends MIS_Get_Information.indication to Information Server's MIS user to request configuration information.
4. Information Server's MIS user responds for the configuration information request by sending MIS_Get_Infromation.response primitive.
5. Information Server's MISF sends MIS_Get_Information response message with the peer's identity (IE_D2D_PEERID) and configuration information (IE_D2D_CONFIG) to discover the peer.
6. MN's MISF sends MIS_Get_Information.confirm to MN's MIS user.

Part (b) NADC PoS-initiated D2D communication

1. NADC PoS's MIS user sends MIS_Get_Information.request primitive to NADC PoS's MISF with its location (QUERIER_LOC), communication service (QUERIER_D2D_SERVICE), and available D2D service communication (QUERIE_D2D_TECHLIST) and requests information of candidate peer for D2D communication.
2. NADC PoS informs Information Server by sending MIS_Get_Information request message.
3. Information Server's MISF sends MIS_Get_Information.indication to Information Server's MIS user to request configuration information.
4. Information Server's MIS user responds for configuration information request by sending MIS_Get_Infromation.response primitive.
5. Information Server sends MIS_Get_Information response message with the peer's identity (IE_D2D_PEERID) and configuration information (IE_D2D_CONFIG) to discover the peer.
6. NADC PoS's MISF sends MIS_Get_Information.confirm to NADC PoS's MIS user.



(a) MN-initiated D2D communication



(b) NADC PoS-initiated D2D communication

Figure 44—Discovery of D2D devices with list of D2D technologies

The primitives/messages used in Figure 44 are described in Table 24.

Table 24—MIS_SAP primitives for requesting configuration information

Primitives/Messages	Service category	Description	Defined in
MIS_Get_Information	Information	Request to get information from repository	7.4.15 of IEEE Std 802.21-2017

Use case specific parameters:

QUERIER_LOC parameter of MIS_Get_Information primitive/message is defined in Table E.15 of IEEE Std 802.21-2017, and D2D specific parameters (QUERIER_D2D_SERVICE, QUERIER_D2D_TECHLIST) are defined in Table E.6 of Annex E.

Use case specific information elements:

D2D specific information elements are defined as follows. The IE identifier values for these information elements are listed in Table F.1.

Data type name	Derived from	Definition
IE_D2D_PEERID	D2D_PEERID	Peer's identity [e.g., MAC address, IP address, and IMSI (International Mobile Subscriber Identity)]
IE_D2D_CONFIG	D2D_CONFIG	Configuration information(e.g., frequency band) to help the MN configure its peer

9.2.1.4.3 Stage 3: Connection for D2D communications

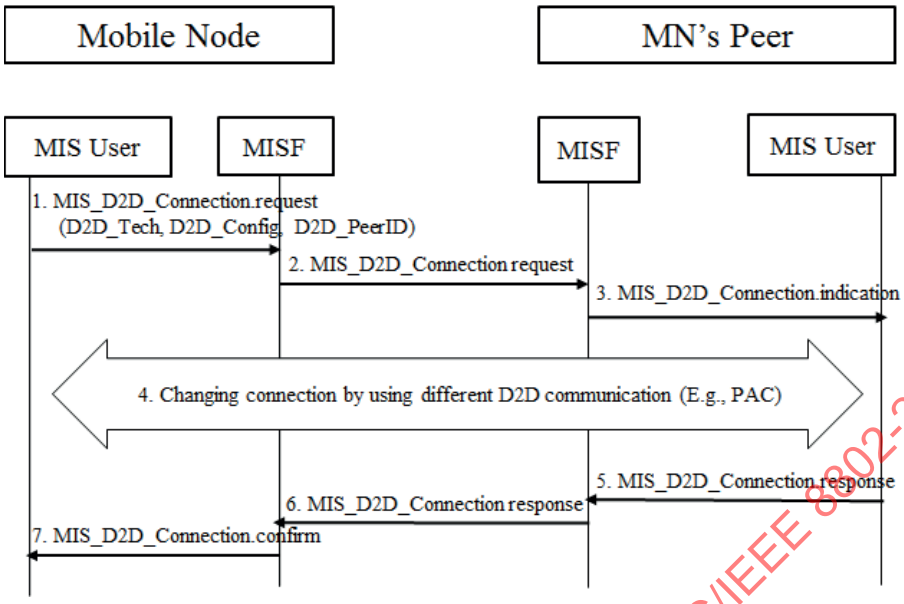
MN or PoS can initiate a change in communication technology of MN's D2D connection. For example, MN or PoS initiates a change of MN's D2D connection from Wi-Fi Direct to IEEE 802.15.8 PAC. Signaling flows shown in part (a) and part (b) of Figure 45 are as follows:

