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An Efficient VHS for Heterogeneous Network Based On IEEE 802.21 MIH

M.Navitha[#1], R.Tamijetchelvy [*2], G.Sivaradje [#3]

[1]Dept. of Electronics & Communication Engineering, Pondicherry Engineering College, Puducherry, India

[2] Dept. of Electronics & Communication Engineering, Perunthalaivar Kamarajar Institute of Engineering & Technology, Karaikal, India

[3]Dept. of Electronics & Communication Engineering, Pondicherry Engineering College, Puducherry, India

ABSTRACT— In recent years a plethora of wireless technologies has become available in the next generation network where mobile users can move between heterogeneous networks. Mobile users may efficiently utilize heterogeneous overlapping network infrastructures while moving among different access networks in order to attain better non-real-time or real-time services, everywhere and at any time the most important issue in such environment is the Always Best Connected (ABC) concept. In order to achieve seamless handoff between the networks and maintain continuity of connection, the IEEE standard 802.21 Media Independent Handover (MIH) is introduced which serves as a glue to connect heterogeneous wireless access technologies. This paper will be executing a novel mobility management system that follows IEEE 802.21 Media Independent Handover (MIH) standard that integrates the connection manager functions to detect network condition to maintain a connection based on two different mobility protocols of MIP and SIP.

KEYWORDS— IEEE 802.21, MIP, SIP, Vertical Handover, WiMAX, WLAN

I. INTRODUCTION

Wireless networks allow a more adaptable communication than the progressive wire line networks because the user is not restricted to fixed position. The growing demand for high speed, bandwidth, low latency and data access at anytime, anywhere and any service are decisive for suggesting the next generation wireless access networks. In the near future, some urban areas will be served by a mix of overlapping signals reaching different distances (signals, for example, from IEEE 802.11a/b/g/n (WiFi), IEEE 802.16 (WiMAX), High-Speed Downlink Packet Access (HSDPA), Long Term Evolution (LTE) can interoperate in order to always offer the best services, everywhere and at any time according to the always-best connected paradigm. Device manufacturers are integrating more network interfaces into their devices. Many cell phone models now support both Wi-Fi and third generation (3G) wireless. Notebook computers are available with built-in support for Wi-Fi, WiMAX, and 3G. As this trend in multi-interface devices continues, operators with multiple networks must facilitate easy access across their multiple technologies through a single device. Wireless access network are designed to work independently without cooperation with each other. Hence there is need for seamless internet connectivity across heterogeneous networks and strong demand for Internet Protocol (IP) based wireless access is the practical solution for the next generation wireless networks. Such Seamless integration of heterogeneous wireless networks supports a ubiquitous arrangement for mobile users. When a mobile user moves across the network, it has to perform handover to maintain its service continuity. During handover, both service continuity and service quality should be promised can be made seamlessly. Support for vertical handover, location management and mobility management are provided within the IP core network. A very recent, systematic, and promising approach that deals with this problem is the initiative under the IEEE label of Media-Independent Handover (MIH) Services, which promises to enhance handover experience when users roam between any access technology, covering both IEEE 802 and non-IEEE 802 networks. Specifically, IEEE MIH Services Working Group (IEEE 802.21 WG) [1] introduced a new Layer 2.5 (L2.5) protocol that combines network functionality from

all different access technologies into a common set of commands, events, and information services. The translation of this set is further used to efficiently manage the lower layers (i.e., use specific link layer primitives for each device interface). The promising IEEE 802.21 MIH standard provides seamless vertical handover in heterogeneous environment without service disruption and maintains the Quality of Service to the users [2, 3]. Performed a case study of vertical handoff delay analysis in [5],

a WLAN-UMTS internetwork using SIP as the terminal mobility management protocol. The suggested idea accomplishes that handoff delay increases when the user moves from WLAN to UMTS networks than bandwidth limited wireless links. Hence soft handoff techniques [6] need to be applied for Session Initiation Protocol (SIP), SIP- based terminal mobility management in heterogeneous wireless IP networks. WiFi / WiMAX vertical handover can be found in [6] introduce the estimation of WLAN network conditions using a Fast Fourier Transform to detect the WLAN signal decay, however it lack a method for estimating the WiMAX network conditions. Paper [7] propose a generic handover criterion, but very difficult to collect parameters such as cost, security, power, QoS and velocity.

The remainder of this research work is organized as follows. The next section presents an overview of the IEEE 802.21 MIH standard, and the section after that one provides overview of different mobility protocols. We describe candidate deployment scenarios. Then, we discuss a proof-of-concept realization and simulation. The final section concludes the paper by addressing the challenges and future roadmap for this standard.

