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AN OPTIMIZED FAST VERTICAL HANDOVER STRATEGY FOR HETEROGENEOUS WIRELESS ACCESS NETWORKS BASED ON IEEE 802.21 MEDIA INDEPENDENT HANDOVER STANDARD

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Abstract — **Owing to ubiquity of wireless technologies, user satisfaction is greatly affected by the factor such as terminal mobility, guaranteeing quality of service, continuous connectivity to access the world anywhere, anytime and any service has gained a significant importance. Hence, the future generation wireless networks have projected as the integration of various wireless access networks. Seamless internetworking of heterogeneous network is still a stimulating assignment and requires interconnectivity at all layers of network architecture. In mobile communication, seamless vertical handover is one of the most challenging issues. The worst case may cause communication interruption, delays and packet losses which affect the real time communication performance. To resolve the problem of prevailing schemes, a marginal fast vertical handover Mobile IP (MIP) protocol using IEEE 802.21 Media Independent Handover (MIH) standard is proposed.**

In this paper optimized vertical handover functionality is illustrated for heterogeneous WLAN/WiMAX networks based on IEEE 802.21 Media Independent Handover which combines network functionality from all different access technologies into common set of Commands, Events and Services. The proposed handover scenario is used to evaluate the vertical handover performance involving multimode terminal with WLAN/WiMAX interfaces and IEEE 802.21 entities. This capability proves an efficient solution for mobility, multihoming and routing for integrating heterogeneous networks. In addition, the proposed scheme can reduce considerably traffic overhead between WLAN/WiMAX networks, handover latency and base station scanning interval time. The presented handover scenario concludes by presenting service continuity during and after vertical handover.

Index Terms—**MIH, SIP, MIP, RSS, Point of Attachment.**

I. INTRODUCTION

Wireless networks allow a more adaptable communication than the progressive wireline 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. 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.

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 [1, 2]. The design and implementation of MIH middleware [3] in Linux platform integrates stream control transmission protocol (SCTP), user motion detection (UMD) and adaptive QoS playout (AQP) algorithm to enhance the performance of handoff process and quality of wireless VoIP. Performed a case study of vertical handoff delay analysis in [4], 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 the UMTS to WLAN. This is due to error-prone and bandwidth limited wireless links. Hence soft handoff techniques 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 by [5] 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 [6] propose a generic handover criterion, but very difficult to collect parameters such as cost, security, power, QoS and velocity. In addition to MIP and SIP, auxiliary combinations have been proposed by considering the limitations of the two protocols. A cooperative related

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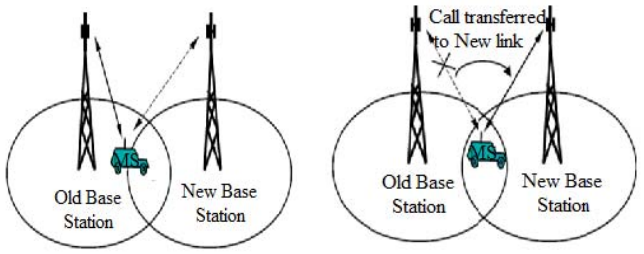
approach is implied in [7] that develops the complementary experiences of MIP and SIP. Mobile IP and session initiation protocol are predominantly expended for IP-based mobility management. MIP switches low level mobility and ad hoc mobility, while SIP handles service and session mobility [8]. The remainder of this article is organized as follows. First, briefly describe the overview of handover categories by examining types and features of handover. Then analyzing the vertical handover for integrated WLAN /WiMAX architecture includes IEEE 802.21 MIH, Mobile IP. Finally conclude the results and discussion.

II. An Overview of HAndover Categories

A. Types of Handover

Mobility is the most important feature of a wireless cellular communication system. An efficient continuous service quality is achieved by supporting seamless handover across heterogeneous and homogeneous networks.

