A Novel Decision Scheme for Vertical Handoff in 4G Wireless Networks

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***Abstract*-Future wireless networks will consist of multiple heterogeneous access technologies such as UMTS, WLAN, and Wi-Max. These technologies differ greatly regarding network capacity, data rates, and other various parameters such as power consumption, Received Signal Strength, and coverage areas. This paper presents two Handoff Decision schemes for heterogeneous networks. A good handoff decision could avoid the redundant handoffs and reduce the packet lose. First scheme makes use of a score function to find the best network at best time from a set of neighboring networks. Score function uses bandwidth, Received Signal Strength (RSS) and access fee as its parameters. Second scheme makes use of classic triangle problem to find the best network from a set of neighboring networks. This problem considers three parameters bandwidth, Received Signal Strength (RSS) and access fee as the three sides of a triangle. If an equilateral triangle is obtained with these parameters of a network then that network will be the best among the set of networks. The best decision model meets the individual user needs but also improve the whole system performance by reducing the unnecessary handoffs.**

Keywords-MIHF, Received Signal Strength, Mobility Management, vertical handoff ,

I. Introduction

Currently, there are various wireless networks deployed around the world. Examples include second and third generation (3G) of cellular networks (e.g., GSM/GPRS, UMTS, CDMA2000), wireless local area networks WLANs (e.g., IEEE 802.11a/b/g), and personal area networks (e.g., Bluetooth). All these wireless networks are heterogeneous in sense of the different radio access technologies. From this fact, it follows that no access technology or service provider can offer ubiquitous coverage expected by users requiring connectivity anytime and anywhere. The actual trend is to integrate complementary wireless technologies with overlapping coverage, to provide the expected ubiquitous coverage and to achieve the "Always Best Connected" (ABC) concept The ABC concept allows the user to use the best available access network. In order to accomplish the integration and inter-working between heterogeneous wireless networks and the ABC concept, many challenging research problems have to be solved, taking into account.

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that all these new wireless technologies were designed without considering any interworking among them In heterogeneous wireless networks, mobile devices or mobile stations will be equipped with multiple network interfaces to access different wireless networks. Users will expect to continue their connections without any disruption when they move from one network to another. This important process in wireless networks is referred to as handoff or handover.

Handoff process among networks using different access technologies is defined as vertical handoff (VHO) [1]. Such a process of changing the connections among different types of wireless and mobile networks is called the vertical handoff. Obviously, the network selection and the vertical handoff decision are two important processes in an integrated wireless and mobile network. Handoff process is initiated by change in different factors like Received Signal Strength (RSS), Signal to Noise Ratio (SNR) etc. When these factors fall bellow the threshold value the Mobile Node (MN) has to search for another AP having RSS greater than threshold value [2, 3]. Wang et al. introduce the policy enabled handoff in [4], which was followed by several papers on similar approaches. Policy enabled handoff systems separates the decision making (i.e. which is the "best" network and when to handoff) from the handoff mechanism. Smart Decision Model [5] smartly performs vertical handoff among available network interfaces. Using a well-defined score function, the proposed model can properly handoff to the "best" network interface at the "best" moment according to the properties of available network interfaces, system configurations / information, and user preferences. A handoff decision scheme with guaranteed QoS [6] for heterogeneous networks make the decision according to the user's communicating types and the performance of the networks. A generic vertical handoff decision function [7] proposed considering the different factors and metric qualities that give an indication of whether or not a handoff is needed. The decision function enables devices to assign weights to different network factors such as monetary cost, quality of service, power requirements, personal preferences etc. A decision strategy [8] considers the performance of the whole system while taking VHO decisions by meeting individual needs. This decision strategy select the best network based on the highest received signal strength (RSS) and lowest Variation of Received Signal Strength (VRSS). Thus it ensures the high system performance by reducing the unnecessary handoffs. Nasser et al. [9] proposed a VHO decision (VHD) method that simply estimates the service quality for available networks and selects the network with the best quality. However, there still lie ahead many challenges in integrating cellular networks and WLANs.

This paper is organized as follows. In Section II, we introduce our proposed system model for an integrated wireless and mobile network. In Section III, different handoff decision strategies are presented. In Section IV, we analyze the performance of the proposed strategy. Finally, we conclude this paper in Section V.