Part (a) MN-initiated D2D communication

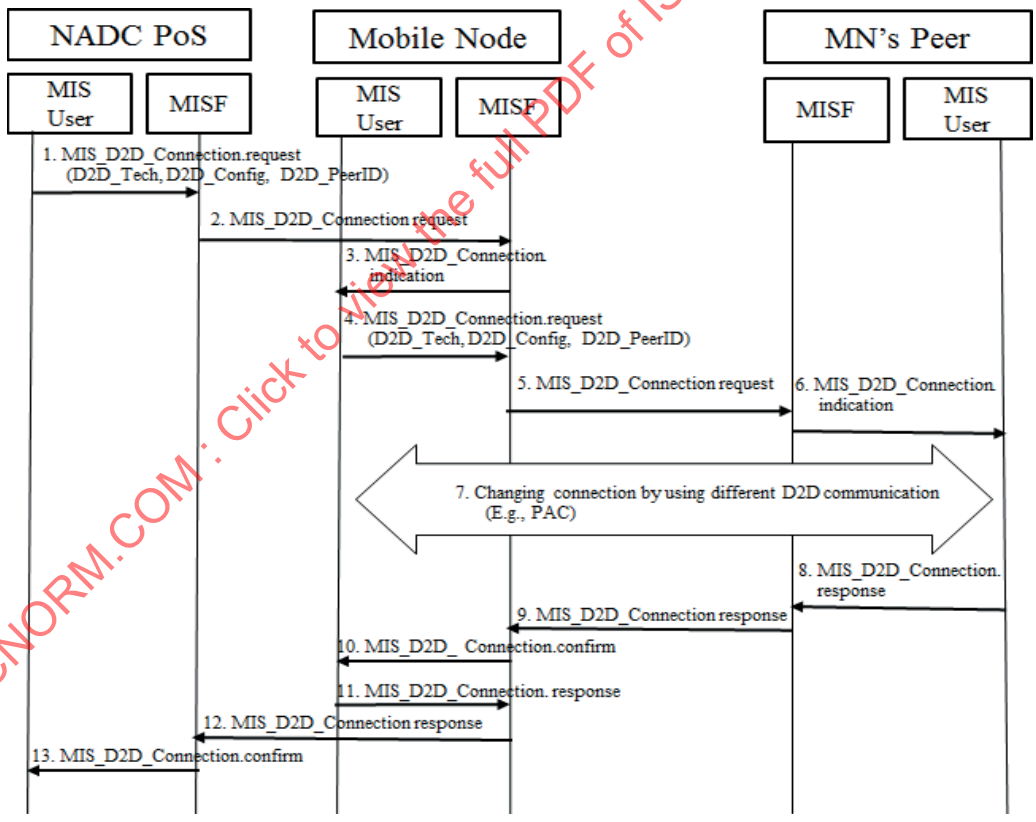
1. MN requests its peer to change its D2D communication into other D2D communication technology (e.g., PAC) by sending MIS_D2D_Connection request message. (Step 1~Step 3)
2. Changing D2D connection between MN and its peer by using other D2D communication (e.g., PAC): Out of Scope (Step 4)
3. MN's peer responds to MN with connection result (success or fail) by sending MIS_D2D_Connection response message. (Step 5~Step 7)

Part (b) NADC PoS-initiated D2D communication

1. NADC PoS requests MN to change its D2D communication technology into other D2D communication technology (e.g., PAC) by sending MIS_D2D_Connection request message. (Step 1~Step 3)
2. MN requests its peer to change their D2D communication into other D2D communication technology (e.g., PAC) by sending MIS_D2D_Connection request message. (Step 4~Step 6)
3. Changing D2D connection between MN and its peer by using other D2D communication (e.g., PAC): Out of Scope (Step 7)
4. MN's peer responds to MN with connection result (success or fail) by sending MIS_D2D_Connection response message. (Step 8~Step 10)
5. MN responds to NADC PoS with connection result (success or fail) by sending MIS_D2D_Connection response message. (Step 11~Step 13)



(a) MN-initiated D2D communication



(b) NADC PoS-initiated D2D communication

Figure 45—Connection for D2D communications

D2D specific primitives/messages used in Figure 45 are described in Table 25.

