Distance-Based Scheme for Vertical Handoff in Heterogeneous Wireless Networks

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***Abstract*— Seamless vertical handoff between different access networks in the next generation wireless networks remains a challenging problem. A recent vertical handoff scheme that is based on Signal to Interference and Noise Ratio (SINR) may not be the best scheme for selecting the service access point or base station. Although this SINR-based scheme has higher system throughput and lower disconnection probability as compared with other vertical handoff schemes, we presume that the distance is a good criterion for decreasing service disconnection probability and increasing system throughput. The Distance-based Scheme for Vertical Handoff (DSVH) that we propose in this paper for heterogeneous wireless networks is a reactive vertical handoff scheme. We suggest that vertical handoff be based on the Received Signal Strength (RSS) and the distances to access points or base stations, where the main goal of this scheme is to enhance system performance in terms of reducing service disconnection probability and increasing system throughput. The simulation experiments show that our proposed scheme, DSVH, significantly outperforms the SINR-based scheme. It reduces the number of dropped users by 20%. However, the throughput improvrmrnt is insignificant; it is about 1%.**

***Index Terms*—Vertical handoff, SINR, RSS, Heterogeneous Wireless Networks**

I Introduction

Nowadays, mobile users demand to be connected with the Internet while they move freely, and Always Best Connected (ABC) has become a very important service for mobile users so as to get high quality services at high data rates [2].

A state-of-the-art Fourth Generation (4G) wireless network is composed of different wireless subnetworks that complement each other [3]. The integration of such heterogeneous subnetworks should allow mobile stations (MSs) to choose the most appropriate access subnetwork among the available alternatives (these include IEEE 802.11 Wireless Local Area Network (WLAN) and IEEE 802.16 Worldwide interoperability for Microwave Access (WiMAX)), in addition to the traditional cellular networks.

One of the important issues in mobility is mobility management. This is concerned with location management and handoff management [6]. Location management enables the system to track the locations of mobile stations continuously as they move from one location to another; this might be in the same system or to a different one. On the other hand, handoff management aims to maintain an active connection with high quality between the MS and the network during the movement of the MS. This process requires keeping track of the state of the MS, either when it is linked with some Base Station (BS) [7] or when it is moving from one BS to another [8].

Handoff can be either horizontal or vertical [1]. A horizontal handoff takes place when the MS switches between points of attachment supporting the same network technology. For example, between two neighboring BSs of a cellular network. On the other hand, a vertical handoff occurs when the MS switches between points of attachment supporting different network technologies, for example, between a cellular network BS and an IEEE 802.11 AP [9][10]. A handoff process can be divided into three stages: initiation process (radio link transfer), decision process and execution process (channel assignment) [11] [12].

In this paper, we are interested in vertical handoff. Several criteria have been proposed in the literature for use in vertical handoff schemes. The main criteria used are discussed below:

- Received Signal Strength (RSS): is the most widely used criterion to decide which network to use for the handoff from a candidate list of networks. It is easy to measure and it is directly related to service quality. Obviously, RSS depends on the velocity of the MS, and on the distance between the MS and its point of attachmen. When a MS notices that the RSS is gradually decreasing, it can be assumed that the MS is moving away from the AP. When the RSS is increasing, then the MS is moving towards an AP. The speed and direction of a mobile node indicate the length of time the current connection can be maintained. Another factor is the coverage area of the network. A small coverage area would cause excessive handoffs between access points within the same network, which can lead to high packet loss.
- Signal to Interference plus Noise Ratio (SINR): is the

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ratio of the power of the received desired signal to the average noise power at the receiver. SINR can be improved by increasing the transmitted power, decreasing the coverage range and using a better Low Noise Amplifier (LNA).

- Available Bandwidth: is the volume of data per unit of time that a transmission medium can handle [1]. It is a good indicator of traffic conditions in the access network. When a high bandwidth network, for example, a WLAN is heavily loaded or congested, the MS can switch to a lower bandwidth connection.

A. *Background on Radio Wave Propagation*

Radio wave propagation deals with the properties and behavior of radio waves as they propagate from the sender to the receiver. There are three key factors that may impede the propagation of waves. They are reflection, diffraction and scattering. Reflection occurs when radio waves collide with a very large object, such as a mountain, a hill and a tower. Diffraction occurs due to collision with an aliasing object (i.e., an object that contains wavy edges and many protrusions surfaces). Scattering happens when the radio waves pass through paths that contain a large number of objects with small dimensions compared with the wavelength, such as foliage, herbs and street signs [14].

Path loss indicates the decline in the power of the wave during transmission from the sender to the receiver. In general, the path loss depends on the properties of the environment, the topography of the earth and the propagation medium, and the distance between the sender, the receiver, and the height of the BS/AP [13].

The propagation or path loss from the sender antenna to the receiver antenna is computed using the equation:

$$P_L = 10 \log [P_t / P_r]$$

Where P_L is the path loss in decibels (db), P_t is the transmitted power in watts, and P_r is the received power in watts.

Several models have been proposed for computing the path loss in various environments. These models are based on experiments in real environments, where all objects that are present in a particular experimental environment are taken into account, whether they are mountains, towers or buildings … etc [15].