II. System Model

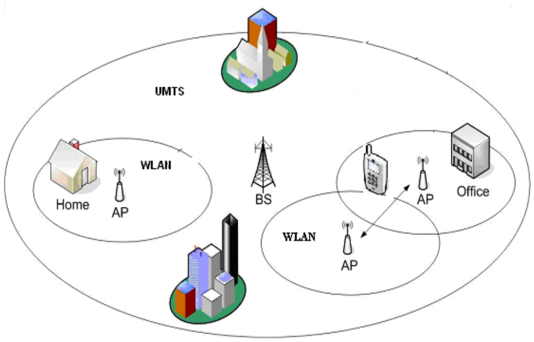

Fig 1 Vertical handoff in heterogeneous networks

As shown in the above figure an MN can be existing at a given time in the coverage area of an UMTS alone. However, due to mobility, it can move into the regions covered by more than one access network, i.e., simultaneously within the coverage areas of, for example, an UMTS BS and an IEEE 802.11 AP. Multiple IEEE 802.11 WLAN coverage areas are usually contained within an UMTS coverage area. A Worldwide Interoperability for Microwave Access (WiMAX) coverage area can overlap with WLAN and/or UMTS coverage areas. In dense urban areas, even the coverage areas of multiple UMTS BSs can overlap. Thus, at any given time, the choice of an appropriate attachment point (BS or AP) for each MN needs to be made. These access technologies have different bandwidth, power consumption, RSS threshold, data rate, jitter, delay etc. So during handoff it is required to find the best network according to user preferences. At the hotspots APs are made available. When the Received Signal Strength of an AP goes low below some threshold value the Mobile Host has to find another best network considering bandwidth, RSS, access fee as parameters. Each of these parameters is given a weight according to preferences. If any of the best AP s are not available handoff has to be performed to Base Station of UMTS. Thus, multiple access technologies and multiple operators are typically involved in Network Selection Decision. The Network Selection decision making algorithm is implemented in Network selection decision Controllers located in access networks. Decision input for NSDCs will be obtainable via the MIHF. The MIHF of NSDC facilitates standard based message exchanges between various access networks or attachment points to share information about the traffic load, bandwidth available, RSS and other network capabilities of each AP. NSDC obtains LLT s from MN via MIHF. LLT regarding MN indicates two possibilities a) RSS for an MN dropped below some specific threshold while MN in service at an AP b) RSS for one or more APs exceeded to a specific threshold while MN in service at BS. Usually AP is preferred attachment point than BS since AP is associated with higher bandwidth cost and higher data rate. When NSDC obtains LLT it executes Network selection decision algorithm and find the best AP, if no other best APs are found for handoff select cellular network as the best available network.

III. Network selection Decision Making Algorithms

Most existing network selection strategies only focused on the individual user's needs. Motivation of this paper is to design a network-selection strategy from a system's perspective, and the network-selection strategy can also meet a certain individual user's needs. In the following, we discuss how our proposed network-selection strategy works.

A. *Algorithm*

1) *Handoff Initiation:*

MN can be in service with AP or BS. When the RSS strength goes low below some threshold value or when the RSS strength in any of the AP goes above some threshold value when the MN is in service with BS, the MN has to find a best network to which it has to perform handoff .When RSS goes low MN gives Link layer trigger to Network Selection Decision Controller in the network in which the MN currently connects to. Thus the handoff process is initiated.

2) *Handoff Decision:*

When handoff process is initiated, the Network Selection decision controller collects the condition of each neighboring network via Media Independent Handover Function (MIHF) and executes Network Selection Decision Controller (NSDC) algorithm. The algorithm first calculates the score of the current network and compares the score with each of the neighboring network's score. The score of the neighboring networks is calculated only if all the parameters have satisfying value to accept a Mobile Host. Our proposed network-selection strategy prefers a call to be accepted by a network with lower traffic load and stronger received signal strength, which can achieve better traffic balance among different types of networks and good service quality. Consequently, we define a score function to combine these two factors-the traffic load and the received signal strength. Therefore, the score to use a network Ni for a call is defined as the score function used is the following:

$$Score = \sum_{j=1}^{k} W_j Norm_j \quad (1)$$

k is the number of parameters. Wj is the weight assigned to the parameter j. Normj is the normalized value of the parameter j. If any of the network with higher score is available handoff to that particular network or if any of the network with optimum score is not available handoff to BS.

