Fast Layer 2 Handover Between WiFi and 3G Cellular Networks

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***Abstract* — This paper presents the events that help achieve the handover operation, based on the IEEE 802.21 standard. It will describe the wireless networks WLAN and 3G, IEEE 802.21 components and handover methods between the two networks. Finally a handover simulation made with the program Omnet++ and an analysis based on the simulation is presented.**

***Index Terms* —WiFi, 3G, Handover, MIH.**

I. INTRODUCTION

Roaming between different wireless access networks like 802.11, WiMAX, UMTS as well as wired like 802.3 will become a necessity for the future network devices because these networks are complementary. However the accomplishment of handovers without breaking the connexion can be dificult because every network has different types of mobility, QoS requirements, protocols and securuty requests. At the same time, interactive applications such as VoIp and video flows have strict requrements on end to end delay and packet loss. The handover procedure adds even more constrain to these requrements because of the dicovery and configuration of the new link process. For these reasons the IEEE 802.21 standard, named Media Independent Handover (MIH) was introduced. It defines technology independent mechanisms that facilitate handovers between IEEE 802 networks and celular networks.

The article is organized as follows. In section 2 are described the 3G and WiFi networks. Section 3 presents the general aspects of the IEEE 802.21 (Media Independent Handover) standard. Layer 2 handover methods are described in Section 4. In section 5 is described the handover simulation and in Section 6 are analyzed the results of the simulation. Section 7 presents the paper conclusions.

II. 3G AND WIFI NETWORKS

A. 3G NETWORKS

3G represents the third generation of standards and technology for the mobile networks and replaces 2.5G. This permits the operators to offer a wider range of advanced services to users, obtaining a larger network capacity and an increased spectral efficiency. The services include voice calls, video calls, and broadband data transfers, all in a mobile environment. The maximum speed that can be achieved is 14,4 Mb/s for download and 5,8 Mb/s for upload [4].

The first 3G system was launched in Japan, in may 2001 and it was using W-CDMA (Wideband Code Division Multiple Access) technology. In Europe the first systems where made in 2001 and they where also using W-CDMA. The 3G networks launched in USA are using CDMA 2000 technology. One of the 3G technologies is UMTS (Universal Mobile Telecommunications System) witch uses W-CDMA for the radio access part [1][2].

B. WIFI NETWORKS

WiFi networks are local wireless networks, on witch the architecture is with or without infrastructure and that can connect one or more terminals on short distances. They are also called Wireless LAN (WLAN) [6].

Today the WiFi networks are starting to become very spread because they offer many advantages compared to the wired networks. The most important feature is mobility. You can connect from many places: from home, from work, from public places, etc. Another advantage could be the fact that this type of network is easy to install, because the only cables required are for connecting the access points. Also, once the access speeds increased and the costs decreased, this technology started to become very popular [5][7].

III. MEDIA INDEPENDENT HANDOVER (MIH)

The IEEE 802.21 architecture is trying to ensure methods and procedures that facilitate handover between networks. These procedures are using the information obtained from both the mobile terminal and the network infrastructure to satisfy the users needs. There are many factors that could determine the handover decision. In general these include service continuity, application class, quality of service, network discovery, network selection, security, power management and handover policy.

There are two types of handover: vertical handover and horizontal handover. Vertical handover is achieved when the mobile station (MS) is moving between PoAs (Point of Attachment) from different technologies, such as form UMTS to WLAN, or from WLAN to WiMAX or from 802.3 to WLAN, etc. It is also called inter-technology handover. Horizontal handover is achieved when a mobile station is moving between PoAs of the same technology, such as from UMTS to UMTS, or from WLAN to WLAN, etc. This type of handover is also called intra-technology handover. Also the handover operation can be initiated by the MS or by the network [8].

A. MIH FUNCTIONS

MIH standard defines the following types of service:

- *Event Service* – Announces the events triggered by the change of a link state or characteristics.
- *Command Service* – Uses the information obtained from Event Service and acts accordingly.
- *Information Service* – Provides a model used for transporting information about neighbouring networks and their capabilities [10].

B. LAYER 2 HANDOVER ELEMENTS

Triggers or layer 2 events are generated by the changes in status and behavior of a transmission at the physical, data link or logical link layers.

Layer 2 events are originated from the Media Independent Handover Function (MIHF) and from there they can be sent to the local or remote higher layers through MIH Events.

The handover decision can be taken based on these events. Triggers help minimize disconnection during the link switch. [8][9].

