Vertical Handover Decision (VHD) Algorithms Analysis and Efficient Approach for VHD

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ABSTRACT

In the fourth generation wireless network, the main objective is to facilitate seamless mobility of users between heterogeneous networks while satisfying QoS requirements Vertical handover decision (VHD) algorithms are essential components of the architecture of the fourth Generation (4G) heterogeneous wireless networks. These algorithms need to be designed to provide the required Quality of Service (QoS) to a wide range of applications while allowing seamless roaming among a large number of access network technologies. In this study paper we are presenting analysis of existing VHD algorithms and presenting new prediction based approach for vertical handoff decision. The prediction based vertical handoff decision algorithm has been proposed based on mobility. For the proposed algorithm HMM (Hidden Markov Model) predictor is applied which has been utilized in this algorithm that can accurately estimate the next location to be visited by a mobile user, given current and historical movement information. This paper we discuss the theoretical analysis of this approach.

Keywords - Horizontal Handover, HMM, Vertical Handover, WLAN, WIMAX, UMTS.

I. Introduction

The future wireless networks current trend is to provide accessibility for connecting to any network anywhere and anytime [1]. In such system, user will be roaming among different wireless access a technology which is known as Vertical Handoff/Handoff [2]. Several issues such as handoff metrics, handoff decision algorithms and handoff technologies are individually considered they have management are to be studied in order to achieve seamless handoff. In horizontal handoff which occurs between similar accesses technologies, the handoff decision is mainly based on Received Signal Strength (RSS) in the border region of two cells. However, in vertical handoff, the situation is more The users in "hot-spot" areas will be provided with high complex, compared to the horizontal handoff, the signal strength is sometimes not sufficient to trigger the vertical handoff as heterogeneous networks have different characteristics and their performance cannot be simply compared using the signal strength of two cells. Other new metrics such as service type, system performance, network conditions, mobile node conditions, user preferences etc . must be considered. Another challenge is that the vertical handoff may not only take place at the cell edge. It could occur at any time depending on the network condition and user preference such as in a situation of network congestion. The decision to trigger a vertical handoff according to the system performance and QoS parameters becomes the main part of vertical handoff process [3].Therefore, an effective and efficient vertical hand off decision algorithm is needed to improve the system performance.

There are many VHD algorithms are presented by various researchers, however those all algorithms have not considered the mobility prediction method s to take proactive measures.

In this paper we are presenting the theoretical study over the Handover mechanism VHD mechanisms and proposed the efficient HMM based VHD algorithm. In below section 2 we will present the literature review o ver the various aspects related to the handover mechanism in various networks as well as VHD. Section 3 present the related work done on VHD. In section 4 we will present the proposed prediction based approach for VHD and its mathematical model further.

II. Literature review

2.1 Introduction to Integrated Systems

The existing demand to somehow provide higher data rate and seamless connectivity has led to the integration of two major communication networks. The complementary characteristics present in Wireless local area network and cellular network, the integration becomes a promising trend for the future generation wireless networks. 802.1 1n, 3G are the latest types of technologies in WLAN and Mobile networks respectively, that are widely used. When these technologies are individually considered they have advantages as well as disadvantages. By collective usage of the advantages of these two technologies, i.e. 3G support's wide coverage area and WLAN support's high data transfer, quality of service can be improved.

The users in "hot-spot" areas will be provided with high Cellular networks and when the user is outside a hot spot coverage area, one can use the cellular network. However, this is not a simple process to implement.
In the study of [Modelling and Analysis of Hybrid Cellular/WLAN System with Integrated Service-Based Vertical Handoff Schemes], a CDMA cellular system is considered along with IEEE 802.11 network. Bandwidths of cellular network and WLAN are Cc and Cw respectively. The total system resources are shared by both data and voice calls in integrated system. Particular channels are assigned to voice calls and hence have more priority over the data calls, in accessing the system resources. The unused b and width by current voice calls is shared by the ongoing data calls. Vertical and Horizontal handoffs are also given priority, accordingly as voice and data calls. To prioritize the handovers, the channel reservation approach is used in the cellular network. Vertical handover voice calls are given the highest priority among both the handover calls by limiting the number of accepted horizontal handover calls, when voice calls are greater than or equal to the threshold. [2]