II. OVERVIEW OF IEEE 802.21 MIH STANDARD

IEEE 802.21 Media Independent Handover (MIH) standard was introduced for seamless mobility in a heterogeneous network comprising of various IEEE 802 and cellular access technologies. Its primary goal is to provide service continuity during and after handover process, quality of service, network discovery and power management. The heart of MIH is the MIH Function (MIHF) placed between MIH User (MIHU) and device interface. MIH supports three important services [8] Media Independent Event Service (MIES), Media Independent Command Service (MICS) and Media Independent Information Service (MIIS) as shown in Fig. 1. MIHU is installed in network accessing point and MIHF is installed in mobile node and reports its status to the upper layers.

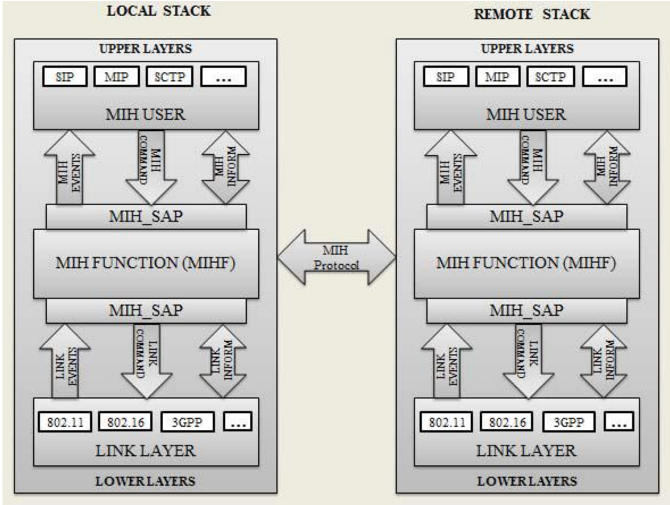

Fig. 1. IEEE 80.21 Media Independent Handover

MIH function provides services to the upper layers through well-defined Service Access Point (SAP). MIH_LINK_SAP handles MIH signalling exchange between the MIHF and technology specific link layers. MIH_ NET_SAP provides communication between peer MIH entities.

A. Media Independent Handover Services

IEEE 802.21 defines three main services that facilitate handovers across heterogeneous networks: MIES, MICS, and MIIS. These three primary services are managed and configured by a fourth service called the management service.

The management service consists of MIH capability discovery, MIH registration, and MIH event subscription. Through the service management primitives, MIHF is capable of discovering other MIHF entities. Registration also can be performed to obtain proper service from a remote entity.

By providing a SAP, the MIHF can communicate with upper layers easily and effectively. Media specific SAPs (LINK_SAPs) enable the MIHF to get the media-specific information that can be propagated to the MIHU using a single media independent interface (MIH_SAP).

B. Media Independent Event Services

The MIES defines events that represent changes in dynamic link characteristics such as link status and link quality. Events may indicate changes in the state and transmission behaviour of the physical, data link, and logical link layers or predict state changes of these layers (e.g., Link_Up, Link_Down). There are two main categories of events: link events that originate from the lower layers and propagate upward and MIH events that originate from the MIHF. MIH users subscribe to receive notifications when events occur. Events also can be classified further as either local or remote. Local events are subscribed to by the local MIHF and are contained within a single node. Remote events are subscribed to by a remote node and are delivered over a network by MIH protocol messages. Event notifications can be sent to the MIHF or any upper-layer entity that can be located within a local or a remote node. For example, a Link_Up event generated from the link layer of a node is forwarded to the MIH user of the same node if it is a local event. If a remote MIH user subscribed to this event, the local Link_Up event is delivered over the network to this remote MIH user as depicted in Fig. 1.

C. Media Independent Command Service

The MICS provides commands to control the link state. Commands can be invoked either locally or remotely by MIH users or by the MIHF itself. For example, an MIH user can control the reconfiguration or selection of an appropriate link (e.g., Link_Get_parameters, Link_Actions). The recipient of a command can be located within the protocol stack that originated the command or within a remote entity. Local commands propagate from the MIH users to the MIHF and then from the MIHF to the lower layers. Remote commands are carried by MIH protocol messages and may propagate from the MIHF in the local protocol stack to the MIHF in a peer protocol stack. For example, a Link_Actions command generated from an MIH user propagates from the MIHF to the link layer of the same node when it is a local command and propagates from the local node MIHF to the link layer of the remote node through peer MIHF when it is a remote command (Fig. 1).

