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Optimization of Handoff Method in Wireless Networks

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Abstracts - Now-a-days many different types of networks communicate among themselves to form of heterogeneous wireless access technologies with diverse levels of performance has been envisioned to characterize the next-generation wireless networks. In heterogeneous wireless networks, handoff can be separated into two parts: horizontal handoff (HHO) and vertical handoff (VHO). VHO plays an important role in fulfilling seamless data transfer when mobile nodes cross wireless access networks with different link layer technologies. Current VHO algorithms mainly focus on when to trigger VHO to improve connection QoS but neglect the problem of how one can synthetically consider all currently available networks (homogeneous or heterogeneous) and choose the optimal network for HHO or VHO from all available candidates. In this paper, we present an analytical framework to evaluate VHO algorithms. This framework can be used to provide guidelines for the optimization of handoff in heterogeneous wireless networks. Subsequently, we extend the traditional hysteresis-based and dwelling-timer-based algorithms to support both VHO and HHO decisions and apply them to complex heterogeneous wireless environments. We refer to these enhanced algorithms as E-HY and E-DW, respectively. Based on the proposed analytical model, we provide a formalization definition of the handoff conditions in E-HY and E-DW and analyze their performance. Subsequently, we propose a novel general handoff decision algorithm GHO to trigger HHO and VHO in heterogeneous wireless networks at the appropriate time. Analysis shows that GHO can achieve better performance than E-HY and E-DW. Simulations validate the analytical results and verify that GHO outperforms traditional algorithms in terms of the matching ratio, TCP throughput, and UDP throughput.

Keywords: Heterogeneous wireless networks, vertical handoff, horizontal handoff, Wireless area networks

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Optimization of Handoff Method in Wireless Networks

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Abstract: Now-a-days many different types of networks communicate among themselves to form of heterogeneous wireless access technologies with diverse levels of performance has been envisioned to characterize the next-generation wireless networks. In heterogeneous wireless networks, handoff can be separated into two parts: horizontal handoff (HHO) and vertical handoff (VHO). VHO plays an important role in fulfilling seamless data transfer when mobile nodes cross wireless access networks with different link layer technologies. Current VHO algorithms mainly focus on when to trigger VHO to improve connection QoS but neglect the problem of how one can synthetically consider all currently available networks (homogeneous or heterogeneous) and choose the optimal network for HHO or VHO from all available candidates. In this paper, we present an analytical framework to evaluate VHO algorithms. This framework can be used to provide guidelines for the optimization of handoff in heterogeneous wireless networks. Subsequently, we extend the traditional hysteresis-based and dwelling-timer-based algorithms to support both VHO and HHO decisions and apply them to complex heterogeneous wireless environments. We refer to these enhanced algorithms as E-HY and E-DW, respectively. Based on the proposed analytical model, we provide a formalization definition of the handoff conditions in E-HY and E-DW and analyze their performance. Subsequently, we propose a novel general handoff decision algorithm GHO to trigger HHO and VHO in heterogeneous wireless networks at the appropriate time. Analysis shows that GHO can achieve better performance than E-HY and E-DW. Simulations validate the analytical results and verify that GHO outperforms traditional algorithms in terms of the matching ratio, TCP throughput, and UDP throughput.

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I. A LITERATURE REVIEW

The convergence of heterogeneous wireless access technologies with diverse levels of performance has been envisioned to characterize the next-generation wireless networks (4G). Recent trends indicate that Wireless Wide Area Networks (WWANs) and Wireless Local Area Networks (WLANs) can coexist to complement their different characteristics and provide both universal coverage and broadband access to users. Mobility management is a main challenge in the

converged network. It addresses two main problems: location management and handoff management [1]. Location management tracks the mobile terminal for successful information delivery. Handoff management maintains the active connections for roaming mobile terminals as they change their point of attachment to the network. In this paper, we focus on handoff management. Handoff (HO) is the mechanism by which an ongoing connection between a mobile terminal or mobile host (MH) and a correspondent terminal or correspondent host (CH) is transferred from one point of access to the fixed network to another [2]. In cellular networks, such points of attachment are referred to as base stations (BSs), and in WLANs, they are called access points (APs). In heterogeneous wireless networks, handoff can be separated into two parts: horizontal handoff (HHO) and vertical handoff (VHO). A horizontal handoff is made between different access points within the same link-layer technology such as when transferring a connection from one BS to another or from one AP to another. A vertical handoff is a handoff between access networks with different link-layer technologies, which will involve the transfer of a connection between a BS and an AP. Seamless and efficient VHO between different access technologies is an essential and challenging problem in the development toward the next-generation wireless networks. In general, the VHO process can be divided into three main steps: system discovery, handoff decision, and handoff execution [24]. During the system discovery phase.