Okumura's Model [16] is a well-known model for predicting the value of the path loss in an urban environment. This model is applicable when the frequency of waves is within the 150-1920 MHz range [17], the distance between the sender and receiver is from 1-100 km, and the height of the antenna of base station is from 30-1000 m. To determine the median path loss between the sender and receiver, Okumura developed a set of curves that give the median attenuation (A_{mu}) relative to free space in an urban area with BS antenna height of 200 m and mobile station (MS) antenna height of 3 m. [15]. Another model, the Hata model, is an extension of the Okumura model [18]. This model is applicable for the 150-1500 MHz frequency range, the sender-to-receiver distance range of 1-20 km, and base station heights from 30 to 200 meters and MS heights from 1 to 10 meters.

B. *Problem Definition and Motivation*

A recent SINR-based vertical handoff scheme [28] [29] has higher system throughput and lower disconnection probability as compared with other vertical handoff schemes**.** However, we presume that the distance is a better criterion for decreasing. service disconnection probability and enhancing system throughput when selecting the best AP or BS. We propose that wave propagation models use the distance to the AP/BS as a main parameter, and propose a reactive distance-based vertical handoff scheme that aims to improve performance as compared with the recent SINR-based vertical handoff scheme. The proposed scheme has been designed and simulated using MATLAB. In order to evaluate the performance of our proposed scheme, we have compared our results to those of the SINR scheme. The reason behind choosing the SINR scheme is that it has high system throughput and low disconnection probability as compared with other vertical handoff schemes.

II Literature Review

Vertical handoff schemes are essential components of the structural design of the forthcoming 4G heterogeneous wireless networks. These schemes need to be designed to provide the required QoS to a wide range of applications while allowing seamless roaming among a multitude of access network technologies [1].

There are many proposed schemes for vertical handoff in heterogeneous networks, which can be grouped into four categories: RSS-based, bandwidth-based, area-based and fuzzy logic-based vertical handoff scheme.

A. *RSS-based Vertical Handoff Schemes*

The idea of the RSS based vertical handoff schemes is to calculate and compare the RSS of the current point of attachment against the others to make handoff decision. A lot of previous work and studies have been conducted in this topic [23] [24] [25] [26]. In this section we discuss three representative RSS based vertical handoff schemes.

Zahran et al [23] [27] proposed an adaptive lifetime-based vertical handoff (ALIVE-HO) scheme which takes into consideration the RSS, handoff latency, application QoS and delay tolerance, by presenting an application-based signal strength threshold (ASST) tuning mechanism to study the performance of vertical handoff between Third Generation (3G) cellular network and WLAN. The ASST have a significant role in future generation wireless networks where access technologies with different characteristics are expected to seamlessly co-exist and efficiently inter-operate. Therefore, the ASST can be optimally tuned for any access network based on practical system characteristics and requirements. In this scheme, the vertical handoff between 3G cellular network and WLAN can be described through two cases; in the first case, when the MS moves towards a WLAN cell. The handoff to the WLAN is trigger if the average RSS measurement of the

WLAN signal is larger than a threshold (MIT_{WLAN}) and the available bandwidth of the WLAN meets the bandwidth requirements of the application. While in the second case, when the MS moves away from the coverage area of a WLAN into a 3G cellular network cell, a handoff to the 3G cellular network is initiated under the conditions that the average RSS of the WLAN connection falls below a predefined threshold (MOT_{WLAN}), and the expected lifetime is less than or equal to the handoff delay. An analytical framework has been proposed to evaluate the performance of adaptive lifetime-based vertical handoff (ALIVE-HO) scheme, which is validated by computer simulation. This analytical framework proved that by introducing the lifetime metric the algorithm adapts to the application requirements and the MS mobility reducing the number of superfluous handoffs, and there is an improvement on the average throughput that provides for the MS because of the MS's ability to remain connected to the WLAN cell as long as possible.

Another scheme was designed to minimize the probability of unnecessary handoffs and to improve the overall network utilization. Yan et al [25] [26] proposed a vertical handoff decision scheme based on the distance of traveling distance within a WLAN cell (i.e. the time that MS is expected to spend within a WLAN area). The proposed scheme uses two thresholds which are calculated by the MS as it enters the WLAN area: Distance traveling threshold which based on RSS change rate (i.e. time that the MS is expected to spend within the WLAN area) and distance threshold which is calculated based on various network parameters such as handoff failure, handoff probability, radius of the WLAN area and handoff delays. A handoff to a WLAN is initiated if the WLAN coverage area is available and the estimated traveling distance inside the WLAN area is larger than the distance threshold. While a handoff to the cellular network is initiated if the WLAN RSS is continuously, fading and the MS reaches a handoff commencement boundary area based on its speed. The performance analysis showed that the main improvement of this scheme is that it minimizes the probability of handoff failures, unnecessary handoffs and connection breakdowns whenever the predicted traveling distance inside the WLAN cell is smaller than the distance threshold value.

B. Bandwidth-based Vertical Handoff Schemes

Bandwidth based vertical handoff schemes considers the available bandwidth for MS as the main criterion to make handoff decision. A lot of previous work and studies have been conducted in this topic [22] [27] [28] [29]. In this section, three representative bandwidth based vertical handoff schemes are discussed.

