# A MIH-based Framework for Network Selection in Future HetNets

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Abstract: The heterogeneity is one of the key concepts of the Next Generation Wireless Networks (NGWNs). How to provide mobile users with the best connection anytime and anywhere become more important. In this paper, we propose an efficient vertical handover framework based on Media Independent Handover (MIH) technology, to address network selection in Heterogeneous Networks (HetNets) environments. A performance analysis is done and results are compared with existing algorithms for vertical handover. Results demonstrate a significant improvement with our developed approach.

## 1 INTRODUCTION

The Next Generation Wireless Networks (NGWNs) are composed of multiple Radio Access Technologies (RATs) that differ in bandwidth, operating frequency, cost, coverage area, and latencies. In this Heterogeneous Networks (HetNets) environments, new Radio Resource Management (RRM) schemes and mechanisms are necessary to benefit from the individual characteristics of each RAT.

An important RRM consideration for overall NGWNs stability, resource utilization, user satisfaction, and Quality of Service (QoS) provisioning is the selection of the most appropriate access network for a handover request. However, choosing the best RAT is not an easy task and there are many criteria to take into account when selecting the access network.

The Media Independent Handover (MIH) defined by the IEEE 802.21 standard was developed, especially to facilitate interoperability and handover among HetNets. This standard is in charge of the handover initiation and preparation stage (Omheni, 2014). It introduces a logical entity called MIH Function (MIHF). This entity hides the specificities of different link layer technologies from the upper layer entities. The upper layers entities communicate with the MIHF to get information about the lower layers. MIHF provides three main services: MIH Event Service (MIES), MIH Command Service (MICS), and MIH Information Service (MIIS). The Media Independent Event Service (MIES) provides services to the upper layers by reporting events corresponding to dynamic changes in link characteristics, status, and quality. The Media Independent Command Service (MICS) enables the upper layers to manage and control the functions of the lower layers (physical and link) related to handovers and mobility. A command to scan for newly available links or to switch between available links are typical examples of MIH commands. The Media Independent Information Service (MIIS) provides information about the characteristics and services of the serving and neighbouring networks while a Mobile Node (MN) moves.

However, no handover decision is made within MIH, "the implementation of the decision algorithm is out of the scope of MIH" (Lampropoulos, 2008). Indeed, if within a single technology, the horizontal handover can rely on the Received Signal Strength Indicator (RSSI), with heterogeneous wireless technologies, the vertical handover should consider a multitude of parameters. The main difficulties for such systems (HetNets) include the complexity and the efficiency of the decision algorithm but also the availability of the different decision criteria and parameters.

In this research work, we propose an enhanced IEEE 802.21 MIH based framework that integrates a Vertical Handover Management Layer (VHML) for



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optimal network selection based on multi-criteria metrics.

The rest of the paper is organized as follows: In section 2, we describe the related work focused on vertical handover and network selection in HetNets. In section 3, we present the proposed framework. In section 4, we present the multi-criteria network selection algorithm. Section 5 shows the performance analysis of the new approach. Finally, section 6 concludes the work and suggests future work.

## 2 RELATED WORK

In this section, we review previous research that has been done by other researchers on vertical handover and network selection in HetNets. (Kumbalavati, 2015) summarized the current works in the vertical handover on all three fronts: initiation, decision and execution. The survey revealed the need for new solutions to enable seamless handover with least handover latency and reduced call drop ratio.

The proposed mechanism in (Pahal, 2014) makes use of signal strength and residual time to initiate handover. In heterogeneous networks, handover decision based on the signal strength and residual time is not sufficient. Indeed, signal strength, available bandwidth, load, speed and packet loss are among the other parameters that affect the requirement of mobile user in terms of QoS guarantee.

