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MIH: State of Art and a Proposed Future Direction in the Heterogeneous Wireless Networks

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Abstract: The handover between different access technologies is considered as one of the most challenging tasks in wireless networks. Vertical handover can achieve the concept of next generation networks in terms of the wireless networking environment, where any service can be optimized and apparently delivered at any time. To achieve seamless handover between heterogeneous wireless networks a new mechanism is needed to work in parallel with IEEE 802.21 standard. The current solution is suitable for wired networks. However, it has a limitation in fourth generation wireless networks like: WiMAX and LTE. The development of these networks will provide more services to the user. On the other hand, new parameters must be considered in the handover process. This paper discusses solutions for achieving seamless vertical handover between different mobile technologies. This review investigated various enhancement of Media Independent Handover (MIH). The results of this investigation can be used in new researches in mobility management protocols and cross-layer techniques. The new research will provide effectual collaboration among assorted wireless networks and therefore enables optimized seamless service mobility to the end-users.

Key words: Vertical handover, heterogeneous wireless networks, IEEE 802.21, MIH

INTRODUCTION

Since the past decade, the mobile technologies have become an essential constituent of our day to day life. The business and technological word has seen enormous growth in the domain of wireless communication due to the escalating demand from all the quarters. Wireless communication technologies have evolved from the first generation to the fourth generation (4G) (Li *et al*., 2009). Each generation offers different technologies, representative standards, radio frequencies, bandwidths, multi-address techniques, core networks and service types. The development of advanced wireless access technologies such as LTE and WiMAX delivers more sophisticated services for customers. The deployments will be able to provide connectivity between heterogeneous networks in a number of specific locations to fulfill the expectation of users (Corici *et al*., 2010; Gunasundari and Shanmugavel, 2007). The emergence of IEEE standards (WiMAX, Wi-Fi) and the potential capacity of fourth generation (4G) networks such as Ultra Mobile Broadband (UMB) or Long Term Evolution (LTE) assure to provide improved bandwidth and coverage (Rouil *et al*., 2010).

Handover is an event or process of transferring an ongoing call or data of a mobile user who moves from one wireless base station to another (Savitha and Chandrasekar, 2011a). The handover falls into two categories such as: horizontal and vertical. The former associated with the handover within the same wireless access technology whereas the later is associated with the handover between heterogeneous wireless accesses technologies. However, the 4G wireless networks are likely to help mechanisms to achieve seamless vertical handover. For this to be achieved, suitable integrations of multiple architectures is needed, which sometimes is referred to as networking solution (Yussof and Hang, 2009; Yussof and Ong, 2010; Rahmati and Farhadnia, 2011), mobility handling, integrated Quality of Service support and a unified AAA (Authentication, Authorization and Accounting) handling which are the most crucial elements of networking solution (Ei and Furong, 2008; Eshanta *et al*., 2009). Supporting multi-technologies mobile devices to have the capability of seamless switching between various wireless access networks like WiMAX and LTE is an important research topic in wireless communications networks.

The IEEE 802.21 working group defines the Media Independent Handover (MIH) to provide information of network environment, cross layer control and services to optimize the vertical handover process (Cicconetti *et al*., 2010; Neves, 2009). This standard supports the increasing user and service demand of full

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mobility and seamless handover of heterogamous mobile networks. The IEEE 802.21 developed MIH framework, which depicts the mechanism to optimize and assist the handovers in the same and varied technologies, regardless of the nature of the network (Neves *et al*., 2011). Nevertheless, the MIH framework is capable of enhancing the handover process in the heterogeneous network using if there is no timely information, the Mobile Node (MN) would disconnected before carrying out all the essential signaling (Kim *et al*., 2011). The present solutions employ the protocols that are created for wired networks, such as Transmission Control Protocol (TCP) and User Datagram Protocol (UDP), which have restrictions in a portable and wireless environment (Leni and Srivatsa, 2008). In order to make sure flawless handover and proficient utilization of resource in different networks, a new mechanism needs to be used extensively. This study focuses on this problem and discusses proposed solutions that are used in parallel with Media Independent Handovers (MIH) scheme to provide flawless mobility with minimized latency and avoiding packet loss.

MEDIA INDEPENDENT HANDOVER (MIH)

In order to optimize the handover process among assorted networks, the IEEE 802.21 standard (Khan *et al*., 2010) has defined a middleware architecture including a cross layer communication protocol and three services as shown in Fig. 1 that helps handovers transversely in assorted networks. These services are administered and organized by a 4th service known as management service. Through the service management primitives, the MIH function is capable of discovering other MIHF entities (Rouil *et al*., 2010). The detail of the three services that were mentioned is listed as follow:

Media independent event services (MIES): This tracks the events and extradites triggers from both the local and remote interfaces. However the events can specify the modification in the state and the transmission behavior, like suggesting a related node modification in link quality, data rate or other alterations associated to Access Point (AP) have occurred.

Media independent command services (MICS): This constitutes a set of instructions that might be transmitted from the higher layers to the lower layers in the protocol stack or reference model, like instructions transmitted from higher layer to MIH function and instructions transmitted from MIH function to lower layers. Commands can be both local and remote.