Yang et al [22] proposed a bandwidth-based vertical handoff scheme between WLAN and Wideband Code Division Multiple Access (WCDMA) network, using the received Signal to Interference plus Noise Ratio as the handoff criteria. This scheme consider the combined effects of SINR from different access networks; where the SINR value from one network being converted to equivalent SINR value to the target network. A handoff to the network with larger SINR is performed, so the handoff algorithm can provide the knowledge of the achievable bandwidth from both access networks to make handoff decisions with QoS consideration. In addition to that, Yang et al [27] recently propose a Multi-dimensional Adaptive SINR based Vertical Handoff scheme (MASVH) for next generation heterogeneous wireless networks. This scheme uses the combined effects of SINR, MS required bandwidth, MS traffic cost and utilization from participating access networks to provide seamless vertical handoff with multi-attribute QoS support. Simulation results confirm that the new MASVH scheme improves the system performance in terms of higher throughput and lower dropping probability, as well as reduces the MS traffic cost for accessing the integrated wireless networks.

Ayyappan et al [28] [29] proposed SINR based vertical handoff scheme for QoS in heterogeneous wireless networks. In order to provide QoS inside the heterogeneous network, the vertical handoff scheme needs to be QoS aware, which can be achieved by gives the SINR based handoff better than RSS based handoff. This scheme considers the received SINR as a handoff criterion, which can be calculated using the Shannon's capacity theorem as $R = W \log2 (1 + \gamma / \Gamma)$ Where, R is the maximum throughput, W is the carrier bandwidth, γ is SINR received at MS, Γ is the gap between uncoded quadrature amplitude modulation and channel capacity. The handoff is initiated when the MS receives higher equivalent SINR from another network. In such cases, the MS tries to switch to another network that will satisfy the service QoS attributes. Simulation results prove that the proposed SINR based vertical handoff scheme provides higher overall system throughput as well as minimum number of dropped MS.

Rafiq et al [30] proposed a vertical handoff scheme that takes into account end-to-end QoS in addition to other common parameters. The scheme present an architecture involving an external host based light-weight server, called Access Link Utilization Monitor (ACUM) that disseminates the available end-to-end bandwidth to the mobile node to assist it in making a decision to maintain end-to-end service quality. The authors also describe a fuzzy logic based algorithm that is used in the handoff decision.

C. Area-based Vertical Handoff Schemes

Area-based schemes make use of geographical information that is gathered by either GPS devices or a physical layer support. Such additional coverage area information is exploited in making proper vertical handoff decision. In this section, two representative area-based vertical handoff schemes are discussed.

The mobility models of MS are used as input data for predicting the next served AP. Zhang et al [31] predict a handoff based on the movement of MS using its current location, direction and velocity, to predict the next location L [x, y] after certain period. It finds a serving AP of the location L and if it different from the current AP, it initiates the handoff to that AP. Distance from AP is another scheme to predict a handoff that based on the current position of the MS. The MS compares the distance from the current associated AP with the distance from the APs of neighbor cells. When MS is moving away from the current AP, it calculates the time when it will get out of the cell. If it determines that it will be out of cell in several scans later, it decides the handoff and searches for the next nearest AP. If there is a nearer AP than the current associated AP, the MS determines the handoff to the nearest AP [31].

D. Fuzzy Logic-basedVvertical Handoff scheme

Shih-Jung [33] proposes the Fuzzy Normalization - HandOver Decision strategy algorithm (FUN-HODS), to obtain system-loading balance and to avoid failures caused by mobile node handovers to network access points with lower velocity capabilities and weaker RSS requirements. The characteristics of fuzzy normalization were applied to handover decisions to make vertical handover decisions as simple as the horizontal one. The simulation experiments proved that the handover fail probability in the FUN-HODS algorithm is lower than the handover fail probability for a traditional fuzzy algorithm when each mobile node has random velocity.

III DISTANCE-BASED SCHEME FOR VERTICAL HANDOFF (DSVH) IN HETEROGENEOUS WIRELESS NETWORKS

A. Overview

As discussed before in section two, the radio wave propagation model has been determined for hotspot communication in wireless access technologies like WLAN and WCDMA network. This model is based on extensive experimental data and statistical analysis to compute RSS for WLAN and WCDMA network. The first idea in our scheme is to rely on this radio wave propagation model to calculate the RSS in both WLAN and WCDMA network as well as to study and evaluate the handoff process between WLAN and WCDMA network and vice versa. Our distance-based algorithm is based on RSS, WLAN and WCDMA network vertical handoff threshold value and minimum distance between mobile user and corresponding APs or BSs. The second idea in our scheme is to calculate the mean throughput value for WCDMA and WLAN based on Shannon capacity theorem [22] [28]. We consider WCDMA as an example of 3G networks. Shannon's theorem is based on the average RSS value, available bandwidth and the total noise or interference power over the bandwidth. It uses these parameters in computing channel throughput. In this paper we compare mean throughput values for WLAN and WCDMA network in both SINR and DSVH schemes, this is to see whether the proposed scheme improves the throughput. The Shannon theorem states that the throughput, R, is an upper bound of data rate that can be sent with a given average RSS through an analog communication channel subject to an additive white Gaussian noise of power Γ.

The expression below represents the maximum possible rate of information transmission through a given channel or system. The channel bandwidth, the received signal level, and the noise level set the maximum throughput rate. It is computed as follows:

$$R = W \log2 (1+ \gamma / \Gamma) \quad (1)$$

Where R is the channel capacity (throughput) in bits per second. W is the bandwidth of the channel in hertz. γ is the total received signal power. Γ is the total noise or interference power over the bandwidth, measured in watt or volt. The RSS and throughput for both SINR and DSVH schemes are calculated and explained next.

