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| Title | **Proposed Text of “Media Independent Handover Service for Software-defined fronthaul radio access network (SDFN)” Section for IEEE 802.21.1 Draft Standard** |
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| Re: | IEEE 802.21 Session #68 in Vancouver, Canada |
| Abstract | According to the discussion during the meeting, this document proposes the revised text of “**Media Independent Service for** Software-defined fronthaul radio access network (SDFN)” Section for IEEE 802.21.1 Draft Standard. This document describes detailed use case and requirements on media independent service such as seamless handover and radio resource management in software-defined fronthaul radio access networks (SDFNs), based on our contributions “Software-defined mobile network service” (DCN 21-15-0022-00-SAUC) presented in the March 2015 IEEE 802 Plenary meeting as well as “Use cases of MIS framework to cooperate with SDN wireless access networks” (DCN 21-14-0157-01-SAUC) presented in the Nov. 2014 IEEE 802 Plenary meeting. |
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**Table of Contents**

[5.7 Media independent service for software-defined fronthaul radio access network (SDFN) 3](#_Toc402520501)

[5.7.1 Introduction 3](#_Toc402520502)

[5.7.2 Service scenarios and call flows 4](#_Toc402520503)

[5.7.3 Service Access Point (SAP) and Primitives 15](#_Toc402520515)

[5.7.4 MIS protocol message types 29](#_Toc402520516)

1. 1. Media Independent Service for Software-defined fronthaul radio access networks (SDFNs)
      1. Introduction

In recent days, Software-defined networking (SDN)-like paradigm has been interested in wireless fronthaul radio access networks (RANs). The SDN approach, characterized by a clear separation of the control and data planes, allows that operators can quicker provisioning and configuration of network connections without requiring independently accessing and configuring each of the network’s hardware devices. RAN can be divided into two parts: one is the fronthaul and the other is backhaul. The fronthaul is the connection between a new network architecture of centralized baseband controllers and remote standalone radio heads at cell sites. (See LTE Base Station Challengers.) The backhaul is is similar concept to fronthaul, which, at its simplest, links the mobile network back to the wired network.

Software-defined Fronthaul radio access network (SDFN) is the RANs (including fronthaul) to the design of SDN-like approach, where the centralized controller enables radio resource configuration and management in heterogeneous RAN environment. This trend also introduces new challenges in seamless mobility because RANs require the shared nature of radio spectrum for mobile users.

RANs differ from mobile core networks in that they mostly deal with L1/L2 functions, specifically radio resource management (RRM) at L1/L2, specifically radio-specific functions such as interference, cell ID, neighbor lists, and handover threshold. The SDFN, RRM separating from the backhaul functions, enables the seamless handover service to evolve independently. The SDFN paradigm also improves adaptability to the diversity of scenarios that will arise from the deployment of a controller in small-cell or multi-radio access technologies. In the RANs, the SDFN alleviates seamless mobility by leaving the non-latency-sensitive functions in a SDN controller and the latency-sensitive decisions by leaving the RRM functionality.

In this Section, we analyze the potential of applying the Media independent services (MIS) framework to SDFN. First, we identify use cases for seamless handover where a MIS approach could bring additional benefits in SDFNs. Then, we drive the main characteristics of a radio resource management framework to support seamless handover in SDFNs. In the framework, we are paying attention to the MIS functions and interfaces. In order to illustrate the operation of the framework, we introduce the high-level interactions required between the defined functions to support our use cases.

MIS framework of IEEE 802.21-2009 standard has been a common platform to support mobility management in heterogeneous networks. MIS framework can support seamless handover in heterogeneous RAN networks by using MIES (Media Independent Event Service), MICS (Media Independent Command Service), and MIIS (Media Independent Information Service). MIES primitives and messages help MN (Mobile Node) 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. The objective of MIIS is to gain knowledge about all heterogeneous networks in the area of interest of the terminal to facilitate handovers when roaming across these networks.

It is possible to expect that MIS Framework enables MN to monitor link, allocate resource, and enables seamless handover of MNs in SDFNs. The SDFN can be characterized by a clear separation of the MIS control and SDN control planes. The SDFN is the simplest solution for future wireless radio access networks integration where various applications connected through SDN networks conserve their independence. The major inconvenience of this approach is the long handover delay.

MIS primitives and messages can be used to transfer network configuration information for handover and mobility management via clear separated SDN control plane in SDFNs, and they can be used to provide seamless radio resource configuration for seamless handover in SDFNs while MN moving. Thus, MIS framework is appropriate for handover resource allocation and mobility management in SDFNs that use various heterogeneous switching by a clearly separation of the SDN control and data plane.

In SDFN, MIS framework requires important modifications to the handover management protocols, the interfaces and the services of the access networks to provide good handover performance.