II. RELATED WORKS

There are three strategies for handoff decision mechanisms: Mobile-controlled handoff (MCHO), network-controlled handoff (NCHO), and mobile-assisted handoff (MAHO) [2]. MCHO is used in IEEE 802.11 WLAN networks, where an MH continuously monitors the signal of an AP and initiates the handoff procedure. NCHO is used in cellular voice networks where the decision mechanism of handoff control is located in a network entity. MAHO has been widely adopted in the current WWANs such as GPRS, where the MH measures the signal of surrounding BSs and the network then employs this information and decides whether or not to trigger handoff. During VHO, only MHs have the knowledge about what kind of interfaces they

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are equipped with. Even if the network has this knowledge, there may be no way to control another network that the MH is about to hand off to. Therefore, MCHO and further assistance from the networks is more suitable for VHO [10]. Two main categories of handoff algorithms are proposed in the research literature [3] based on 1) the threshold comparison of one or more metrics and 2) dynamic programming (DP)/artificial intelligent techniques applied to improve the accuracy of the handoff procedure. The first category is the traditional algorithms widely used in radio cellular systems, which employs a threshold comparison of one or several specific metrics to make a handoff decision. The most common metrics are received signal strength (RSS), carrier-to-interference ratio (CIR), Signal-to-interference ratio (SIR), and bit error rate (BER) [2]. In heterogeneous wireless networks, even though the functionalities of access networks are different, all the networks use a specific signal (beacon, BCCH, or reference channel I) with a constant transmit power to enable RSS measurements. Thus, it is very natural and reasonable for VHO algorithms to use RSS as the basic criterion for handoff decisions. In order to avoid the ping-pong effect, additional parameters such as hysteresis and dwelling timer can be used solely or jointly in the handoff decision process. In [4], in addition to the absolute RSS threshold, a relative RSS hysteresis between the new BS and the old BS is added as the handoff trigger condition to decrease unnecessary handoffs. Marichamy et al. [5] proposes a handoff scheme based on RSS with the consideration of thresholds and hysteresis for mobile nodes to obtain better performance. However, in heterogeneous wireless networks, RSS from different networks can vary significantly due to different techniques used in the physical layers and cannot be easily compared with each other. Thus, the methods in [4] and [5] cannot be applied to VHO directly. Hatami et al. [6] use the dwelling timer as a handoff initiation criterion to increase the WLAN utilization. It was shown in [7] that the optimal value for the dwelling timer varies along with the used data rate or, to be more precise, with the effective throughput ratio. In [8], Yliantila et al. extend the simulation framework in [6] by introducing a scenario for multiple radio network environments. Their main results show that the handoff delay caused by frequent handoff has a much bigger degrading effect for the throughput in the transition region. In addition, the benefit that can be achieved with the optimal value of the dwelling timer as in [7] may not be enough to compensate for the effect of handoff delay. In [9], Park et al. Propose a similar dwelling-timer-typed approach by performing the VHO if a specific number of continuous received beacons from the WLAN exceed or fall below a predefined threshold. Additionally, in the real-time