Table 25—MIS_SAP primitives for making D2D connection

Primitives/Messages	Service category	Description	Defined in
MIS_D2D_Connection	Command	This primitive/message is used for an MN and its peer to make a connection of D2D communication technology.	9.3.2

Use case specific parameters:

D2D specific parameters of MIS_D2D_Connection are defined as follows.

Parameter	Description
D2D_Tech	Information of D2D communication technologies that MN or its peer uses
D2D_Config	Configuration information (e.g., frequency band) to help the MN configure its peer
D2D_PeerID	Peer's identity (e.g., MAC address, IP address, and IMSI)

9.2.2 D2D communication without network assistance

Various technologies for D2D communication have been developed recently. Smart devices such as smart phones and tablet PCs already implement Wi-Fi Direct. Future smart devices may implement developing technologies of D2D communication technologies such as 3GPP ProSe and PAC. For future smart devices, it is important for the smart devices to select the most appropriate technology of D2D communication that supports the best QoS or QoE.

By using D2D communication, smart MNs in close proximity directly share data such as video clips or local information without network assistance. D2D communication serves local advertisement information or emergency information such as location of emergency shelters.

The MIS framework supports MNs to select appropriate technology of D2D communication without any network assistance. Existing MIS framework enables MNs to monitor link status, which is status (e.g., signal strength and data rate) of physical layer and data link layer by using media independent event service (MIES) and selects the most appropriate access network by using media independent control service (MICS) even without network assistance. Therefore, if MIES and MICS are extended for supporting D2D communication, it is possible for MNs to monitor link status of D2D communications and select the most appropriate technology of D2D communication without network assistance.

9.2.2.1 D2D service flows example

Jane is a user of an MN that supports D2D communication. Smith is a user of a peer node of Jane's MN.

a) Jane's MN and Smith's MN transfer data through D2D communication "P" (e.g., Wi-Fi Direct).

b) Jane's MN detects that link status (e.g., signal strength and data rate) of D2D communication "P" is getting worse due to some reason such as radio interference.

c) Jane's MN discovers the most appropriate D2D communication "Q" (e.g., PAC) that is different from D2D communication "P" by monitoring link status of "Q."

d) Jane's MN requests Smith's MN to change D2D communication "P" into D2D communication "Q."

e) Jane's MN and Smith's MN make a connection by using D2D communication "Q."

f) Jane's MN and Smith's MN transfer data through D2D communication "Q."

9.2.2.2 Signaling architecture

Figure 46 shows control signaling for D2D communication without network assistance. The service flows are explained specifically in 9.2.2.1. The following assumptions apply to Figure 46:

a) MN's peer provides communication service that the MN wants to be served.

b) MN and its peer should communicate by using the same D2D service communication technology.

c) MN monitors link status of D2D communication.

d) MN and its peer change their D2D communication technology without any network assistance.

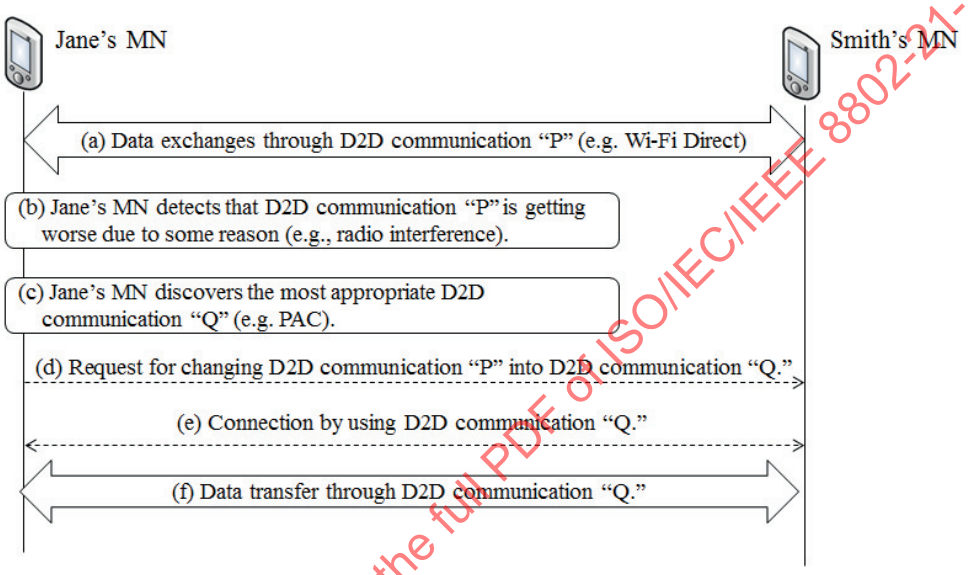


Figure 46—Control signaling of D2D communication without network assistance

9.2.2.3 Stages for D2D communication without network assistance

D2D communication without network assistance comprises the following two stages as in Figure 47:

1. In the first stage, MN discovers pairs for D2D communications.
2. In the second stage, MN orders D2D devices to make D2D communications.