Handoffs are broadly classified into two categories, hard handoff and soft handoff. Hard handoff is Break-before-make and can be divided into two intra and intercell handoffs as shown in fig.1. The soft handoff is Make-before-Break and divided into multiway and softer handoffs. Softer handover is defined as the user equipment combines more than one radio link to improve the reception quality.



a. Before Handoff b. After Handoff Completion

Fig. 1. Hard Handoff Scenario

Intertechnology: When a mobile node moves between one point of attachment (PoA) to another point of attachments (PoAs) of different access technologies eg. WiMax, WLAN, UMTS etc. This type of handover is also termed as ***vertical handover,*** which may affect the quality of service (QoS) of different applications. Since different access networks can offer [9] significantly different bandwidth and delay profiles.

Intratechnology: Handoff of a mobile terminal takes place between base stations of same network technology such as between two WLAN access points. The mobile terminal may be equipped with a single interface thus may need to change its layer 3 identifier depending on the type of movement. It is also termed as ***horizontal handover*** as depicted in fig.2. Horizontal Handover across homogeneous network is not an important issue for the mobile users. Handover decision can be based on data rate, traffic across the cell, bandwidth, received signal strength etc. Balanced traffic reduces the call blocking probability.

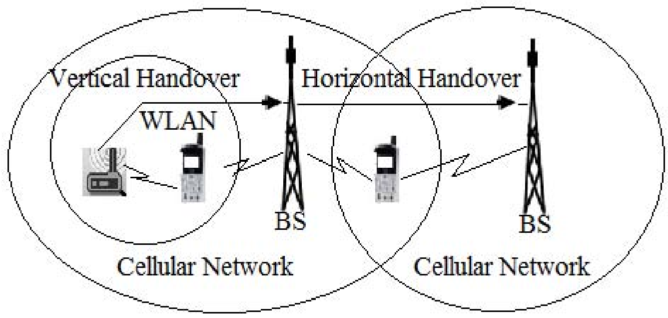


Fig. 2. Vertical and Horizontal Handover

B. Features of Vertical Handover

Vertical Handover is an important issue in 4G heterogeneous wireless networks in order to provide seamless service anywhere and anytime. Some desirable features should take into consideration for making handover. *Reliability*, call should have good quality after handover. Reliability depends on signal to noise ratio, bit error rate etc.

Handover should be *seamless* i.e. fast and does not provide service degradation or interruption. *Balanced traffic* in all cells reduces the call blocking probability. And also handover decision should on the basis of received signal strength (RSS), velocity of a mobile terminal, network connection time, bandwidth, power, cost, security and user preference.

C. Vertical Handover Criteria

One of the most important challenges in heterogeneous network is the mobility management. There are two main parts for mobility management, location management and handover management [2]. A handover process can be split into three phases: handover decision, candidate network selection and time to trigger. *Handover decision* is the process to decide when and to which access network has to perform the handover.

A vertical handover decision may depend on several disputes relating to power, user preference, bandwidth, cost, security etc. *Candidate network selection* is the process where the mobile user equipment searches for reachable wireless networks through queries and responses. Then the candidate network is known based on their response.

Power and network selection time are the most significant considerations for system performance. *Time to trigger* is an important issue for the mobile users which causes the probability of handover failure and unnecessary handover. This affects the system performance and interrupts the service continuity.

III. Analysis of Vertical Handover For Integrated WiMAX / WLAN Architecture

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. Mobile IP

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.

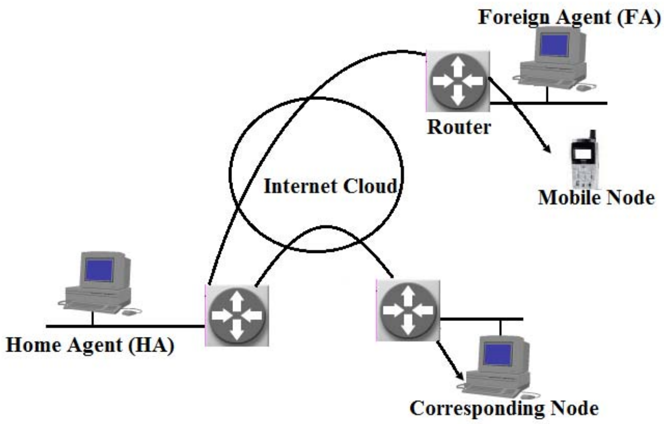


Fig. 3. Mobile IP architecture

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 tunneling which yields larger delay restricted to delay sensitive applications.

