A review on characteristic features of MIH Standard and few MIH based Vertical Handoff algorithms

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Abstract: In the 4G - Network system, heterogeneous access technologies will be intergraded, and user will be allowed to roam across heterogeneous network. The devices are capable with several integrated wired and wireless interfaces. In such heterogeneous networks, vertical handover (VHO) is a critical challenge to achieve always best connectivity (ABC) services. In order to address this issue IEEE has proposed a new standard: 802.21 Media Independent Handover (MIH). The goal of the IEEE 802.21 standard is to develop a specification that provides link layer intelligence and other related network information to upper layers to optimize handovers between heterogeneous media. It provides the necessary functionality by exchanging network information that helps Mobile Nodes to connect to the best network among available network. The core entity of the standard is the Media Independent Handover Function (MIHF) which provides abstract services to higher layers through a unified interface. The MIH framework cannot be a standalone solution for executing handovers, and needs to be used with a higher layer mobility protocol. In this paper a study on architectural details of MIH and survey on few vertical handoff algorithm based MIH are discussed.

Index terms: Media Independent Handover, Media Independent Handover Function (MIHF), Media Independent Event Service (MIES), Media Independent Command Service (MICS), Media Independent Information Service (MIIS), MIH Service Access Points, MIH algorithms.

1 Introduction

The architecture for the 4G - networks aims to integrate various heterogeneous wireless access networks over an IP (Internet Protocol) backbone, and thus increases the efficiency of the whole system and improves the users' experience [1]. Seamless handoff is a key requirement for 4G networks. A seamless handoff is defined as a handoff scheme that maintains the connectivity of all applications on the mobile device when the handoff occurs. Seamless handoffs aim to provide continuous end-to-end data service in the face of any link outages or handoff events. In order to provide seamless handoff, one of the main design issues is the vertical handoff support [6]. Unfortunately Current 802 standards do not provide the facility, or even the availability, of information triggers for handover. In order to address issues relating to heterogeneous network handover, the IEEE have proposed a new standard: 802.21, also referred to as Media Independent Handover [2]. The 802.21 standard will enable a mobile device to detect and initiate handover from one network to another [3]. Currently the 802.21 standard is at draft stage and no implementations are available. Apart from IEEE 802.21, there are various standardization bodies like 3GPP (3rd Generation Partnership Project) [4], 3GPP2 [5] has been working on standard development to enable handoff between heterogeneous access networks including both 802 and non-802 networks.

2 Overview of IEEE 802.21 (Media Independent Handover)

The IEEE Media Independent Handover protocol, also known as 802.21, defines an approach to facilitating service transition based on triggering and providing network detection and selection assistance [10]. 802.21 support seamless handover between homogenous and heterogeneous networks. 802.21 does not in itself implement network handover, rather it provides information to allow handover to and from a range of networks including cellular, GSM, GPRS, WiFi, Bluetooth [11]. The network handover enabling function within the protocol is implemented through the MIH function. The MIH function provides new service access points (SAPs) and allows for information to be queried by the upper layers (Layer 3 and higher). Both mobile devices and network hardware must implement the standard to work, but everything should remain backward compatible for non-MIH aware devices. The MIH function offers a generic mobility management interface for multiple different radio access technologies to its MIH users. The following figure 1 gives overview of the standard IEEE 802.21 [11].

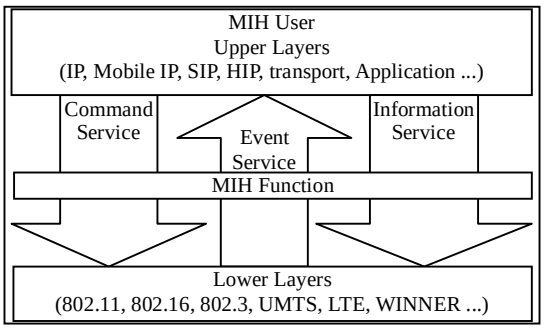

Fig 1: Overview of 802.21

In order to connect to the most appropriate network, the IEEE 802.21 standard uses the process of network discovery and selection to exchange network information, and it is based on certain mobile policies. The MIH in IEEE 802.21 uses two types of handovers: network controlled handovers and user controlled handovers [12]. In case of network controlled handovers even though user battery consumption is less, it results in huge signalling overhead and high processing load in the network elements. Where in case of user controlled handovers the user initiates appropriate actions and there is high battery power consumption.

3 MIH Services

The MIH function provides three basic services - event service, command service and information service. The event service offers delivery of link status messages to the MIH users. The command service offers generic service primitives for controlling the handover. Both events and commands can be local or remote. The information service allows for information retrieval during handover preparation [13].