Media independent information service (MIIS): This service offers a set of information aspects, such as: query/response structure to permit nodes to find out and acquire the information of networks. The information for example the existing network in a neighborhood, capabilities, services provided by a node, network point of attachment, IP version, network operator cost and other network information.

The users of get the services via the Service Access Point (SAP) and the services are provided by MIH. The higher layers (L-3 and above) and lower layers (L-2 and below) respectively (Khan *et al*., 2010; Marques *et al*., 2010) have the MIHF interfaces served by MIH-SAP and MIH-LINK-SAP.

IEEE 802.21 provides a clear interface that:

- Furnishes concurrent link state event reporting (Event Service)
- Enables user to control link state of handover (Command Service)
- Offers automatic or on demand intersystem information (Information Service)

The scope of IEEE 802.21 standard is to establish mechanisms that facilitate seamless connectivity among

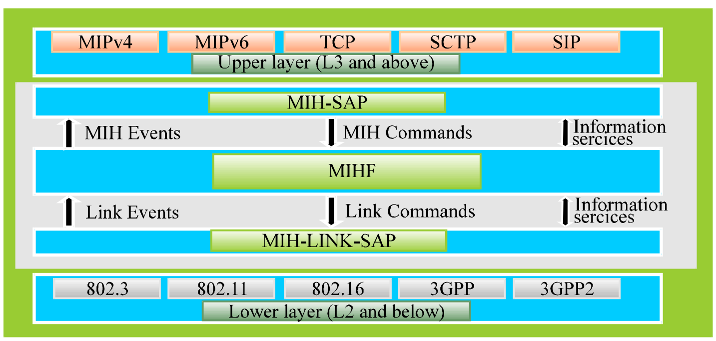

Fig. 1: The MIH reference model (Khan *et al*., 2010; Marques *et al*., 2010)

heterogeneous networks such as IEEE 802 and cellular networks.

VERTICAL HANDOVER (VHO)

The handover process comprises at least two infrastructure nodes and one client node. The client node is required to be attached to one of the infrastructure nodes. When the condition of the connectivity parameters of a link is dropped below a threshold value, the handover process will begin. This process can be divided into steps in a number of ways. Some research works carry out the division based on classification of phases such as the one proposed by Velayos and Karlsson (2003), where handover consists of three phases (Detection, Discovery, Execution). Other research works (Savitha and Chandrasekar, 2011b) use the division where handover consists of the following phases as shown in Fig. 2.

Handover initiation phase: Dynamic checking of network parameters such as signal strength and link quality of available networks are carried out constantly. Handover process begins whenever there is a better signal strength or link quality.

System discovery phase: In this phase the mobile user discovers its neighbor network and exchanges information about quality of service (QoS).

Handover decision phase: This phase compares the Mobile user's QoS and the neighbor network QoS and makes the decision to which network the mobile user has to initiate the connection.

Handoff execution phase: This phase establishes the new connection and releasing the old connection. If the MN decides to implement Vertical Handover (VHO), it executes the VHO procedure that is required to be associated with the new mobile network.

Most researchers have focused mainly in the VHO decision phase, which describes the handover decision and how the decision makers choose the best from available networks. Also, there are many researchers who are trying to find the optimum mobility management solution in the handover execution.