B. The SINR-based Scheme for Vertical Handoff in Heterogeneous Wireless Networks

This section illustrates how we can calculate the RSS and throughput for both WLAN and WCDMA network based on SINR Scheme.

γ that is received at mobile user i when associated with $WCDMA_{BSj}$ [22] [29] can be represented as:

$$\gamma_{BSj\,,\,i} = G_{BS}\ P_{BS} / (P_B + \ \Sigma\,(G_{BS}\,P_{BS}) - G_{BS}\ P_{BS}) \quad (2)$$

Where G_{BS} is the channel gain power between mobile user i and BS_j. P_{BS}: is transmitting power of BS_j. P_B: is the background noise power at mobile user receiver end.

γ that is received at mobile user i when associated with $WLAN_{APj}$ [22] [28] can be represented as follows:

$$\gamma_{AP\,j\,,\,i} = G_{AP}\ P_{AP} / (P_B\ +\ \Sigma\ (G_{AP}\ P_{AP})) \quad (3)$$

Where G_{AP} is the channel gain power between mobile user i and AP_j. P_{AP}: is transmitting power of AP_i. P_B: is the background noise power at mobile user receiver end.

In SINR scheme, Shannon's capacity formula is applied, as it is, where the value of γ represents the RSS at the mobile user. Therefore, we can use the Shannon's capacity formula (1).

C. The Distance-based Scheme for Vertical Handoff (DSVH) in Heterogeneous Wireless Networks

The distance-based scheme for vertical handoff in heterogeneous wireless networks that we propose is a reactive vertical handoff scheme. We suggest that vertical handoff be based on the RSS and the distances to access points or base stations, where it is able to consistently offer the mobile user with maximum available throughput during vertical handoff.

Okumura et al and Bertoni et al have developed various empirical path loss models based on RSS measurements [11]. These models are the best and most-used models for path loss distance in urban areas where there are many urban structures but not many tall buildings.

The Path Loss (PL) in dB for cellular networks (CN) environment is given by:

$$PL = 135.41+12.49 \log(f) - 4.99 \log(h_{bs}) + [46.84 - 2.34 \log(h_{bs})] \log(d) \quad (5)$$

Where d is distance in kilometer and f is the frequency in MHz. h_{bs} is the effective base station antenna height in meters.

Moreover, RSS for cellular networks is expressed in dBm as:

$$P_{CN} = P_t + G_t - PL - A \quad (6)$$

Where P_{CN} is the RSS of CN in dBm. P_t is the transmitted power in dBm. G_t: is transmitted antenna gain in dB. PL: is total path loss in dB. A: is connector and cable loss in dB.

In WLANenvironment, the path loss in dB is given by [11]:

$$PL = L + 10\,n \log(d) + S \quad (7)$$

Where L is constant power loss. n is path loss exponent with values between 2 to 4. d: represents the distance between the MS and WLAN access point. S: represents shadow fading which is modeled as Gaussian with mean $\mu=0$ and standard deviation σ with values between 6-12 dB depending on the environment.

Moreover, the RSS for WLAN is expressed in dBm as:

$$PW = Pt - PL \quad (8)$$

Where Pt is the transmitted power and PL is the path loss in dB.

In DSVH, Shannon's capacity formula is applied, where the value of γ represents the total RSS at the mobile user based on the distance, which it is computed previously in (6) and (8). Therefore, we can rewrite the Shannon's capacity formula, which is used to calculate the throughput in DSVH, as follows:

$$R = W \log_2 (1 + RSS / \Gamma) \quad (9)$$

Where R is the channel capacity (throughput) in bits per second. W is the bandwidth of the channel in hertz. RSS is the total received signal power. Γ is the total noise over bandwidth measured in watt or volt.

IV Performance Evaluation and Analysis

In this section, we discuss the performance metrics used to evaluate our scheme. We then present and analyze the results of the simulation experiments that compare SINR with DSVH.

D. Performance evaluation metrics for vertical handoff schemes

For the purpose of evaluating our proposed scheme DSVH and comparing its performance with the performance of the SINR scheme, we examined the overall system throughput and number of dropped mobile users for DSVH and SINR under identical input parameters, such as number of nodes, bandwidth and transmitted power.

Vertical handoff schemes can be quantitatively compared under various usage scenarios by measuring the mean and the maximum handoff delays, the number of handoffs, the number of failed handoffs due to erroneous decisions, and the overall throughput of a session maintained over a typical mobility model.

These metrics are further explained below:

- Number of Handoffs: the movement of MS would cause the change of RSS value received either from AP or BS. Reducing the number of handoffs is usually preferred as frequent handoffs affect the network resources. A handoff is considered dispensable when a handoff back to the original point of attachment is needed within certain time duration [1].
- Throughput: refers to the average data rate of successful packets delivery over a communication channel to all MSs in a network. Handoff to a network candidate with higher throughput is usually desirable. The throughput is usually measured in bits per second (bps), and sometimes in data packets per second or data packets per time slot.

E. Simulation Environment

All simulation experiments that we were carried out on a mobile technology T3400 2.2 GHz laptop that has a dual-core Intel Pentium 64 × 2 CPU and 2 GB RAM. The operating system is the Windows Vista 32-bit operating system. The proposed scheme was added to the MATLAB (matrix laboratory) version 7.7.0.

