Intelligent Vertical Handover for Heterogeneous Wireless Network

Ali Safa Sadiq, Kamalrulnizam Abu Bakar, Kayhan Zrar Ghafoor, and Jaime Lloret

***Abstract*—In heterogeneous wireless networks the most challenging issue is obtaining an efficient vertical handover during mobile nodes roaming process. Efficient network selection process can achieve satisfactory Quality-of-Service of the ongoing applications. In this paper, we propose an Intelligent Network Selection (INS) scheme based on maximization scoring function to efficiently rank the available wireless network candidates. Three input parameters are utilized for each network candidates which are: Faded Signal-to-Noise Ratio, Residual Channel Capacity, and Connection Life Time. The results show that, the INS scheme more efficient in decreasing each of probability of unnecessary handovers, link connection breakdown probability in addition to handover failure probability in comparison with the state of the arts.**

***Index Terms*—Efficient Vertical Handover, Intelligent Network Selection, Faded SNR, Residual Channel Capacity, Connection Life Time, Maximization Score Function.**

I. INTRODUCTION

The latest wireless communication technologies are developed in the form to provide a desirable Quality-of-Services (QoS) for applications. A variety of wireless technologies are involved recently to maintain the broadband coverage with desirable QoS and seamless mobility. In order to maintain an active session when a Mobile Node (MN) roams across these different wireless access technologies, a vertical handover process must be performed efficiently. Vertical handover can be defined as a process of maintaining the wireless access link connectivity when MN across different networks (Global Mobility). Thus, the vertical handover starts by selecting the next wireless access network to maintain the connection′s visibility. Hence, decision making is the first and most important stage during vertical handover process, followed by link layer process and channel assignment. These three stages are the most challenging and researchable issues in vertical handover process [1], [2], [3], and [4].

Therefore, MN suppose to select the most appropriate network in order to maintain the required QoS of ongoing applications. For instance, when MN decides to perform handover to a network with low or unstable signal quality due to fading phenomena, the probability of handover failure will be higher. Furthermore, the network selection process should avoid the network candidate with low provided channel bandwidth which normally caused due to many associated MNs with this particular network candidate. Besides, the link connection break down probability supposedly considered with any network selection process during a vertical handover decision making. By looking toward the aforementioned aspects, an efficient vertical handover can be achieved for heterogeneous wireless networks with the desirable QoS of the running applications.

Hence, in this paper an efficient vertical handover is proposed for heterogeneous wireless networks by utilizing the proposed INS scheme. The proposed INS scheme performs the developed maximization scoring function in order for rank the available wireless network candidates then efficiently selects the next wireless network access link to camp on. Three network selection criteria were considered via the developed maximization scoring function. The faded Signal-to-Noise Ratio, Residual Channel Capacity, and Connection Life Time are the considered input metrics into maximization scoring function in our proposed INS scheme. Throughout proposed INS scheme, the vertical handover between Universal Mobile Telecommunications System (UMTS) which is a third Generation (3G) mobile cellular system for networks and Wireless Local Area Network (WLAN) efficiently performed.

It is worthy mentioning that, the reason behind choosing UMTS as one of the heterogeneous wireless networks is that, UMTS 3G networks is considered as a popular network access provider nowadays due to the high elaboration of UMTS infrastructure in the urban area. Besides, UMTS networks can maintain wide wireless coverage area and high mobility facilities. On the other hand, UMTS with some cases cannot cover optimally some areas such as tunnels, the trains under ground and area near to the mountains or the sea. Hence, the IEEE 802.11 WLAN can be the good solution to cover these area with wireless access network as a WiFi zones to provides the world Internet. Form the reasons mentioned above, UMTS and WLAN to be selected as the two heterogeneous networks utilized by our proposed INS scheme in this paper.