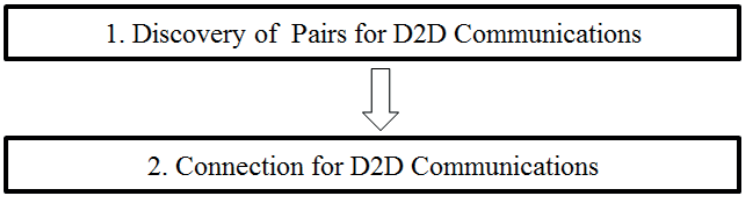


Figure 47—Stages for D2D communication without network assistance

9.2.2.4 Signaling flows and primitives/messages

9.2.2.4.1 Changing connection of D2D communication

MN changes communication technology of its D2D connection depending on its link status. For example, MN changes Wi-Fi Direct of MN's D2D connection into IEEE 802.15.8 PAC depending on its link status. Signaling flows shown in Figure 48 are as follows:

1. Connection between MN and its peer by using D2D communication (e.g., Wi-Fi Direct): Out of Scope (Step 0)
2. MN monitors its link status of current D2D communication technology and determines to change the D2D communication technology into other D2D communication technology. (Step 1)
3. MN requests its peer to change their D2D communication into different D2D communication technology (e.g., PAC) by sending MIS_D2D_Connection request message. (Step 2~Step 4)
4. Changing connection between MN and its peer by using other D2D communication technology (e.g., PAC): Out of Scope (Step 5)
5. MN's peer responds to MN with connection result (success or fail) by sending MIS_D2D_Connection response message. (Step 6~Step 8)