service, the number of continuous beacon signals should be lower than that of the non-real-time service in order to reduce the handoff delay. More parameters may be employed to make more intelligent decisions. Lee et al. [10] propose a bandwidth aware VHO technique, which considers the residual bandwidth of a WLAN in addition to RSS as the criterion for handoff decisions. However, it relies on the QBSS load Defined in the IEEE 802.11e Standard to estimate the residual bandwidth in the WLAN. In [11], McNair et al. propose a method for defining the handoff cost as a function of the available bandwidth and monetary cost. In [12], actual RSS and bandwidth were chosen as two important parameters for the cost function. Chang et al. [13] propose an adaptive cost-based with predictive RSS approach to perform VHO in heterogeneous wireless networks. One main difficulty of the cost approach is its dependence on some parameters that are difficult to estimate, especially in large cellular networks. Mohanty and Akyildiz [14] developed a cross-layer (Layer 2 + 3) handoff management protocol CHMP, which calculates a dynamic value of the RSS threshold for handoff initiation by estimating MH's speed and predicting the handoff signaling delay of possible handoffs. The second category of handoff algorithms use dynamic programming (DP) [15] or artificial intelligence techniques such as pattern recognition [16], [17], neural networks [2], or fuzzy logic [3], [18], [19] to improve the accuracy and effectiveness of the handoff procedure. Veeravalli and Kelly [15] pose the handoff problem as a finite-horizon DP problem and obtain the optimal solution through a set of recursive equations. The optimal solution is complicated and nonstationary, and it requires prior knowledge of the MH's exact trajectory. Subsequently, Veeravalli and Kelly [15] derive a simple locally optimal algorithm from the DP solution, which can be designed to be independent of the location of the MH. In [16], pattern- recognition-based handoff algorithms train a system using available metrics (for example, RSS) and the locations where handoff should be made so that the system acquires knowledge of the RSS patterns at such locations. Pahlavan et al. [2] present a simple neural-network-based approach to detect signal decay and make handoff decisions. Guo et al. [19] propose an adaptive multicriteria VHO (AMVHO) decision algorithm. This algorithm uses a fuzzy inference system (FIS) and a modified Elman neural network (MENN). The FIS adopts crucial criteria of the VHO as the input variables and makes the handoff decision based on the defined rule base. The MENN helps in the prediction for the number of users in the after-handoff network, which is a pivotal variable of the FIS. It is important to mention that the complexity of such artificial-intelligence-based algorithms is very high, and its implementation in MHs with limited computing and

storage capability may not be possible. In addition, training of the neural network has to be done beforehand. To sum up, the application scenario of current VHO algorithms is relatively simple. For example, most VHO algorithms only consider the pure VHO scenario, where the algorithm only needs to decide when to use a 3G network and when to use a WLAN [1], [10], [19], [20], [21]. In fact, at any moment, there may be many available networks (homogeneous or heterogeneous), and the VHO algorithm has to select the optimal network for HHO or VHO from all the available candidates. For example, if the current access network of MH is a WLAN, the MH may sense many other WLANs and a 3G network at a particular moment, and it has to decide whether to trigger HHO or VHO. If the HHO trigger is selected, MH then needs to decide which WLAN is the optimal one. Consequently, an analytical framework to evaluate VHO algorithms is needed to provide guidelines for optimization of handoff in heterogeneous wireless networks. It is also necessary to build reasonable and typical simulation models to evaluate the performance of VHO algorithms. In addition to the MR, we also use TCP throughput

III. ASSUMPTION AND EVALUATION CRITERIA

1) Assumption

As mentioned earlier, MCHO and further assistance from the networks is more suitable for VHO. Thus, we assume that the VHO algorithms take the MCHO strategy for handoff decisions, and the network environment satisfies the following conditions (note that we take 3G and IEEE 802.11b WLANs as representative examples of WWAN and WLAN, respectively; however, the proposed analytical framework and handoff algorithms are readily extendible to heterogeneous wireless networks formed by other WWANs and WLANs):

- Neither the WLAN nor the 3G network has network mobility. In other words, the entire network, as a unit, does not change its point of attachment to the Internet and its reachability in the topology.
- Neither the signal strength of the WLAN nor the signal strength of the 3G network will change as time passes. In other words, the signal coverage area is stable.
- We assume that there is no height difference between the AP in a WLAN and the BS in a 3G network. This means that the AP and BS are located in the same 2D space, and the MH only moves in this 2D space.

- There is no object that influences or shelters the wireless signal in the range of MH's movement. There is no restriction on MH's movement either, which means that the MH can move in any direction with any speed. In this paper, we do not consider the influence of the pricing model and user's special preferences for handoff.

The purpose of handoff is to maintain the connection and achieve the best possible QoS.

2) Evaluation Criteria for Handoff Methods

In order to evaluate the performance of handoff algorithms, we have defined a new metric, matching ratio, *in*. Matching means that the decision of the algorithm is the optimum access network at the moment. For example, when the 3G network could provide better QoS, it is said to be matching if the algorithm chooses the 3G network. The matching ratio (MR) is the percentage of the matching period per time unit. Higher MR means that the handoff algorithm can provide better QoS. In addition to the MR, we also use TCP throughput and UDP throughput as evaluation criteria for handoff algorithms.