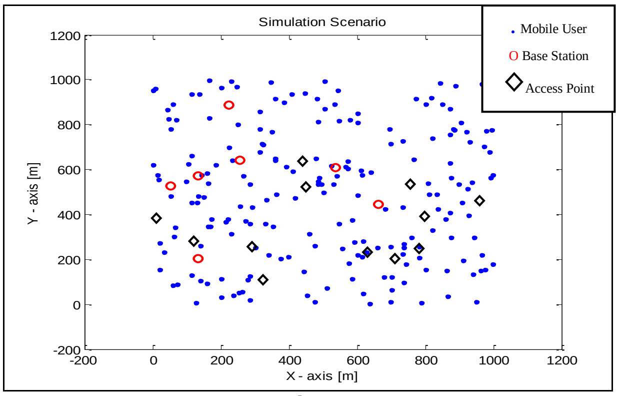

Figure 1. Simulation Scenario

Fig.1 present the simulation scenario of the network that we are based on it to evaluated and analyze the performance of the proposed distance-based scheme comparing with SINR scheme. For the experiments, the simulated network consists of 7 BSs, 12 APs and 200 MS randomly located in a space of 1000 m × 1000 m. Positions changes randomly based on a random way model [34][22].

Table 1 summarizes the different configuration values that were used in the simulations, these values that are used in SINR scheme [22][28] are also used as it in our scheme because our work aims to compare our scheme with the SINR scheme.

Table 1. simulation parameters

Parameter	Values
Simulator	MATLAB version 7.7.0
Simulation area	1000 × 1000 m^2
Simulation time	200 seconds
Number of nodes	200 nodes
Number of access points	12
Number of base stations	7
Threshold (cellular network to WLAN)	-80 dBm
Threshold (WLAN to cellular network)	-85 dBm
Antenna height of base station	30 m
Access point transmitter power	20 dBm
Base station transmitter power	33 dBm
Cable loss	5 dB
Channel gain power	33 dBm
Base station operating frequency	894 MHz
Background noise power for WLAN	-96 dBm
Background noise power for WCDMA	-104 dBm
Bandwidth for WCDMA	5 MHz
Total noise or interference power over	16 dB

F. Simulation Process Flow Chart

The following flowchart represents the process that we have used in our simulation. As we can see in Fig.2, the positions of the mobile users, APs and BSs are determined randomly. The distance between each mobile user and all APs and BSs are computed to connect each mobile user with the nearest AP or BS. Then, Path Loss (PL) and RSS are computed for each mobile user based on the attached AP or BS by using the equations that are illustrated previously in section four. The threshold (-80 or -85 dBm) is used to determine dropped users. Finally, we apply Shannon's capacity theorem to compute the mean throughput for both SINR and DSVH based on the RSS and SINR values that result from the previous steps.

G. Number of Mobile Users Factor

The purpose of the simulation presented in this experiment is to study the effect of varies number of mobile users on the mean value of dropped mobile users in both SINR and DSVH schemes. In all scenarios of this experiment, the number of mobile users ranges from 100 to 300 mobile users with an increment of 50 mobile users. The subsequent sections discusses the effect of varies number of mobile users on the mean value of dropped mobile users in both WLAN and WCDMA network. The simulation results presented in Fig.3 illustrate the mean value of dropped mobile users for both SINR and DSVH schemes in WCDMA network. From this Figure we can show that as the number of mobile users increases in DSVH scheme, the mean value of dropped mobile users not changed, it is equal to 7. The reason is that no equations that we have adopted in the DSVH scheme take into account the number of mobile users as in (5) and (6).