Fast handover for MIPV6 (FMIPV6) provides [11] handover based on L2 triggers which enables the mobile node quickly detect its movement to new subnet. HMIPV6 supports special network entity mobile anchor point (MAP). MAP acts as a home agent to mobile node and channels all traffic to mobile node through care of address. Proxy MIPV6 (PMIPV6) introduces proxy mobile agent (PMA) acts as a relay node between home agent and mobile node.

B. IEEE 802.21 Media Independent Handover

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 [12] media independent event service (MIES), media independent command service (MICS) and media independent information service (MIIS) as shown in fig. 4. MIHU is installed in network accessing point and MIHF is installed in mobile node and reports its status to the upper layers.

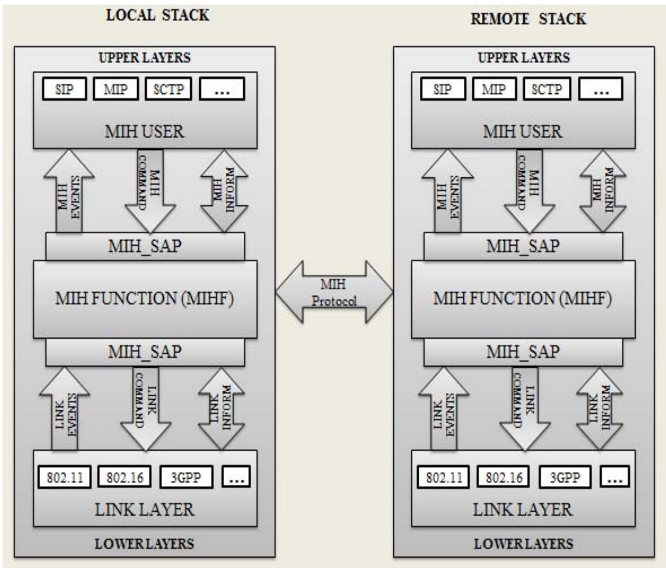


Fig. 4. IEEE 80.21 Media Independent Handover

MIHF: MIH function provides services to the upper layers through well-defined service access point (SAP). MIH_ LINK_SAP handles MIH signaling exchange between the MIHF and technology specific link layers. MIH_ NET_SAP provides communication between peer MIH entities.

MIES: It provides link up, link down and link going down events as handoff triggers from the device interfaces and report to the upper MIHU layer for the need of handover. It also collects the information about link characteristics, link status and link quality for any change and report to higher layers.

MICS: It enables the MIH user to control and manage the physical, data link and logical link layers. MIH user uses commands such as MIH_SWITCH, MIH_GET_STATUS etc. to configure, retrieve information from physical and link layers.

MIIS: Provides a set of information element query / response for information transfer. It helps the mobile node to discover and collect the handover candidate information from currently attached network.