* + 1. Service scenarios and call flows
       1. Media Independent Service framework architecture

Our goal is to identify use cases for seamless handover in SDFNs, where a MIS approach could bring additional benefits of the radio resource management of the RANs separating from the SDN controller. In SDFN, handover can occur 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 media independent service (MIS) provides a framework and corresponding mechanisms by which an MISF entity can discover and obtain network information existing within SDFN to facilitate the handovers. Then, we drive the main characteristics of a MIS framework for SDFNs. The proposed 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. Fig. 2 presents the reference model of the MIS framework for SDFN, which includes the following network entities:

* Mobile Node (MN): This is a user device, such as a smart phone, which equips radio interfaces of multiple radio access technologies. MN exchanges message with more than one network entity. A set of handover-enabling functions within the protocol stacks of the network elements is called the MIS Function (MISF).
* MIS Point of Service (MIS PoS): This is an MIS network entity that exchanges MIS messages with the Mobile node.
* MIS Point of Attachment (PoA): This is the endpoint of a L2 link as it may exchange message with the Mobile Node. Traditionally, PoA has been treated as a base station in radio access network, base station in cellular networks, and access point in WLAN, that making independent control plane decisions on the radio layer. MISF in PoA establishes link connection with the MN. It is responsible for medium access control that is expressed in terms of management information including the operating channel or the transmission power, the beacon interval or the contention parameters used by the medium access control.
* PoA Controller (MIS PoS): This is an MIS PoS that can manage handover control and resource control of PoAs. PoA controller enables handover, cell association, and resource allocation at each PoA in concert with its neighbors to minimize the handover delay and maximize the network utilization. It 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, in a way that is related to the controlling flow of new incoming MN.
* SDN Controller: A network entity that can manage resources of access switches. It is responsible for data forwarding where traffic is sent to, from the underlying PoA that forwards traffic to the selected destination, in a way that is related to the controlling flow.
* Information Server: A server that manages mobility information of MNs on PoA. This server has a real-time view of the MN and is capable of the access control and resource allocations of MNs in a media-independent way.

For handover execution phase, the crucial problem is the dependence on the media as well as the infrastructure network. For that reason, we designed a MIS framework for the handover execution phase to overcome the major issue of these dependencies in the SDFN. In the SDFN, radio access networks (RANs) have the capability to operate in 3GPP LTE, WiMAX and Wi-Fi interfaces, and are equipped with MISF supporting handover management protocol like depicted in Fig. 1. PoA Controller (PoS) will centralize the MIS Functions of RANs. The PoA Controller (PoS) maintains service continuity, service adaptation to varying quality of service, battery life conservation, network discovery, and link selection. MIS users use MIS services such as a handover management and radio resource management via the PoA Controller. The PoA Controller (PoS) helps MIS users to implement effective handover procedures to support service continuity across heterogeneous network interfaces. The PoA Controller (PoS) facilities seamless handover between heterogeneous PoAs. MIS users utilize MIS functions across different entities to query resources required for handover operation between heterogeneous networks. The radio resource information maintained in the PoA Controller (PoS) could help in the decision making of the handover as well as the radio resource optimization.

Separating RANs, SDN controller enables network control functions to evolve independently. As a consequence, in SDFN’s environment, vertical handover procedure becomes more challenging especially for RANs. It is clear that the coordination techniques between the PoA Controller (PoS) and SDN Controller should benefit from such centralized radio resource coordination architecture at multi-layer RAN. The coordination could be implemented by introducing a new API between the PoA Controller (PoS) and the SDN controller. We refer to this interface as the East/West interface of the SDN Controller.

The service framework architecture inherits some advantages as follows:

* The PoA Controller (PoS) could be implemented in the cloud for elastic, scalable and flexible deployment.
* Radio resource management and network control functions would be implemented as software, simplifying experimentation with and validation of new functions in the PoA Controller and the SDN Controller, respectively.
* Lower investments would be required, since intelligence would be taken from hardware to software.
* Consolidation around a central control structure would allow for greater automation, thereby reducing operational cost.



Figure 1—Reference model of MIS framework in SDFNs

In SDFN, we assume that the PoA Controller (i.e., radio access point (RAP) Controller) is able to connect a variety of different PoAs, and PoA selection is derived from a mixture of user preferences, access network conditions and operator policies in a full SDN-based network. Radio access point acts as MIS PoA by achieving radio resource management on behalf of attached MNs.

Each PoA and its related MNs are co-located in a specific area or vehicle including a wireless RAN such as Wi-Fi network, WiMAX network or any other wireless network. So that, each end-user of MN can reach internet or communicate with a corresponding node via its PoA.

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 active network connection. During the handover, PoA Controller can control resources of PoAs that use various communication technologies (e.g., WLAN, Wi-Fi Direct, Bluetooth, and LTE) by using MIES message. PoA Controller directly configures radio resources (e.g., frequency, time, and power) at PoAs according to MICS message. The MICS message can be forwarded to SDN switches or indirectly forwarded by the SDN controller through the East/West interface.

SDN-based switch can also operate as a gateway between wireless RAN (or MNs) and a backhaul network. The latter is a cellular core network that may be connected to any other network. Fig. 1 shows the main functional entities in the RAN side and the architecture of the proposed handover management model. The Context aware Handover Controller at the MN side interacts with the Handover Manager of the PoA Controller and plans the execution of the handover management protocols. The MIS user at MN makes use of MIS signaling messages to achieve handover initiation and preparation. The context information module at the PoA Controller is able to extract relevant information from received triggers based on MIS signaling. Each mobile user has a local repository of its own context information. Then the PoA periodically queries the mobile users to establish its connectivity. The MIIS in our system can be incorporated with the information server. The information server at the core network sends handover policies to the PoA Controller and receives context information of each PoA controller and its attached users.