IV. ARCHITECTURE OF HANDOFF MANAGEMENT SYSTEM

Phalavan made a summary of issues related to handoff [2]. These issues are divided into architectural issues and handoff decision algorithms. In this paper, we focus on the design and evaluation of handoff decision algorithms in heterogeneous wireless networks. The fundamental aim of handoff is to make good use of network bandwidth and improve the QoS of applications. In Fig. 1, we show the general modules and procedures of the modules of handoff management system. Our system. Some of these modules collect the link-layer and network-layer information useful for handoff management, and other modules use this information to decide on the appropriate time to initiate handoff and execute the handoff procedures.

V. ANALYTICAL FRAMEWORKS OF VERTICAL HANDOFF METHODS

During the handoff decision process, two factors should be considered. On one hand, the MH should try maximizing the utilization of a high bandwidth and low cost access network. On the other hand, the number of unnecessary handoffs should be minimized to avoid degrading the QoS of current communication and overloading the network with signaling traffic.

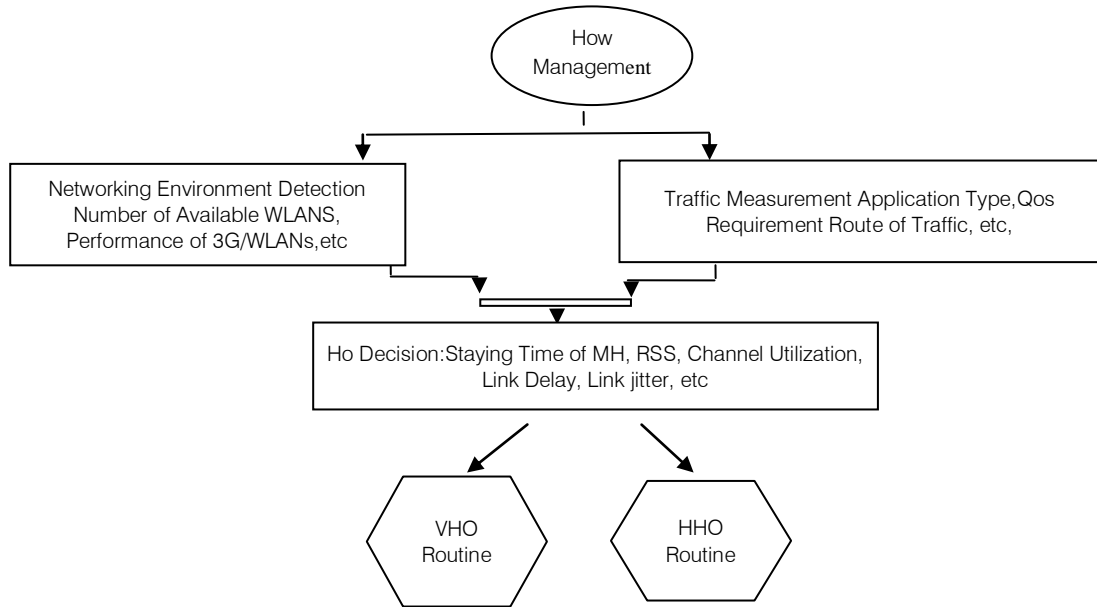


Fig : the modules of handoff management system

VI. ENHANCEMENT OF EXISTING HANDOFF ALGORITHMS AND THEIR PERFORMANCE ANALYSIS

The hysteresis-based algorithm (HY) is a traditional HHO algorithm that is widely used in radio cellular systems. However, because RSSs measured from different networks display a significant variety due to different techniques in the physical layers and cannot be compared with each other, HY cannot be applied to VHO directly. In this paper, we extend the traditional HY to support both VHO and HHO decisions and apply it to complex heterogeneous Wireless environments. We name the enhanced algorithm as E-HY. Based on the definition of the handoff policy of E-HY can be described by the following (hy denotes hysteresis): $\vartheta(N-1) \neq \Phi(N) \leftrightarrow D \neq \vartheta(N-1)(N) < -hy$. The relevant deductions for obtaining the above expression are provided in Appendix A.

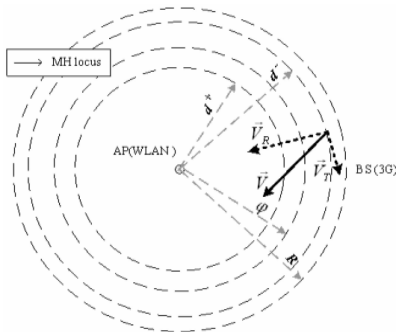


Fig 2. Traversing Scenario for performance analysis.