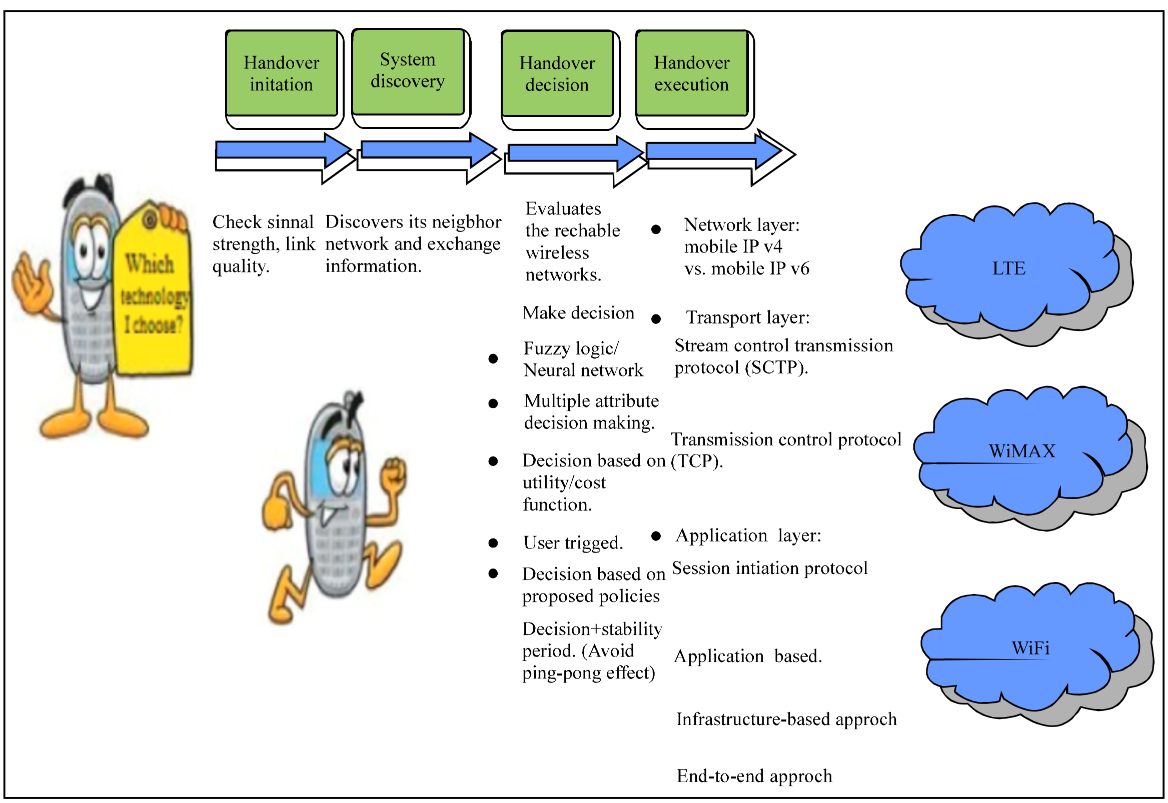

Fig. 2: Handover process

Table 1: Challenges in vertical handover

ZZ	Description of challenges	MIH proposed solutions and research development
Network discovery and selection	Automatic scanning	Enables inter-RAT network advertisements
	Allows users to choose between different technologies	Offers a means to inquire candidate target networks and their properties
IP session continuity	Reducing the user interruption throughout handover	Offers link layer triggers to optimize the performance of handover
Minimize latency and single radio transmission	Minimize handover latency	Enables target network preparation
	Just one of the dual-radio devices will be able to transmit during handovers	Furnishes signaling for resource query
Control the network selection	To direct the target network that has to be selected by users (network-initiated handovers)	Facilitate operators to implement handover policies and decisions
	Reporting of radio measurements	Enables inter-RAT measurement reporting
Seamless connection and mobility	Omnipresent connectivity and the capability to flawlessly and steadily roam across networks of diverse technologies	An enhancement of MIH proposed by the author secure to cater for this challenge is as follow: A MIH service layer that operates by an exchange center shared by participate service provider
Reduce power consumption	To avoid unnecessary handover	Using MIH information service (IS) to avoiding unnecessary scanning
Seamless operation of services and applications between technologies	No interruption of service and application between different technologies	Maintain an information database of the appropriate environment for applications and service

CHALLENGES IN VERTICAL HANDOVER

Researchers have faced a lot of challenges in order to provide handover in heterogeneous networks. These challenges are derived from previous works together with proposed solutions based on MIH are described in Table 1.

The essence of this table is identification of the challenges faced by the vertical handover and how to use MIH to find an optimum solution for these challenges.

ENHANCEMENT ON MEDIA INDEPENDENT HANDOVER FRAMEWORK

Swapping of connectivity among various wireless technologies is called vertical handover. It constitutes four phases: handover initiation, network discovery, handover decision and handover execution. The MN acquires the neighbor networks information like: available bandwidth, monetary cost, security of the network, delay and packet loss in the network discovery phase. During the decision phase, by using the information obtained from neighboring networks, the MN decides which network it will be connected. After that in the handover execution stage, the MN carries out handover to the target network. MIH can be used in both the network discovery and handover decision phases. Hence, research works on MIH can be classified into two categories: (1) how to choose a suitable target network? and (2) how to decrease the delay in the handover process?

A number of network selection methods with QoS provision were introduced. An intelligent network selection method based on multi-homed session initiation protocol (SIP)-based network mobility (NEMO) setting was proposed by Huang *et al*. (2009). Furthermore a new network-initiated handover scheme that constitutes QoS measurement setup, passive reservation and activation steps to aid the stability of QoS between the UMTS and Wimax 802.16e networks was introduced by Baek *et al*. (2008). Kim and Lee (2009) suggested a load balancing networks. In contrast, to minimize the handover delay by using MIH, Huang *et al*. (2008) proposed a pre-binding update scheme, which uses the information of the network that obtained from the IS. Magagula and Chan (2008) analyzed the lessening of handover delay in the network-based localized mobility management structure which is helped by MIH services. The Enhanced Information Server (EIS) was introduced by Kim *et al*. (2011) to speed up vertical handover process. Nevertheless, these works have not focused much in terms of the design of the IS architecture and the development of appropriate algorithms for seamless vertical handover. Therefore, these issues open up opportunities for future research work.