II. RELATED WORKS

Several research works recently have discussed the vertical handover decision making and network selection process which used to elect the best network candidate. Throughout these research works, some mathematical theories have been developed and utilized for addressing these issues. The authors in [1], discussed the most important mathematical theories used for network selection process with heterogeneous networks. Moreover, they compared the schemes of various mathematical theories and discussed how to come out with combining form of these mathematical theories all together. Furthermore, they proposed an integrated scheme utilizing multiple attribute decision making for the network selection process.

However, the proposed integrated scheme is computationally expensive because many selection metrics should be

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identified for each particular network candidate with each decision making round. In the other words, the preparations process before combining all the attributes in addition to the weighting and attribute adjustment procedures normally gain low decision making speed. Besides, the vertical handover decision is directly taken when the first available network of the best candidate obtained via integrated scheme is better than the current network. This can lead to obtain unnecessary handovers in such cases especially with real-time applications when the current network still can maintain the real-time session.

On the other hand, the utility theory was analyzed by [5] in the way to identify a suitable vertical handover decision mechanism. The Sigmoidal utility function was considered for the network selection process. Though, the main issue can be observed using utility function is that, the parameters within the sigmoidal function could be different to appropriate for different features of the selected attributes [1]. Moreover, the considered attributes are only the network′s bandwidth and the price in the utility function regardless some other network selection aspects.

Some other studies such as [6] and [7] developed vertical handover algorithms between a WLAN to a 3G network and vice versa. Throughout these algorithms the handover normally trigger when the MN enters the boundary area of the WLAN. Hence, the handover procedures suppose been completed before the MN leaves the WLAN coverage. These algorithms are functioning efficiently when the handover from WLAN to 3G is needed. Besides, they can maintain the handover failure probability from WLAN to 3G networks. Contrary, the vertical handover can be considered as inefficient when the MN moves across an area close to the coverage boundary of the WLAN with a high velocity. In this situation, the vertical handover to the WLAN will be unnecessary. Hence, there are still some open issues within these proposed vertical handover algorithms due to the wastage in network resources which normally occurred via unnecessary handovers.

III. Design Phase of Intelligent Network Selection (INS) Scheme

In the proposed INS scheme three network performance′s criteria considered which are the faded Signal-to-Noise Ratio (SNR), Residual Channel Capacity and Connection Life Time. Therefore, in order to describe the key challenges in each particular selection metric and the way which been used to extract the status evaluation value for each one, a detailed discussion presented in the subsections below for each single metric.

A. Faded Signal-to-Noise Ratio

Basically, SNR is a signals power ratio divided by the noise power in a particular point of the transmission. The obtained SNR value can be considered as a high quality when the value of power of received signal is more than value of the noise power. SNR value also can be effected by different situations, such as vibrations, wind, the rain, temperature. Whenever the signal power is equal or goes below the noise power, the SNR value is considered as low quality value which can not carry on the ongoing session. The SNR value measured and obtained by MN via AP′s beacon frames which periodically sent every 100 ms.

	Element ID	Length	CFP Count	CFP Period	CFP MaxDuration (TU)	CFP DurRemaining (TU)	T_AP_idle
Octets:	1	1	1	1	2	2	1

Fig. 1: The modified CF Parameter Set element with $T_{AP_{idle}}$ [12].

In order to obtain the range of the SNR input metric of WLANs, the SNR_{Range} value is identified to be 50 dB as based in [8]. Thus, in INS scheme the MN keeps monitoring the SNR during its movement process in the way to ensure the SNR level of the current and target networks be in the acceptable level. Thus, by considering the SNR status as an input metric, the QoS of the performing application will be ensured.

Furthermore, the faded wireless channel is considered in the proposed INS scheme in order to achieve the high accuracy of a vertical handover decision. When MN roams, the received signal from APs or BSs fluctuating via time. This is due to the fading phenomena which basically categorized into two main kinds, Large-Scale fading (slow fading) and Small-Scale (fast) [9]. The slow fading is the average signal power loss due to motion over large areas. In the other words, it can be defined as the received signal variation due to MN′s movement away from the transmitter. Hence, for instance, in order to obtain the coverage area of WLANs; the log-distance path loss model utilized in the physical layer of IEEE 802.11 in the simulated scenario. Besides, Rayleigh or Rician random variable distribution is used to model fast fading of SNR in the proposed INS scheme.