2.2 Horizontal and Vertical Handovers in Integrated Systems

An essential element of cellular communications is Handoff. This chapter of the thesis gives a summary of handover and mobility among heterogeneous networks. When a mobile station moves from one wireless cell to another wireless cell, it is a Handoff (or handover). It is classified as horizontal (intra-system) and vertical (inter- system). Vertical refers to the overlapping of wireless networks. With the help of a simple tale, the problem of vertical mobility can be illustrated. Consider a relay team of mouse and a rabbit. To carry a carrot as fast as they can is the task. A mouse can go far, but it cannot carry heavy loads. The rabbit, in this example is restricted in the fence. In the fence, it can carry a heavy load of carrots, but it has to give the carrots to the mouse at the fence. The rabbit represents a WLAN, and the mouse a cellular network. The event where the exchange of carrot loads between rabbit and mouse is called hand off, more precisely vertical handoff. This process refers to transition from WLAN to cellular network and vice versa. The carrot represents the payload, which is carried by mouse (cellular network) and the rabbit (WLAN). Payload means data in terms of bits or bytes, which is a part of bigger files. To make the communication seamless, the problem is to make best of mouse and rabbit carrying the carrot together. The access technology changes in vertical handover.
A mobile node moves with the single technology network from one access point to the other one in a horizontal handover. For example, if a mobile user moves from one base station to base station of other area, then the mobile user of GSM network makes a horizontal handover. A horizontal handover is a traditional handover. In other words, the difference between vertical and horizontal handover is that the vertical handover changes the access technology and the latter does not change [3].
In comparison with micro and macro mobility, they are differentiated into subclasses such as vertical and horizontal micro mobility, vertical and horizontal macro mobility. Vertical micro mobility is the handover within the same domain using different wireless technologies. Horizontal micro mobility is the handover among the same domain using the same wireless technology. Vertical macro mobility is handover among different domains using different wireless technologies and horizontal macro mobility is handovers within various domains, using same wireless technology.
The handoff process can be characterized as hard handoff or soft handoff. Before making a handoff if there is a break in the communication, it is referred as a hard handoff (brake before make) and whereas in soft handoff, there is a connection to both of the base stations for some time before making the handoff (make before break).
To enhance the capacity and QoS of cellular systems, efficient hand off algorithms are cost effective ways. In a horizontal handover, the main concern is to maintain the ongoing service even if the IP address changes because of the movement of the mobile node. The ongoing service is done either by dynamically updating the changed IP address or by hiding the change of IP address. Vertical handover takes place when the mobile node moves over heterogeneous access networks. The used access technology is also changed along with the IP address in the vertical handover, as the mobile nodes moves across different networks which use different access technology. In such cases, the main issue is to maintain the ongoing service even when there is a change not only in IP address but also in network interfaces, QoS characteristics etc. [4]

The main capabilities of Vertical handovers over Horizontal handovers are:

1. Vertical handovers use different access technology.
2. Vertical handovers use multiple network interfaces.
3. Multiple IP addresses are used in Vertical handovers.
4. QoS parameters can be changed in Vertical handovers and multiple parameters are used.
5. Multiple network connections are used in Vertical handovers.

2.3 Integrated Serviced based Handoff (ISH) and ISHQ Handoff Schemes:

Service dependent handoff schemes are introduced in the integrated system of cellular/WLAN. On the basis of whether the vertical handoff request can be queued or not, the service schemes are of two types. Integrated service based handoff and integrated service based handoff with queuing capabilities [2]. These two schemes are explained in detail in the section below.

a. Integrated Serviced based Handoff (ISH) Scheme:

In this proposed ISH scheme, the only calls that can request admission to the cellular network are originating voice calls from area A and a handoff voice calls from its neighboring cells. If < , the originating call from area A is accepted and if == , the call is rejected. Also if < , the handoff voice call from the neighbouring cell is accepted and when == , it is rejected. From area B, a voice call will try to access the cellular network, and if < , it is accepted. The call will now go to WLAN when = = , and in WLAN if < , it accepts the call and rejects if otherwise. For calls moving into B area, no handoff is executed fo r ongoing voice calls. A vertical handoff would take place, when a voice call which was accepted by the WLAN moves out of B area. In a cellular network, if < , the vertical handoff voice calls can be accepted.