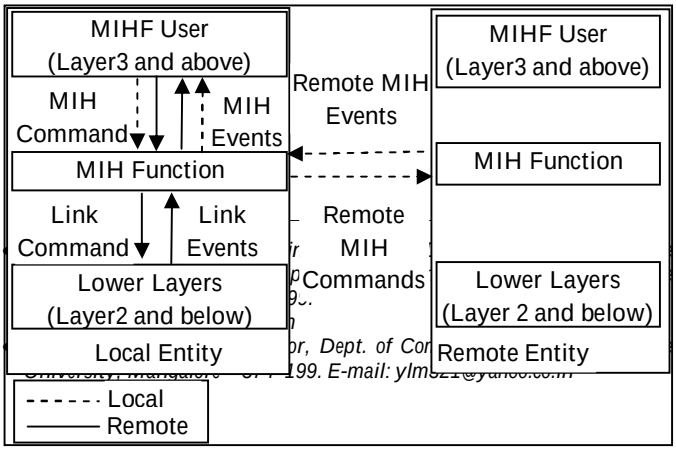

Fig 2: Event, command and information services flow mode

3.1 Media Independent Event Service

The Media Independent Event Service (MIES) includes all MIH actions that helps to detect and notify the events that are relevant to the selection and maintenance of the link over which the mobile terminal obtains network access. Which means the event service offers delivery of link status messages to the MIH users [14]. Input events may affect the state of the MIH decision engine. State changes in the decision engine may generate output events. With respect to a given MIH instance, events may be either local or remote depending on whether they originate at the same network element/station or at a different one [14].

The MIES also provides event classification, event filtering and event reporting corresponding to dynamic changes in link characteristics, links status, and link quality [10]. The MIH Function registers Link Event notifications with the interfaces. Any upper layers entities can register for an MIH Event notification, either in groups or with predetermined thresholds. These entities can be in a local or remote stack. Link Event generated by the lower layers is sent it to the MIH Function and which will report to any entity that has registered either an MIH Event or a Remote MIH Event. The information reported is meant to merely notify of an event occurrence. MIES can indicate or predict the changes in state and transmission behaviour of the physical, data link and logical link layers. This service can also be used to indicate management actions or command status on part of network or some such management entity. Some of the common events defined include “MIH Link Up”, “MIH Link Down”, “MIH Link Going Down”, etc [15].

The Event Service may be broadly divided into two categories, Link Events and MIH Events. Both Link and MIH Events typically moves from a lower to higher layer. Link Events are those events that originate from event source entities below the MIH Function and typically terminate at the MIH Function. Entities generating Link Events include various IEEE802-defined, 3GPP-defined and 3GPP2-defined interfaces but is not restricted to only those interfaces. Within the MIH Function, Link Events may be further propagated, with or without additional processing, to upper layer entities that have registered for the specific event. Events that are propagated by the MIH to the upper layers are defined as MIH Events [16].

With respect to a given MIH instance, events may be either local or remote depending on whether they originate at the same network element/station or at a different one. Local events are generated and consumed within the same network element or station. Remote events originate at a different network element/station from that of the MIH instance that consumes them. Typically, a remote event originates at a network element to be consumed at a mobile terminal, or it originates at a mobile terminal to be consumed at a network element. A peer input trigger brings notification of the remote event to the target MIH instance [27].

3.2 Media Independent Command Service

The command service offers generic service primitives for controlling the handover. MICS refers to the commands sent from the higher layers to the lower layers in order to

determine the status of links or control and configure the terminal to gain optimal performance or facilitate optimal handover policies [16]. The mobility management protocols should combine dynamical information and static information to help in the decision making. The dynamic information includes regarding link status and parameters, and it is provided by the MICS. The static information includes regarding network status, network operators or higher layer service information and it is provided by the Media Independent Information Service. The receipt of a certain command request may cause event generation, and in this way the consequences of a command could be followed by the network and related entities. Commands can be delivered locally or remotely. Through remote commands the network may force a terminal to handover, allowing the use of Network Initiated Handovers and Network Assisted Handovers. A set of commands are defined in the specification to allow the user to control lower layers configuration and behaviour, and some PHY layer commands have being specifies too. Commands are classified into two main categories namely MIH command and Link command [15].

MIH commands are sent by the higher layers to the MIHF if the command is addressed to a remote MIHF, otherwise it will be sent to the local MIHF which will deliver the command to the appropriate destination through the MIHF transport protocol [15]. To enable network initiated handovers as well as mobile initiated handovers, the command service provides a set of commands to help with network selection. Link commands are originated in the MIHF, on behalf of the MIH user, in order to configure and control the lower layers. Link commands are local only and should be implemented by technology dependant link primitives to interact with the specific access technology.