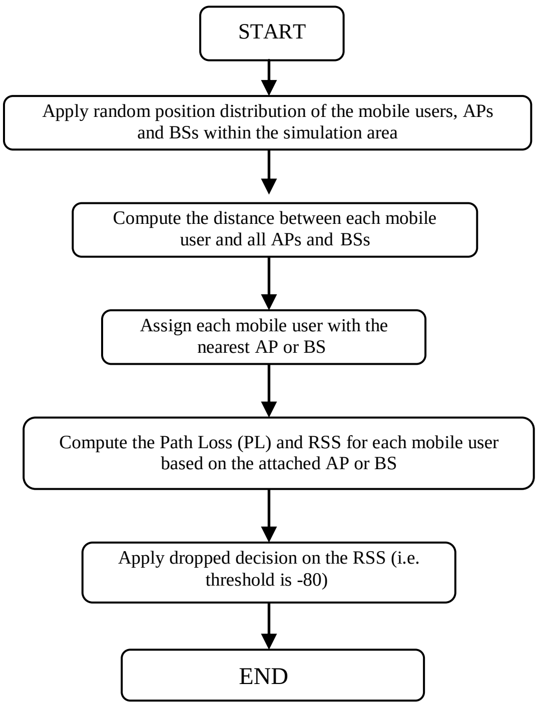

Figure 2. Simulation Process

While in SINR scheme, as the number of mobile users increases the mean value of dropped mobile users becomes decreases from 17 until it reaches to 4 when the number of mobile users becomes 300 MSs. The reason is that the equation that we have adopted in the SINR scheme take into account the channel gain power between each mobile user and it's base station (2). In general, the DSVH scheme outperforms the SINR scheme, if the number of mobile users not exceeded the 250 mobile users, but after that, the SINR scheme will be better than DSVH scheme for handling the vertical handoff process, whereas the mean value of dropped mobile users becomes lower.As a result, DSVH scheme achieves major enhancement in terms of reducing the mean value of dropped mobile users comparing with SINR scheme when the number of MS not exceeded the 250 by 20%. The simulation results presented in Fig.4 illustrate the mean value of dropped mobile users for both SINR and DSVH schemes in WLAN. From this Figure we can show that as the number of mobile users increases in DSVH scheme, the mean value of dropped mobile users is fixed, it is equal to 4. The reason is that no equations that we have adopted in the DSVH scheme take into account the number of mobile users as in (7) and (8). While as the number of mobile users increases in SINR scheme, the mean value of dropped mobile users decreases from 18 until it reaches to 4 when the number of mobile users becomes 300 MSs.

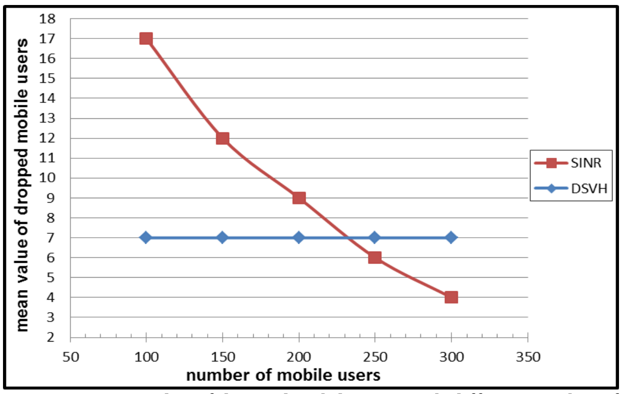

Figure 3. Mean value of dropped mobile users with different number of MSs for WCDMA network in both SINR and DSVH schemes

Thereason behind decreasing the number of dropped mobile users is that the decrease in the number of access points could leads to reduce the interference that may affect on the mobile users, and thereby increase the signal strength and then decrease the number of dropped users (3). In general, the DSVH scheme outperforms the SINR scheme, if the number of mobile users not exceeded the 300 mobile users, but after that when the number of mobile users exceeded the 300 mobile users, the SINR scheme will be better than DSVH scheme for handling the vertical handoff process, whereas the mean value of dropped mobile users becomes lower. As a result, DSVH scheme achieves major enhancement in terms of reducing the mean value of dropped mobile users comparing with SINR scheme by 10%, as the number of users increases until it reaches 300 mobile users, after that the contrast may occurred.

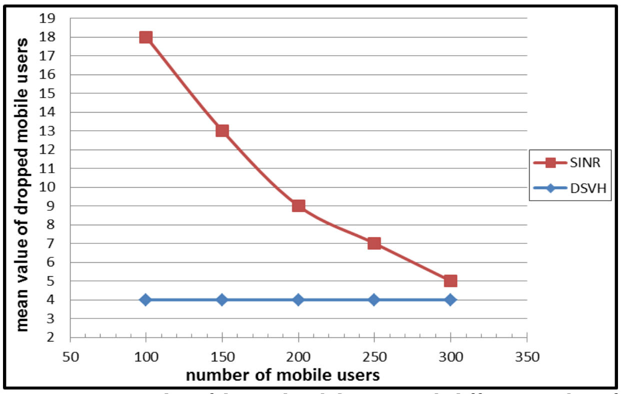

Figure 4. Mean value of dropped mobile users with different number of MSs for WLAN in both SINR and DSVH schemes

H. The Number of Base Station Factor

The purpose of the simulation presented in this experiment is to study the effect of using different number of base stations on the mean value of dropped mobile users in both SINR and DSVH vertical handoff schemes. In all scenarios of this experiment, the number of base stations varies from 3, 5, 7 and 9 base stations, while the number of mobile users is fixed, it is equal to 200. The simulation results presented in Fig.5 illustrate the mean value of dropped mobile users for both SINR and DSVH schemes in WCDMA network. From this Figure , we can show that the mean value of dropped mobile users in our proposed scheme DSVH is less than the mean value of dropped mobile users in SINR scheme while the number of base station not above 8, but when the number of base station exceeded 8, the SINR scheme becomes better than DSVH scheme for handling the vertical handoff process.

In addition, we can see that as the number of base stations increases in the DSVH scheme, the mean value of dropped mobile users becomes increase from 3 until it reaches to 10. The reason maybe that the increase in the number of base stations may lead to decrease the distance between the base station and the mobile user during his movement, but this decrease will be for a few periods.

Thus, the vertical handoff process for the mobile user to another base station may increase with a decrease of time that may be linked to the mobile user with a previous base station. While as the number of base stations in SINR scheme increases, the mean value of dropped mobile users becomes decreases from 14 until it reaches to 7 when the number of base stations becomes 9 base stations. This is because the SINR scheme influenced by a number of base stations in a positive ratio, so when the number of base stations increased, the percentage of signal strength to noise ratio be higher.