To support vertical handovers across HetNets, several projects have begun to exploit the IEEE 802.21 MIH standard. (Omheni, 2014), proposed an MIH based approach for handover initiation and preparation in HetNets. The proposed framework is based on the concepts of IEEE 802.21 for context information gathering and optimized handover decision-making. In addition, they presented a network selection architecture and scheme that provide a resource efficient mobility management that aims at selecting the most suitable network interface for each application. In (Amali, 2014), the authors described a new framework of improved media independent handover to perform vertical handover in the context of HetNets. New functional entities are introduced in the terminal side to optimize the handover decision-making in the proposed framework. Authors in (Bae, 2011) proposed a Data Rate based vertical Handover Triggering Mechanism (DR-HTM) based on IEEE 802.21 standard in order to maximize capacity of both WLANs and cellular networks. In DR-HTM, whenever a mobile node discovers WLAN, it obtains achievable data rate of the WLAN by using remote MIH services. Based on the information, the mobile node determines execution of vertical handover. In (Buiati, 2014), the authors proposed a zone-based media independent information service using the IEEE 802.21 standard to accelerate the neighbour discovery procedure. In the proposed scheme, the access networks are associated and grouped in mobility zones, through an efficient set of rules, to minimize the amount of control messages flowing in the core network.

A number of researchers have proposed different network selection methods for HetNets environments. A multi-criteria access network selection algorithm is proposed in (Verma, 2013). The proposed methodology combines the Analytical Hierarchy Process (AHP) to decide the relative weights of criteria set according to network's performance, as well as the Grey Relational Analysis (GRA) to rank the network alternatives. This method mathematically presents a complex solution. Processing a large number of parameters the computational time is increasing and the user terminal and infrastructure network elements are additionally loaded so it is problematically interesting but not adequate for a direct implementation. Similar to this approach, a combination of two Multi Attribute Decision Making (MADM) methods: Analytic Network Process (ANP) method and the Technique for Order Preference by Similarity to the Ideal Solution (TOPSIS) method, was proposed in (Lahby, 2011) in order to develop an intelligent network selection strategy. The ANP method is used to find the differentiate weights of available networks by considering each criterion and the TOPSIS method is applied to rank the alternatives. In (Ahuja, 2014) authors proposed a network selection scheme based on weight estimation of QoS parameters in HetNets. In this proposed scheme, the weight estimation for the set of the network attributes is computed using entropy and TOPSIS approach. The numerical results show that the proposed model can be effectively implemented to select the desired network in a heterogeneous environment employing triple-play services.

In this paper we focus on vertical handover in next generation wireless networks. Our objective is to propose an efficient vertical handover framework based on IEEE 802.21 MIH standard to address network selection in future HetNets.

# 3 PROPOSED FRAMEWORK

IEEE 802.21 has been basically designed to facilitate the handover between heterogeneous networks, but the logic of selection is left without implementation. Thus, we propose an IEEE 802.21 enhanced MIH framework that integrates a Vertical Handover Management Layer (VHML) for network selection algorithm. We propose to implement our proposed VHML between the MIHF layer and the upper layer. Our new architecture retains message flow introduced by MIH and MIH function. The introduction of VHML between MIHF and the upper layers must preserve the continuity of message flow (commands and events) between local and remote MIH-entities. Figure 1 shows the overall proposed architecture.

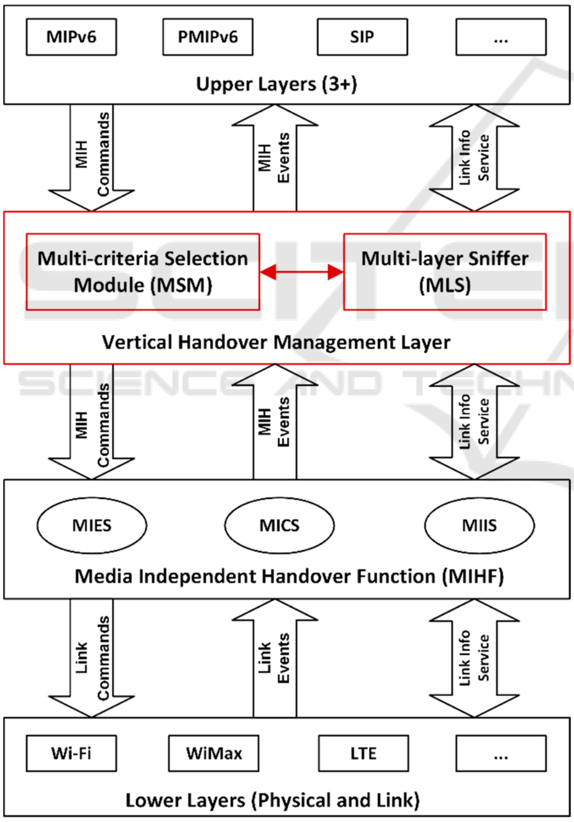


Figure 1: Proposed Vertical Handover Framework.

