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IEEE Standard for
Local and metropolitan area networks—

Part 21.1: Media Independent Services

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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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Contents

1. Overview 11
1.1 Scope 11
1.2 Purpose 11
1.3 General 11
1.4 Assumptions 12
1.5 Media independence 12

2. Normative references 13

3. Definitions 14

4. Acronyms and abbreviations 19

5. Media independent handover service 22
5.1 Introduction 22
5.2 General design principles 24
5.3 Deployment example and functional model for MIS services 24
5.4 Single-radio handover procedures 27
5.5 Proxy operations 28
5.6 Media independent event service 35
5.7 Media independent command service (MICS) 35
5.8 Media independent information service 37
5.9 Media dependent SAPs 38
5.10 MIS_LINK_SAP primitives 39
5.11 MIS_SAP primitive 43
5.12 MIS_NET_SAP primitive 84
5.13 MIS protocol messages 88

6. Media independent service for software-defined radio access networks 102
6.1 Introduction 102
6.2 Service scenarios and signaling flows 105
6.3 Service access points (SAPs) and primitives 110
6.4 MIS protocol messages 111

7. Media independent service for home energy management system 111
7.1 Introduction 111
7.2 Service scenarios and signaling flows 112

8. Media independent service for radio resource management 119
8.1 Introduction 119
8.2 Service scenarios and signaling flows 119
8.3 RRM service specific MIS_LINK_SAP primitives 136
8.4 RRM service specific MIS_SAP primitives 138
8.5 RRM service specific MIS protocol messages for command service 145

9. Media independent service for D2D communication 148
9.1 Introduction 148
9.2 Service scenarios and signaling flows 148
9.3 D2D service specific MIS_SAP primitives 159
9.4 D2D service specific MIS protocol messages 162

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Annex A (informative) Bibliography 164
Annex B (informative) Handover procedures 167
Annex C (normative) Mapping MIS messages to reference points 180
Annex D (normative) Media specific mapping for SAPs 181
Annex E (normative) Data type definition 182
Annex F (normative) Information element identifiers 188
Annex G (normative) MIS protocol message code assignments 189
Annex H (normative) Protocol implementation conformance statement (PICS) proforma 192
Annex I (informative) Authentication and key distribution procedures 195
Annex J (informative) Mobile node's network access identifier format 200
Annex K (informative) Network discovery for single-radio handover 201
Annex L (normative) Handover decision 204
Annex M (informative) Practical uses of proxy Information Server 206
Annex N (informative) Certificate revocation list guidelines 207

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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

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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.

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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.

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3. Definitions

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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.

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[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.

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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.

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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.

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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.

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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**.

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