B. Residual Channel-Capacity

Channel capacity which can be represented by bandwidth, is defined as a remainder of frequency space of the mobile node [10]. For instance, the channel band size in IEEE 802.11 is 20 MHz which reflects to 20 MHz total bandwidth provided via each channel. Whereas, in UMTS based on cellular networks have an allocation of 25 MHz total bandwidth in the 900 MHz frequency range [11]. In addition, the variation average of residual capacity of wireless channel depends on the time that the MN remains in each WLAN or UMTS network during its roaming process.

In WLANs, the AP uses Network Allocation Vector (NAV) [12] to infer the status of wireless channel. In BBS APs send Beacon frames containing a CF Parameter Set information element. This frame can be also received even by MNs are not associated with the BSS. Basically, when the NAV counts down to the zero, MN is able to sends or receives data frames via the WM which is illustrated as (old NAV).

Before MNs receive the beacon frame consist of Contention Function (CF) parameter set element, normally their NAVs will be setted to the CFPMaxDuration value at the nominal start time of each CFP. This initial NAV′s time in our proposed INS scheme insert to the modified parameter called cfp_{length}. This variable contains the default length in seconds of the CFP. When MN receives the beacon frame from an AP, the $NAV_{Duration}$ will be calculated by each MN in the way to synchronize their NAV timer; that each MN can use the WM without contention. This updating process of $NAV_{Duration}$ tackle by MN at the beginning of each CFP after receive the NAV settings via beacon frames for the MNs under CP.

By looking at Figure 1, the CF Parameter Set element format contains the set of parameters which are necessary to support the PCF procedure. The information field in CF format consist of 6 octets which distributed as the $CFPCount$, $CFPPeriod$, $CFPMaxDuration$ and $CFPDurRemaining$ fields. From $CFPMaxDuration$, MN can obtain the maximum duration in Time Unit (TU) microsecond and will be inserted to cfp_{length}. Whereas, $CFPDurRemaining$ implies to the remaining time in the present CFP. This value normally used by MNs to update their NAVs during CFPs. When MN (which is associated with BSS or not) receives the CF Parameter Set information element will set their NAVs to the $CFPMaxDuration$ as it mentioned before. On the other hand, the $CFPDurRemaining$ will be used by MNs to update their NAVs during CF process.

Thus, residual channel capacity can be calculated by determining the average time between last moment the AP was idle to the busy moment then multiplying by the elaborated transmission data rate. In our proposed INS scheme, a time indicator $T_{AP_{idle}}$ has been modified in order to capture the last time that the AP was $idle$, which represented as a CFP. This $T_{AP_{idle}}$ will be included in the modified CF Parameter Set Element which periodically send via AP′s beacon frame as it shown in Figure 1.

By using Formula 1 the residual channel-capacity R_{CC} can be obtained for each AP in the MN′s scanning range. Where, $T_{AP_{Busy}}$ is the total time periods that AP will be busy from the last monitored time after CFP, $T_{AP_{idle}}$ is the last time in second that the AP was $idle$ and Transmission Data Rate equals to 11 Mbps for WLANs based on IEEE 802.11b standard [12]; which represented the total channel-capacity (11 Mbps). $T_{AP_{Busy}}$ can be divided to sub time periods that the AP being busy. During $T_{AP_{Busy}}$ the MN should keep waiting to be able to use the AP′s channel after this timer became expired. Formula 2 illustrates the summation process of all the busy time periods in WLANs. Where T_{cp} is the time period that the AP is busy due to CP, T_{pifs} is time interval which utilized in PCF to assign the priority access to the AP′s channel by MNs after CP, and $T_{Ack_{pifs}}$ is the time delay normally spent by MN to gain the Acknowledgement of $PIFS$ from PC (AP).