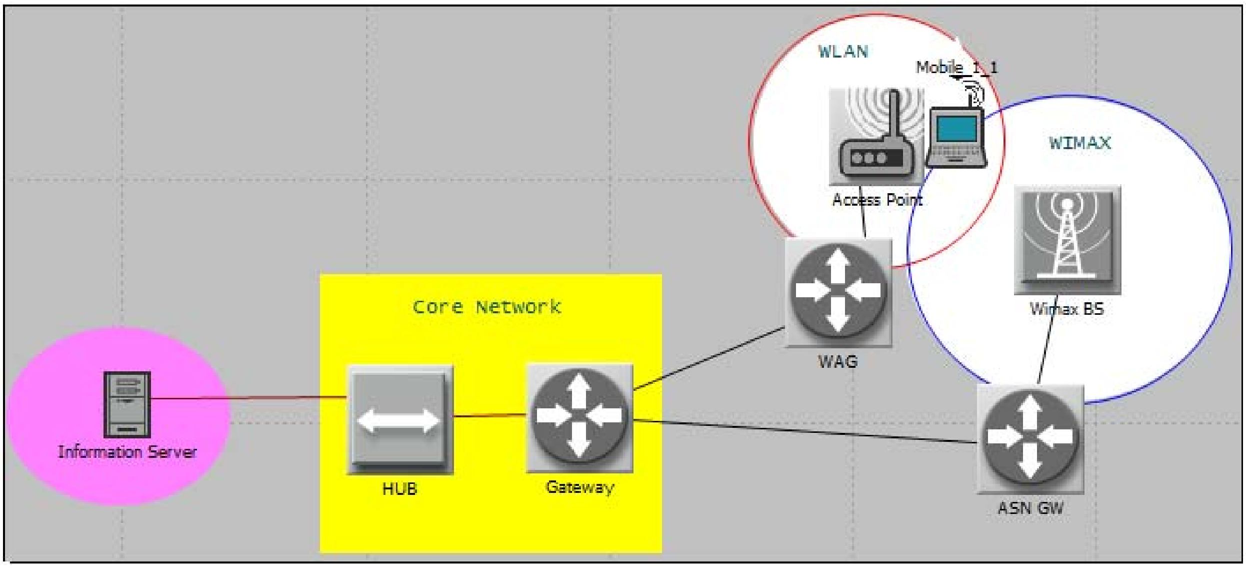


Fig. 5 Vertical Handover between WLAN / WiMAX networks (Scenario 1)

C. 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 [13] 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 solution (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.

D. Vertical Handover in WiMAX / WLAN Internetwork

An internetworking environment is constructed for WLAN/WiMAX networks and analyzed its handover delay performance. The first scenario describes the general vertical handover performance for WLAN / WiMAX networks as shown in fig. 5. It consist of information sever maintains database, gateways, WLAN access point, WiMAX base station and a mobile node. Initially the mobile node is in WLAN coverage, if the received signal strength is weak then the mobile node initiates the need for handoff. WLAN AP searches for candidate network to access and takes time to discover its neighbour. Hence the handover delay is maximum and the worst case will cause service interruption that affects quality of service.

Second scenario is the proposed vertical handover performance based on IEEE 802.21 MIH standard. The architecture consists of corresponding network (CN), MIIS sever maintains database, gateways, WLAN access point, WiMAX base station and a mobile node (MN) as in fig. 6 The IEEE 802.16 base station provides full [14] coverage area over the simulation process, whereas IEEE 802.11 accessing point covers less area and initiates handover to WiMAX networks. Internetworking with IEEE 802.21, WLAN defines a new MAC state convergence function and provides additional service. Initially mobile node is in WLAN coverage and MIH user (MIHU) is installed in WLAN access point. The lower layer reports periodic RSS measurement to MIHU through MIES command. If the LINK_GOING_DOWN event is triggered, MIHU can initiate handover necessity. The MIHU discovers the candidate network from MIIS server and indicates WiMAX network is accessible. MIHU checks the data rate, traffic, cost, security and other resource availability in WiMAX. Finally, the mobile node starts handoff to WiMAX network with fraction of seconds and hence delay is minimized. The resource allocated to mobile node in WLAN is released in order to consume power.