Many researchers have proposed new methods to enhance MIH for achieving seamless mobility requirements. Neves (2009) had proposed a method called EMIHF. The proposed framework expands MIH by offering the ability to equip QoS resources in the target network while preparing for handover. Neves *et al.* (2011) also investigated a new concept in Media Independent Handover (MIH). This novel idea employs a context-aware information server, which is capable of storing, managing and delivering concurrent dynamic information entities recovered from the network and the terminal. Examples of objects are available network resources, user preferences, mobile nodes characteristics and running services. Lampropoulos *et al*. (2008) identified the seamless mobility principles and employed this principle as the base for evaluation of MIH to satisfy the necessities by mobile applications on minimum obstruction during an inter-technology handover. Cicconetti *et al*. (2010) proposed novel principles and technical solutions to enable network-assisted handover in the heterogeneous wireless networks by exploiting the MIIS concept of IEEE 802.21. The other researches that have proposed Enhancements to Media Independent Handover can be categorized according to the following classifications.

Enhancement in the vertical handover prediction: Many studies have adopted Received Signal Strength (RSS) as a key indicator of network availability. In wireless networks, although a rapidly deteriorating value of RSS can indicate that the MN is approaching the coverage boundary and may soon perform an imminent handover (horizontal or vertical); in heterogeneous networking the metric alone cannot be considered as a reliable trigger. Therefore a more robust and proactive metric is needed that not only gives the current status of network coverage availability but it can also predict during of the coverage and availability of the probable network services. This knowledge is important in the handover initiation process during vertical handover, as it can at a very early stage allow the mobile node (MN) to take important decisions on matters of resource allocation and QoS management. The researchers who discuses the prediction mechanism can be summarized as follows. Joe and Shin (2010) proposed a mobility based prediction algorithm with dynamic Link Going Down (LGD) triggering for VHO by applying the IS of MIH. Jung *et al*. (2010) proposed an efficient VHO scheme to allow the MN to handover between mobile WiMAX and WLAN networks. Yoo *et al*. (2010) discussed Timely effective handover mechanism using MIH primitives in heterogeneous wireless networks. Yoo *et al*. (2009) proposed a new predictive link trigger mechanism using a Least Mean Square (LMS) linear prediction for seamless VHO networks. With assist of the neighbor network information that obtained from MIH IS. Yousaf *et al*. (2009) presented an intelligent model for generating MIH LGD trigger reliably. Liu *et al*. (2008a) proposed a new method to estimate when a device needs to take practical actions and prepare handovers. Liu *et al*. (2008b) introduced a novel proficient triggering scheme to predict when a device requires to carry out proactive actions and prepare for handovers. With the smart triggering, events such as LGD might be predicted more than 1 second ahead of time. Popovici *et al*. (2011) presented a new predictive mechanism to describe video streaming application build to evaluate our prototype system. Liang *et al*. (2011) presented an auto- retreating RSS prediction with hysteresis for a mobile node (MN) to implement a predictive vertical handover. Fallon *et al*. (2010) presented a Service Oriented Link Triggering Algorithm (SOLTA) which triggers the Link Going Down (LGD) and Link Down (LD) events based on link layer metrics but subject to the performance characteristics of the supported class of service. Salih *et al*. (2012) proposed a fuzzy based prediction algorithm with dynamic of links triggering for vertical handover by applying the Information Server (IS) of IEEE 802.21. The proposed solution can minimize unnecessary handover.

Enhancement in the vertical handover decisions: The process employed by the mobile terminal to choose the best from a set of available networks is called as handover decision. Consequently, this is the most significant step that influences the normal operation of mobile communication. Particularly this is true when the mobile terminals make a VHO decision, where there is availability of a lot of access networks with diverse characteristics (Parameters) (Dhar *et al*., 2011; Ei and Furong, 2010). The VHO decision is one of the critical issues in the environment of heterogeneous networks. MIH framework is introduced to enhance the user experience of mobile devices by helping handover in the heterogeneous wireless networks. However, the information obtained from MIH is very important in the VHO decision process. Figure. 3 shows the vertical handover decision framework by using MIH with decision algorithm.

Andersson (2010) has presented a new control plane, named “Mobile Mediator Control Function”, which offers a set of events and commands through an additional service access point. Monger *et al*. (2008) have proposed the Generic Metering Infrastructure (GMI), an information distribution system that might be useful for handover in the heterogeneous network environment. Ramachandran and Haiharan (2008) have presented an algorithm to improve congestion control in MIH framework.

There are four main directions in the research of VHO decision algorithms based on. Policy, fuzzy logic and Multiple Attribute Decision Making (MADM) and rank aggregation approaches. In the policy based approach, a cost function is defined and the users are permitted to design rules for selecting the best wireless network. Here, the features of various networks are considered to determine the best trade-off. The cost of using a particular