$$R_{CC} = \frac{T_{AP_{idle}}}{T_{AP_{Busy}}} \times Transmission\ Data\ Rate \quad (1)$$

$$T_{AP_{Busy}} = T_{cp} + T_{pifs} + T_{Ack_{pifs}} + T_{total\ media\ access\ delay} + T_{Accuracy-Recovery} \quad (2)$$

The T_{pifs} can be divided in to, T_{sifs} which is the time interval between each two transmitted frames during CF process, $T_{Ack_{sifs}}$ is the time delay in order to obtain the Acknowledgement of $SIFS$ from PC (AP) and T_{Slot} is the time slot added in order to calculate the T_{pifs} in PCF. In our proposed INS scheme T_{sifs} value set to (28000000 picosecond (ps)) and T_{Slot} equals to (50000000 ps). Formula 3 calculates the T_{pifs} value. Whereas, $T_{Accuracy-Recovery}$ is precision sensitive computations considered in calculation process of $T_{AP_{Busy}}$ which equals to 1 ps.

$$T_{pifs} = T_{sifs} + T_{Ack_{sifs}} + T_{Slot} \quad (3)$$

On the other hand, in order to achieve the accuracy in the calculation process of residual channel-capacity, the MAC delay $T_{MAC_{delay}}$ was considered as one of the delay time contributes in total $T_{AP_{Busy}}$. Contrary, Formula 4 calculates the $T_{total\ media\ access\ delay}$, where $T_{Received-Packet}$ is the arrival time of the packet that is currently tackled by the PCF and $T_{Packet-Sent}$ is the recorded time that the packet has been sent to PCF.

Thus, the $T_{total\ media\ access\ delay}$ will keep updating during our proposed INS scheme′s process between each two data fragments after the end of $Media\ Access\ Duration$, in the way to keep tracking the changing in $T_{total\ media\ access\ delay}$ and update the entries of Formula 2 to evaluate the $T_{AP_{Busy}}$ regularly.

$$T_{total\ media\ access\ delay} = T_{Received-Packet} - T_{Packet-Sent} \quad (4)$$

In UMTS based cellular networks, the MN receives channel system information via the Broadcast Control Channel (BCCH)during radio recourse management procedures [11]. It is worth mention that, the RR-connection setup and service request phases in UMTS networks controlled by BS of each cell. Therefore, we assumed in this paper that each MN will receive a fixed channel-capacity which represented by maximum data rate 2048 kbit/s with mobility of 10 km/h and 384 kbit/s with mobility of 120 km/h [11]. For this reason, residual channel-capacity R_{CC} for each UMTS network equals to the total utilized data rate. This is due to the fact that, MN receives all the BS′s channel-capacity during its allocated access time based on Wideband Code-Division Multiple-Access (W-CDMA) process [11].

By looking at Figure 2, we can observe when MN′s number decreases contribute in increasing the R_{CC}. In the other words, when the number of MNs which are currently associated with one particular AP is low, this reflects $T_{AP_{Busy}}$ currently is low respectively. Thus, yields more R_{CC} value which indicates that this particular AP more preferable to tackle the handover process with low time delay.

C. Connection Life Time

In order to decrease the link connection breakdown probability, the MN should take the handover decision intelligently by avoiding unnecessary handover decisions. In heterogeneous networks (UMTS and WLAN), the current handover management algorithms trigger the handover from UMTS (3G networks) to WLAN′s AP when the MN approaching the WLAN′s coverage area. Thus, the handover process must finish during the time that the MN still under WLAN′s coverage area or before leaves the WLAN in the way to obtain sufficient time connection with WLAN. Otherwise, link connection breakdown situation inevitably occurs since MN is not in the radio coverage of WLAN. Therefore, it is a pressing need to consider connection life time of AP in the way to minimize the unnecessary handovers from UMTS

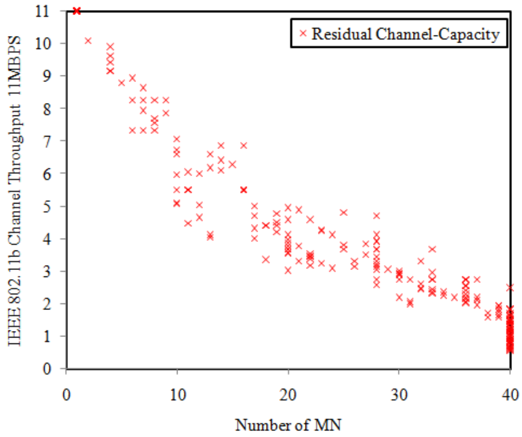

Fig. 2: The variation of Residual Channel-Capacity with Changes in Number of MNs.