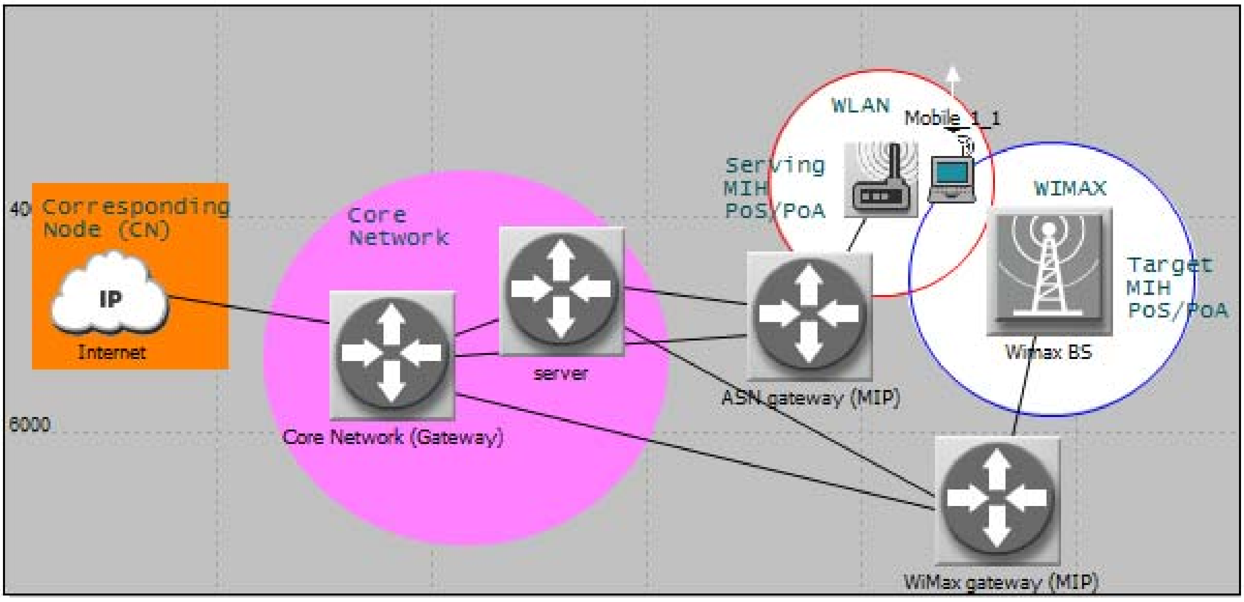


Fig. 6 Vertical Handover between WLAN / WiMAX networks based in IEEE 802.21 MIH standard (Scenario 2)

IV. RESULTS AND DISCUSSIONS

This section investigates the proposed vertical handover scenario between IEEE 802.11 (WLAN) and IEEE 802.16 (WiMAX) networks. Fig. 6 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. Candidate network on the other end collects the neighbour advertisement and acknowledges to it as depicted in fig. 7 and fig.8.

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. The proposed method proves that the handover from WLAN to WiMAX network yields less delay with support of media independent handover as in fig. 9. 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. The vertical handover delay for first scenario is maximum because WLAN AP takes more time to discover its neighbour as in fig. 10.

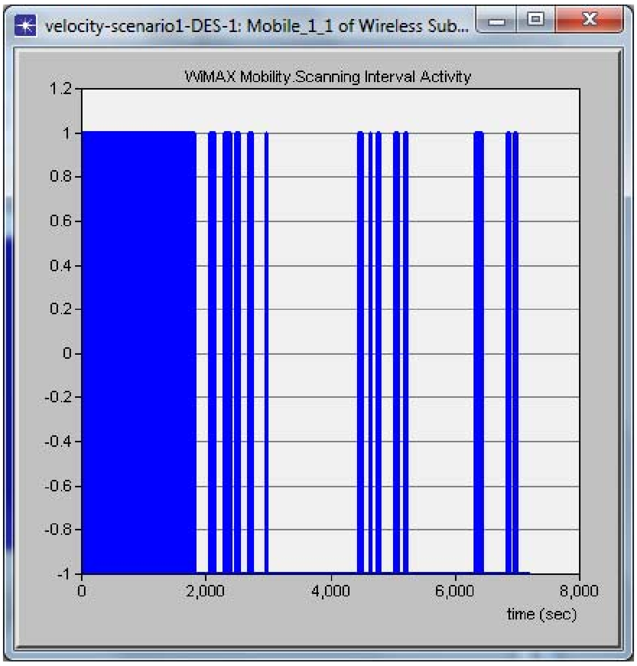


Fig. 7 WiMAX scanning interval activity

Thus IEEE 802.21 proves to be efficient and fast for vertical handover across heterogeneous wireless access environment. An another way for energy efficient use of the wireless interfaces could be to keep them in power save mode when not used. MIHU in WLAN now have the new IP address of WiMAX base station and inform to mobile node to switch to the new address. After handover is completed, mobile node switch to new IP address and old link is terminated. Vertical handover decision, target network selection and time to trigger are correctly satisfied.