D. Media Independent Information Service

The MIIS defines a set of information elements (IEs), their information structure and representation, and a query-response-based mechanism for information transfer. The MIIS provides a framework for MIH entities to discover information useful for making handover decisions. For example, the MIIS can be used to discover specific information about networks within a specific geographical area to enable more effective handover decision making and execution. The MIIS uses both resource description framework (RDF) and type-length-value (TLV) format to specify a media-independent way of representing information across different technologies.

In cases where the information required for handover decisions is not available locally, the MIH protocol can be used to access remote information sources. Network and other information can be stored in a network element referred to as an information server. MIH can provide Link up, Link down and Link going down events (MIES) to monitor the link status continuously as shown in Fig. 2. Handoff is prepared if link going down events comes as a result. If the link is going down, then the MIH user provides MICS command to the users (lower layers) to switch links based on MIHF. Then Address configuration (ASCONF) ASCONF-Path Failure sends from MN to CN to notify that the IP address is going to fail. The client gets the available network information from the information server through MIIS queries and responses. Then the client database is updated with this information, available neighbour candidates are known, and best candidate is selected based on RSS, bandwidth, and user preference. Afterwards MN sends ASCONF-Delete old IP to indicate CN to delete old IP address and add new IP address. The above mentioned idea is implemented based on conditional probability of link down (RSS_{i-1}) and link going down (RSS_i)[9].

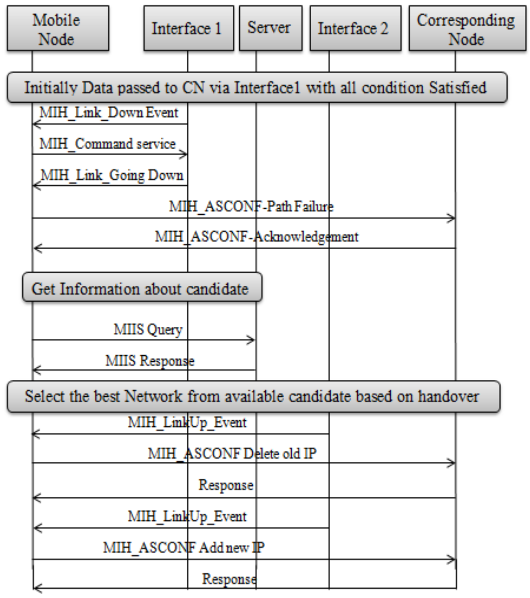

Fig. 2 Vertical handover decision based on MIHF (MIES, MICS, MIIS) [9]

Let X and Yare two samples. The conditional probability of a distribution function of a random variable is given by

$$P(Y \le y/X=x)=\frac{P\{Y \le y\&X=x\}}{P\{X=x\}} \quad (1)$$

$$P(y/x)=\frac{\int_{-\infty}^{y} f(x,y)dy}{f_x(x)}=\frac{\int_{-\infty}^{y} f(x,y)dy}{\int_{-\infty}^{\infty} f(x,y)dy} \quad (2)$$

$$P(y/x)=\frac{f(x,y)}{f_x(x)}=\frac{f(x,y)}{\int_{-\infty}^{\infty} f(x,y)dy} \quad (3)$$

Probability function follows Gaussian distribution and the cumulative distribution function describes the probability for a random variableas given in equation (4) and (5). Consider, a handover from WLAN to cellular networks is executed if RSS of the current network is less than the RSS threshold as given in equation (6).

$$P(x)=\frac{1}{\sigma\sqrt{2\pi}}\exp\frac{(x-\mu)^2}{2\sigma^2} \quad (4)$$

$$Q(x)=\frac{1}{\sqrt{2\pi}}\int_x^{\infty} e^{\frac{-y^2}{2}}dy \quad (5)$$

$$P(i)=P\{RSS_i<RSS_{thr}) \quad (6)$$

For assumption, in a time *(i-1)* mobile station is in WLAN coverage, therefore RSS value is greater than the RSS threshold and in a time *i* mobile station is not in WLAN coverage , therefore RSS value is less than the RSS threshold. Therefore the probability of handover from WLAN to cellular network is predicted by conditional probability in equation (7) and (8).

$$P(i)=P\{RSS_i<RSS_{thr}\,\&\,RSS_{i-1}>RSS_{thr}\} \quad (7)$$

$$P(i)=\frac{P\{RSS_i<RSS_{thr},RSS_{i-1}>RSS_{thr}\}}{P\{RSS_{i-1}>RSS_{thr}\}} \quad (8)$$

