

IEEE Standard for Local and metropolitan area networks—

Part 21: Media Independent Handover Services

Amendment 3: Optimized Single Radio Handovers

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

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USA

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as amended by IEEE Std 802.21a™-2012,
and IEEE Std 802.21b™-2012)

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

**Part 21: Media Independent Handover
Services**

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IEEE Computer Society**

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IEEE-SA Standards Board

Abstract: Additional IEEE 802® media access independent mechanisms that optimize handovers between possibly heterogeneous IEEE 802 systems and between IEEE 802 systems and cellular systems to enable improved handover performance for single-radio devices are specified in this standard.

Keywords: IEEE 802®, IEEE 802.21™, IEEE 802.21c™, management, media independent handover, mobile node, mobility, seamless, point of attachment, point of service, preregistration, proactive authentication, single-radio

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Introduction

This introduction is not part of IEEE Std 802.21c™-2014, IEEE Standard for Local and Metropolitan Area Networks—Part 21: Media Independent Handover Services—Amendment 3: Optimized Single Radio Handovers.

This standard extends the media access independent mechanisms that enable the optimization of handovers between possibly heterogeneous IEEE 802® systems and may facilitate handovers between IEEE 802 systems and cellular systems. The extensions enable mobile devices with single-radio designs to improve handover latencies and avoid packet loss.

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1. Overview

1.4 Assumptions

Insert at end of 1.4

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

- a) The mobile device can transmit 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.

3. Definitions, abbreviations, and acronyms

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.¹

Insert these definitions in appropriate order

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 802.11™-2012.

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

proxy Information Server: a Server that can assist the mobile node 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 PoA: an entity that provides service to a mobile node and a target point of attachment via the source network. To the MN, this entity appears to be a point of attachment (PoA) in the target network. It can be a non-PoA network entity and can collocate at a MIH PoS, and it enables such services as preregistration of the MN.

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

single radio MIH packet: a packet which may contain one or more of the following commands MIH_Prereg_Xfer, MIH_N2N_Prereg_Xfer, MIH_Prereg_Ready, or MIH_CTRL_Transfer in its payload.

¹IEEE Standards Dictionary Online subscription is available at:
http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html.

source network PoS: the Point of Service in the network of the Mobile Node's current Point of Attachment

source radio: the MN's radio interface that transmits and/or receives over the radio link which the MN currently has established with the source network

SRHO-capable node: a MIHF capable node that can process single radio MIH packets.

target network PoA: a Point of Attachment in the target network, to which an MN will be attached after a handover has been completed.

target network PoS: a Point of Service in the target network of the target Point of Attachment, which will serve a Mobile Node after a handover has been completed.

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

4. Abbreviations and acronyms

Insert these definitions in appropriate order

ANDSF	access network discovery and selection function
ANQP	Access Network Query Protocol
HPoS	home network PoS
SPoS	source network PoS
SRHO	single radio handover
TPoA	target network PoA
TPoS	target network PoS

5. General architecture

5.1 Introduction

Insert 5.1.10 and 5.1.11

5.1.10 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 can be quite 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 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 can be 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 must 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.

5.1.11 Securing single-radio messages using PoS

Enabling movement between the networks of roaming partners for single-radio smartphones 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^{TM2} [B1], 3GPP2 [B2], and the WiMAX Forum^{®3} [B10]. Using the PoS, signaling messages related to security information between roaming partners can be exchanged and as a result low-latency optimized session handover can be achieved. Communications between the source and target networks must 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 10.3). Improving the security model and reducing authentication

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³ WiMAX Forum is a trademark of the WiMAX Forum.

delay enables crucial improvements in handover performance, because single-radio systems cannot take advantage of parallel authentication operations.

5.2 General design principles

Insert 5.2.3

5.2.3 Single radio handover MIHF design principles

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

- a) Tunneling mechanism to deliver the preregistration messages
- b) Control for preregistration states and delivery for preregistration contexts

5.4 Media independent handover reference framework

Insert 5.4.4

5.4.4 Single Radio MIHF relationship to reference model

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. 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 can be 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 MIH message which is then exchanged via an active link between the MIHFs of a local and a remote node using MIH protocol over higher layer transport (TCP or UDP over IP).

5.5 MIHF reference models for link-layer technologies

Insert 5.5.8

5.5.8 Single radio handover functional model and signaling flow

The functional model for single radio handover is shown in Figure 10a.