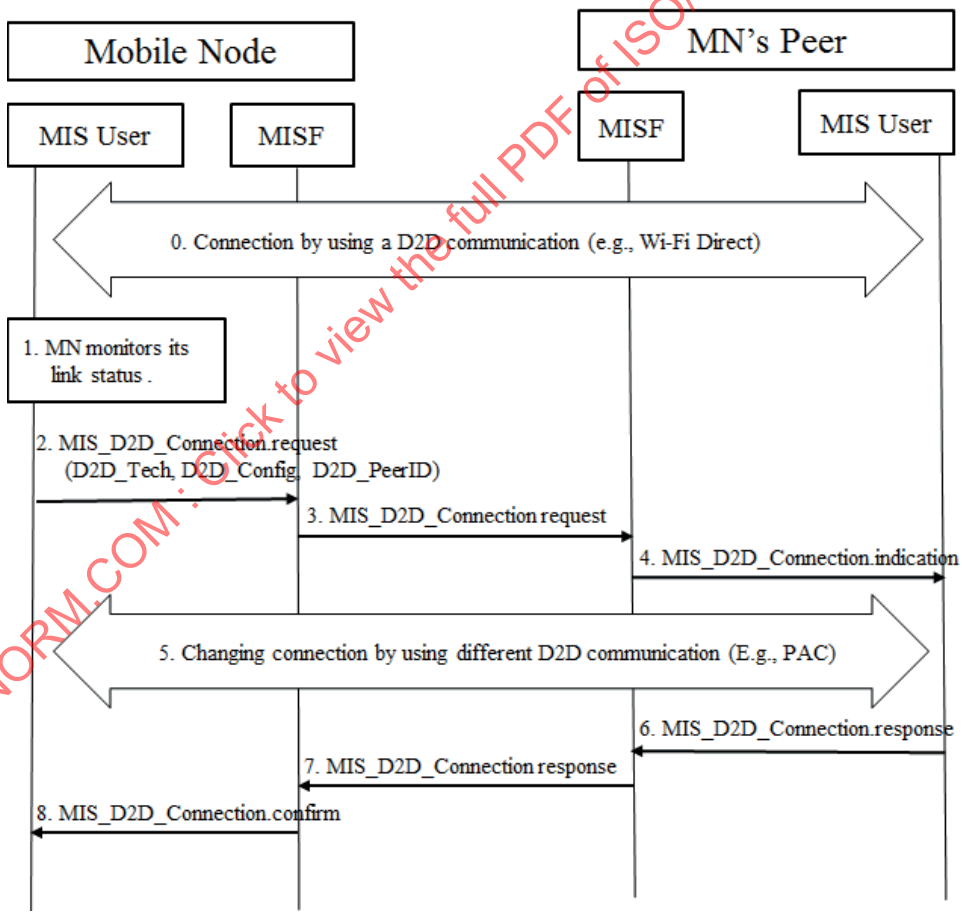


Figure 48—Changing connection of D2D communication

Use case specific primitive/message:

MIS_D2D_Connection primitive/message is explained in 9.2.1.4.3.

Use case specific parameters:

D2D_Tech, D2D_Config, and D2D_PeerID are explained in 9.2.1.4.3.

9.3 D2D service specific MIS_SAP primitives

The following primitives are specific to the D2D use case and shall be used with others that are defined in IEEE Std 802.21-2017.

9.3.1 MIS_Register

MIS_Register is used by MN for registration with the Information Server. This is communicated over a MIS_Register request message that contains the configuration information and its available D2D communication technologies. This primitive is defined in 7.4.2 of IEEE Std 802.21-2017. The following additional parameters are needed while using this primitive for D2D registration:

Use case specific parameters:

Name	Data type	Description
D2D_Techlist	LIST(D2D_TECH)	List of available D2D technologies
Config_Info	LIST(LOCATION, FREQ_ID)	Configuration information for making a D2D connection

D2D_Techlist and Config_Info parameters need to be added to MIS_Register.request and MIS_Register.indication that are specified in 7.4.2 of IEEE Std 802.21-2017.

9.3.2 MIS_D2D_Connection

9.3.2.1 MIS_D2D_Connection.request

9.3.2.1.1 Function

MIS_D2D_Connection is used for an MIS user to request an MISF make a D2D connection with its configuration information including its available D2D communication technologies.

9.3.2.1.2 Semantics of service primitive

MIS_D2D_Connection.request (
D2D_PeerID,
D2D_Tech,
D2D_Config
)

Parameters:

Name	Data type	Description
D2D_PeerID	MISF_ID	This identifies a peer for D2D communication.
D2D_Tech	LIST(D2D_TECH)	Technology for D2D communication
D2D_Config	LIST(FREQ_ID)	Configuration information for making a D2D connection

9.3.2.1.3 When generated

This primitive is invoked by MIS user when it needs to connect to its peer before making a D2D connection.

9.3.2.1.4 Effect on receipt

On receipt, the local MISF sends an MIS_D2D_Connection request message to the destination MISF.

9.3.2.2 MIS_D2D_Connection.indication

9.3.2.2.1 Function

This primitive is used by an MISF to notify an MIS user that an MIS_D2D_Connection request message has been received.

9.3.2.2.2 Semantics of service primitive

```
MIS_D2D_Connection.indication   (
                                SourceIdentifier,
                                D2D_Tech,
                                D2D_Config
                                )
```

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker of this primitive, which is a remote MISF.
D2D_Tech	LIST(D2D_TECH)	Technology for D2D communication.
D2D_Config	LIST(FREQ_ID)	Configuration information for making a D2D connection.

9.3.2.2.3 When generated

This primitive is generated by the remote MISF when an MIS_D2D_Connection request message is received

9.3.2.2.4 Effect on receipt

The remote MIS user performs the necessary actions to process the connection request and respond with an MIS_D2D_Connection.response.

9.3.2.3 MIS_D2D_Connection.response

9.3.2.3.1 Function

This primitive is used by an MIS user to send the processing status of a received connection request.

9.3.2.3.2 Semantics of service primitive

MIS_D2D_Connection.response (
DestinationIdentifier,
Status
)

Parameters:

Name	Data type	Description
DestinationIdentifier	MISF_ID	This identifies a remote MISF, which shall be the destination of this response.
Status	STATUS	Status of operation.

9.3.2.3.3 When generated

This primitive is invoked by the MIS user to report back the result after completing the processing of a connection request.

9.3.2.3.4 Effect on receipt

Upon receipt, the local MISF sends an MIS_D2D_Connection response message to the destination MISF.