- Lower Layers

The lower layers (Physical and Link) are responsible for effective interface switching and handover trigger generation through MIES. It gathers link quality information and provides measurements.

- The MIHF Module

This layer is responsible for different tasks related to the vertical handover initiation and links control. It allows communication in both directions between lower and upper layers through three services: event, command and information services.

- The Media Independent Event Service (MIES): It detects events and delivers triggers corresponding to dynamic changes in link characteristics, status and quality to the Multi-criteria Selection Module (MSM) in the proposed Vertical Handover Management layer (VHML).

- The Media Independent Command Service (MICS): It provides a set of commands to the VHML to control handover relevant link states. The VHML is able to control the physical and the link layer through the MICS.

- The Media Independent Information Service (MIIS): It provides the information model for query and response on network resources and capabilities. It allows the MN to discover and obtain network information within a neighbouring area.

- The Vertical Handover Management Layer

This additional layer is responsible for vertical handover management. VHML is composed of two main functional entities responsible for context gathering, intelligent handover decision-making and accurate handover triggering: Multi-layer Sniffer (MLS) and Multi-criteria Selection Module (MSM). Each functional entity has specific roles in the architecture, as follows:

- The Multi-layer Sniffer (MLS): It detects, subtracts and gathers information from several sources in different protocol layers. For instance, from the application layer, it determines the application-level QoS and user preferences. At network layer and via IEEE 802.21 MIH, MLS collects information about the available Points of Attachment (PoAs) and sends them its QoS requirements based on its context and preferences. From lower layers, MLS gathers physical and link layers information such as RSS, packet delay and packet loss rate via MIES.

- The Multi-criteria Selection Module (MSM): It is responsible for network selection. It gets information about users and application requirements from the MLS. It communicates with the MIIS to get information about the characteristics and services of neighbouring networks.

Based on the trigger events provided by the MIES, on neighbour networks information provided by the MIIS and users and application requirements from MLS, this block checks for available networks, and selects the most appropriate as a target network. If this latter provides sufficient QoS, the mobile node hands over to this network. When a vertical handover is required, the MSM sends decision notification to the MICS to activate the lower layers handover, and a notification to the upper layers to activate the IP layer handover.

- Upper Layers

When a handover is required, the upper layers handle the handover execution. Several IP protocols at the network layer, such as Mobile IPv4 (MIPv4), Mobile IPv6 (MIPv6), Proxy Mobile IPv6 (PMIPv6), Hierarchical MobileIPv6 (HMIPv6), are able to perform the handover according to various strategies.

# 4 NETWORK SELECTION ALGORITHM

Currently, the implementation of the IEEE 802.21 standard considers only the radio signal strength indicator as a parameter to determine the best network. In next generation wireless networks, handover decision based only on RSSI is not sufficient to satisfy users' need. In fact, radio signal strength, available bandwidth, delay, and packet loss are among other parameters that have an impact on the mobile user in terms of QoS. For example, a bad QoS, when using a real time application, may be due to the poor support for bandwidth allocation and data rate because of high load in the serving network while the radio signal strength is good.

In this section, we propose a new access network selection algorithm, based on additional parameters. The considered factors are defined as:

$$F = (R,V,E,B,D,L,C,S) \quad (1)$$

Where R, V, and E denote the RSS, the user velocity and battery status respectively. B, D, and L denote the available bandwidth, delay, packet loss rate of the network respectively. C, S denote the cost of the network in monetary units per bit, and the security level respectively.

Since network selection in an environment of heterogeneous RATs depends on several factors, we focus on the MADM approach to realize a dynamic interface selection. The main objective of MADM approach is to determine the optimal network from a set of candidate networks. Each alternative is defined by a set of attributes. In our algorithm, alternatives represent the candidate access networks and attributes represent the candidate access networks characteristics.

The MADM essentially consists of four steps: identification of alternatives and attributes, development of the attributes, weight determination, and selection of the best alternative.