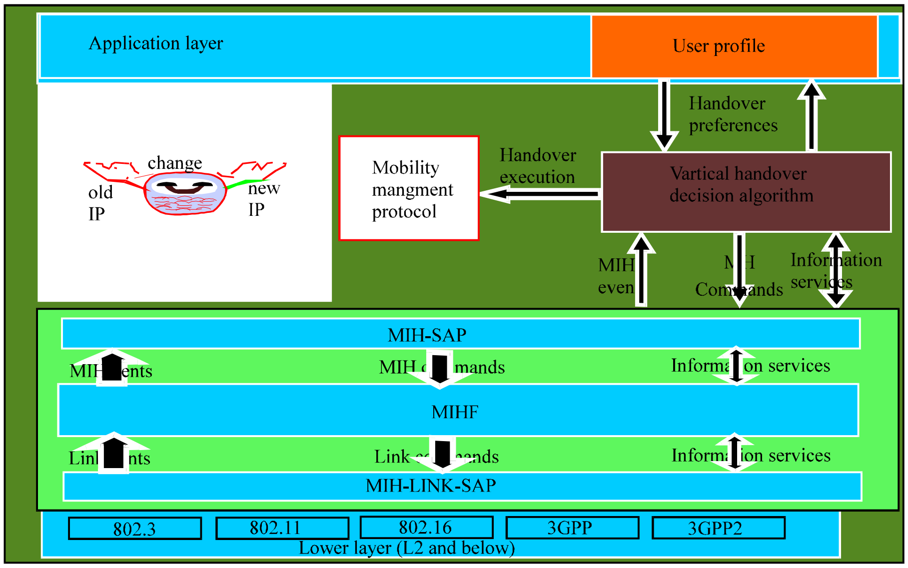

Fig. 3: Vertical handover decisions making

Table 2: Decision matrix

	Parameters to consider				
Networks to select	Delay	Power consumption	Cost	Bandwidth	Parameters to consider (J)
WiMAX	V1,4	V1,3	V1,2	V1,1	V1,j
LTE	V2,4	V2,3	V2,2	V2,1	V2,j
Wi-Fi	V3,4	V3,3	V3,2	V3,1	V3,j
UMTS	V4,4	V4,3	V4,2	V4,1	V4,j
networks (I)	Vi,4	Vi,3	Vi,2	Vi,1	Vi,j

network is a function of many factors namely, the available bandwidth, the monetary cost of using the network, power consumption of mobile devices and delay. These parameters are shown in Table 2. An example of policy-based approach is the Always Best Connected (ABC) method that selects the best from available networks (Gazis *et al*., 2005).

Dimitriou *et al.* (2011) discussed the need of facilitating architecture for distributed VHO decision making. The main problem of this method is difficult to evaluate the dynamically changing parameters such as network load, Table 2.

The fuzzy logic inference system based on fuzzy logic-based approaches is employed as follows: Each decision factor, which is a particular network parameter, is associated with a rule or the member function. The level of truth generated by each rule that was pre-proposed is then obtained and calculated. The sum of these truth values will be used as a handover decision indicator for each base station. Jun *et al.* (2009) proposed a VHO decision algorithm depending on fuzzy inference system for handover decision between Wi-Fi and WiMAX.

In MADM-based approach, network selection is devised as a multiple attribute fuzzy decision-making problem. The fuzzy logic is employed to correspond with the vague information of some features of the mobile networks and the user preferences. There are two steps in fuzzy MADM method: The first step changes the fuzzy data into a real number. The second step employs the classical MADM methods to establish the level of the candidate networks. Wu *et al.* (2009) proposed a MADM-based terminal-controlled VHO decision scheme using MIH services in integrated Wi-Fi and WiMAX networks environment to offer connectivity with QoS services. Khan *et al.* (2010) proposed the user-centric interface selection decision, where negotiation among users and network operators is carried out using multi-attribute auctioning mechanism. Jiadi *et al.* (2009) introduced a user-adaptive VHO scheme depending on MIH in the integration of UMTS, Wi-Fi and WiMAX networks. The scheme uses a decision making method based on classical fuzzy MADM method and chooses the most suitable network for users. Rehan *et al.* (2009) developed an inclusive cross-layer solution, called Vertical Handover Decision (VHOD) approach. Tawil *et al.* (2008) introduced a novel Distributed Vertical Handoff Decision (DVHD) scheme using the MIH Function as an intermediate for message transportation between the MN and the heterogeneous Target Visited Networks (TVNs). The classical MADM methods that are most commonly used are listed as:

- GRA (Grey Relational Analysis) Andersson *et al.* (2010)
- SAW (Simple Additive Weighting) (Yang *et al.*, 2008; Filho and Madeira, 2011)
- MEW (Multiplicative Exponent Weighting) (Yang *et al.*, 2008)
- TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) (Liu, 2007)
- AHP (Analytic Hierarchical Process) (Ramirez and Ramos, 2010; Yang and Wu, 2008)

The approach based on rank aggregation has enormous prospect to handle this issue. Here, the problem of network selection is illustrated as a rank aggregation problem. Consequently the multiple ranks are acquired on a set of networks based on various decision factors. A single rank for each bases station is then acquired by aggregating the decision factors and the top ranked network is chosen as the preferred network. Two weighted Markov chain (WMC) based methods have been introduced. Wang *et al.* (2010) proposed an Enhanced MIH framework by using rank aggregation method. Wang *et al.* (2009) elucidated, two decision factors dependent problems. There are: (1) Imprecise dimension on decision factors and (2) Various networks have identical decision factor values.