$$Score_i = wg.G_i + ws.S_i + wf.F_i \quad (2)$$

where Gi is the complementary of the normalized utilization of network Ni, Ri is the relative received signal strength from network Ni, Fi is the normalized access fee of network Ni and wg (0 ≤ wg ≤ 1) ws (0 ≤ ws ≤ 1),wf (0 ≤ wf ≤ 1), are the weights that provide preferences to Gi, Si, Fi respectively. The larger the weight of a specific factor, the more important that factor is to the user and vice versa The constraint between wg ,ws and wf is given by

$$wg + ws + wf = 1 \quad (3)$$

Even though we could add the different factors in the VHDF to obtain network score, each network parameter has a different unit, which leads to the necessity of normalization. The complementary of normalized utilization Gi is defined by

$$Gi = \frac{B_{if}}{B_i} \quad (4)$$

where Bif is the number of available bandwidth units in network Ni, Bi is the total number of bandwidth units in network Ni.

In general, stronger received signal strength indicates better signal quality. Therefore, an originating call prefers to be accepted by a network that has higher received signal strength. However, it is difficult to compare the received signal strength among different types of wireless and mobile networks because they have different maximum transmission power and receiver thresholds. As a result, we propose to use relative received signal strength to compare different types of wireless and mobile networks. Si in (2) is defined by

$$Si = \frac{P_i^{c} - P_i^{th}}{P_i^{\max} - P_i^{th}} \quad (5)$$

where P_i^{c} is the current received signal strength from network Ni, P_i^{th} is the receiver threshold in network Ni, and $P_i^{\max}$ is the maximum transmitted signal strength in network Ni. It is to note that we only consider the path loss in the radio propagation model. Consequently, the received signal strength (in decibels) in network Ni is given by

$$P_i^{c} = P_i^{\max} - 10\gamma \log(r_i) \quad (6)$$

where ri is the distance between the mobile user and the BS (or AP) of network Ni, and γ is the fading factor . Therefore, the receiver threshold in network Ni is given by

$$P_i^{th} = P_i^{\max} - 10\gamma \log(R_i) \quad (7)$$

The relative received signal strength from network Ni is rewritten as

$$S_i = 1 - \frac{\log(r_i)}{\log(R_i)} \quad (8)$$

Ri is the radius of cell of network i

Access fee Φi is given by

$$\Phi_i = \frac{(1-\varphi_i)}{\varphi_{\max}} \quad (9)$$

where φmax is the highest access fee that the mobile user likes to pay, and φi is the access fee to use network *Ni*. The mobile user does not connect to a network that charges more than φmax. If an originating call has more than one connection option, the score of all candidate networks are calculated by using the score function in (2). The originating call is accepted by a network that has the largest score, which indicates the “best” network. If there is more than one “best” network, the originating call is randomly accepted by any one of these “best” networks.

Flow chart

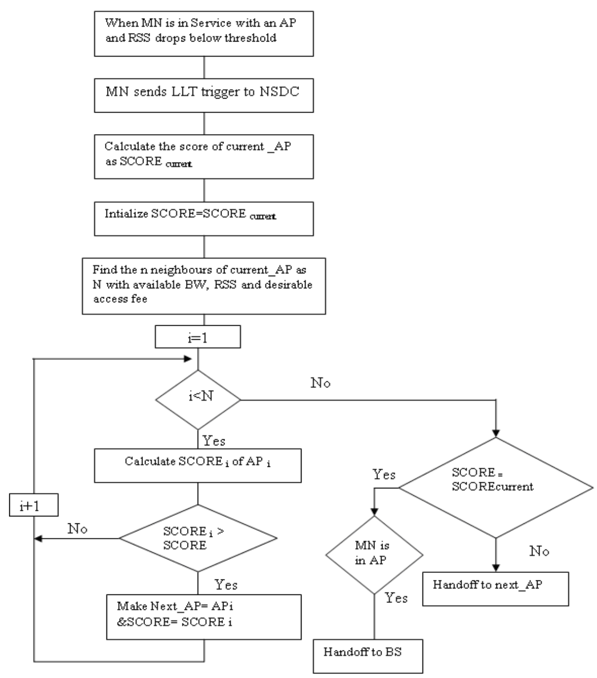

Fig 2: Handoff decision Algorithm 1

Here this algorithm checks only if bandwidth is available and not checking it greater than threshold. As the available bandwidth decreases i.e. the load increases there is more chance for the RSS to go low. Thus the call dropping probability increases and holding time decreases. In this algorithm if any of the parameters have greater value the score increases even if others have less value.