Simplify the denominator term in eqn. (8) based on normal probability density function with mean μ and variance σ is given by

$$f(x)=\frac{1}{\sigma\sqrt{2\pi}}\exp\left[-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2\right] \quad (9)$$

$$P\{RSS_{i-1}>RSS_{thr}\}=P\left\{\frac{x-\mu}{\sigma}>RSS_{thr}\right\} \quad (10)$$

Where $RSS_{i-1}=(x-\mu)/\sigma$, for simplicity assume RSS_{thr} =Z
in equation (10)

$$P\{RSS_{i-1}>RSS_{thr}\}=\int_{RSS_{thr}}^{\infty}\frac{1}{\sqrt{2\pi}}\exp^{-RSS_{thr}^2/2}dRSS_{thr}$$
(11)

$$P\{RSS_{i-1}>Z\}=\int_Z^{\infty}\frac{1}{\sqrt{2\pi}}\exp^{-Z^2/2}dZ = Q(Z) \quad (12)$$

The numerator term in eqn. (8) derived according to the assumption $RSS_i<RSS_{thr}$ = x and $RSS_{i-1}>RSS_{thr}$ =y

$$P\{RSS_i<RSS_{thr},RSS_{i-1}>RSS_{thr}\}=P(x,y)$$
(13)

Therefore, from equation (12) the probability of handover from WLAN to Cellular networks was found and will reduces the number of handover occurring by taking periodic RSS sample into account [9].

III. MOBILTY PROTOCOLS OVERVIEW

A. Mobile IP (MIP)

Mobile IP is a standard network layer protocol which allows the mobile users to move from one network to another by maintaining a permanent IP address. Mobile IP has three basic functionalities [10], mobile node, home agent and the foreign agent. Home agent (HA) keeps the information about mobile users whose permanent home address is in the home agent's network. Foreign agent (FA) stores the information about mobile user visiting its network as in Fig. 3. Foreign agents also advertise Care-of-Addresses (CoA), which are used by Mobile IP. There are several versions of MIP and provides better session continuity. Mobile IPv4 basically uses triangular routing, the mobile node sends data directly to the corresponding host, whereas data to the mobile node is send via HA and FA. This increases processing time, latency, packet loss and proves to be less efficient. MIPv6 is an important protocol, allows a mobile user to transparently maintain its connection when moving from one subnet to another subnet. When connecting through a foreign network, a mobile user sends its location information to a home agent, which intercepts packets, intended for the user and tunnels them to the current location. In order to provide the reliable QoS, the IP connection should be continuous across the routers. MIPv6 requires every mobile node to support address auto configuration, candidate discovery and decapsulation.

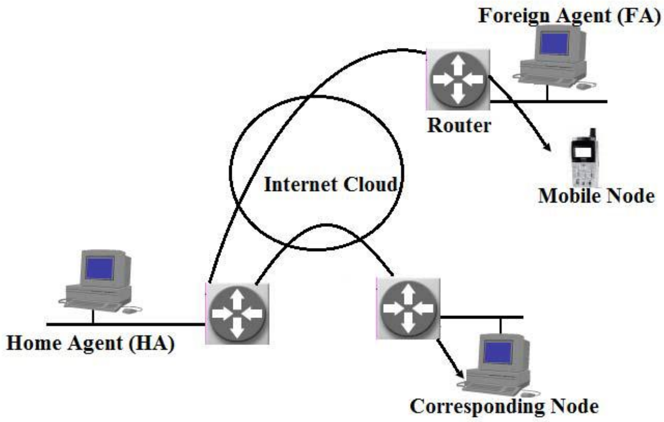

Fig. 3 Mobile IP architecture

MIPv6 supports global IP mobility. Mobile node can maintain its home agent throughout its movement. MIPv6 is location and path management protocol. Major issue in MIPv6 is Duplicate Address Detection (DAD) and tunnelling which yields larger delay restricted to delay sensitive applications.

B. Session Initiation Protocol (SIP)

Session Initiation Protocol is an application-layer control protocol that can establish, modify, and terminate multimedia sessions. SIP defines several logical entities, namely user agents, redirect servers, proxy servers, and registrars. SIP provides different type of motilities like user, session, service and terminal mobility. SIP inherently supports personal mobility and can be extended to support service and terminal mobility. Terminal mobility allows a device to move between IP sub-nets, while continuing to be reachable for incoming requests and maintaining sessions across subnet changes. Mobility of hosts in heterogeneous networks is managed by using the terminal mobility support of SIP.