MICS enables MIH users to manage and control link behavior relevant to handover. As shown in Fig. 1, MICS is initiated by higher layers, and MICS commands are sent to lower layers through the MIHF. MIES defines the functions of event classification, event filtering, and event reporting to upper layers. Specifically, different events such as ‘‘Link Up”, ‘‘Link Down”, ‘‘MIH Link Up”, and ‘‘MIH Link Down” are defined. ‘‘Link Up” and ‘‘Link Down” events are generated by lower layers (layer 1 or layer 2), and these events are noticed to the MIHF. Then, the MIHF reports these situations to upper layers by triggering ‘‘MIH Link Up” and ‘‘MIH Link Down” events. The following fig. 3 shows MICS and MIES models.

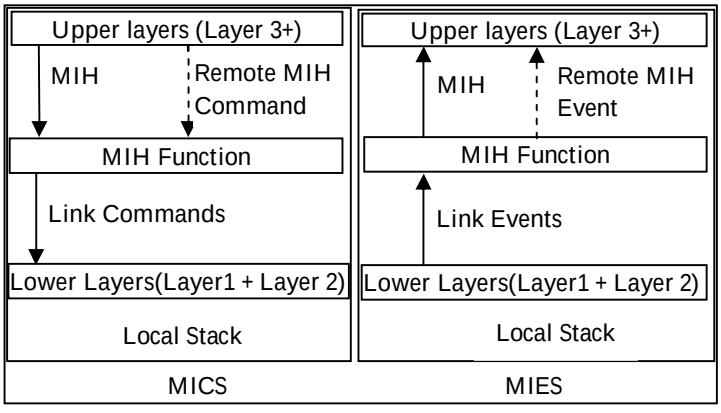

Fig 3: MICS and MIES models

3.3 Media Independent Information Service

The Media Independent Information Service (MIIS) provides a storage infrastructure for information that can be relevant to MIH decisions and a transport mechanism for requesting and distributing such information [11]. It provides the capability for obtaining the necessary information for handovers including neighbor maps, link layer information, and availability of services. Basically, this service provides a two way street for all the layers to share information elements (IEs) to be used to make handover decisions. Following are the four main concerns should be noted regarding the information [12]:

- Access neighbor maps for networks in a geographic area from any network entity.
- Static link layer informational parameters such as QoS support and restricted networks.
- Use reports to allow efficiency.
- Vendor specific features like Prioritize networks, network labels.

MIIS also provides a framework and corresponding schemes by which the MIHF entity can discover and obtain network information within geographic area. It provides a set of information elements, the information structure and its representation and a query/reply type scheme. It also provides access to both static and dynamic information. The dynamic information such as channel information, MAC address and other information about higher layer services will help to make effective handover decisions [17]. This information can be made available via both L2 and L3 layers.

The important component of MIIS is Information Elements (IEs). Information Elements provide necessary information that is essential for a handover module to make intelligent handover decision [16]. The list of supported Information Elements can be very large and may vary from one application to another. The MIIS provides support for only those Information Elements that are necessary for mobility applications. The information service elements can be classified into three groups [17]:

1. General Network Information (GNI): These information elements give a general overview of the network, such as location, name, network ID, POA (Point of Attachment) of the network, IP version, operator of the network.

2. Link Layer Information (LLI): These information elements include the information related to link layer layers such as, link layer parameters (channel, frequency, PHY types), data rates, neighbor information, security, QoS.

3. Higher Layer Information (HLI): These information elements include higher layer services or applications that are supported by the respective network. Some examples are support for Multimedia Message Service (MMS), Mobile IP (MIP), Virtual Private Network (VPN), types of applications supported (e.g. VoIP, e-mail, IPsec VPNs, streaming media, location based), pricing of access (e.g. “a fee is be required” versus “access to the network is free”), use of NAT, roaming partners.

4 MIH SAP

The MIH layer exchanges messages with other layers and functional planes using Service Access Points (SAPs). Each service access point consists of a set of service primitives that specify the information to be exchanged and the format of the information exchanges. The specification of the MIH layer includes SAPs that are media-independent (i.e., insensitive to the interface types that the mobile terminal can support) and others that are medium-dependent [27].

Media-independent SAPs interface the MIH layer with the upper data plane layers, with the network management plane, and with the MIH Communication Module. Medium-dependent SAPs interface the MIH layer with the lower data-plane layers and with their respective management plans [27].

The following three are the important SAPs specified in the MIH services [27]:

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

5 MIH based Vertical Handoff Algorithms

Vertical handover is a process of performing the handover between different wireless technologies, involving the three phases: network discovery, handover decision, and handover execution. In the network discovery phase, an MN gets the neighbor network information such as cost, network security, jitter, bit error rate (BER), and so on. Using the obtained neighbor network information, the MN (or the IS) decides the target network which will be connected in the handover decision phase. During the handover execution phase, the MN does handover to the target network. The role IEEE 802.21 MIH is involved in system discovery and handover decision phase. In this section we will give the glimpse of vertical handoff algorithms based on MIH standard.