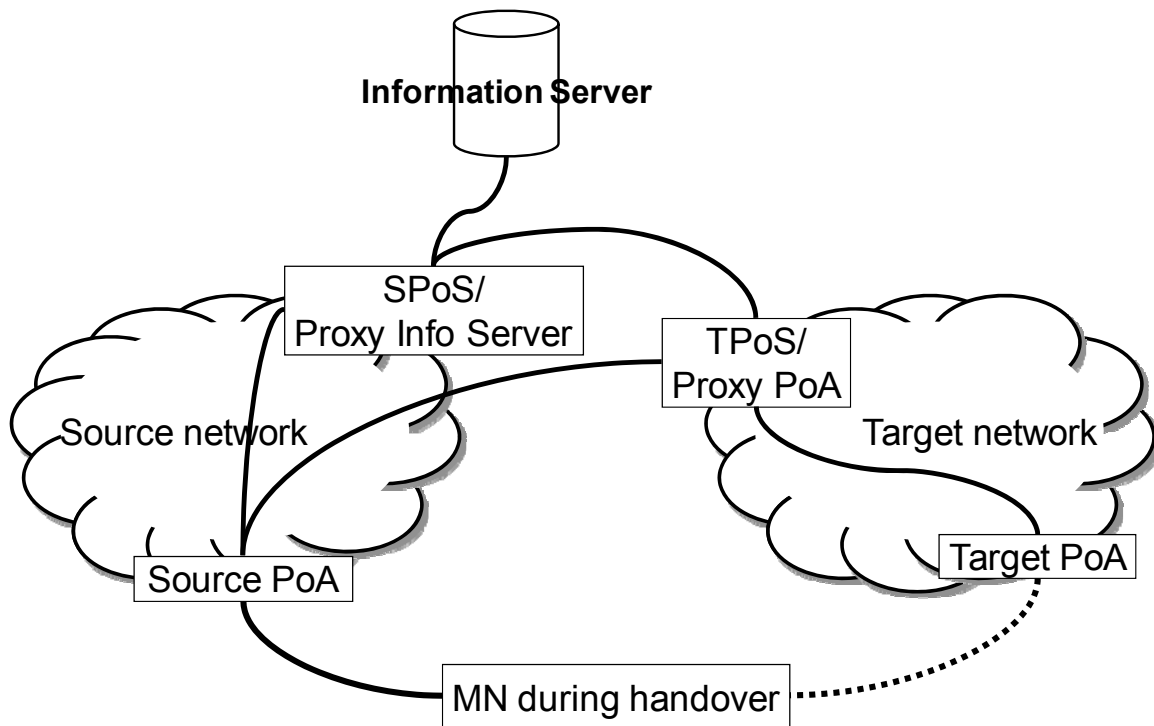


Figure 10 a—Single radio handover functional model

The services in the source network are: SPoS (the source network PoS) and the proxy Information Server (see 5.9). The services in the target network are: TPoS and the proxy PoA.

Insert 5.8 and 5.9

5.8 Single radio handover procedures

A single radio handover following the reference model in 5.4.4 may consist of various handover procedures and involve different information elements (Clause 7) and messages (Clause 8). Examples of handover are described in Annex N. Figure 11a shows the single radio handover process consisting of 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 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 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 TPoSs.

- 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 can be made by 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 can perform preregistration procedures within 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.
- d) 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.
- e) 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.