Here SIP is implemented using Third Generation Partnership Project (3GPP) IP Multimedia Subsystem (IMS) which will support real time session negotiation and management. Advantages of IMS are, can support end to end QoS during session setup, capable of controlling the IP based networks and media session establishment. By default the 3GPP selects SIP as the signalling protocol for IMS. It consist of different Call State Control Function (CSCF) like Proxy CSCF(P-CSCF) is the first contact point in the architecture, secondly Serving CSCF (S-CSCF) which performs user registration and session management and the last one is Interrogating CSCF(I-CSCF) is the entrance for Home Network and selects the proper S-CSCF.

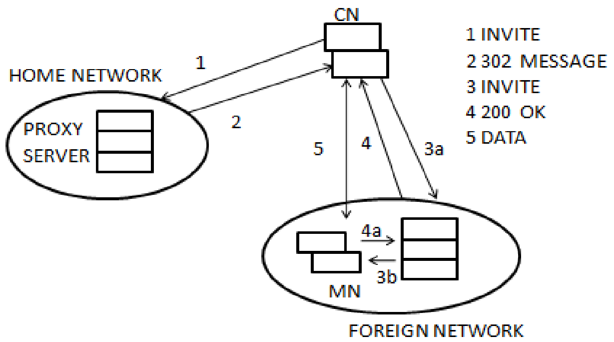

Fig. 4 Working of SIP

SIP not only uses IP addresses but also URLs. SIP Proxy servers store both the actual URLs and logical URLs of user's devices. These logical URLs change as the destination devices change. When a SIP user agent moves from one to another network, the IP address changes accordingly. SIP UA registers itself with the Location server with new logical URL and IP address. This registration helps Proxy servers to route the caller's INVITE requests to correct location. After the INVITE message has been responded positively by 200 OK messages, a direct communication link is established between the participants.

IV. ANALYSIS OF VERTICAL HANDOVER FOR INTEGRATED ARCHITECTURES

Hybrid network architecture allow the user to benefit high throughput IP-connectivity in 'hot-spots' and to attain service roaming across heterogeneous radio access technologies. The IP-based infrastructure transpires a key part of next generation mobile systems which allows an efficient, cost-effective and seamless interworking between the overlay networks.

A. Integrated WiMAX / WLAN Architecture

An integrated 802.16 / 802.11 networks can be used to extend the service availability for mobile internet applications. Resource management and admission control of 802.16 and 802.11 should be considered jointly to [11] achieve high network utilization and high level quality of service.

1) IEEE 802.11 (WLAN): Wireless local area network supports both infrastructure and ad hoc networks. It has several STAtions (STAs) are connected to Access Points (APs). The STAs and AP within the same radio coverage form a Basic Service Set (BSS). The 802.11 standard allows stations to roam among set of APs connected to distributed systems. WLAN data functionality is provides by Physical Medium Dependent (PMD) responsible for modulation, Physical Layer Convergence Protocol (PLCP) and Medium Access Control (MAC) sublayer for security, packet ordering etc.

2) IEEE 802.16 (WiMAX): WiMAX (Worldwide Interoperability for Microwave Access) and standard for the physical and medium access layers. It is IEEE 802.16 standard, basically built up of three main components: the Subscriber Station (SS), the Access Service Network (ASN), and the Connectivity Service Network (CSN). An ASN is typically built up of a set base stations (BSs) and one or more ASN GateWays (ASN-GWs) interconnecting the ASN with the CSN. The ASN delivers MAC layer services to the subscriber station while the CSN provides layer 3 services. WiMAX uses scheduling for entry into the network and this proves to be bandwidth efficient. It allows the base station to balance the quality of service for different applications. WiMAX operate at higher bit rates but limited to distance.

3) Vertical Handover in WiMAX / WLAN Internetwork using MIP: This section investigates the vertical handover scenario between IEEE 802.11 (WLAN) and IEEE 802.16 (WiMAX) networks. Fig. 5 illustrates the integrated heterogeneous environment using OPNET software. Initially the mobile node is in WLAN coverage and exchanges their data with the corresponding node through IP connectivity. WLAN accessing point is equipped with MIH user and mobile node is equipped with MIH function. MIHF periodically observes the link quality and gets its status through MIES command. If the link going down event is triggered MIHU in WLAN accessing point initiates the need for handoff. Then the MIHU in WLAN accessing point discovers candidate network from MIIS server. MIIS server response to MIHU with its already scanned results immediately. MIIS collects the information about the candidate networks with query and response.