Mobility management enhancement: Seamless mobility is acquired by utilizing an appropriate mobility management scheme that is at the network layers. There are suggestion on new layers for dealing mobility and novel ideas for handling mobility in the network. When a MN moves a user's session between networks, the IP address will be modified to permit work (Awan *et al.*, 2008). When a MN moves a user's session between networks, the IP address will be modified to permit the Corresponding Node (CN) to connect to the MN and enable the user to continue. Therefore, mobility management needs to be used. The mobility management problem has been resolved in various layers (Kusin and Zakaria, 2011; Abed *et al.*, 2011). These include the network, transport and application layers. The most common methods used are Fast Mobile IPv6 (FMIPv6),

Table 3: Mobility management enhancement

Z	Mobility management descriptions	Limitation
Network	Noor and Edwards (2011) presented a new dynamic QoS suppling mechanism for network mobility integrated with MIH in different wireless network	Does not compare the proposed mechanism with other mobility layer management solutions like PMIPv6, FMIPv6 and PFMIPv6
MIP	The proposed mechanism has improved network performance higher than MIPv6	
	Trong *et al.* (2008) have introduced an improved handover mechanism beyond a heterogeneous environment with various network interfaces. The mechanism was implemented in a MN with the MIH services and advance duplicate address detection (A-DAD)	This approach can reduce the handover latency, the consequences of the utilization of MN's power. But, the mechanism is sensitive to the movement speed of the MN
	Magagula *et al.* (2008) have introduced the experimental results of a proxy mobile Ipv6 (PMIPv6) scheme to reduce handover authentication delay in IEEE 802.21 based network	The proposed mechanism did not discuss the other handover delay (discovery, con-figuration, and binding update procedures)
FMIPv6	Mussabbir *et al.* (2007) have introduced a mechanism that optimizes the FMIPv6 handover procedure with the help of MIH services for vehicular networking	The anticipation mechanism is helpful, however it also adds more problems such as handover starting earlier and the issue of losing connectivity due to unexpected deprivation of the wireless link
	Solouk *et al.* (2009) have introduced an enhanced link layer mechanism to help FMIPv6 for seamless VHO. They have proposed a novel access router discovery method and consequently introduced VHO algorithm	Many problems such as ping-pong effect are bound to happen when the actual target network is not selected precisely
Transport layer	Griffith *et al.* (2010) have supplied a general framework that can be used to obtain performance metrics for MIH message over either UDP or TCP	There is limitation in varying network parameters such as data rate, MIH message size and the network transit time delay distribution
TCP	Rouil *et al.* (2008) introduced solution to use SCTP as an efficient transport solution for MIH. The solution combines a path selection algorithm and the use of MIH services to optmize SCTP's behavior	The default retransmission mechanism and movement detection need to be optimized by using the MIH services
	Chung *et al.* (2010) implemented the MIH on the Linux operating system. The MIH module was integrated with SCTP, the adaptive QoS playout (AQP) algorithm and two MIH-IS based user motion	The developed MIH software can enhance the performance of MIH-based VoIP system. But they did not apply it internet protocol television (IPTV)

Table 3: Continue

Z	Mobility management descriptions	Limitation
	detection (UMD) algorithms into a high quality VoIP system	
	Rouil *et al.* (2010) proposed an effective solution for transferring MIH messages and evaluate its borders using SCTP	The connectivity that is required to carry out handover probably suffers from augmented packet loss
	Arun and Moni (2010) proposed an efficient solution using a sender-side stream control (3SE), transport-layer protocol extension, which alters the SCTP protocol	The delay faced by a wireless station while receiving the data packets 3SE re-sequencing times are higher than SCTP
	Jung *et al.* (2007) proposed SIP-based inter networking scheme between Wi-Fi and WiMAX with MIH functionality	They did not provide solution for the problem of uneven traffic flow due to the VHO
Application layerer	Kim *et al.* (2008) suggested a codec adaptation for vertical handover (ACAV), aiming not only to increase the throughput but also to minimize delay at MN's. The proposed ACAV mechanism uses invite and update messages in SIP	Each network eventually must provide the bandwidth occupation
SIP	Kou *et al.* (2010) have combined SIP, FMIP and MIH protocols by cross-layer design andoptimized these protocols signaling flows to enhance the performance of VHO	Not concerned with how to choose the handover target network, they assume the link layer VHO decision is always applicable and they proposed that HDM algorithm is in charge of choosing the target network
	Lebre *et al.* (2011) presented a framework, which integrates a cross-layer abstraction approach towards sensor devices of different families, while enables the integration of media-independent sensor information into context consumers with the goal of optimizing network management, as well as application operation and usability	Power management can be a critical aspect due to usage of batteries with limited life-time in most of the sensor nodes
Other application	Andersson *et al.* (2010) described and evaluated a new architecture that expands the MIH information service. This architecture depends on a three-layer structure with location-to-service translation (LoST) servers, service provider servers and independent evaluator servers. The evaluator servers are occupied with coverage and quality of service information offered by loyal users	The automatic decision process only uses static information and did not consider dynamic information

Stream Control Transmission Protocol (SCTP) and Session Initiation Protocol (SIP). Table 3 shows the proposed solutions that are based on the combination of mobility management protocols with MIH for achieving enhancement in the handover process. The table also includes the limitation of the research work.