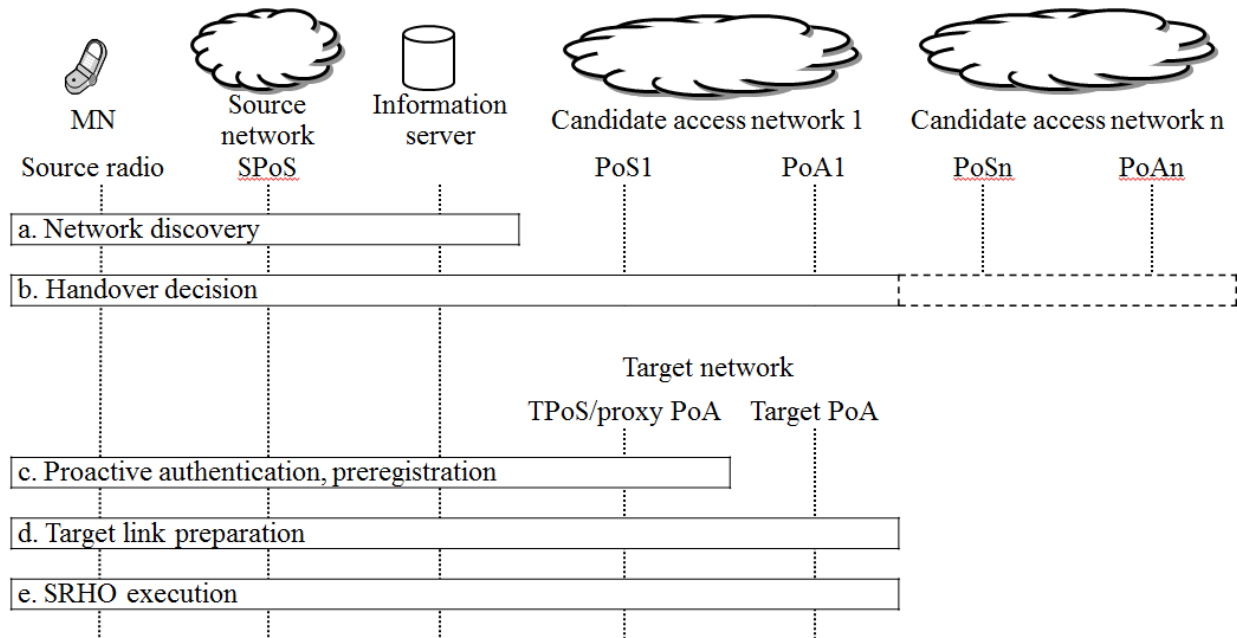


Figure 11 a—Single radio handover procedures

5.9 Proxy operations

5.9.1 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 may signal to the proxy PoA as if signaling to the target PoA (TPoA), and the TPoA may respond by signaling to the proxy PoA as if signaling to the MN. The MN may signal to the proxy Information Server as if signaling to the Information Server, and the Information Server may respond 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) [B10] 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) [B1].

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) [B3].

In a network employing a centralized or distributed mobility management architecture, the proxy services may be collocated within the mobility management anchors [B6].

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 and the signaling messages defined in this specification.

5.9.2 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 can directly access the Information Server, it can discover its target network by using MIH_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 ANQP messages in a Wi-Fi access network while the information is available in an ANDSF server that is located in a cellular provider's network. Network discovery in this scenario can be 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 11b 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 MIH_CTRL_Transfer request or a non-MIH message such as ANQP query.
- b) The SRHO-capable PoA transmits the MIH_CTRL_Transfer request message to the proxy Information Server. If the SRHO-capable PoA received a non-MIH message in step a), the SRHO-capable PoA encapsulates the query message into the MIH_CTRL_Transfer request message and transmits the message to the proxy Information Server (see 7.4.33).
- c) The proxy Information Server extracts the encapsulated payload message and forwards the MN's request to another functional entity such as a MIH User. This entity is responsible for transmitting the MN's request to the information server. The interface specification between this functional entity and the information server (i.e., the ANDSF server) is out of scope of this document. Note

that any translation between different protocols (e.g., ANQP and ANDSF) is performed at the MIH User level, which is out of the scope of this specification.

- d) The proxy Information Server transmits a MIH_CTRL_Transfer response message to the SRHO-capable PoA by encapsulating the response that is obtained from the functional entity (i.e., MIH User).
- e) The SRHO-capable PoA responds to the MN with information about the target network using MIH_CTRL_Transfer request or a non-MIH message such as an ANQP response. In case the MN did not use MIH as the protocol to transmit the original query, the SRHO-capable PoA decapsulates the MIH_CTRL_Transfer response message and forwards the content (e.g., the ANQP response) to the MN. If the MN used the MIH protocol for the initial query, then the SRHO-capable PoA forwards the MIH_CTRL_Transfer response message to the MN.