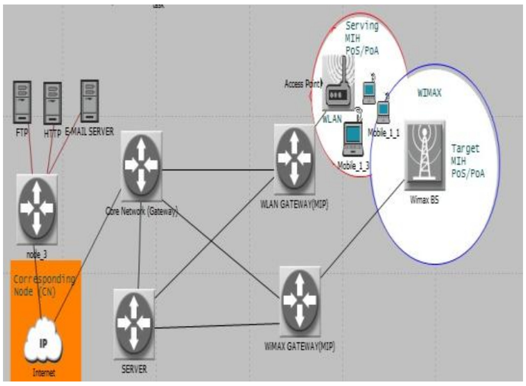

Fig. 5 Vertical Handover between WLAN / WiMAX networks based in IEEE 802.21 MIH standard using MIP

The MIHU knows WiMAX is the candidate network to WLAN accessing point and starts handover preparation to WiMAX network. In handover preparation phase, MIHU exchange its information to MIHF in mobile node to access for WiMAX network through MICS command. The mobile node scan the signal strength of WiMAX base station whether can be accessible or not. If it is accessible, mobile node announces to MIHU. The MIHU in WLAN accessing point can communicate with MIHU in WiMAX base station for resource availability check. If everything satisfied, WiMAX is chosen as the target network to handover. After resource activation has completed, mobile node starts handover execution from WLAN to WiMAX network.

Handover delay is very less because the time taken to select the neighbour network is very faster with the database is already existed in MIIS server. Fig.6. shows the handover delay for the entire three users who do handover simultaneously. Candidate network on the other end collects the neighbour advertisement and acknowledges to it as depicted in Fig. 7 and Fig.8. Fig. 9 shows the Routing Information Protocol (RIP), which is the intra-domain mobility protocol which is the alternative of short test path route selection and it take the hop count as the routing metric. And it also avoids routing loops by keeping minimum number of hop counts. Since the MIP is network layer mobility protocol the routing information's is more.