* + - 1. Media Independent Service reference model

A network reference model including MIS services is shown in Figure 2 to better illustrate the MIS reference points for SDFN. Moving from left to right, the model includes an MIS-capable mobile node (MN) that supports multiple wired and wireless access technologies. An MN exchanges MIS information with its MIS point of service (PoS) within the PoA Controller. The MISF in any Network Entity becomes an MIS PoS when it communicates directly with an MN-based MISF. 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.

The MN can use L2 transport for exchange MIS information with an MIS PoS that resides in its Network PoA. The MN can use L3 transport for exchanging MIS information with an MIS PoS that resides in its PoA Controller. This framework supports use of either L2 and L3 mechanisms for communication among MIS network entities.

Figure 2 shows the MISF communication model. The model shows MISFs in different roles and the communication relationships among them. It is important to note that each of the communication relationships in the communication model does not imply a particular transport mechanism. Rather, a communication relationship only intends to show that passing 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.

Figure 2— MIS reference model for SDFN 

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

1. MISF on the MN
2. MIS PoS on the Network Entity that includes the serving PoA of the MN
3. MIS PoS on the Network Entity that includes a candidate PoA for the MN
4. MIS PoS on the Network Entity that includes the PoA Controller

The communication model also identifies the reference points between different instances of MISF.

* Reference point RP1: Reference point RP1 refers to MISF procedures between the MISF on the MN and the MIS PoS on the Network Entity of its serving PoA. RP1 encompasses communication interfaces over both L2 and L3 and above. MISF content passed over RP1 are related to MIIS, MIES, or MICS.
* Reference point RP2:Reference point RP2 refers to MISF procedures between the MISF on the MN and the MIS PoS on the Network Entity of a candidate PoA. RP2 encompasses communication interfaces over both L2 and L3 and above. MISF content passed over RP2 are related to MIIS, MIES, or MICS.
* Reference point RP3: Reference point RP3 refers to MISF procedures between the MISF on the MN and the MIS PoS on the PoA Controller. RP3 encompasses communication interfaces over L3 and above and possibly L2 transport protocols like Ethernet bridging, or multi-protocol label switching (MPLS). MISF content passed over RP3 are related to MIIS, MIES, or MICS.
* Reference point RP4: Reference point RP4 refers to MISF procedures between an MIS PoS in a Network Entity and an MIS PoS instance in PoA Controller. RP4 encompasses communication interfaces over L3 and above. MISF content passed over RP4 are related to MIIS, MIES, or MICS.
* Reference point RP5: Reference point RP5 refers to MISF procedures between an MIS PoS in a Network Entity and an MIS PoS instance in different Network Entities. RP5 encompasses communication interfaces over L3 and above. MISF content passed over RP5 are related to MIIS, MIES, or MICS.
* Reference point RP6 for East/West interface: Reference point RP6 for East/West interface refers to MISF procedures between PoA Controller and SDN Controller. RP5 encompasses East/West interfaces over SDN Controller. MISF content passed over RP5 are related to radio resource management and switch configuration.
  + - 1. MISF Services

The MISF provides the media independent event service (MIES), the media independent command service (MICS), and the media independent information service (MIIS) that facilitate handovers across heterogeneous RANs. Clause 5.7.3 provides a general description of these services. These services are managed and configured through service management primitives, as discussed in the following sub-Clause.

1. A media independent event service (MIES) that provides event classification, event filtering and event reporting corresponding to dynamic changes in link characteristics, link status, and link quality.
2. A media independent command service (MICS) that enables MIS users to manage and control link behavior relevant to handovers and mobility.
3. A media independent information service (MIIS) that provides details on the characteristics and services provided by the serving and neighboring networks. The information enables effective system access and effective handover decisions.
   * + 1. MISF SAPs

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 active network connection.

During the handover procedure, PoA Controller can control resources of PoAs that use various communication technologies (e.g., WLAN, Wi-Fi Direct, Bluetooth, and LTE) by using MIS message. PoAs directly configure radio resources (e.g., frequency, time, and power) according to MIS message. The MIS message can be forwarded to SDN switches or indirectly forwarded by the SDN controller through the East/West interface.

Figure 3 shows MISF in a protocol stack and the interaction of the MISF with other elements for handover control in SDFNs. All exchanges between the MISF and other functional entities occur through service primitives, grouped in service access points (SAPs). Each SAP consists of a set of service primitives that specify the interaction between the service user and provider.

The specification of the MISF includes the definition of SAPs that are media independent and recommendations to define or extend other SAPs that are media dependent. Media independent SAPs allow the MISF to provide services to the upper layers of the mobility-management protocol stack, the network management plane, and the data bearer plane. The MIS\_SAP and associated primitives provide the interface from MISF to the upper layers of the mobility-management protocol stack. Upper layers need to subscribe with the MISF as users to receive MISF generated events and also for link-layer events that originate at layers below the MISF but are passed on to MIS users through the MISF. MIS users directly send commands to the local MISF using the service primitives of the MIS\_SAP. Communication between two MISFs relies on MIS protocol messages.

Media dependent SAPs allow the MISF to use services from the lower layers of the mobility management protocol stack and their radio resource management planes. All inputs (including the events) from the lower layers of the mobility-management protocol stack into the MISF are provided through existing media-specific SAPs such as MAC SAPs, PHY SAPs, and logical link control (LLC) SAPs. Link Commands generated by the MISF to control the PHY and MAC layers during the handover are part of the media-specific MAC/PHY SAPs and are already defined elsewhere.