B. Algorithm 2

1) Handoff Initiation

MN can be in service with AP or BS. When the RSS strength goes low below some threshold value or when the RSS strength in any of the AP goes above some threshold value when the MN is in service with BS, the MN has to find a best network to which it has to perform handoff .When RSS goes low MN gives Link layer trigger to Network Selection decision controller in the network in which the MN currently connects to. Thus the handoff process is initiated.

2) Handoff Execution:

Handoff execution is based on classic triangular problem. According to triangular problem we consider triangles representing the conditions of networks. Each side of the triangle corresponds to each parameter. The parameters this problem considers in this paper are Received Signal Strength, Bandwidth and Access cost. If all the parameters have desired value (value MN expects) then the resultant triangle will be equilateral (S1=S2=S3=a, three sides equal) and if two of the parameters have desired value the triangle will be isosceles (S1≠S2=S3 or S1=S2≠S3, two sides equal). If S1≠S2≠S3 then the triangle is scalene. The networks that give equilateral triangle and isosceles will be in candidate list 1 and candidate list 2 respectively. Select one network from list1 as best network and if list1 is empty select best network from list2. Then perform handoff to the selected best network. If both lists are empty handoff to BS.

Flow chart

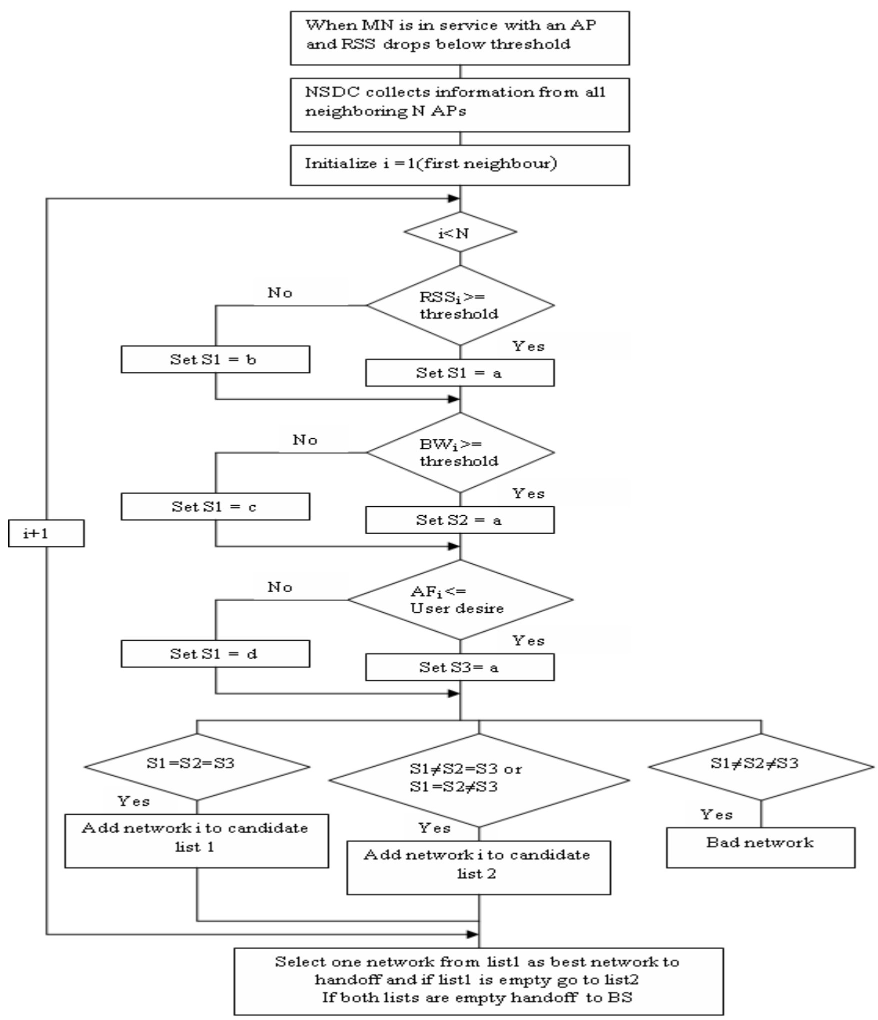

Fig 3: Handoff decision Algorithm 2

RSS can be measured as

$$P_i^c = P_i^{\max} - 10\gamma \log(r_i) \qquad (10)$$

where P_i^c is the current received signal strength from network *Ni*, *ri* is the distance between the mobile user and the BS (or AP) of network. $P_i^{\max}$ is the maximum transmitted signal strength in network Ni γ is the fading factor

Bandwidth is given by
Available Bandwidth of the network = Bandwidth of the network − sum of Bandwidth used by all MNs Attached to the network.