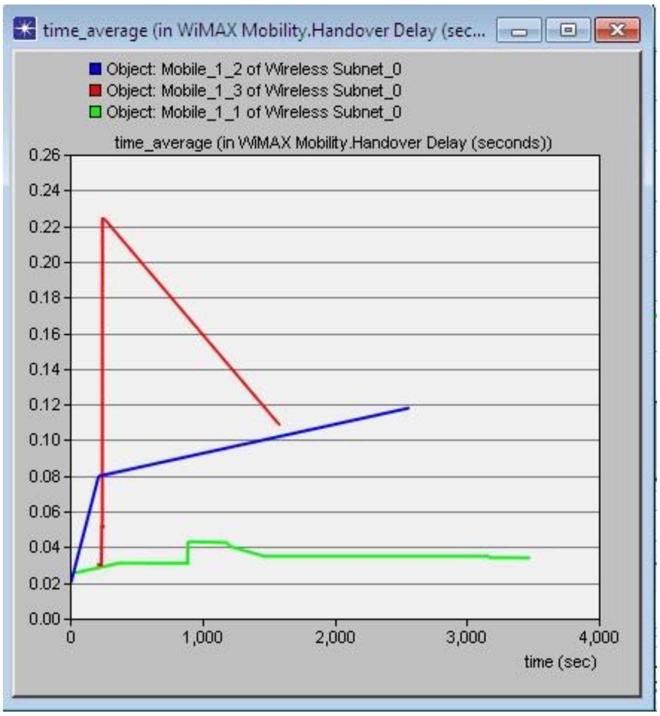

Fig. 6 Handover delay for all the three users using MIP

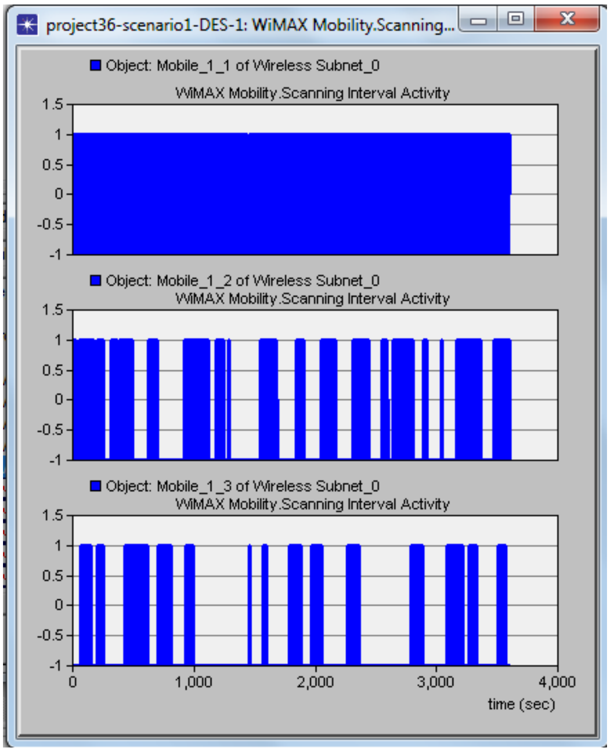

Fig. 7 WiMAX scanning interval activity of all the three users using MIP

4) Vertical Handover in WiMAX/ WLAN Internetwork using SIP: Handover based on SIP follows the same procedure of MIP but once the user moved to target Point of Attachment (PoA) the data is transferred to the mobile user by using SIP protocol. The scenario is showed in

Fig.10. Once the user moves out of coverage area of the WLAN, link down event is send from MIHF to MIHU. The MIHU will enquire the MIIS about the neighbouring network and it gives the information about the WiMAX network. The node will communicate the P-CSCF first and it sends the information to the I-CSCF, it selects the appropriate S-CSCF and once the link going down event is send, the handover is imitated and user moves to the WiMAX network and binding information is updated in the cache.

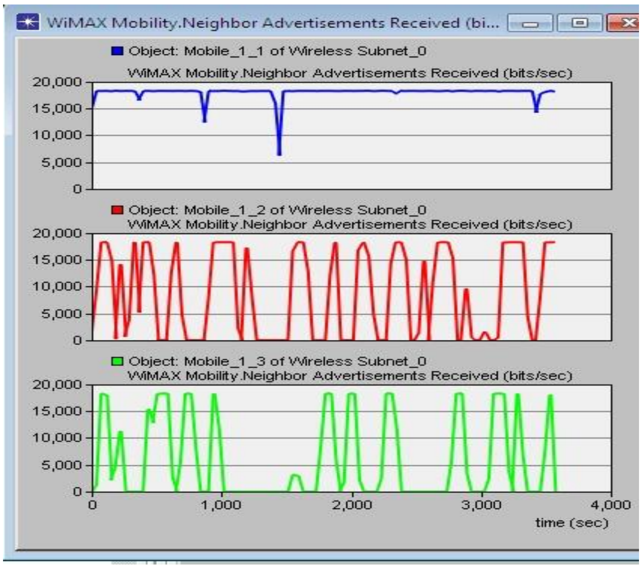

Fig. 8 Candidate network advertisement using MIP

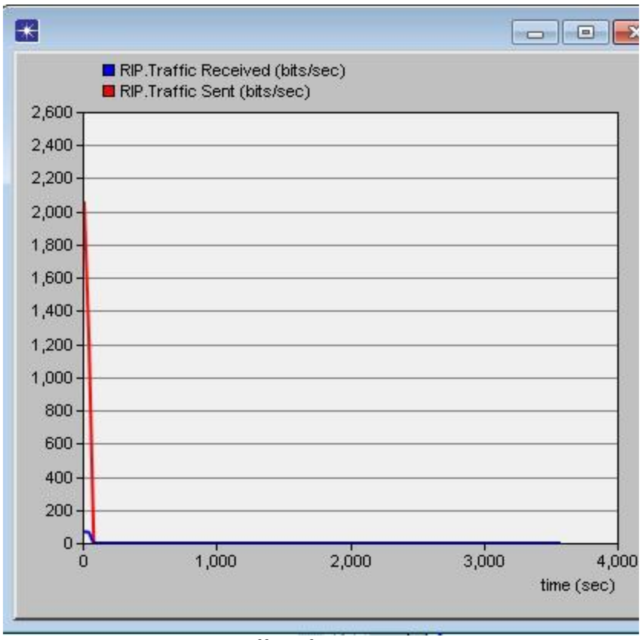

Fig. 9 RIP traffic information using MIP

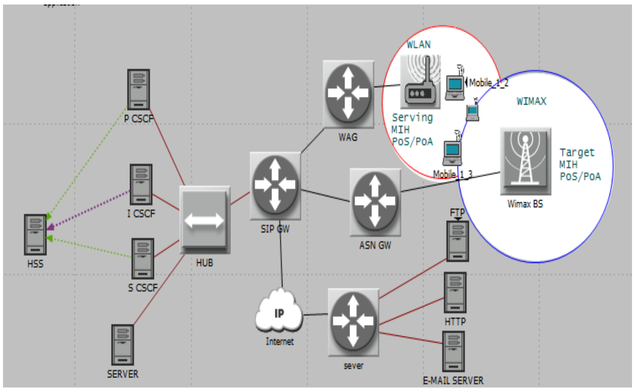

Fig. 10 Vertical Handover between WLAN / WiMAX networks based in IEEE 802.21 MIH standard using SIP