An overview of current status of the IEEE 802.21 specification is given in [22]. Kim et al. [18] presented an enhancement to existing MIH information server and proposed improved vertical handover procedure based on enhanced information server (EIS). In the proposed procedure wireless channel conditions are estimated by exploiting spatial and temporal locality at the EIS thus eliminating the channel scanning procedure. The procedure requires localizing techniques or GPS to measure the MN's current location. Simulation result shows that the proposed scheme reduces the vertical handover latency.

In [19] Makris et al. proposed a mobile-assisted vertical handover mechanism based on IEEE 802.21 framework. The advantage of proposed method is that, it takes into consideration of network parameters as well as user preferences and thus provides service continuity and increased system efficiency. Another VHO schemes based on IEEE 802.21 to support vertical handoff between Wi-Fi and WiMAX was proposed by Eastwood et al. [20]. The drawback of the proposal is the lack interaction between the MIH framework and the QoS specifics of the access technologies. Performance measurements of the proposed procedure are also not given.

Christakos et al. [21] showed that the handover performance can be improved for Fast Mobile IPv6 by using Media Independent Information Service (MIIS). Pre-authentication allows the MN to authenticate with the target while connected elsewhere on the network. In this method, MIIS is used to provide Authentication information and thus reducing the handover time. The limitation of the proposed method is that, an MIH signal to indicate the authentication of MN with PoA is not considered in this work. A handover decision algorithm using MIH services is proposed in [26]. The algorithm is used to support vertical handoff between Wi-Fi and WiMAX networks with QOS provision. The algorithm uses Analytic Hierarchical Process (AHP) to calculate the weights of various traffic parameters and uses simple additive weighting (SAW) or MEM to calculate the QoS score. The simulation results show that the proposed algorithm provides smaller handover times and lower dropping rate than the basic vertical handover method.

In [25] Neves et al. proposed enhancement to MIIS, by adding context-aware information. The proposed context-aware information server is able to store, manage and deliver real-time dynamic information retrieved from both the network and the terminal side entities like user preferences, running services, mobile nodes characteristics and available network resources. The advantage of the proposed method is that, by using context-aware information server the handover preparation and decision phases are optimized.

Similarly, another method based on context-aware information is proposed by Ghahfarokhi et al [24]. In this method enhancement to Media Independent Handover to include context-aware handover decision is given. In the proposed method the idea of handoff-aware network context gathering is used for renewal of dynamic context in MIH information server. The proposed method efficiently accommodates the dynamic context of access networks along with the ordinary static context in IS. The advantage of this proposed method is that it makes use of a multi-policy scheme to select the target point of attachment. The following table gives comparison of the algorithms.

Algorithm	Features	Application Area	Merits	Demerits	Simulation tool
[18]	Enhanced IS and Channel conditions estimated by exploring spatial & temporal	Between WiMAX and HSDPA	Channel scanning time is eliminated, Reduced handover	requires localizing techniques or GPS to measure the MN's	COST-231 Hata model

	locality.		latency	current location	
[19]	Mobile assisted handoff and takes into account of user preference, network parameter.	Between UMTS WLAN	Service continuity, increased system efficiency, fast handover	Requires network to calculate the position & velocity of the MN, simulation of the algorithm is remaining.	-
[21]	MIIS is used to provide authentication information, uses pre-authentication concept.	Between WiMAX and WLAN	Improvement in FMIPv6 performance, Reduced handover time	MIH signal to indicate authentication of MN with AP is not considered	NS2
[26]	Using AHP to calculate weights of various traffic parameters & SAW to calculate QoS score	Wi-Fi to WiMAX	Smaller handover time, lower dropping rate	Limited to Wi-Fi to WiMAX	-
[25]	Integration of MIH with wireless technology, Based on context-aware IS which is able to store dynamic information of real-time application	UMTS, Wi-Fi, WiMAX	Optimized handover preparation & decision phase	Several extension needed to 802.21 to update message	NS2

Table 1: Comparative summary of Vertical Handoff Algorithms based on MIH

6 Conclusion

A present challenge in 4G networks is to provide seamless mobility, regardless of the access technology in use. One of the most promising frameworks to handle seamless mobility 4G networks is the Media Independent Handover (MIH) standard. In this paper, we presented an overview of the IEEE 802.21 Media-Independent Handover Services standard. This standard focuses to provide the seamless handovers in heterogeneous environments. For this MN must be capable of connecting to multiple access networks via multiple interfaces. The new IEEE 802.21 standard specifies link layer intelligence and other related network information to upper layers in order to optimize handovers between networks of different types. Thus IEEE 802.21 is an important step towards 4G network. It is expected that in the future it is widely deployed and there will be major works to be carried out to further amend and extend it in order to provide for even better services.

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