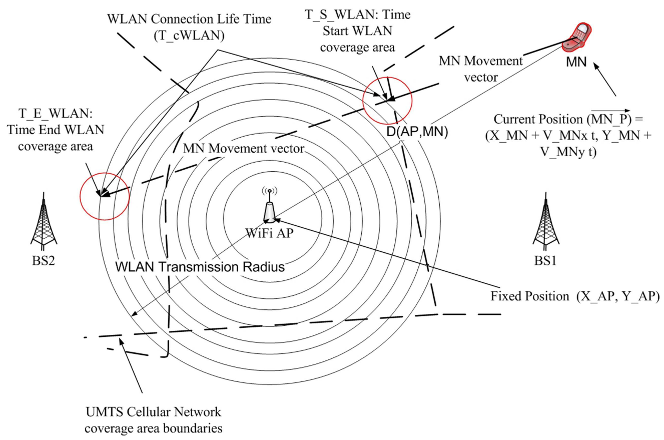

Fig. 3: Vertical handover scenario from UMTS to WLAN based on connection life time calculation.

to WLAN. Thus, link connection breakdown probability will essentially decreased.

When MN connecting with UMTS network, the connection life time is normally longer enough than when it is connecting with WLAN. The reason is that, UMTS′s coverage area normally larger than the one with WLAN′s AP. The one cell of UMTS networks can provides coverage up to 5 Kilo Meter (KM) [11] which allows the MN to connect for longer time in compare with WLAN′s AP which normally covers only hundreds meters [12]. Hence, the connection life time of each AP calculated and considered in our proposed INS scheme to avoid the unnecessary handovers with WLAN.

Figure 3 illustrates the scenario in which the MN is moving towards wifi′s AP when currently connecting with UMTS′s BS1. In the meanwhile, MN reaches the WLAN′s coverage area boundaries at time period point (time starts WLAN coverage area $T_{S_{WLAN}}$). We supposed that each AP in WLANs covers a circular geometry area within a fixed transmission radius. This is based on the transmission power that utilized for each AP of WLANs in the physical layer settings. Therefore, the distance between each starting boundary′s points and the opposite points are the same.

As depicted in Figure 3, when MN entered the AP′s coverage area at $T_{S_{WLAN}}$ with certain velocity vector, it will reach the point that the MN leaves this AP at time period point (time end of WLAN coverage area $T_{E_{WLAN}}$). The time consumed between $T_{S_{WLAN}}$ to $T_{E_{WLAN}}$ identified as the WLAN connection life time (T_{cWLAN}). This T_{cWLAN} normally changing based on the distance between MN′s current position vector (Moving Point) and AP′s position (Fixed Point) with respect of current MN′s velocity.

The value of connection life time t can be calculated as:

$$\bar{t} = \frac{(\gamma_x V_{MN_x} + \gamma_y V_{MN_y})}{(V_{MN_x}^2 + V_{MN_y}^2)} \tag{5}$$

assume that $\gamma_x = (X_{MN} - X_{AP})$ and $\gamma_y = (Y_{MN} - Y_{AP})$ of the current x and y axis of MN′s position, and $\vec{V_{MN_x}}$, $\vec{V_{MN_y}}$ are the velocity vectors of each x and y axis respectively. Whereas, t is the time which will be monitored since the time that MN started obtaining the AP′s RSS until the current time in the way to calculate the MN′s position vector at t.