If < , the data call originating from area B will be allowed to access WLAN and if otherwise is rejected. Similarly, if < , the data call moving into area B is handed to the WLAN, and it remains in the cellular network otherwise. And if < , the data call originating from area A and data vertical handover requests to cellular network is accepted and rejected otherwise.

b. Integrated Serviced based Handoff With Queue (ISHQ) Scheme :

Voice calls are handled the same way in both the proposed schemes ISHQ and ISH. In ISHQ handover scheme, there are two queues Qc and Qw with and as their respective capacities. The queue Qc is for handling vertical handover requests of data to cellular networks and the queue Qw is for vertical handoff requests and originating data calls that are entering into the WLAN from area B. There may happen three different probabilities depending upon the arrivals to the queue. If < , the vertical handoff requests to the cellular network is accepted. If = , the request will be queued in Qc , and if the queue Qc is full on the arrival of requests, the requests will b e dropped . These requests in the queue Qc will be served on the basis of first-in, first-out (FIFO) basis once the channel becomes available. This data call request is then deleted from Qc once it is handed over to the WLAN. Also if < , data vertical handoff requests to WLAN or data calls originating from area B are processed by the WLAN. If = these requests are queued in Qw and when the queue Qw is full on the arrival of many requests, the requests are blocked.

2.4 Vertical Handover

Vertical handover is happened when a mobile node moves across heterogeneous access networks. Differently from horizontal handover, the used access technology is also changed as well as IP address, because the mobile nodes moves different access network which uses different access technology. In this case, the main concern of vertical handover is to maintain on-going service although not only the change of IP addresses but also the change of network interfaces, QoS characteristics, and etc. In horizontal handover, which occur between similar networks, the handover decision is mainly based on received signal strength (RSS) in the border region of two cells. However, in vertical handover, the situation is more complex, compared to the horizontal handover, the signal strength is sometime not sufficient to trigger the vertical handover because of heterogeneous networks have different system characteristics and their performance cannot be simply compared using the signal strength of two cells. Other new metrics such has service type, system performance, network conditions, and mobile no de network. Therefore, the user can choose the best access point with maximum bandwidth for connecting to the internet.

A handover process can be split into three stages: handover information gathering, handover decision and handover execution [2].

Handover Information Gathering: used to collect all the information required to identify the need for handover and can subsequently initiate it. It can be called also handover initiation phase or system disco very.

Handover Decision: used to determine whether and how to perform the handover by selecting the most suitable access network (taking into account some criteria such as user preferences) and by giving instructions to the execution phase. It is also called network or system selection.

Handover Execution: used to change channels conforming to the details resolved during the decision phase.

2.5 VHD Criteria

Handover criteria are the qualities that are measured to give an indication of whether or no t a handover is needed. We can regroup different criteria as follows:

- Received signal strength (RSS) is the most widely used criterion because it is easy to measure and is directly related to the service quality. There is a close relationship between the RSS readings and the distance from the mo bile terminal to its point of attachment. Majority of existing horizontal handover algorithms use RSS as the main decision criterion, and RSS is an important criterion for VHD algorithms as well.

- Available b and width is a measure of available data communication resources expressed in bit/s. It is a good indicator of traffic conditions in the access network and is especially important for delay-sensitive applications.
- Network connection time refers to the duration that a mobile terminal remains connected to a point of attachment determining the network connection time is very important for choosing the right moment to trigger a handover so that the service quality could be maintained at a satisfactory level.
  For example, a handover done too early fro m a WLAN to a cellular network would waste network resources while being too late would result in a handover failure.
- Cost: For different networks, there would be different charging policies, therefore, in some situations the cost of a network service should be taken into consideration in making handover decisions.
- Power consumption becomes a critical issue especially if a mobile terminal's battery is low. In such situations, it would be preferable to handover to a point of attachment which would help extending valuable battery life.
- Security: For some applications, confidentiality or integrity of the transmitted data can be critical. For this reason, a network with higher security level may be chosen over another one which would provide lower level of data security.
- User preferences: A user's personal preference towards an access network could lead to the selection of one type of network over the other candidates.