9.3.2.4 MIS_D2D_Connection.confirm

9.3.2.4.1 Function

This primitive is used by the local MISF to convey the result of a connection request to an MIS user.

9.3.2.4.2 Semantics of service primitive

MIS_D2D_Registration.confirm (
SourceIdentifier,
Status
)

Parameters:

Name	Data type	Description
SourceIdentifier	MISF_ID	This identifies the invoker of this primitive, which is a remote MISF.
Status	STATUS	Status of operation.

9.3.2.4.3 When generated

This primitive is used by an MISF to notify an MIS user the result of an MIS_D2D_connection request.

9.3.2.4.4 Effect on receipt

Upon receipt, the MIS user determines the result of the connection request.

9.4 D2D service specific MIS protocol messages

The following messages are specific to D2D use case and shall be used with others that are defined in IEEE Std 802.21-2017.

9.4.1 MIS_Register

9.4.1.1 MIS_Register request

The corresponding MIS primitive of this message is defined in 9.3.1. The MN's MISF sends this message to the MISF of Information Server to request registration with its configuration information including its available D2D communication technologies. D2D_Techlist and Config_Info TLVs need to be added to MIS_Register request message that is specified in 8.6.1.3 of IEEE Std 802.21-2017.

Use case specific TLVs

D2D_Techlist (D2D technology list for D2D registration TLV)
Config_Info (Configuration information for D2D registration TLV)

9.4.1.2 MIS_Register response

The corresponding MIS primitive of this message is defined in 9.3.1. This message specified in 8.6.1.4 of IEEE Std 802.21-2017 returns the result of MIS_Register request.

9.4.2 MIS_D2D_Connection

9.4.2.1 MIS_D2D_Connection request

The corresponding MIS primitive of this message is defined in 9.3.2.1. An MISF sends this message to request the establishment of a D2D connection with its configuration information including its available D2D communication technologies.

MIS Header Fields (SID=3, Opcode=1, AID=20)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
D2D_PeerID (MSIF ID TLV)
D2D_Tech (D2D technology for D2D connection TLV)
D2D_Config (Configuration information for D2D connection TLV)

9.4.2.2 MIS_D2D_Connection response

The corresponding MIS primitive of this message is defined in 9.3.2.3. This message returns the result of MIS_D2D_Connection request.

MIS Header Fields (SID=3, Opcode=2, AID=20)
Source Identifier = sending MISF ID (Source MISF ID TLV)
Destination Identifier = receiving MISF ID (Destination MISF ID TLV)
Status (Status TLV)

Annex A

(informative)

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Annex B

(informative)

Handover procedures

This annex supplements Clause 5.

B.1 Mobile-initiated handover procedure

The mobile-initiated handover procedure operates as follows (see Figure B.1):

1) The MN is connected to the serving network via the current PoS and it has access to the MIS Information Server.
2) The MN queries information about neighboring networks by sending an MIS_Get_Information request message to the Information Server. The Information Server responds with an MIS_Get_Information response message. This information is attempted as soon as the MN is first attached to the network.
3) The MN triggers a mobile-initiated handover by sending an MIS_MN_HO_Candidate_Query request message to the Serving PoS. This request contains the information of potential candidate networks.
4) The Serving PoS queries the availability of resources at the candidate networks by sending an MIS_N2N_HO_Query_Resources request message to one or multiple Candidate PoSs.
5) The Candidate PoSs respond with an MIS_N2N_HO_Query_Resources response message and the Serving PoS notifies the MN of the resulting resource availability at the candidate networks through an MIS_MN_HO_Candidate_Query response message.
6) The MN decides on the target of the handover and notifies the Serving PoS of the decided target network information by sending the MIS_MN_HO_Commit request message. Also, the MN commits a link switch to the target network interface by invoking the MIS_Link_Actions request primitive.
7) The Serving PoS sends the MIS_N2N_HO_Commit request message to the TPoS to request resource preparation at the target network. The TPoS responds with the result of the resource preparation by an MIS_N2N_HO_Commit response message.
8) The new layer 2 connection is established and certain mobility management protocol procedures are carried out between the MN and the target network.
9) The MN sends an MIS_MN_HO_Complete request message to the TPoS. The TPoS sends an MIS_N2N_HO_Complete request message to the previous Serving PoS to release resource, which was allocated to the MN. After identifying that the resource is successfully released, the TPoS sends an MIS_MN_HO_Complete response message to the MN.