The MISF relevant SAPs include the following:

1. The MIS\_SAP specifies a media independent interface between the MISF and upper layers of the mobility management protocol stack. The upper layers need to subscribe with the MISF as users to receive MISF-generated events and also for link-layer events that originate at layers below the MISF but are passed on to MISF users through the MISF. MISF users directly send commands to the local MISF using the service primitives of the MIS\_SAP.
2. The MIS\_LINK\_SAP specifies an abstract media dependent interface between the MISF and lower layers media-specific protocol stacks of technologies such as IEEE 802.3, IEEE 802.11, IEEE 802.16, 3GPP, and 3GPP2. For different link-layer technologies, media-specific SAPs provide the functionality of MIS\_LINK\_SAP. Amendments are suggested to the respective media-specific SAPs to provide all the functionality as described by MIS\_LINK\_SAP.
3. The MIS\_NET\_SAP specifies an abstract media dependent interface of the MISF that provides transport services over the data plane on the local node, supporting the exchange of MIS information and messages with remote MISFs.



Figure 3— Relationship between different MISF SAPs🡪

* + - 1. Stages for handover procedure

In SDFNs, handover refers to the ability of transferring an ongoing call or data session from one radio access technology to another, without any interruption, to the ongoing services. Radio resource allocation for Handover procedure comprises four stages as shown in Figure 4.

1. In the first stage, the MN may query the Information Server to discover candidate networks and their handover policies by starting handover initiation. This handover initiation enables the MN to 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 may query the PoA controller to discover candidate PoAs and their resource availability. Such information includes whether candidate networks and MN support radio resource management 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 can be made by the MN or the network based on parameters such as signal strength, target QoS, cost, resource availability, and operator policy. After then, radio resource allocation has been 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 radio access network with newly allocated radio resources as an action of Handover execution. After then, PoA reports its allocated radio resources to Information Server, PoA Controller (or SDN controller), and neighboring PoAs.

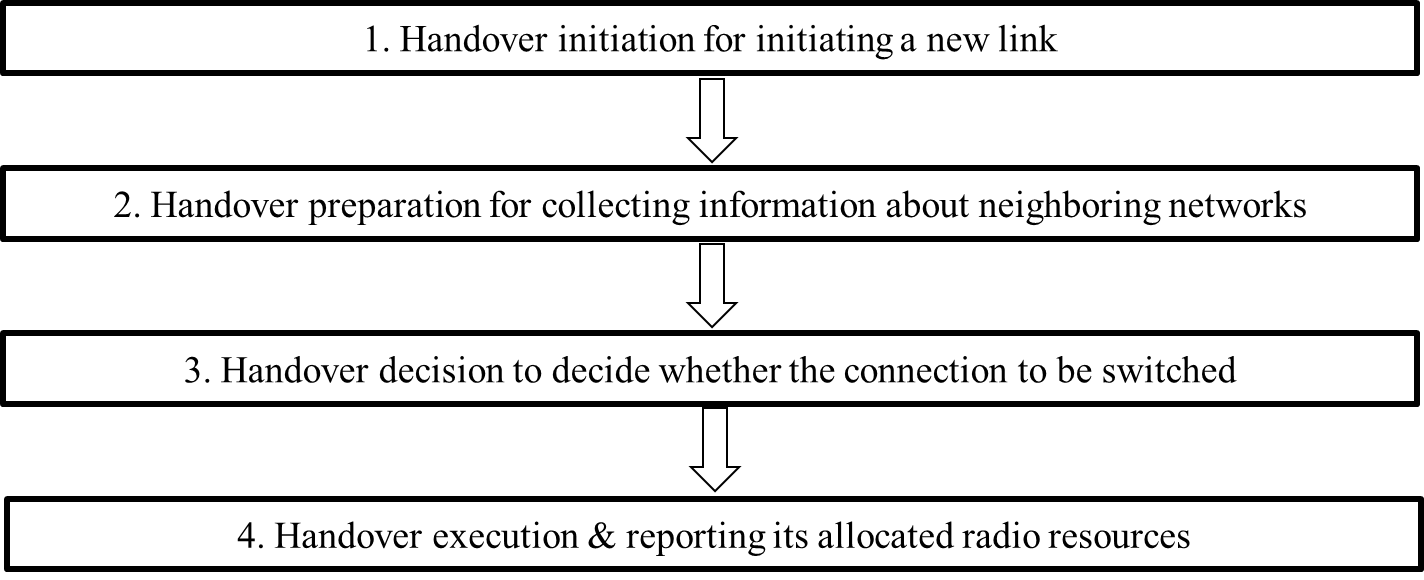
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Figure 4—Stages for seamless handover in SDFNs

* + - 1. Signal flows

Over the SDFNs, handover triggers generated by the link layer are exploited by the MISF incorporated in the PoAs to make easy vertical handover. This procedure has the four phases described in previous Session (Handover Initiation, Handover preparation, Handover decision and Handover execution).

* + - * 1. Stage 1: Handover Initiation

The handover initiation phase is start when the Mobile Node is connected to the serving network via the current PoA 1. The Mobile Node 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 Mobile Node is first attached to the PoA 1.and it has access to the MIS Information Server. Figure 5 shows an example signal flow for handover initiation.