Formula 5 provides two types of connection life time between MN and AP. When the obtained $\bar{t}$ value is positive, this indicates that the MN currently at the same direction with the AP or towards this AP. On the other hand, when the value is negative this will infer that the MN moving away or on the opposite side from the AP. Eventually, the obtained connection life time of each AP in the scanning range will be inserted into proposed INS scheme. Thus, it will collaborate with the other two metrics (SNR and Residual Channel-Capacity) to achieve a high level of accuracy in network selection process. Therefore, when an AP provides high connection life time, this can contributes positively increasing the quality cost of that particular AP and when this time is low will contribute oppositely.

IV. Utilized Maximization Scoring Function

After the three input metrics of INS scheme have been identified, an aggregating function will be considered to combine all network selection criteria into a single function INS which is used to elect the best candidate network. The developed score function is a single ranking measure that combines all aforementioned metrics into a single one. Consider a score function INS based on j network selection metrics $\eta_i = \{\eta_{i1}, \eta_{i2}, \eta_{i3}, ..., \eta_{ij}\}$ (in the proposed INS scheme, all three aforementioned network selection metrics should to be maximized), for each of them the candidate network n_i has numerical values in the range $[\eta_i^{min}, \eta_i^{max}]$. Thus, a multi-metric scoring function is given as follows [13]:

$$f(\eta_{i1}, \eta_{i2}, \eta_{i3}, ..., \eta_{ij}) = X \times \eta_{i1}^{\sigma_1} \times \eta_{i2}^{\sigma_2} \times \eta_{i3}^{\sigma_3} .....\eta_{ij}^{\sigma_j} + Y_{max} \tag{6}$$

where: Y_{max} is the maximum value of the multi criteria function $f(\eta_{i1}, \eta_{i2}, \eta_{i3}, ..., \eta_{ij})$, X is the variable dependent weights of the limiting condition, and $(\sigma_1, \sigma_2, \sigma_3 ...., \sigma_j)$ is a j-weight array used to assign the priority to the handover decision making metrics, i.e. the network criteria metric with a higher weight factor contributes more on the network election process. In the proposed INS scheme, three input metrics were utilized to make handover decision between UMTS networks and WLANs. Thus, the network selection value is calculated as follows:

$$\begin{aligned} &f(SNR_i, R_{(cc)i}, t_{(connection)i}) \\ &= X \times SNR_i^{\sigma_1} \times R_{cc_i}^{\sigma_2} \times t_{connection_i}^{\sigma_3} + Y_{max} \end{aligned} \tag{7}$$

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The maximum value of $f(SNR_i, R_{(cc)i}, t_{(connection)i})$ occurs when its derivative equals to zero, hence the value of X is given by:

$$X = \frac{-Y_{max}}{SNR_{max}^{\sigma_1} \times R_{(cc)_{max}}^{\sigma_2} \times t_{(connection)_{max}}^{\sigma_3}} \quad (8)$$

For instance, when the obtained cost value of three input metrics $f(SNR_i, R_{(cc)_i}, t_{(connection)_i})$ for one AP candidate belongs to WLAN equals to 0, means the handover is highly recommended with that particular WLAN. On the other hand, if the obtained value via Formula 7 equals to 1; indicating that the handover is not preferred to be performed with this AP candidate. Thus, the X value can be calculated by using Formula 8, where Y_{max} =1 (the maximum number can be achieved via this formula in the range between 0 to 1), maximum SNR value is 50 dB, Maximum $R_{(cc)}$ is 1, Maximum $t_{(connection)}$ equals to 1. Therefore, when $\sigma_1 = 0.9$, $\sigma_2 = 0.2$, $\sigma_3 = 0.049$ with the aforementioned maximum metrics$'$ values and when apply Formula 8 as $X = \frac{-1}{50^{0.9} \times 1^{0.2} \times 1^{0.049}}$ which results $X = -0.0296$.