III. Related Work on VHD

Research on design and implementation of Vertical Handoff Decision (VHD) algorithms has been carried out by many scholars using various techniques. Based on the handoff decision criteria, VHD algorithms are categorized as RSS based algorithms, Bandwidth based algorithms, User Mobility based algorithms and Cost function based algorithms.

In RSS based algorithms RSS is used as the main criteria for decision in this group . Various schemes have been developed to compare RSS of the current p oint of attachment with that of the candidate point of attachments. They are: Relative RSS, RSS with hysteresis, and RSS with hysteresis plus dwelling timer method [5 , 6]. Relative RSS is not applicable for VHD, since RSS from different types of networks cannot be compared directly due to the disparity of the technologies involved . In RSS with hysteresis method, handoff is performed whenever the RSS of new Base station (BS) is higher than the RSS of old BS by a predefined value. In RSS with hysteresis plus dwelling timer method, whenever the RSS of new BS is higher than the RSS of old BS by a predefined hysteresis, a timer is set. When it reaches a certain specified value, handoff is processed. This minimizes Ping pong handoffs. But other criteria have not been considered.

In bandwidth based algorithms, the available bandwidth for a mobile terminal is the main criteria. In [7], a bandwidth based VHD method is presented between WLANs and a WCDMA network using Signal to Interference and Noise ratio (SINR). It provides higher throughput than RSS based handoffs since the available bandwidth is directly dependent on the SINR. But it may introduce excessive handoffs with the variation of the SINR. These excessive handoffs are reduced by a VHD heuristic based on the Wrong Decision Probability (WDP) prediction [8]. The WDP is calculated by combining the probability of unnecessary and missing handoffs. This algorithm is able to reduce the WDP and balance the traffic load. But in both the papers, RSS is not considered.

A hand off to a target network with high bandwidth but weak received signal is not desirable as it may result in breakdown of connection. In user mobility based algorithms, velocity information is a critical one for handoff decision. In the overlay systems, to increase the system capacity, micro/pico cells are assigned for slow moving users and macro cells are assigned for fast moving users by using velocity information [9]. It decreases the number of dropped calls. An improved handoff algorithm [10] has been presented to reduce the number of unnecessary handoffs by using location and velocity information estimated from GSM measurement data of different signal strengths at MS received from base stations. From these papers, it is seen that velocity and location information are also having great effect on handoff management. Therefore they should be taken into account in order to provide seamless handoff between heterogeneous wireless networks.

Cost function based algorithms combine metrics such as monetary cost, security, power consumption and bandwidth in a cost function. The handoff decision is made by comparing the result of this function for the candidate networks [11, 12, and 13]. Different weights are assigned to different input metrics depending on the network conditions and user preferences.

A dynamic decision model (DDM) [14] has been proposed to decide the best network at best moment for handoff. The decision model makes the right vertical handoff decisions by determining the best network among available networks based on, the factors such as RSS of network and velocity of mobile station along with static factors like Usage Expense, Link capacity (offered bandwidth) and power consumption. This model not only meets the individual user needs b ut also improve the whole system performance by reducing the unnecessary handoffs. A trajectory-aware handoff algorithm [15] makes the decision based on position, velocity, signaling delay, and RSS of mobile station. In this algorithm, velocity of MS is divided into two parts as radial velocity and tangential velocity. For more precise handoff initiation, tangential velocity of MS is neglected, and only radial velocity of MT is considered in handoff decision making. Moreover, before handoff decision, least square line method is applied to RSS of MS to avoid unnecessary back-and-forth handoffs (ping-pong handoffs) between different services. All the above algorithms have not considered the mobility prediction methods to take proactive measures.