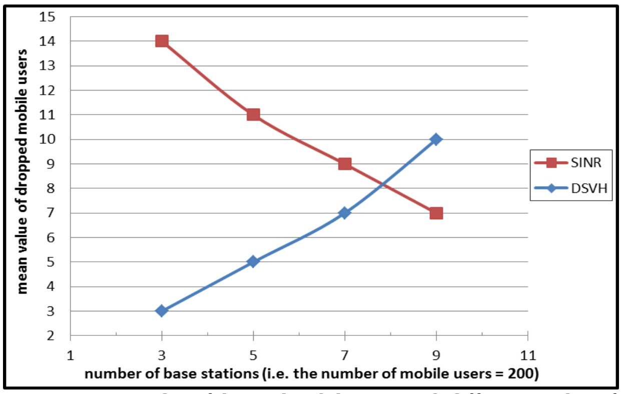

Figure 5. Mean value of dropped mobile users with different number of base stations for WCDMA network in both SINR and DSVH schemes

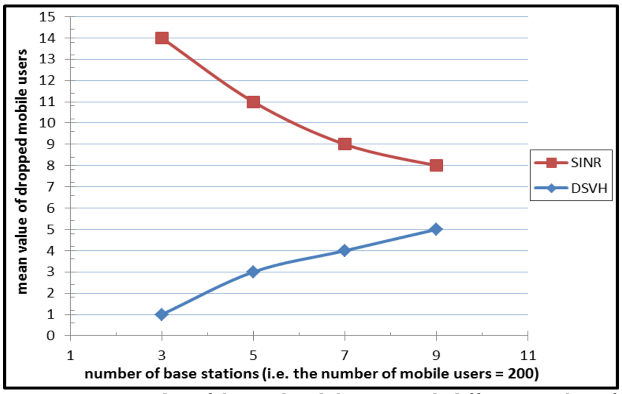

Figure 6. Mean value of dropped mobile users with different number of base stations for WLAN in both SINR and DSVH schemes

On the contrary, from DSVH scheme. In general, DSVH scheme achieve major enhancement in terms of reducing the mean value of dropped mobile users comparing with SINR scheme when the number of base stations not exceeded 8 base stations by 20%.

The simulation results presented in Fig.6 illustrate the mean value of dropped mobile users for both SINR and DSVH schemes in WLAN. From this Figure , we can show that the mean value of dropped mobile users in our proposed scheme DSVH is less than the mean value of dropped mobile users in SINR scheme. In addition, as the number of base stations increases in the DSVH scheme, the mean value of dropped mobile users becomes increase from 1 until it reaches to 5. While in SINR scheme, as the number of base stations increases the mean value of dropped mobile users decreases from 14 until it reaches to 8 when the number of base stations becomes 9 base stations. Of course, in both cases, the reasons are the same as those shown for the WCDMA network. In general, DSVH scheme achieve major enhancement in terms of reducing the mean value of dropped mobile users comparing with SINR scheme when the number of base stations not exceeded 8 base stations by 30%.

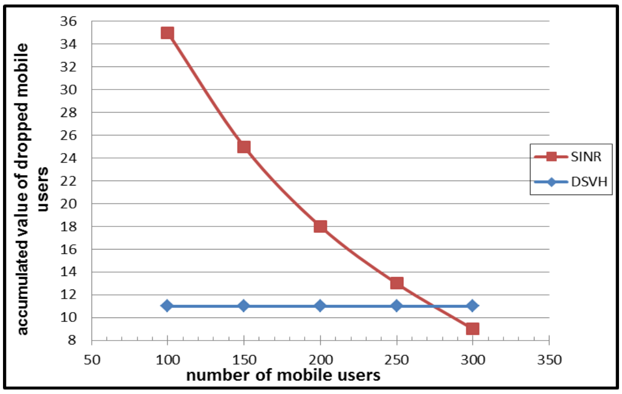

Figure 7. Accumulated value of dropped mobile users in both WLAN and WCDMA network for SINR and DSVH schemes with varies number of mobile users

I. Accumulated value of dropped mobile users with varies Number of Mobile Users

Fig.7 display the accumulated value of dropped mobile users in both WLAN and WCDMA network with varies number of mobile users. From this Figure , we can show that as the number of mobile users increases in DSVH from 100 to 300, the value of dropped mobile users is fixed, it is equal to 11. While in the SINR scheme as the number of mobile users increase the mean value is decreases from 35 to 13 if the number of mobile users is 250. However, when the number of mobile users reaches to 300 the mean value of dropped mobile users in SINR scheme becomes lower than the mean value of dropped mobile users in the DSVH scheme.

In general we can said, if the number of mobile users not exceeded the 250 the enhancement of mean value of dropped mobile users in DSVH outperforms the enhancement of SINR scheme by 20 %. On the other hand, Fig.8 shows the accumulated value of dropped mobile users in both WLAN and WCDMA network with varies number of base stations. From this Figure , we can see that as the number of base stations increases from 3 to 9, the mean value of dropped mobile users in DSVH scheme is increases from 4 to 15 mobile users. While as the number of mobile users increase in the SINR the mean value of dropped users is decreases from 28 to 15 if the number of base station is 9.