Figure 5—Signal flows for handover initiation procedure

* + - * 1. Stage 2: Handover Preparation

Figure 6 shows an example signal flow for handover preparation. When detecting MIS\_MN\_Link\_Detected\_indication, the Mobile Node triggers a mobile-initiated handover by sending an MIS\_MN\_HO\_Candidate\_Query request message to the PoA Controller. This request contains the information of potential candidate networks. The PoA Controller extracts context information of both attached users and neighboring radio access networks. 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. The Candidate PoAs respond with an MIS\_N2N\_HO\_Query\_Resources response message and the PoA Controller notifies the Mobile Node of the resulting resource availability at the candidate PoAs through an MIS\_MN\_HO\_Candidate\_Query response message. Thus, RANs and MN have 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 6—Signal flows for handover preparation procedure

* + - * 1. Stage 3: Handover Decision

After executing the selection mechanism and determining the preferred candidate target radio access network, the Mobile Node 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. 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 to the Target PoA to request resource preparation at the target network. The Target PoA responds with the result of the resource preparation by an MIS\_N2N\_HO\_Commit response message. The target PoA 2 can reply to the PoA Controller (MIS PoS) by sending MIS\_N2N\_HO\_Commit.response to prepare connection with newly allocated resources. The PoA Controller (MIS PoS) can respond to PoA 1 by sending MIS\_MN\_HO\_Commit.response message to prepare connection with newly allocated resources and PoA 1 itself can allocate its radio resources.



Figure 7—Signal flows for handover decision procedure

* + - * 1. Stage 4: Handover Execution

When the MN moves its attachment from a previous PoA (PoA 1) to a new PoA (PoA 2), certain handover execution procedure is carried out between the Mobile Node and the PoA Controller as follows: After radio link has been activated with the MIS\_Link\_Up.indication, the Mobile Node establishs the new layer 2 connection and sends an MIS\_MN\_HO\_Complete request message to the PoA Controller. The PoA Controller sends an MIS\_N2N\_HO\_Complete request message to the previous Serving PoA to release resource, which was allocated to the Mobile Node. After identifying that the resource is successfully released, the PoA Controller sends an MIS\_MN\_HO\_Complete response message to the Mobile Node to preserve connectivity to the correspondent (Figure 8 (m)) are exchanged between PoA 2 and the PoA Controller (MIS PoS), which are incorporated with PoA 1 (Figure 8 (n) and (o)). The handover procedure is completed when MN receives MIS\_MN\_HO\_Complete.response (Figure 8 (p)) from PoA 2.



Figure 8—Signal flows for handover execution procedure

* + 1. Service access point and primitives
       1. MIS\_SAP primitives
          1. MIS\_LINK\_SAP primitives

— Link\_Detected.indication

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| Link\_Detected.indication | LinkDetectedInfo | Link of a new access network has been detected.  This event is typically generated on the MN when  the first PoA of an access network is detected. This  event is not generated when subsequent PoAs of the  same access network are discovered. | 7.3.1  IEEE 802.21 2009 |

— Link\_Up.indication

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| Link\_Up.indication | LinkIdentifier, OldAccessRouter, NewAccessRouter, IPRenewalFlag, MobilityManagementSupport | A layer 2 connection is established.  This event is typically generated on the MN when  A layer 2 connection is established. All  layer 2 activities in establishing the link connectivity are expected to be completed at this point of time. | 7.3.2  IEEE 802.21 2009 |

— Link\_Action.request

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| Link\_Action.request | LinkAction, ExecutionDelay, PoALinkAddress | This event generates this primitive upon request from the MIS user to perform an action on a pre-defined link-layer connection. This primitive is used by the MISF to request an action on a link-layer connection to enable optimal handling of link-layer resources for the purpose of handovers. The link-layer connection can be ordered (e.g., to shut down) to remain active, to perform a scan, or to come up active and remain in stand-by mode. | 7.3.14  IEEE 802.21 2009 |

— Link\_Action.confirm

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| Link\_Action.confirm | Status, ScanResponseSet,LinkActionResult, | The link-layer technology generates this primitive to communicate the result of the action executed on the  link-layer connection. Upon receipt of this primitive, the MISF determines the relevant MIS command that needs to be used to  provide an indication or confirmation to the MIS user of the actions performed on the current link-layer  connection. | 7.3.14  IEEE 802.21 2009 |

* + - 1. MIS\_SAP primitives
         1. — MIS\_Link\_Detected.indication

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_Link\_Detected.inidication | SourceIdentifier, LinkDetectedInfoList | The primitive is sent to MN, MISF users to notify them of a local event (i.e., Link\_Detected.indication), or of receipt of MIS\_Link\_Detected indication message from a remote MISF (i.e., a remote Link\_Detected event has occurred). | 7.4.6  IEEE 802.21 2009 |

* + - * 1. — MIS\_Link\_Up.indication

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_Link\_Up.inidication | SourceIdentifier, LinkIdentifier, OldAccessRouter, NewAccessRouter, IPRenewalFlag, MobilityManagementSupport | The primitive is sent to MN’ MISF users to notify them of a local event, or is the result of the receipt of an MIS\_Link\_Up indication message to indicate to the remote MISF users who have subscribed to this remote event. The MIS\_Link\_Up.indication is sent to MN’ MISF users to notify them of a local event (i.e., Link\_Up.indication), or is the result of the receipt of an MIS\_Link\_Up indication message to indicate to the remote MISF users who have subscribed to this remote event that a remote link up event occurred. | 7.4.7  IEEE 802.21 2009 |