## 4.1 Identification of Alternatives and Attributes

In this step, all alternatives and attributes involved in the choice of the best RAT will be determined. The application scenario for our proposed scheme for the best network selection is a heterogeneous network consisting of 3GPP LTE and WLAN networks.

Network metrics are: RSS (R), MN velocity (V), battery status (E), available bandwidth (B), delay (D), packet loss rate (L), cost (C) and security level (S). Some of these parameters can be provided by the IEEE 802.21 standard such as the link quality, security level, and cost. While others must be estimated such as the available bandwidth and the energy associated with the MN battery consumption. The proposed MLS entity is responsible for gathering all information about the attributes of each alternative.

## 4.2 Attributes Development

Since the process MADM uses different attributes with different units of measurement, it is necessary to use the normalized vector of process when the input matrix X becomes normalized matrix R.

$$r_{ij} = x_{ij} \Big/ \sqrt{\sum_{i=1}^{n} x_{ij}^2}, \qquad r_{ij} \in [0\ 1] \quad (2)$$

Where, $i \in \{1,\ldots,n\}$ is an alternative (i.e. access network) among the set n of the alternatives, and $j \in \{1,2,3,4,5,6,7,8\}$ is an attribute (selection parameter) from the set F of attributes involved in the choice of the best RAT.

## 4.3 Weight Initialization using Entropy Method

We have used entropy method [12] for weight initialization. As it is more accurate, more appropriate and is convenient to implement. The entropy method consists of the following algorithm.

***Step 1:*** It is necessary to transform the model such that all the attributes must be maximized.

***Step 2:*** Determine the entropy of the attributes based on the relation:

$$e_j = \left[\frac{-1}{\ln(n)}\right] \times \sum_{i=1}^{n} \left[r_{ij} \ln\left(r_{ij}\right)\right], \quad j \in \{1,2,3,4,5,6,7,8\} \tag{3}$$

***Step 3:*** Determine the deviation within each criterion:

$$d_j = 1 - e_j, \ \ for\ j \in \{1,2,3,4,5,6,7,8\} \tag{4}$$

***Step 4:*** Determine the weight coefficients: If the user equally prefers all of the parameters, then:

$$w_j = \frac{d_j}{\sum_{j=1}^{8} d_j} \tag{5}$$

If the user determines the subjective weights, then:

$$w_j = \frac{d_j\, w_j}{\sum_{j=1}^{8} d_j w_j} \tag{6}$$

Where $w_j$ is the weight selected according to the service. After determining the initial weight coefficients using the entropy method, the weights are computed for the requested service using the following equation.

$$\begin{pmatrix} weight \\ estimation \\ of \\ requested \\ service \end{pmatrix} == \begin{pmatrix} weight \\ combination \\ of\ QoS \\ parameters \\ initialized \\ through \\ entropy \end{pmatrix} \times \begin{pmatrix} Threshold \\ values \\ of \\ attributes \\ of\ the \\ requested \\ service \end{pmatrix} \tag{7}$$

## 4.4 Network Selection using TOPSIS Method

TOPSIS is one of MADM techniques based on the concept that the chosen alternative should have the shortest Euclidean distance from the ideal solution and the longest from the non-ideal solution. The algorithm calculates perceived positive and negative ideal solutions based on the range of attribute values available for the alternatives. The premise of the algorithm is that the best solution is the one with the shortest distance to the positive ideal solution and longest distance from the negative ideal solution, where distances are measured in Euclidean terms. This method is simple and it gives an indisputable sequence of solution preference. The following steps are involved in the application of TOPSIS to the network selection problem.

***Step 1:*** After criteria weights estimation, in general, normalized matrix moves into the weighted matrix:

$$V = W.R \tag{8}$$

Here, V represents the updated weight matrix, i.e., the multiplication of the weight coefficients matrix generated by the entropy method and the proposed weight assignment algorithm with the normalized weight matrix.