Thus, we can get the definition of $\vartheta(N)$ in E-HY as In addition, we can extend the traditional dwelling timer-based algorithm to support both VHO and HHO decisions and get the handoff policy of E-DW (tdw denotes the dwelling timer) as Next, we will analyze the performance of E-HY and E-DW during the process of an MH traversing one WLAN. Consider the movement scenario as shown in Fig. 2, where the coverage area of the WLAN is a circle whose center is its AP.

VII. A NOVEL GENERAL HANDOFF METHOD AND ITS PERFORMANCE

According to the analysis in the previous section, we can see that a simple method to improve the MR is to use the E-HY algorithm when $v > v_{HO}$ and use the E-DW algorithm when $v < v_{HO}$. However, it is difficult to obtain the velocity of the MH, especially VR. In a practical environment, we must get the position coordinates of the MH and periodically determine their changes to calculate

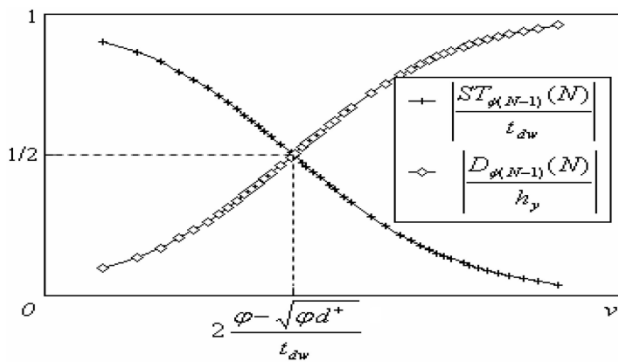


Fig 3. MR of E_HY, E-Dw and GHO as v changes

Fig 3. Analysis of Influence factors in the handoff policy of GHO the velocity of the MH. Constantly monitoring the MH's accurate position is expensive, power consuming, and subject to the influence of the environment. In order to improve the MR, let us examine the handoff conditions of E-HY and E-DW again. we can get the numerical solution of MRGHO. Compared with E-HY and E-DW, GHO can achieve better MR, as shown in Fig. 4. In Fig. 4, the x-axis adopts the logarithmic scale in order to show the instance when v is very large. In addition, the related computing requirement of GHO is very simple to be suitable for mobile devices with limited computing capacity.

VIII. PERFORMANCE EVALUATION

1) Simulation Scenario

We design and implement a simulation model, as shown in Fig. 4, to act as a benchmark for the performance evaluation of the VHO algorithms. Assume that MH takes a random rectilinear motion without pause in the square containing four APs, as shown in Fig. 3. The side length of the square is $a = 600$ m. This square is completely covered by a 3G network. The coverage area of each AP is a circle whose radius is $R = 150$ m. The position coordinates of the four APs are (u, u) , $(-u, u)$, $(-u, -u)$ and $(u, -u)$. By setting u as different values, this model can simulate different handoff scenarios. When $u = 150$ m, as shown in Fig. 5, there is no overlapping between the coverage areas of the different APs. When $u = 100$ m, as shown in Fig. 5 there is a significant overlap between the coverage areas of Product operator is defined as

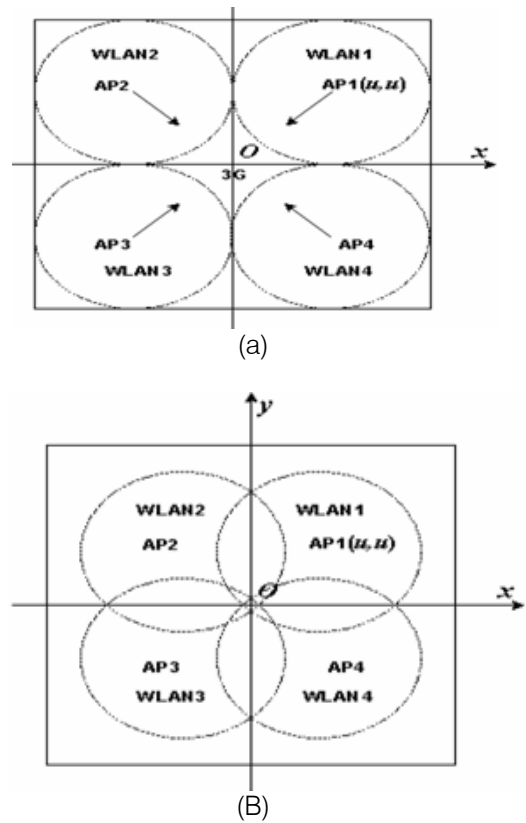


Fig 4. Simulation model when model (u, u)