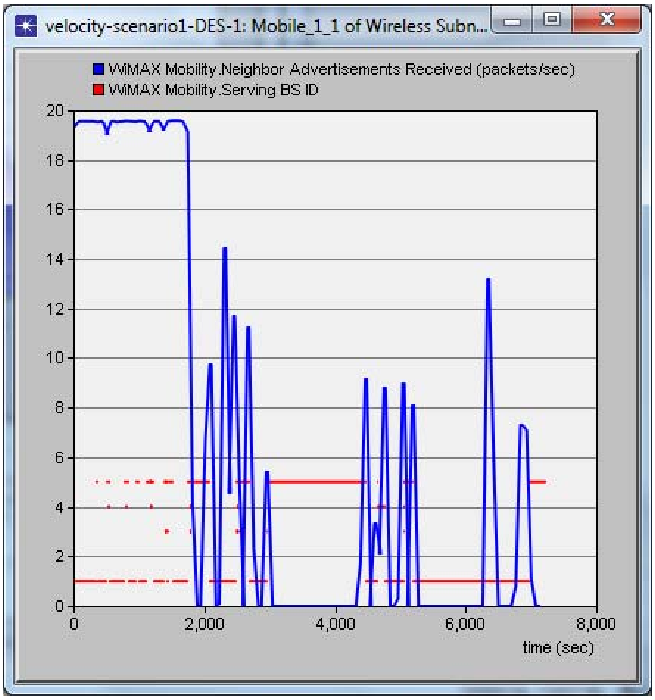


Fig. 8 Candidate network advertisement and Base station ID

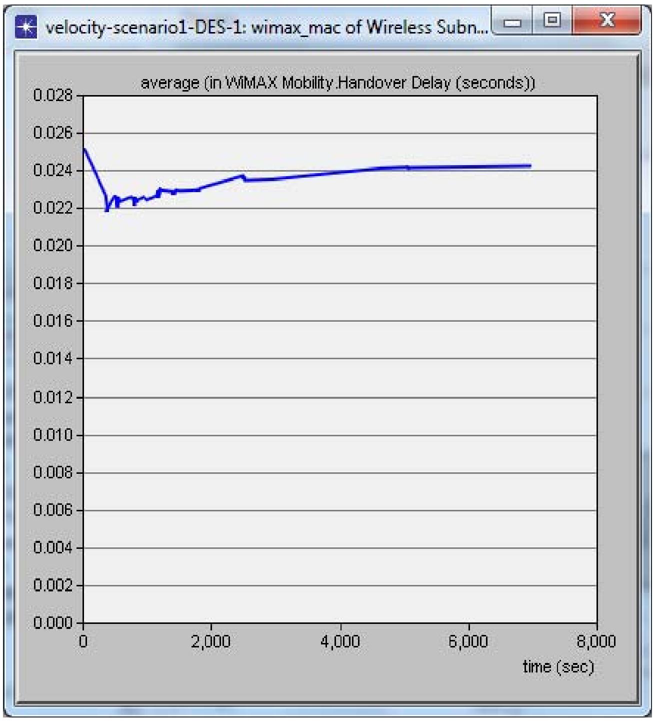


Fig. 9 Handover delay based on IEEE 802.21 MIH standard (Scenario 2)

The traffic flows from WLAN to WiMAX link and the load is shared from WLAN to WiMAX cell. The load in each cell is correctly balanced as in fig. 11. The resource allocated to mobile node in WLAN cell is released after handover is completion phase. Thus provides seamless connection between the networks and also power economy.