***Step 2:*** The ideal solution is the set:

$$A^{+} = \left\{\left(\max v_{ij} | j \in J\right), \left(\min v_{ij} | j \in J'\right)\right\} \tag{9}$$

Where J is the set of criteria that is being maximized and J' is the set of criteria that is being minimized. This model is transformed while finding the weight coefficients such that all of the parameters are maximized and are based on that relation as well. The ideal solution in this case is the set:

$$A^{+}\left\{\left(\max v_{ij} | j \in \{1,2,3,4,5,6,7,8\}\right)\right\} \tag{10}$$

The non-ideal solution in this case is the set:

$$A^{-}\left\{\left(\min v_{ij} | j \in \{1,2,3,4,5,6,7,8\}\right)\right\} \tag{11}$$

***Step 3:*** The distance between each alternative, from the positive ideal $D_i^{+}$ and negative ideal solution $D_i^{-}$, are defined as follows:

$$D_i^{+} = \sqrt{\sum_{j=1}^{8} \left(v_{ij} - v_j^{+}\right)^2} \tag{12}$$

$$D_i^{-} = \sqrt{\sum_{j=1}^{8} \left(v_{ij} - v_j^{-}\right)^2} \tag{13}$$

***Step 4:*** Finally, the ranking of networks is performed by considering the relative closeness to the ideal solution, expressed as:

$$D_i = \frac{D_i^{-}}{D_i^{-} + D_i^{+}} \tag{14}$$

Where the best network is the one with the largest relative closeness to the ideal solution.

# 5 PERFORMANCE EVALUATION

## 5.1 Simulation Model

To evaluate the performance of the proposed enhanced MIH-based multi-criteria network selection scheme, we used the open-source MATLAB simulator. The simulated network is presented in Figure 2. We consider a 3GPP LTE networks overlaying WLAN networks. Mobile users are uniform randomly distributed within the networks and may freely move in accordance with the Random Walk point mobility model. The used propagation model in this simulation is the cost 231 indoor office model.

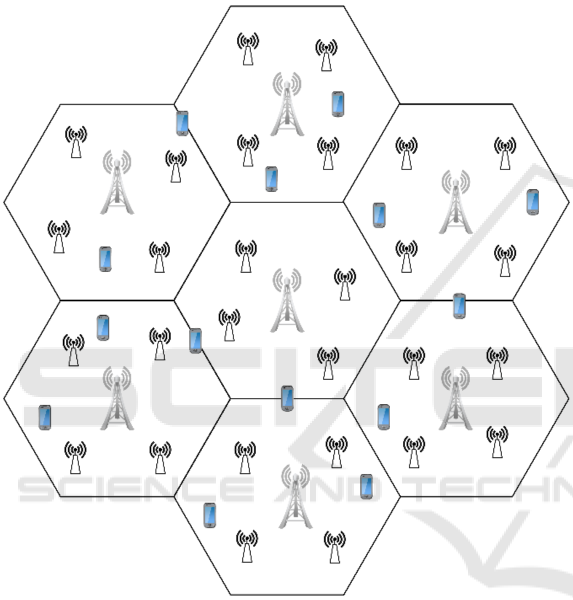

Figure 2: Scenario topology.

The simulation results are obtained using typical values of simulation parameters from Table 1 (Chaari, 2017). We have measured the packet loss rate and vertical handover blocking probability. We compare our work to RSSI based algorithm and adaptive threshold algorithm (Amali, 2014).

Table 1: Simulation parameters values.

| Parameters | Values |
|---|---|
| Number of Macro cells | 7 |
| Number of Small cells per Macro cell | 4 |
| eNodeB transmit power | 46 dBm |
| 3GPP LTE system bandwidth | 20MHz (100RB; 180 kHz/1 RB) |
| WLAN IEEE 802.11n data rate | 100 Mbps |
| LTE coverage(m) | 1000 |
| Wi-Fi coverage(m) | 250 |
| Total number of mobile nodes | 420 |
| Mobile nodes distribution model | Uniform randomly |
| Mobile nodes Mobility model | random walk model |
| Propagation model | cost 231 indoor office model |
| Mobile nodes traffic model | Video application |
| Mobile node speed | Varies from 3 to 120km/h |

## 5.2 Simulation Results

### 5.2.1 Packet Loss Rate

Packet loss rate is the ratio of the number of lost packets and the total number of sent packets. Figure 3 presents the rate of packet loss, according to the rate of arrival handover requests values. We notice from the curves that our proposed algorithm outperforms the RSSI based algorithm and adaptive threshold algorithm. This is because our proposed algorithm makes the best network selection which could minimize the total number of unnecessary handovers resulting in improving the total packet loss rate of the whole network.