* + - * 1. — MIS\_Get\_Information.request

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_Get\_Information.request | DestinationIdentifier, InfoQueryBinaryDataList, InfoQueryRDFDataList, InfoQueryRDFSchemaURL, InfoQueryRDFSchemaList, MaxResponseSize,QuerierNetworkType, UnauthenticatedInformationRequest | This primitive is generated by an MIS user that is seeking to retrieve information. This primitive is used by an MIS user to request information from an MIS information server. The information query is related to a specific interface, attributes to the network interface, as well as the entire network capability. The service primitive has the flexibility to query either a specific data within a network interface or extended schema of a given network. It is assumed that the available information could be broadcast in access technology specific manner such as in IEEE Std 802.11 and IEEE Std 802.16. | 7.4.25.1  IEEE 802.21 2009 |

* + - * 1. — MIS\_Get\_Information.confirm

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_Get\_Information.confirm | SourceIdentifier, Status, InfoResponseBinaryDataList, InfoResponseRDFDataList, InfoResponseRDFSchemaURLList, InfoResponseRDFSchemaList | This primitive is generated by the MISF on receiving an MIS\_Get\_Information Response message from a peer MISF. The MIS user that requested the information utilizes the Info Response parameters and takes suitable action. However, if Status does not indicate “Success,” the recipient ignores any other returned values and, instead, performs appropriate error handling. | 7.4.25.4  IEEE 802.21 2009 |

* + - * 1. — MIS\_MN\_HO\_Candidate\_Query.request

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_ MN\_HO\_Candidate\_Query.request | DestinationIdentifier, SourceLinkIdentifier, CandidateLinkList, QoSResourceRequirements, IPConfigurationMethods, DHCPServerAddress, FAAddress, AccessRouterAddress | 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 can be supported in the candidate network. This primitive also includes the current IP configuration server address [e.g., DHCP server, foreign agent (FA) IP address, AR IP address] when the current IP configuration method is included. 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. | 7.4.18.1  IEEE 802.21 2009 |

* + - * 1. — MIS\_MN\_HO\_Candidate\_Query.indication

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_ MN\_HO\_Candidate\_Query.indication | SourceIdentifier,  SourceLinkIdentifier, CandidateLinkList, QoSResourceRequirements, IPConfigurationMethods, DHCPServerAddress, FAAddress, AccessRouterAddress | This primitive is used by MISF to indicate the receipt of MIS\_MN\_HO\_Candidate\_Query request message  from an MN. This primitive is generated by MISF on receiving MIS\_MN\_HO\_Candidate\_Query request message from a peer MISF in an MN. | 7.4.18.2  IEEE 802.21 2009 |

* + - * 1. — MIS\_MN\_HO\_Candidate\_Query.response

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_ MN\_HO\_Candidate\_Query. response | DestinationIdentifier, Status, SourceLinkIdentifier, PreferredCandidateLinkList | This primitive is used by MIS users to inform MISF of the result of the candidate query request. 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. | 7.4.18.3  IEEE 802.21 2009 |

* + - * 1. — MIS\_MN\_HO\_Candidate\_Query.confirm

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_ MN\_HO\_Candidate\_Query.confirm | SourceIdentifier,  Status,  SourceLinkIdentifier,  PreferredCandidateLinkList | This primitive is used by MISF to inform MIS users of the receipt of candidate query and IP address related information response. This primitive is generated by MISF on receiving MIS\_MN\_HO\_Candidate\_Query response message from a peer MISF in the network. | 7.4.18.4  IEEE 802.21 2009 |

* + - * 1. — MIS\_N2N\_HO\_Query\_Resources.request

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Query\_Resources.request | DestinationIdentifier,  QoSResourceRequirements,  IPConfigurationMethods,  DHCPServerAddress,  FAAddress,  AccessRouterAddress,  CandidateLinkList | 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. 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 networkinitiated handover, this primitive is generated after receiving the MIS\_Net\_HO\_Candidate\_Query response message from the MN. | 7.4.19.1  IEEE 802.21 2009 |

* + - * 1. — MIS\_N2N\_HO\_Query\_Resources.indication

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Query\_Resources.indication | SourceIdentifier,  QoSResourceRequirements,  IPConfigurationMethods,  DHCPServerAddress,  FAAddress,  AccessRouterAddress,  CandidateLinkList | 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 so that the upper layer entity can identify the link resource usage and provide IP address related information for the impending handover. This primitive is generated by MISF when the MISF on the candidate network receives MIS\_N2N\_HO\_Query\_Resources request message from a peer MISF on the serving network. | 7.4.19.2  IEEE 802.21 2009 |

* + - * 1. — MIS\_N2N\_HO\_Query\_Resources.response

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Query\_Resources.response | DestinationIdentifier,  Status,  ResourceStatus,  CandidateLinkList, | 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. 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. | 7.4.19.3  IEEE 802.21 2009 |

* + - * 1. — MIS\_N2N\_HO\_Query\_Resources.confirm

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Query\_Resources.confirm | SourceIdentifier,  Status,  ResourceStatus,  CandidateLinkList, | 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. 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. | 7.4.19.4  IEEE 802.21 2009 |

* + - * 1. — MIS\_MN\_HO\_ Commit.request

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_ MN\_HO\_Commit.request | DestinationIdentifier,  LinkType,  TargetNetworkInfo | This primitive is used by MIS users on an MN to notify the serving network of the decided target network information. The MIS user generates this primitive to notify the serving network of the target network information. | 7.4.20.1  IEEE 802.21 2009 |