RIWCoS PROJECT

RIWCoS is a project that aims to integrate different wireless communications technologies into a common hybrid communication infrastructure. The main objective is to develop, demonstrate an open, secure, fast-reconfigurable content delivery platform based on MIH framework. This platform is for high quality services (transport and distribution) by using different wireless access networks for mobile and residential end users. Consequently, the platform provides service continuity to the mobile users while they are crossing multiple access networks based on different mobile technologies. This includes Cellular Mobile Telecommunication Networks (LTE and UMTS) and IP-based Wireless Networks (WLAN and WMAN) (Obreja *et al.*, 2010).

As far as this study is concerned, all RIWCoS related publications are virtual implementations based on simulation package such as QualNet and SDL. The RIWCoS simulation model consists of two main entities, a basic simulation scenario created in QualNet and RIWCoS protocol prototype developed in Specification and Description Language (SDL). Both components are necessarily interconnected through a specially developed interface. The overall RIWCoS architecture consists of an Interoperability Manager module for each wireless communication system for the purpose of mobility management. In a MIH enabled network, this module should interoperate with the MIH function (Fig. 4) to ensure the cooperation between the different technologies. It has the following functionalities: provision of information to the mobile terminal about the neighbor networks, requirement of link state information and MIH messages handler. Link Interoperability Modules (one for each of the link layer technologies) ensure cooperation between technology specific link layers and the Interoperability Manager they are used to add MIH functionalities to each type of MAC layer. There is also a Resource Manager (RM) entity whose main function is to collect information and perform handover decisions based on a certain algorithm. The information is based on parameter monitoring performed by the Link Interoperability Modules and the selection process which takes into account the user profile, link quality parameters, network load and quality of service (Vulpe and Obreja, 2011).

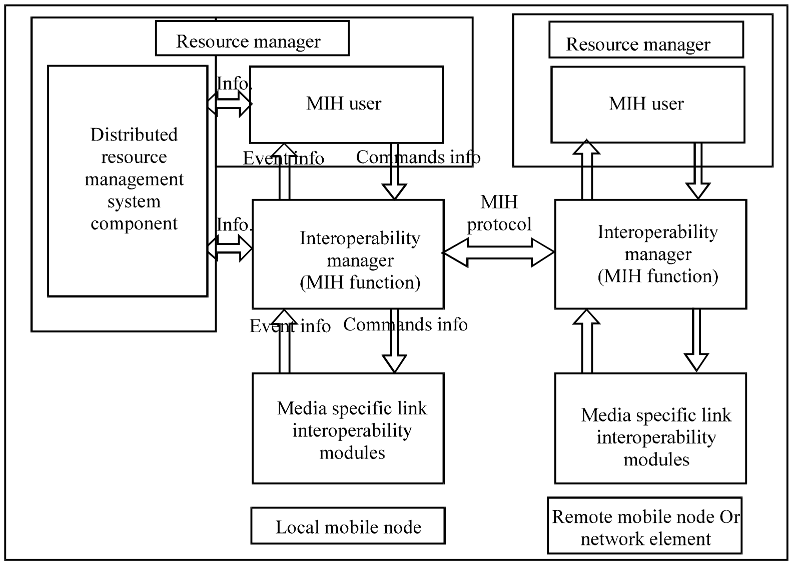

Fig. 4: RIWCoS system architecture (Vulpe and Obreja, 2011)

Latkoski *et al*. (2009, 2010a) have provided a unique combination of protocol development and network simulation method by merging the SDL developer and QualNet simulator. Also, Latkoski *et al*. (2010b) has introduced an approach of developing prototypes and optimizing reconfigurable mobile multi-interface terminal. Fratu *et al*. (2011) have described the roadmap of RIWCoS design for recognizable interoperability and stability of service in wireless hybrid communications: This includes the MIH standard, generic modules design and specification and incorporation. Ognenoski *et al*. (2009) have elaborated the design of RIWCoS. Whereas, Gavrilovska *et al*. (2008) have elaborated the interoperability issue towards 4G development (Atanasovski *et al*., 2010; Latkoski *et al*., 2011). The summarized the RIWCoS development procedure of a novel architecture for organizing the resources in heterogeneous wireless networks. The researchers of RIWCoS project claimed the capability of integration between different networks and provide a solution for mobility management. Nevertheless, the RIWCoS project did not provide anything substantially different from MIH. No mention of enhancement on mobility management and handover decision.

DISCUSSION

The convergence of mobile networks and services poses a serious challenge for network engineers. At the core level, the convergence will lead to an all IP network. At the access level, the coexistence of various technologies will offer excellent opportunities for services availability and quality. To take advantage of these opportunities a common mobility management framework is required. It should be able to provide service continuity, to optimally manage the network resources for the purpose of improving the performance and capacity of system and to complete the service quality offered to the users.

Most functionality that requires supporting session continuity is depending on the intricate interactions that are precise to each and every technology. IEEE 802.21 standard offers a cross layer solution that enables higher layers to communicate with lower layers to offer constant session without focusing the details of each technology. It provides the missing, technology-independent abstraction layer. This concept can be subjugated by the IP stack or any upper layer to enhance the interaction with the fundamental technologies and eventually lead towards an enhanced handover performance. With multiple networks that support vertical handover, terminals can move between these networks without losing connectivity or interrupting active services. Not only this allows users to move freely but also release them the burden of network selection or other related activities.