MIH defines the following categories of triggers:

- *State change*
  - *Link_Detected* – Denotes the presence of a new PoA when the MS is in its coverage area. This PoA is from a different network than the one on witch the MS is connected.
  - *Link_Up* – This primitive is generated when a new layer 2 connection is established through that interface.
  - *Link_Down* – This notification is sent when a layer 2 connection it's no longer available for sending frames, which is when the connection is down.
- *Link parameters*
  - *Link_Parameters_Report* – Indicates changes in link parameters when they exceed pre-specified thresholds. This primitive can also be generated at specific time intervals for different parameters.
- *Predictive*
  - *Link_Going_Down* – This notification in sent when the prediction that the layer 2 link will disconnect in a specific time interval is made. The indication can be used to initiate the handover operation.
- Link handover
  - Link_Handover_Imminent – It is generated when the data link handover decision was made and its execution is imminent.
  - Link_Handover_Complete – This event is generated every time a data link handover was completed.
- *Link transmission*
  - *Link_PDU_Transmit_Status* – Indicates the data link transmission status of a higher layer PDU (Protocol Data Unit).

C. MIH REFERCENCE MODEL FOR WIFI NETWORKS

The MIH reference model for wIfi (IEEE 802.11) is shown in Figure 1. The payload from MIHF services is carried through IEEE 802.11 either by data frames, using the primitives defined in LSAP (Logical Link Control Service Access Point), or either by the management entity (MLME – MAC Layer Management Entity), using MLME_SAP.

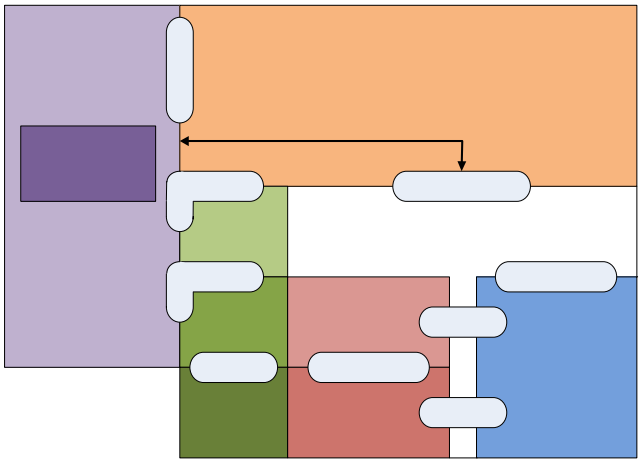

Figure 1 MIH reference model for WiFi Networks

Sending MIH messages through LSAP is allowed only after a successfully authentication and association of the mobile station with the AP (Access Point). Before the authentication and association with the AP only MIH Information Service and MIH Capability Discovery messages can be sent through MLME_SAP [8].

D. MIH REFERCENCE MODEL FOR 3G NETWORKS

The interaction between MIHF and 3G based systems is shown in Figure 2.

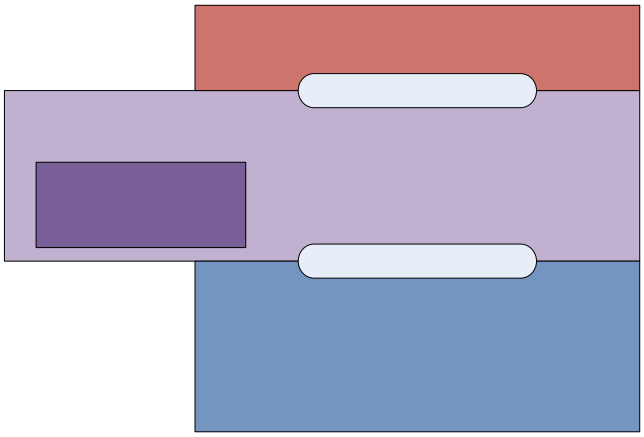

Figure 2 MIH reference model for 3G Networks

IV. HANDOVER SIMULATION

The simulation is trying to illustrate the operations of vertical handovers between WLAN and 3G technologies and horizontal handovers between WLAN networks, from the perspective of the layer two.

This simulation presents a mobile station that is moving through the coverage areas of some APs or UMTS base stations and performs handovers between them. The mobile station has two radio interfaces: one 3G and one 802.11. Also there are illustrated some primitives generated by the layer 2 events: Link_Up, Link_Down, Link_Going_Down, Link_Handover_Complete, and other messages exchanged for the association procedure.

For simplicity reasons and because there was no need for other additional functions for performing the simulation, the modules from the 802.11 and 3G technologies are implemented simplified, it is present only the layer two part.

The source codes of the modules that assure the MS mobility are taken from the INET Framework simulation package.

Handover decision is taken based on the signal to noise ratio (SNR) of the received signal. The SNR is proportional with the distance between the mobile station and the access point. If the SNR is lower than a pre-estabilished treshold the MS will predict that the layer 2 link will disconnect soon and the apropiate actions for handover preparation will be taken [11][12][13][14].

The simulated topology is presented in Figure 3.