The handover delay is more on compare to MIP because the routing information is provided is less in SIP. And the handover is executed in application layer so the excess delay in SIP is due to following reason of excess signalling for all the three users as shown in Fig. 13 while its only 0.025 to 0.23 sec while in SIP it's from 004 to 0.35 sec. And the RIP information provided is less as shown in Fig.12 because of application layer it provides only less number of intra domain traffic information. And the candidate network advisement is received through Media Independent Handover Information Server.

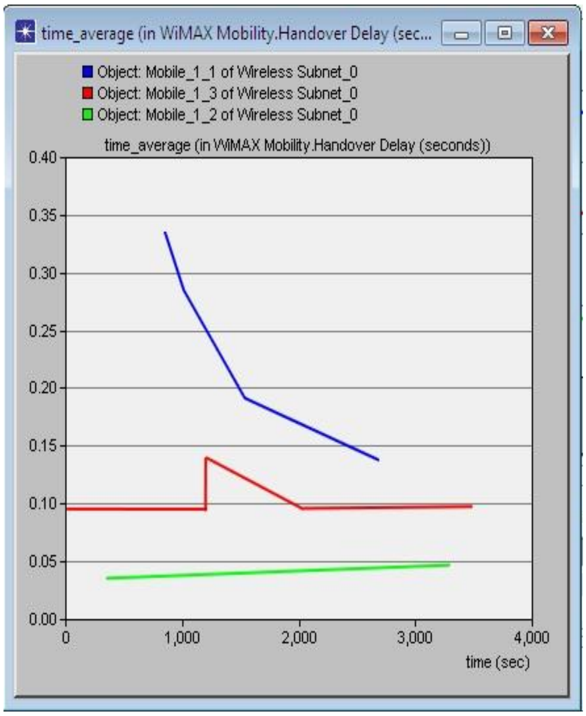

Fig. 11 Handover delay for all the three users using SIP

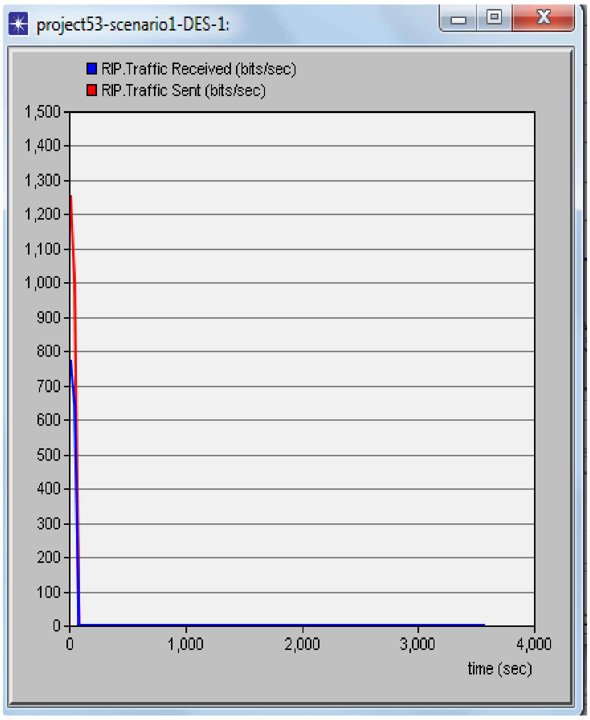

Fig. 12 RIP traffic information using SIP

V. CONCLUSIONS

The integrated WLAN / WiMAX architecture with IEEE 802.21 MIH provides optimized handover procedures. This method proves to be energy efficient and more secure with gateways and less vulnerable for the attackers. Because during handover preparation phase, discovery of neighbour network is immediately known from the MIIS server. This method also proved that the handover delay is less in MIP and while using SIP it provides the best result on application maintains and support more load. Hence the handover from WLAN to WiMAX network takes less time and maintain its communication without service interruption on using MIP but provides less application support. Future work will aim to integrate more wireless access network and analyze its mobility pattern with different layered protocols.

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