* + - * 1. — MIS\_MN\_HO\_ Commit.indication

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_ MN\_HO\_Commit.indication | SourceIdentifier,  LinkType,  TargetNetworkInfo | 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 mobile node. 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. | 7.4.20.2  IEEE 802.21 2009 |

* + - * 1. — MIS\_MN\_HO\_ Commit.response

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_ MN\_HO\_Commit. response | DestinationIdentifier,  Status,  LinkType,  TargetNetworkInfo | This primitive is used by an MIS user on the serving network to communicate with a peer MIS user on the mobile node from which an MIS\_MN\_HO\_Commit request message is received. | 7.4.20.3  IEEE 802.21 2009 |

* + - * 1. — MIS\_MN\_HO\_ Commit.confirm

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_ MN\_HO\_ Commit.confirm | SourceIdentifier,  Status,  LinkType,  TargetNetworkInfo | This primitive is generated by the MISF on the mobile node to confirm that an MIS\_MN\_HO\_Commit response message is received from a peer MISF on the serving network. This primitive is generated by the MISF on the mobile node when it receives an MIS\_MN\_HO\_Commit response message from a peer MISF on the serving network. | 7.4.20.4  IEEE 802.21 2009 |

* + - * 1. — MIS\_N2N\_HO\_Commit.request

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Commit.request | (  DestinationIdentifier,  MNIdentifier,  TargetMNLinkIdentifier,  TargetPoA,  RequestedResourceSet | 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. The MIS user on the serving network invokes this primitive when a single target network has been decided. | 7.4.22.1  IEEE 802.21 2009 |

* + - * 1. — MIS\_N2N\_HO\_Commit.indication

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Commit.indication | SourceIdentifier,  MNIdentifier,  TargetMNLinkIdentifier,  TargetPoA,  RequestedResourceSet | 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. This primitive is generated by an MISF on receiving an MIS\_N2N\_HO\_Commit request message from a peer MISF on the serving network. | 7.4.22.2  IEEE 802.21 2009 |

* + - * 1. — MIS\_N2N\_HO\_Commit.response

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Commit.response | DestinationIdentifier,  Status,  MNIdentifier,  TargetLinkIdentifier,  AssignedResourceSet | This primitive is used by an MIS user to respond to an MIS\_N2N\_HO\_Commit.indication primitive. This primitive is generated by an MISF User in response to a received MIS\_N2N\_HO\_Commit.indication primitive. | 7.4.22.3  IEEE 802.21 2009 |

* + - * 1. — MIS\_N2N\_HO\_Commit.confirm

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Commit.confirm | SourceIdentifier,  Status,  MNIdentifier,  TargetLinkIdentifier,  AssignedResourceSet | 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. 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. | 7.4.22.4  IEEE 802.21 2009 |

* + - * 1. — MIS\_MN\_HO\_Complete.request

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| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_ MN\_HO\_Complete.request | DestinationIdentifier,  SourceLinkIdentifier,  TargetLinkIdentifier,  HandoverResult | This primitive is optionally used by MIS users to indicate the completion of MIS level handover aiding procedure. This primitive is generated when MIS level handover procedure is complete. | 7.4.23.1  IEEE 802.21 2009 |

* + - * 1. — MIS\_MN\_HO\_ Commit. Complete

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_ MN\_HO\_Complete.indication | SourceIdentifier,  SourceLinkIdentifier,  TargetLinkIdentifier,  HandoverResult | This primitive is used by MISF to inform MIS users locally that an MIS\_MN\_HO\_Complete request message is received. This primitive is generated when an MIS\_MN\_HO\_Complete request message is received. | 7.4.23.2  IEEE 802.21 2009 |

* + - * 1. — MIS\_MN\_HO\_ Complete.response

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_ MN\_HO\_Complete. response | DestinationIdentifier,  Status,  SourceLinkIdentifier,  TargetLinkIdentifier | This primitive is used by MIS users to send a response to the MIS\_MN\_HO\_Complete request. This primitive is generated when the MIS user wants to respond to the MIS\_MN\_HO\_Complete.indication. | 7.4.23.3  IEEE 802.21 2009 |

* + - * 1. — MIS\_MN\_HO\_ Complete.confirm

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_ MN\_HO\_ Complete.confirm | SourceIdentifier,  Status,  SourceLinkIdentifier,  TargetLinkIdentifier | This primitive is used by MISF to inform MIS users locally that an MIS\_MN\_HO\_Complete response message is received. MISF generates this primitive when an MIS\_MN\_HO\_Complete response message is received. | 7.4.23.4  IEEE 802.21 2009 |

* + - * 1. — MIS\_N2N\_HO\_Completerequest

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Complete.request | DestinationIdentifier,  MNIdentifier,  SourceLinkIdentifier,  TargetLinkIdentifier,  HandoverResult | 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. The MIS user invokes this primitive when handover operations have been completed. | 7.4.24.1  IEEE 802.21 2009 |

* + - * 1. — MIS\_N2N\_HO\_Complete.indication

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| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Complete.indication | SourceIdentifier,  MNIdentifier,  SourceLinkIdentifier,  TargetLinkIdentifier,  HandoverResult | This primitive is used by the MISF to indicate the status of the handover operation. This primitive is generated by the MISF on receiving an MIS\_N2N\_HO\_Complete request message from a peer MISF. | 7.4.24.2  IEEE 802.21 2009 |