V. INS Algorithm Process for Vertical Handover Decision-Making

In order to identify and select the most qualified network candidate as the next wireless access point, each MN should execute the INS algorithm in the network access area. Figure 4 shows the flow chart digram of our proposed INS scheme for handover decision making. Firstly, we assume that each MN is aware about its own current associated network (net_i) ID and its cost (Cr_{c_i}) based on previous INS execution. Thus, in each iteration the INS algorithm reads the net_i and Cr_{c_i} of current associated network.

Two main wireless interfaces should be regularly checked by the proposed INS algorithm. One of them is the WLAN. When net_i is a WLAN, firstly the MN$'$s status must be identified whether it is in $idle$ or $busy$ mode. When MN is in the $idle - mode$ which determined by(parameter $idle$ which determines whether MN_i in idle state or not), the INS algorithm selects the network with Max_{c_i} using MaxNetworkCost Procedure. Afterwords, the handover with this selected network will be initiated without considering any other network or mobility aspects. This is because, in $idle-mode$ the MN does not run any application in order to result unnecessary handover. Thus, any handover decision might be processed by MN even it is unnecessary will not negatively reflect the performance of the network. Afterwards, when handover already performed the $net_{ID},\ Max_{c_i}\ and\ R_{c_i}$ of selected new network will be placed into current network parameters as mentioned in INS algorithm.

During the time of $busy-mode$ of MN$'$s wireless channel, various real time or non-real time applications might be executing. For instance, VoIP and Video conferencing are considered as real-time applications due to their sensitivity to the packet latency. Whereas, FTP and HTTP refer to data applications which normally used for transfer data and information over wireless medium. Therefore, our INS algorithm considers the real-time application sensitivity before handling and handover decision with new selected network as presented in Figure 4.

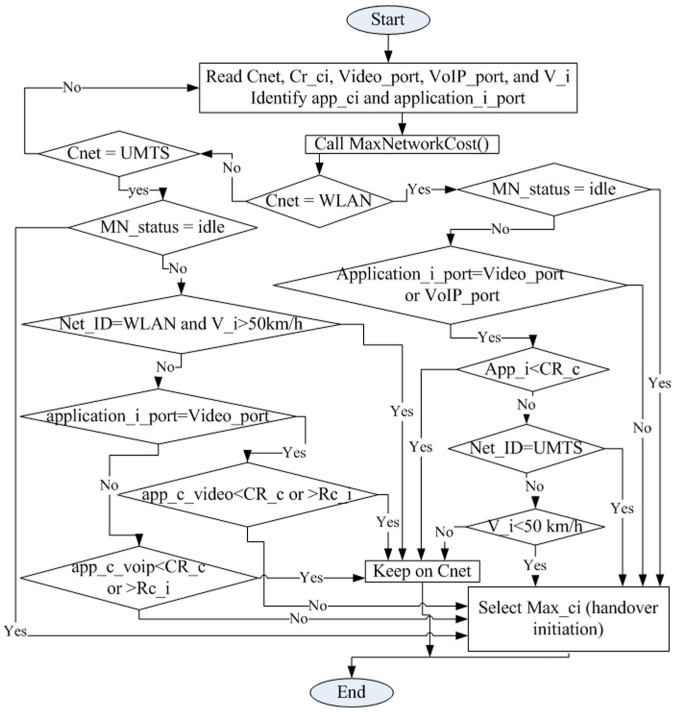

Fig. 4: INS Flow Chart.

VI. Results

Basically, it is significant to minimize the handover failures and unnecessary handovers during MN roaming process. Furthermore, optimize the network resource usage, the wireless link connection breakdown should be avoided especially with WLAN (due to limited coverage area). Therefore, We presented in this section the performance analyses of INS scheme in terms of the probability of unnecessary handovers, the link connection breakdown probability, and the handover failure probability. The proposed INS scheme compared with each of single with multi-criteria utility functions [5] and the integrated scheme [1].