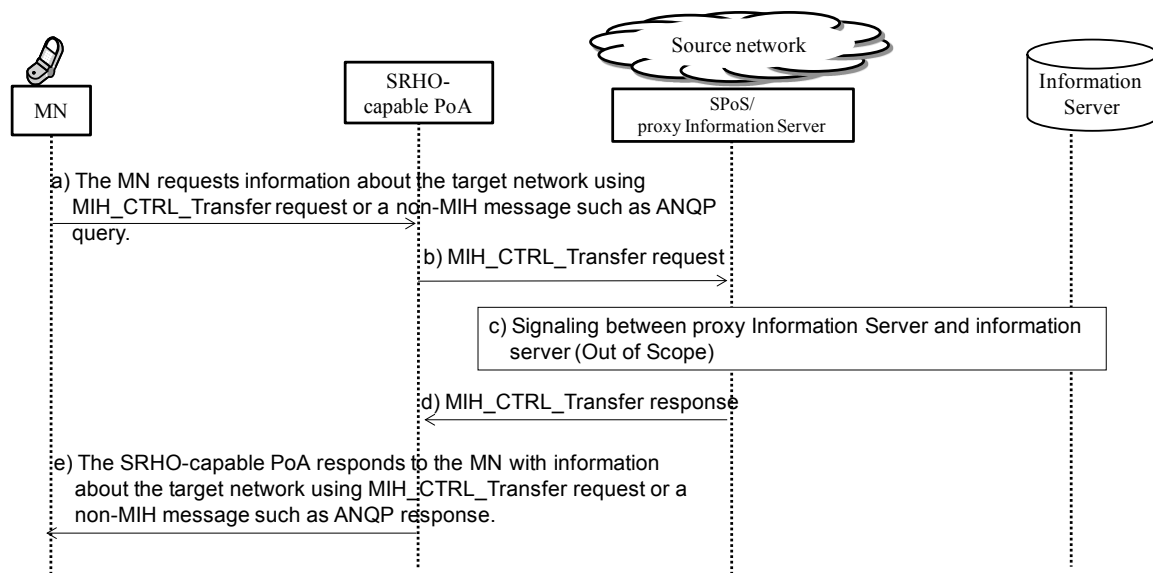


Figure 11 b—Network discovery using a proxy Information server

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

5.9.3 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 11c and Figure 11d). The second part of this communication depends on whether the TPoA is SRHO-capable (Figure 11c) or whether it is a legacy PoA lacking such capability (Figure 11d). If the target PoA is SRHO-capable, the L2 frame is encapsulated into a MIH packet to be forwarded to the target radio.

Figure 11c shows the transport of the target radio control frame as a payload of a MIH 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 PHY₁ and L2₁ to connect to the source network. The MN uses Reference Point 1 (RP1) (see Figure 2) 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 MIH packet. The TPoS/proxy PoA communicates with the SRHO-capable TPoA using Reference Point 5 (RP5) (see Figure 2) over network layer transport. When the MIH packet arrives at the SRHO-capable TPoA, it is decapsulated to retrieve the target $L2_2$ frame.

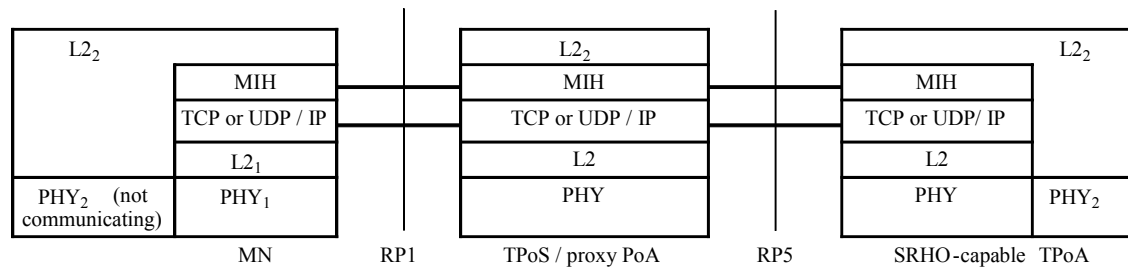


Figure 11c—Transport of the L2 frame of the target interface via a MIH using the logical connection at the Target PoS to the SRHO-capable TPoA.

Figure 11d also shows the transport of the target radio L2 control frame as a payload of a MIH 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 MIH user at the proxy PoA has to communicate with the TPoA using other mechanisms which are out of scope of this specification.