IV. HMM Based VHD: Proposed Approach

Thus according to problem stated in above section, in this project we are presenting the new algorithm based on mobility prediction. A method of mobility prediction, i.e., predicting a mobile node's next location based on Hidden predicting a mobile node's next location based on Hidden Markov Model (HMM) has been proposed. HMM predictor can accurately estimate the next location to be visited by a mobile no de, when the current and historical movement information is available. In this prediction method, it has been assumed that the MN is moving and able to regularly send its physical position to the serving BS. Once the MN position has been determined , if a MN is likely to perform a handover, the serving BS triggers the Handoff decision control process. This case always happens in the heterogeneous networks like UMTS, WiMAX, WI-FI, WLAN.

A proactive handoff technique has been developed in which the Handoff Decision Controller (HDC) collects the following factors from the neighbouring attachment points (AP or BS): Current Network Load, Strong RSS and Power consumption of using the network access device. A combined weight value has been calculated . Based on these values the priorities are assigned to networks and MS can handoff to a higher priority network.

Finding the optimal BS from the network for Vertical handover is NP-complete problem:

We are using the HMM model for selection of optimal BS. In its discrete form, a hidden Markov process can be visualized as a generalization of the Urn problem: For example, in a room which not at all visible to an observer there is a genie. The room contains urns X1, X2, X3 ... each of which contains a known mix of balls, every ball is labeled with y1 , y2, y3 ... The genie selected an urn in that room as well as randomly draws a ball from that urn. Afterwards it puts that ball into conveyor belt in which the observer can senses the sequence of the balls however not the sequence of urns from which they were drawn. There is some process for the genie in order to choose urns; the urn choice for the n-th ball basically depends only upon a random number and the choice of the urn for the (n - 1)-th ball. The urn selection doesn't depends directly over urns this single previous urn; and hence, this is called as Markov process. This process is presented in below figure 1.

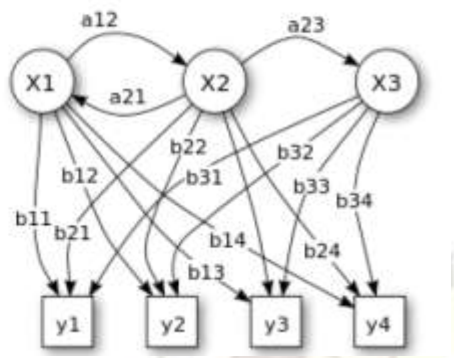

Figure 1: Probabilistic parameters of a hidden Markov model (example)
x — states
y — possible observations
a — state transition probabilities
b — output probabilities

V. Performance Metrics

For the evaluation of Vertical handover decision approaches we have to majorly focus over the use of following performance metrics.

- Handover delay: It refers to the period between the initiation and completion of the handover method. Hand over delay is expounded to the complexness of the VHD method, and reduction o f the handover delay is particularly necessary for delay-sensitive voice or multimedia system sessions.
- Range of handovers: Reducing the amount of handovers is typically most well-liked as frequent handovers would cause wastage of network resources.
- Handover failure probability: A handover failure occurs once the happens is initiated however the target network doesn't have comfortable resources to complete it, or once the mobile terminal moves out of the

coverage of the target network before the method is finalized. Within the former case, the handover failure chance is expounded to the channel availableness of the target network, whereas within the latter case it's associated with the mobility o f the user [3].

- Throughput: The throughput refers to the info rate delivered to the mobile terminals on the network. Handover to a network candidate with higher throughput is typically fascinating.

VI. Conclusion and Further Work

In this literature paper, we have studied the problems associated the vertical handovers. We have presented the literature survey over the handover concepts in details. Further we presented the related works done over the VHD approach. The new solution is presented to overcome the issues associated with existing methods of VHD. This approach is based on use of HMM prediction model. A HMM predictor has been used which accurately estimates the next location visited by a mobile user, given current the received signal strength values of the MNs. The home AP thus predicts the list of possible APs in the movement direction of a mobile node and send s a request to the predicted APs. The current Network Load, Strong RSS and Power consumption are estimated in each AP. These APs after calculating combined weight value, sends it back to the home AP. The home AP then selects an optimum AP for the MN to perform handover, based on the sorted weight values. The information about the selected APs, are sent to the mobile user so that the user can move to that particular AP. For the future work we will work on practical impacts and simulation studies of this approach and presents its comparative study in terms of above defined performance metrics.

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