2) Simulation Results

Figs. Next 6,7 MR v (m/s), and u (m) in in E-DW, E-HY, and GHO. We can see that as v increases, the MR of E-DW will decrease, whereas, as u increases, its MR increases. In contrast, v has little influence on MR in E-HY. When u increases, E-HY's MR will increase, but the change range is small (between 86.8 percent and 92.1 percent). For GHO, when v is slow, the change trend of its MR is similar to E-DW, whereas, when v is fast, the change trend of its MR is similar to E-HY. When v is slow, the MR of E-DW is about 5 percent higher than E-HY, whereas, when v is fast, E-HY can get about 20 percent higher MR than E-DW. No matter what the value of v is, GHO can get better MR than E-DW and E-HY. This conclusion is consistent with the analytical results in the previous sections. In our simulations, we respectively set $u = 150$ m; 145 m; 140 m; . . . ; 100 m. Random rectilinear motion means that the MH randomly chooses the destination in the square area, moves straight to the destination with constant speed v , and then repeats the procedure. Choosing a destination and changing the direction will not consume time. Destination selection satisfies a uniform distribution in the square area. In order to get rid of random causes, each simulation includes more than 10,000 continuous random rectilinear motion procedures. In order to evaluate the performance of the algorithms under different moving speeds of the MH, for each value of u , we respectively

set v as 1, 2, 5, 10, and 20 m/s when performing the simulations. We can consider 1 and 2 m/s as the speed of pedestrians, whereas 5, 10, and 20 m/s reflect the speed of different vehicles in the city.

IX. RESULT

Comparison when $u=150m$

	Algorithm	V=1m/s	V=20m/s
MR	E-DW	97.20%	69.30%
	E-HY	92.10%	92.10%
	GHO	98.20%	95%
TCP throughput	E-DW	191kbps	48kbps
	E-HY	182kbps	89kbps
	GHO	193kbps	94kbps
UDP throughput	E-DW	140kbps	71kbps
	E-HY	134kbps	105kbps
	GHO	141kbps	109kbps

	Algorithm	V=1m/s	V=20m/s
MR	E-DW	91.00%	69.30%
	E-HY	86.80%	92.10%
	GHO	92.00%	95%
TCP throughput	E-DW	207kbps	48kbps
	E-HY	207kbps	89kbps
	GHO	193kbps	94kbps
UDP throughput	E-DW	140kbps	71kbps
	E-HY	134kbps	105kbps
	GHO	141kbps	109kbps

Comparison when $u=100m$

X. CONCLUSION AND FUTURE WORK

In this paper, we first presented an analytical framework to evaluate VHO algorithms. This framework can be used to provide guidelines for the optimization of handoff in heterogeneous wireless networks. Subsequently, we extended the traditional hysteresis-based and dwelling-timer based algorithms to support both VHO and HHO decisions. We referred to these algorithms as E-HY and E-DW, respectively. Analysis showed that the MR of E-HY has no relation with the MH's moving speed. Based on the analysis, we proposed a novel handoff decision algorithm GHO to trigger HHO and VHO at appropriate times in heterogeneous wireless networks. GHO synthetically of E-DW and E-HY. In addition, when the moving speed is slow, the handoff condition in GHO will be more similar to E-DW, and when the moving speed is high, its handoff condition will be more similar to E-HY. Analysis

and simulations show that GHO can achieve better performance than E-DW, E-HY, and PreRSS-Cost. In our future work, we will explore the optimal weight values of the influence factors in and how we can determine them in different scenarios. In addition, we will investigate bandwidth-aware VHO techniques, which determine them in different scenarios.

XI. FUTURE ENHANCEMENTS

11.A. Scope of the Project:

- 1) A vertical **handoff algorithm** which enables a mobile node to intelligently select **wireless access network** among multiple access.
- 2) Secure Data Transmission through LAN
- 3) Establishing a call between the wireless communication device and the at least one serving base station.

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