Figure 5, illustrates the performance analyses in comparison form of INS scheme and the state of the arts. We can observe that, our proposed INS scheme could perform the best to minimize the handover failures, unnecessary handovers, and link connection breakdown probabilities. The reason behind that is, our INS scheme efficiently could address the issues within network selection process when the vertical handover from UMTS to WLAN is required. This is achieved by precisely identifying the residual channel capacity and link connection life time of each WLAN available candidate. Thus, when the MN$'$s velocity increasing the INS scheme performed the best in maintaining the probability of unnecessary handovers, the link connection breakdown probability, and the handover failure probability as it shown in Figures 5a, 5b and 5c respectively.

VII. Conclusion

In this paper an intelligent scheme INS has been proposed to efficiently make vertical handover decision. The proposed INS scheme has been designed based on the maximization scoring function to efficiently rank the available wireless network candidates. The results shown that, the proposed INS

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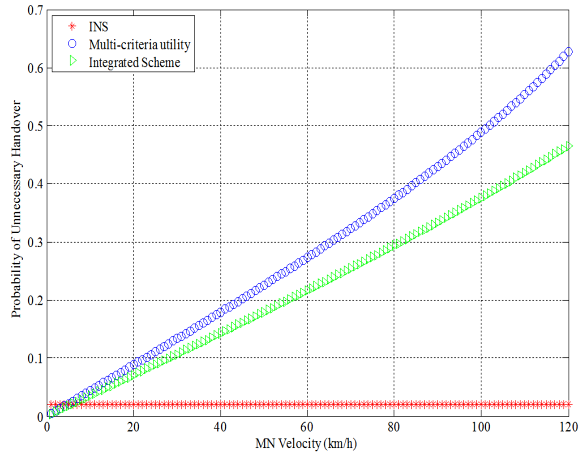
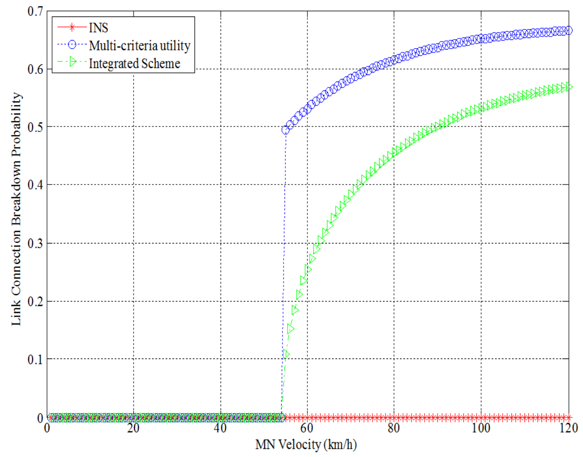
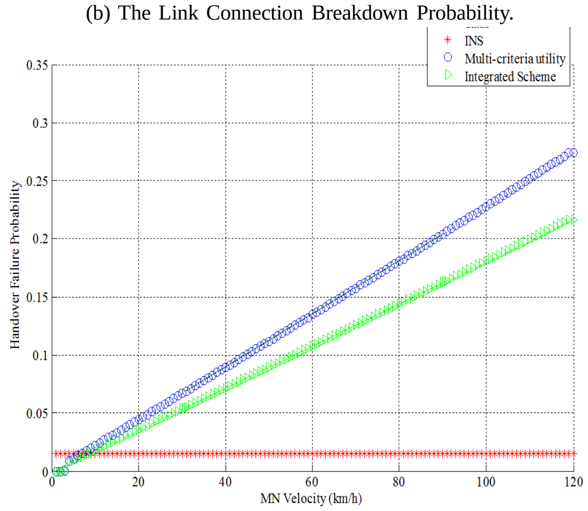


(a) The Unnecessary Handovers Probability.



(b) The Link Connection Breakdown Probability.



(c) The Handover Failure Probability.

Fig. 5: The performance analyses of INS Scheme in contrast to state of the arts vs. MN Velocity.

scheme performed more efficient in decreasing each of probability of unnecessary handovers, link connection breakdown probability in addition to handover failure probability in comparison with the state of the arts. We are currently working on developing an intelligent vertical handover algorithm utilizing the proposed INS scheme and trying implement it with respect of different mobility aspects.

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