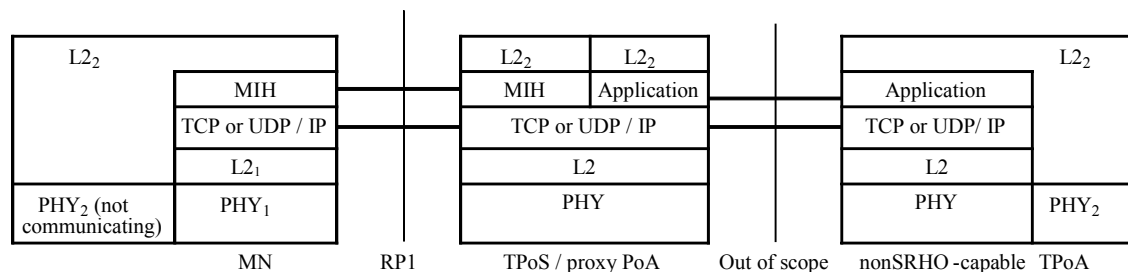


Figure 11d—Transport of L2 frame via the proxy PoA to a legacy TPoA which is not SRHO-capable.

The procedures of communication between the MN and the TPoA are shown in Figure 11e and are as follows:

- 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.
- 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 MIH message if the TPoA is a SRHO-capable node (The target PoA supports MIH_Prereg_Xfer messaging.).
- 2) Otherwise, the proxy PoA may signal 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 for the fact that the messages used for the proxy to PoA signal with the TPoA are outside the scope of this document. L2 frames can be passed to the target PoA either by way of proxy PoA or by MIH_Prereg_Xfer commands.

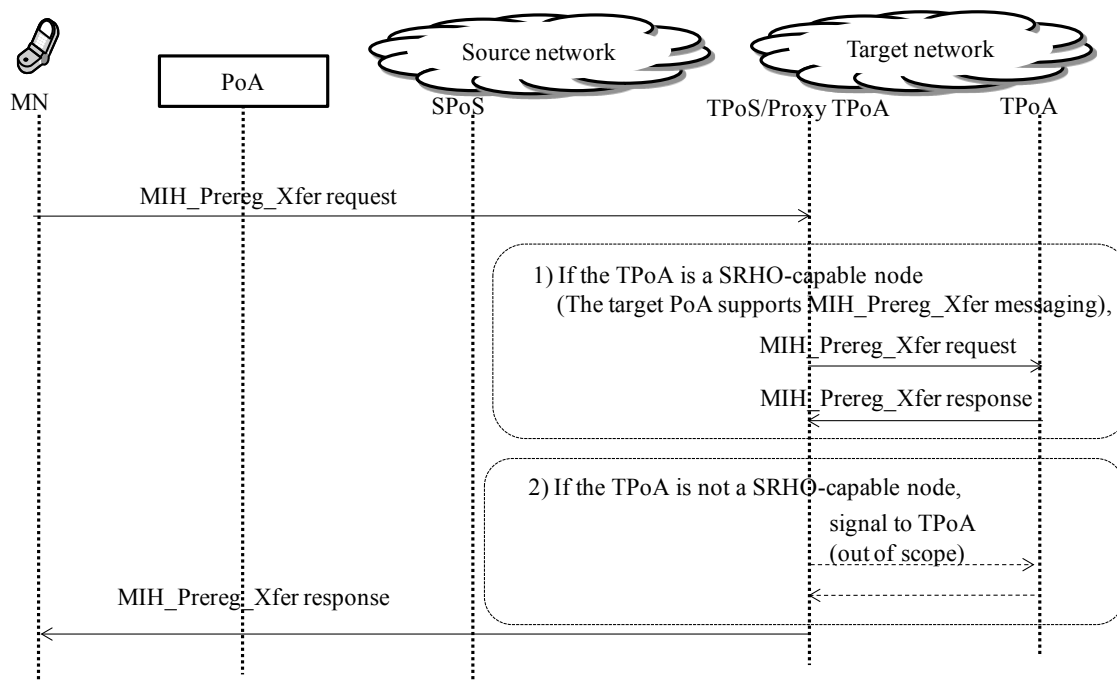


Figure 11e—Communication between the MN and the TPoA.

As shown above, the MN and the target network can exchange link-layer PDUs without using the target PoA's physical radio channel. The exchanged single-radio control frames are processed by the MIHF which receives them at port 4551, the assigned transport layer protocol's port number [B31].