* + - * 1. — MIS\_N2N\_HO\_Complete.response

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Complete.response | DestinationIdentifier,  Status,  MNIdentifier,  SourceLinkIdentifier,  TargetLinkIdentifier,  ResourceRetentionStatus | This primitive is used to send a response to a handover complete request. | 7.4.24.3  IEEE 802.21 2009 |

* + - * 1. — MIS\_N2N\_HO\_Complete.confirm

|  |  |  |  |
| --- | --- | --- | --- |
| **Link event name** | **Parameters** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Complete.confirm | SourceIdentifier,  Status,  MNIdentifier  SourceLinkIdentifier,  TargetLinkIdentifier,  ResourceRetentionStatus | The MIS user responds with this primitive after processing the handover complete request. This primitive is generated by MISF on receiving MIS\_N2N\_HO\_Complete response message from a peer MISF. | 7.4.24.4  IEEE 802.21 2009 |

* + 1. MIS protocol message types
       1. MIS protocol messages
          1. —MIS message for event service
          2. —MIS message for command service

|  |  |  |  |
| --- | --- | --- | --- |
| **MIS message** | **primitives** | **Description** | **Defined in** |
| MIS\_MN\_HO\_Candidate\_Query request | 7.4.18.1. | This message is used by an MISF on the MN to communicate to a network MISF, an intent to initiate a handover. | 8.6.3.9  IEEE 802.21 2009 |

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| --- | --- | --- | --- |
| **MIS message** | **primitives** | **Description** | **Defined in** |
| MIS\_MN\_HO\_Candidate\_Query response | 7.4.18.3 | 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. | 8.6.3.10  IEEE 802.21 2009 |

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| --- | --- | --- | --- |
| **MIS message** | **primitives** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Query\_Resources request | 7.4.19.1. | 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. | 8.6.3.11  IEEE 802.21 2009 |

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| --- | --- | --- | --- |
| **MIS message** | **primitives** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Query\_Resources response | 7.4.19.3 | 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.. | 8.6.3.12  IEEE 802.21 2009 |

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| --- | --- | --- | --- |
| **MIS message** | **primitives** | **Description** | **Defined in** |
| MIS\_MN\_HO\_Commit request | 7.4.20.1. | This message is used by the MISF on the mobile node to notify the Serving PoS of the decided target network information. | 8.6.3.13  IEEE 802.21 2009 |

|  |  |  |  |
| --- | --- | --- | --- |
| **MIS message** | **primitives** | **Description** | **Defined in** |
| MIS\_MN\_HO\_Commit response | 7.4.20.3 | This message is used by the MISF on the Serving PoS to respond to an MIS\_MN\_HO\_Commit request message. | 8.6.3.14  IEEE 802.21 2009 |

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| --- | --- | --- | --- |
| **MIS message** | **primitives** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Commit request | 7.4.22.1. | 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. | 8.6.3.17  IEEE 802.21 2009 |

|  |  |  |  |
| --- | --- | --- | --- |
| **MIS message** | **primitives** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Commit response | 7.4.22.3 | 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. | 8.6.3.18  IEEE 802.21 2009 |

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| --- | --- | --- | --- |
| **MIS message** | **primitives** | **Description** | **Defined in** |
| MIS\_MN\_HO\_Complete request | 7.4.23.1. | This message is used by the MISF on the MN to communicate the status of handover operation to the MISF on the target network. | 8.6.3.19  IEEE 802.21 2009 |

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| --- | --- | --- | --- |
| **MIS message** | **primitives** | **Description** | **Defined in** |
| MIS\_MN\_HO\_Complete response | 7.4.23.3 | This message is used by the MISF on the target network to communicate the response following the completion of handover operation to the MN. | 8.6.3.20  IEEE 802.21 2009 |

|  |  |  |  |
| --- | --- | --- | --- |
| **MIS message** | **primitives** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Complete request | 7.4.24.1. | This message is used by the MISF to communicate the status of handover operation. | 8.6.3.21  IEEE 802.21 2009 |

— MIS\_N2N\_HO\_Complete.response

|  |  |  |  |
| --- | --- | --- | --- |
| **MIS message** | **primitives** | **Description** | **Defined in** |
| MIS\_N2N\_HO\_Complete response | 7.4.24.3 | 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. | 8.6.3.22  IEEE 802.21 2009 |

* + - * 1. —MIS message for information service

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| --- | --- | --- | --- |
| **MIS message** | **primitives** | **Description** | **Defined in** |
| MIS\_Get\_Information request | 7.4.25.1 | This message is used by an MISF to retrieve a set of Information Elements provided by the information service. A single MIS\_Get\_Information request message carries only one query list. However, there can be multiple queries in that list in the order of the most preferred query first.. | 8.6.4.1  IEEE 802.21 2009 |

|  |  |  |  |
| --- | --- | --- | --- |
| **MIS message** | **primitives** | **Description** | **Defined in** |
| MIS\_Get\_Information response | 7.4.25.3 | This is used as a response to the MIS\_Get\_Information request message. The total response message size shall not exceed the value indicated in the Max Response Size TLV of corresponding MIS\_Get\_Information request message. The order of the query response shall be in the same order as the query requests. | 8.6.4.2  IEEE 802.21 2009 |