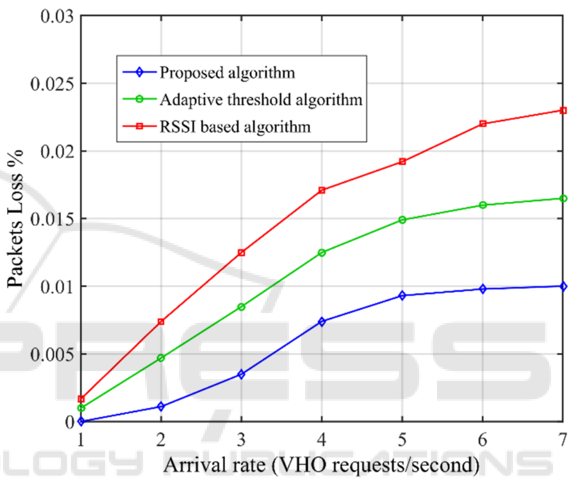


Figure 3: Scenario topology.

From the figure 3, in case of using our proposed scheme we can observe that the growth of packet loss rate for video traffic starts from a rate equal to 2 requests/s, and the probability begins to grow and reaches a value of 1 % for a rate equal to 7 calls/s. Whereas, for adaptive threshold algorithm and the RSSI based algorithm, the probability of packet loss can reach about 1.7 % and 2.3% respectively for a rate equal to 7 calls/s. The packet loss rate is comparatively high for the other two methods because the high number of unnecessary handovers during a session.

### 5.2.2 Handover Blocking Probability

Handover blocking probability is the ratio of the number of dropped handover requests and the total number of handover requests. Figure 4 shows the performance comparison of handover blocking probability for video service.

The handover blocking probability in case of using our proposed algorithm is always the lowest, followed by the adaptive threshold algorithm, and the RSSI based algorithm.

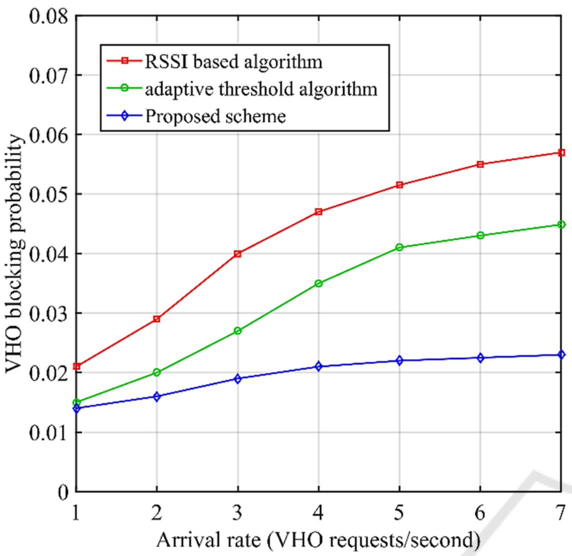


Figure 4: VHO blocking probability.

By comparing the curves, we note that the proposed network selection algorithm, gives a slight increase in handover blocking rate. This rate can reach the order of 2%. While the handover blocking rate for the other solutions increases rapidly with the increment of the total number of handover requests arrival rate. It increases to 4.5% in the case of using the adaptive threshold algorithm, and around of 6% in the case of using and the RSSI based algorithm. These results of handover blocking probability are observed for simulation experiments involving more than 7 requests / second.

## 6 CONCLUSIONS

In HetNets environments, architectural and implementation schemes are of prime importance to achieve ubiquitous access and seamless mobility. In this paper, we present an architectural solution. We propose an IEEE 802.21 enhanced MIH framework that integrates a Vertical Handover Management Layer for multi-criteria network selection.

Simulation results show that the proposed network selection algorithm performs better than other existing algorithms. It significantly reduces handover blocking probability rate and packet loss rate.

Regarding our future plans, we mainly intend to further elaborate on the handover management particularly we will interest to handover in vehicular communication in advanced 5G network.

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