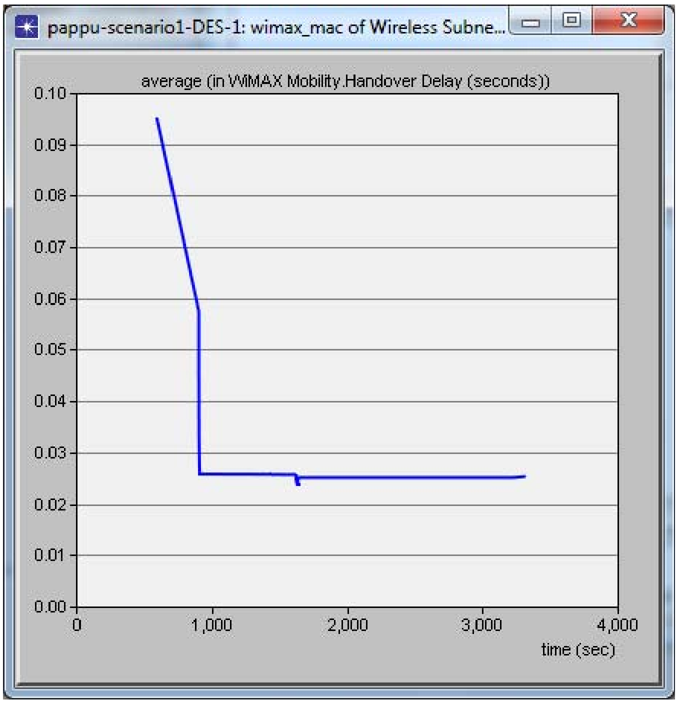


Fig. 10 Handover delay for first scenario

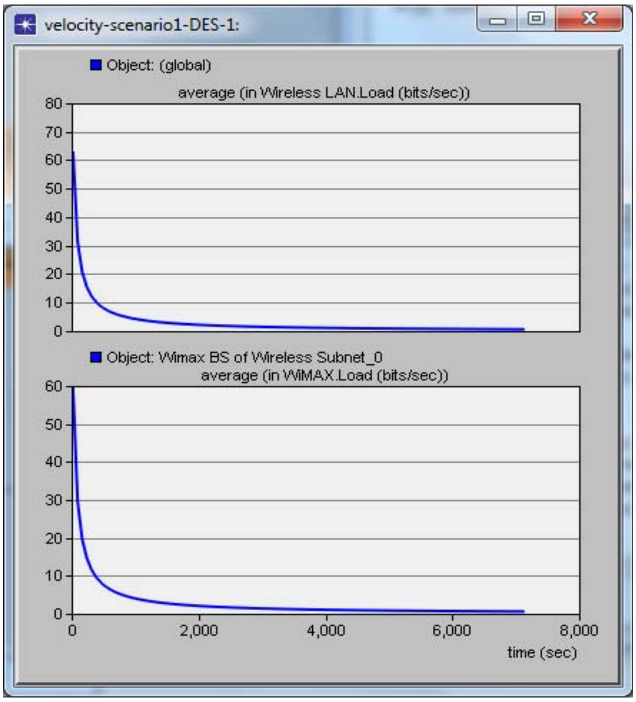


Fig. 11 Average load balanced in WLAN / WiMAX architecture

The original WiMAX physical layer used orthogonal frequency division multiplexing and provides strong performance in multipath and non-line-of-sight environments. Data streams to and from individual users are multiplexed to groups of subchannels [15] on the downlink and uplink as depicted in fig. 12.

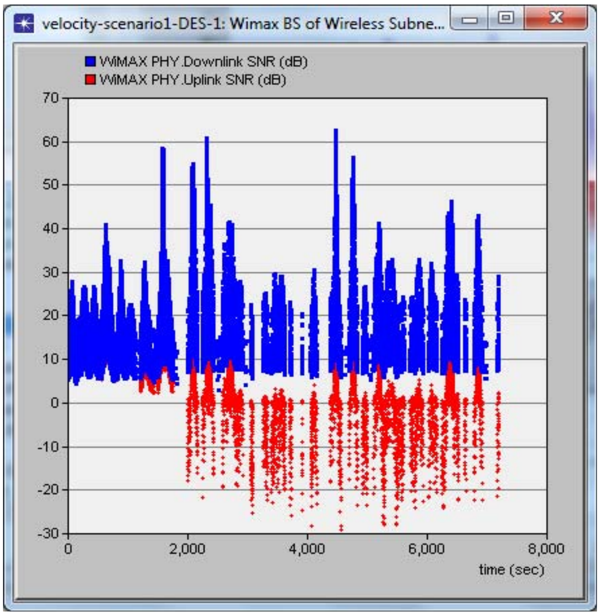


Fig. 12 WiMAX uplink and downlink SNR

V. CONCLUSION

The integrated WLAN / WiMAX architecture with IEEE 802.21 MIH provides optimized handover procedures. The proposed 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. Hence the handover from WLAN to WiMAX network takes less time and maintain its communication without service interruption. After handover is completed, the traffic flows through WiMAX link and load is balanced in both the network. The resource allocated to mobile node in WLAN is released thus saving the power and maintains the service quality. Future work will aim to integrate more wireless access network and analyze its mobility pattern with different layered protocols.

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