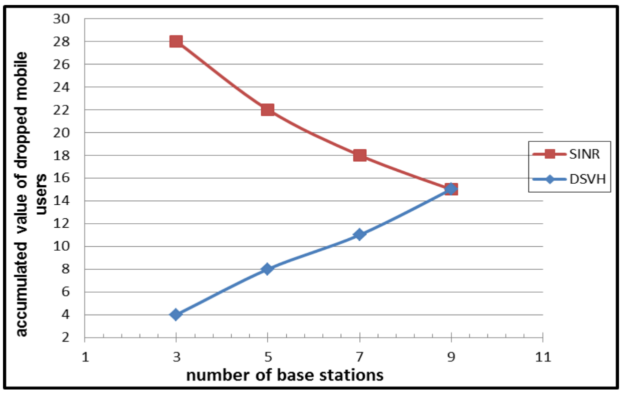

Figure 8. Accumulated value of dropped mobile users in both WLAN and WCDMA network for SINR and DSVH schemes with varies number of base stations

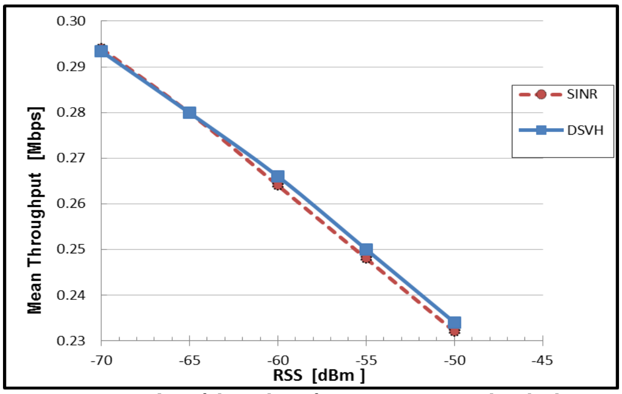

Figure 9. mean value of throughput for WCDMA network in both SINR and DSVH schemes

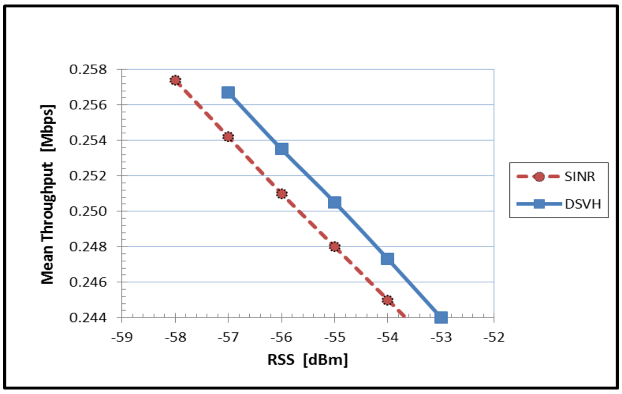

Figure 10. Mean throughput with zoom for WCDMA network in both SINR and DSVH schemes

J. Mean Value of Throughput

Fig.9 illustrates the mean value of throughput for both SINR and DSVH in WCDMA network. As we can see, the DSVH scheme outperforms the mean value of throughput for SINR. Fig.10 represents the same Figure but with a zoom to better illustrate the differences between the two schemes. We can see that the enhancement on the mean throughput is very slight (less than 1%).

Next, we measure the ratio of improvement defined as:

***Improvement* = (*New value – Old value*)/*Old value* * 100 %**

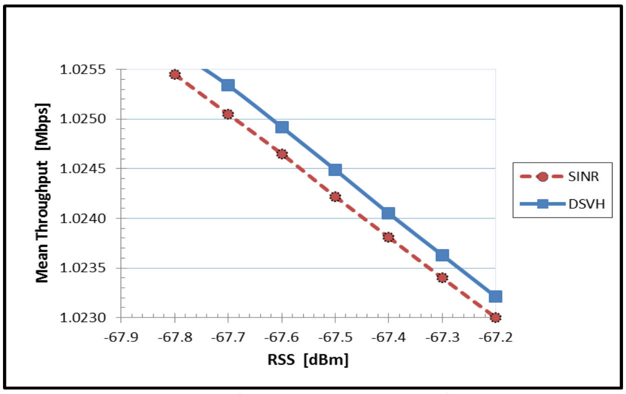

Figure 11. Mean value of throughput with zoom for WLAN in both SINR and DSVH schemes

Fig.11 illustrates the mean values of throughput for both SINR and DSVH in WLAN with a zoom to better illustrate the differences between the two schemes. As we can see the DSVH scheme outperforms the mean value of throughput for SINR. The enhancement on the mean throughput is very slight (less than 1%).

V CONCLUSIONS AND FUTURE WORK

In this paper, we present the design and simulation of our distributed distance-based scheme for vertical handoff in heterogeneous wireless networks and provide performance measurements using the MATLAB. The major issues in our paper are presented below.

Our scheme shows that the distance is a better metric for minimizing service disconnection probability and maximizing system throughput when selecting the best AP or BS. The main goal of our scheme has been achieved. It is to enhance and provides higher overall system performance in terms of minimizing service disconnection probability during vertical handoff as compared with the SINR based vertical handoff scheme.The simulation experiments show that our proposed scheme, DSVH, significantly outperform the SINR scheme in terms of reducing the number of dropped users. It reduces this number by 20%. The throughput remains almost the same; its improvement is very slight (i.e. Less than 1%). There are still several research points that can be investigated based on this work. It would be interesting to explore our proposed scheme with a scheme that takes in consideration additional parameters, such as the velocity and mobility direction and the location of mobile users by using GPS technology. Devising an algorithm that is useful in a wide range of conditions and user preferences. Once possible solution would be to implement several vertical handoff algorithms and then adopt adaptive methods that choose an algorithm intelligently based on conditions and user preferences.

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