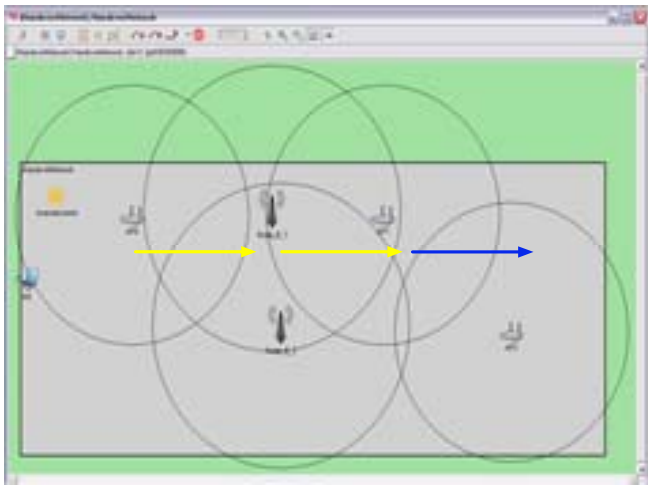

Figure 3 Simulated topology

V. SIMULATION ANALYSIS

A. HANDOVER ANALYSIS DEPENDING ON THE BIT ERROR RATE

When the moving speed of the mobile station increases, the bit error rate (BER) of the received messages increases too. Also BER could increase because of the communication channel interference. If the messages received during handover have errors, the MS cannot perform seamless handover because the connection will be broken before handover completion. With the help of the simulation, the number of successful vertical handovers from a total of 10 depending on the BER was measured. The results can be seen in Table 1.

TABLE I. HANDOVER SUCCES PERCENTAGE DEPENDING ON THE BER

BER (10^{-2})	1	5	10	20	30	40	50	60
Successful HO (%)	90	80	80	70	50	20	20	0

The graphical results are illustrated in Figure 4.

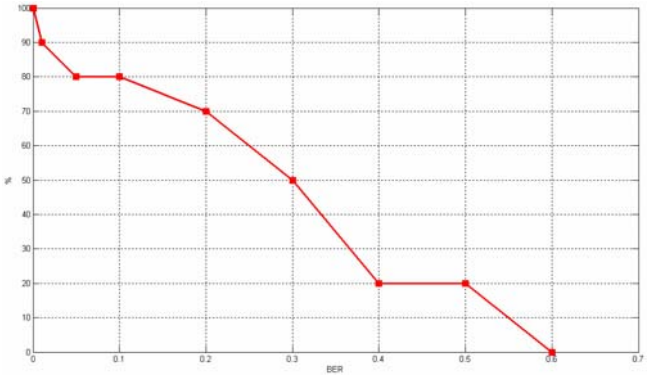

Figure 4 Handover success percentage depending on the BER

B. HANDOVER ANALYSIS DEPENDING ON MOVING SPEED OF THE MOBILE STATION

If the moving speed of the mobile station is increasing, the handover operation cannot be performed successfully because the mobile station cannot calculate the SNR in useful time and transmit Link_Going_Down. With the help of the simulation program, the number of successful vertical and horizontal handovers from a total of 10 depending on the moving speed of the MS was measured. The speed is expressed in meters per second. The results are shown in Table 2 and Figure 5.

TABLE II. HANDOVER SUCCES PERCENTAGE DEPENDING ON THE MOVING SPEED OF THE MS

Speed (m/s)	0-12	13-15	16-20	21-25	26-30	30-35	36-40
Successful HO (%)	100	80	70	50	30	20	10

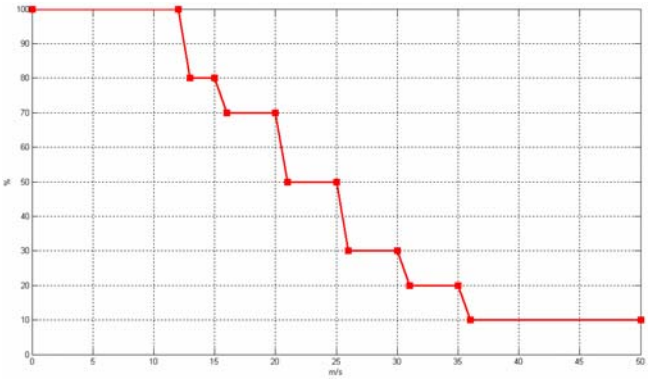

Figure 5 Handover success percentage depending on the moving speed of the MS

We observed that with the increasing of the moving speed the handover operation is affected

VI. CONCLUSIONS

From the presented graphics it can be seen that for a BER equal or greater then 0,6 the handover operation fails. Also for a moving speed greater then 35 m/s the rate of successful handovers is very small, around 10 %.

The handover decision algorithm based on signal to noise ratio is not very efficient because if the speed of the mobile station increases the handover cannot be performed seamless.

To improve the handover performance, decision algorithms witch consider the moving speed of the MS and the coverage area of the AP can be implemented.

That paper highlights the first implementations of OMNET++ simulator in UPB laboratory. The OMNET++ libraries were used and modified accordingly, especially for the INET platform.

The study is focused on handover simulation and analysis over heterogenous networks, as part of global study of unified services over heterogenous networks.

Next studies will be concentrated on: co-operative HO in 3G systems, HO QoS mechanisms, MIH security, impact of vertical HO on cooperative content distribution systems.

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