The seamless vertical handover performance among different wireless networks by the minimization of the vertical handover latency is the primary driving force of researchers in the wireless heterogeneous networks. Most researchers attempt to find a mechanism for reducing the handover latency at authentication and message exchange amid different access networks that facilitates IEEE 802.21. The MIH provides an interface between layer (3) and layer (2) with Information Server (IS)

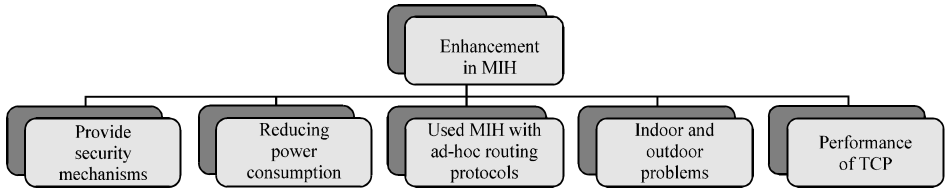

Fig. 5: Proposed methods for enhancement in MIH

that only manages static network information on the access technologies but has a limitation in the exchange of parameters between different technologies. The proposed solutions combine MIH with another protocol in the network layer and above that have the facilities to change IP between different technologies at the link layer, the network layer (IPv4, MIPv4, FMIPv4, IPv6, MIPv6, FMIPv6), the transport layer (TCP, SCTP), or the application layer (SIP). The most effective solution is to use either FMIPv6 or SCTP. The use of any one of the above mentioned technologies depends on their support for the protocol.

A network selection mechanism must take into account a wide variety of information including user objectives, application requirements, network conditions, device position, mobility patterns, coverage availability and geographical context before bundling the traffic streams on to available wireless channels. Intelligent resource management and call admission control mechanisms that proactively negotiate resources with the network in order to minimize the occurrence of unnecessary vertical handovers have been introduced. The main problem in the VHO decision is how to evaluate the dynamically changing parameters. Many vertical handover algorithms are proposed to solve the handover decision problems but until now there is no ideal solution. An efficient assessment system is essential for appropriate network selection. How VHO decision is made by choosing the most excellent from the multiple candidate networks? Here, the various issues must be investigated as follows: (1) it is not required to measure all decision factors, hence it becomes crucial to use partial knowledge. (2) The measurements can be imprecise for some decision factors, such cases, the network selection process should be powerful. Various decision factors should be built into a hierarchical structure. Therefore, a novel method should be introduced for selecting network in heterogeneous wireless environment.

The QoS-based algorithm had shortcomings in handling multiple constraint resources as it is mainly based on the perceptions of the designer. It could not reach an optimum solution in all cases. This is due to the inefficiency of the QoS-based algorithm. Furthermore, the needs of network operators and subscribers must also be fulfilled by cooperative uses of both network infrastructure and MN. Consequently, more rational handover decision needs to be developed. There is need of enhancing the experience of mobile devices users. Most MIH related studies were focused on seamless mobility service and combined MIH with vertical handoff decision algorithm. In contrast, there are other areas of research that could benefit from MIH. These areas provide a lot of opportunity to allow convergence between different technologies. Figure, 5 shows the proposed areas for enhancement in MIH.

MIH protocol does not provide security mechanisms. An effective mechanism is needed to interconnect a wide variety of heterogeneous wireless networks for the purpose of providing users with secure connectivity.

MIH discovery process always scans for candidate networks. This process increases the power usage of mobile device. Therefore, new techniques are needed to reduce power consumption by minimizing unnecessary handover.

MIH function can be used with an ad-hoc routing protocol to improve performance in the ad-hoc mobile networks. However, the integration of MIH function with an ad-hoc routing protocol can help to promptly detect node mobility and significantly reduce the duration of routing convergence. The MIH can provide an interface between layer 2 and layer 3 by obtaining the necessary information that help ad-hoc routing protocols that are based on the polling trigger mechanism to detect node mobility and to invoke route convergence.

The MIH framework can support terminal mobility scenarios as well as Femtocells RAT or Picocells RAT frequency selection. The compatibility between MIH and these base stations can solve the indoor and outdoor problem.

TCP is a reliable protocol that is connection oriented, responsible for an end- to-end communication. The TCP is designed for wired networks and it possible to apply TCP for an end-to-end connectivity between different wireless technologies if they are carried out under the MIH framework.

CONCLUSION

This study has investigated various enhancements on the Media Independent Handover protocol for providing seamless vertical handover between different mobile technologies. We had discussed the mechanisms that are integrated with MIH to achieve seamless handover between different wireless networks. The continuous development of MIH enabled network depends on two factors. First, the end users can benefit from services provided by different technologies. Second, the effective parameters from different technologies can be identified. The convergence between different wireless technologies can be achieved by using MIH as the key missing technology for achieving the next generation networks (NGNs).

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