Access Fee is the fee that is assigned to each network usage. It may vary from network to network. User usually prefers the low network fee.

IV. Performance Analysis

Simulations have been performed for the 3G cell overlay structure. In this scenario three networks of different data rates co-exist in the same wireless service area. Network 1 and Network 2 represent 802.11b wireless LANs, with bandwidths of 2Mbps and 1Mbps, respectively. Network 3 is modeled as a UMTS network, which supports multiple users simultaneously.

The expected graphs are shown below

Bandwidth	10	20	30	40	50	60	70	80	90	100
Holding Time algorithm 1	2.5	4.5	5.7	6.1	6.3	6.5	6.9	7	7	7
Holding Time algorithm 2	3.5	5.5	6.5	7	7.5	8	8.5	9	9.5	9.5

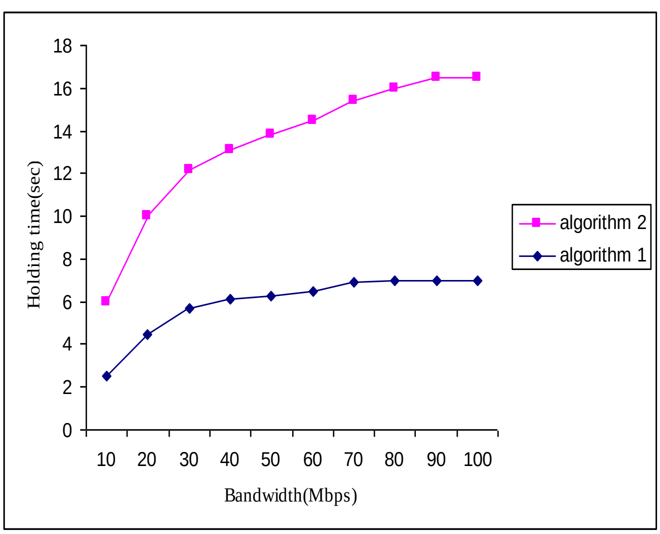

Fig 4: Holding time Vs RSS

RSS	5	10	20	30	40	50	60
algorithm 2 call dropping probability	0.5	0.4	0.3	0.25	0.2	0.1	0.09
algorithm 1 call dropping probability	0.8	0.75	0.7	0.65	0.55	0.4	0.3

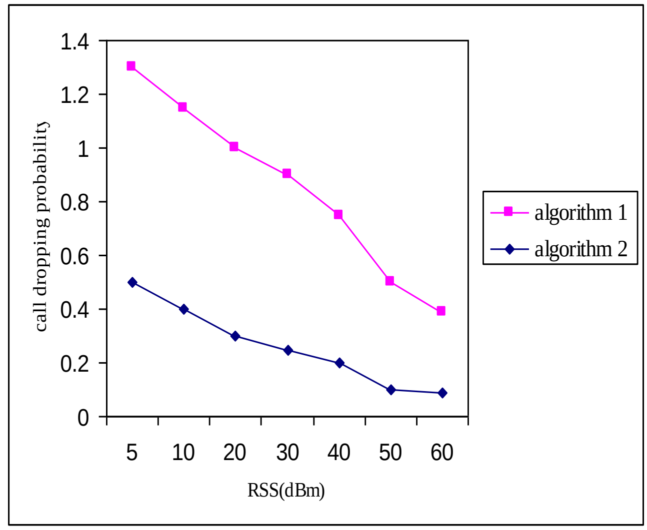

Fig 6: Call dropping probability Vs RSS

V. Conclusion

Thus this paper describes two different handoff decision algorithms. First algorithm uses a score function to find the best network at best time from a set of neighboring networks. Second algorithm uses classic triangle problem to find the best network from a set of neighboring networks. If an equilateral triangle is obtained with three parameters of a network then that network will be the best among the set of networks. Since the second algorithm performs handoff only if the constraints are above the threshold value. The call dropping probability is reduced and holding time is increased.

VI. References

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