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Prediction based Vertical Handoff Decision Algorithm in Heterogeneous Wireless Networks

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ABSTRACT- Next generation wireless communications will integrate multiple wireless access networks. Vertical handoff plays an important role in heterogeneous networks. In this paper, a prediction based vertical handoff decision algorithm has been proposed based on mobility. A Hidden Markov Model (HMM) predictor has been utilized in this algorithm that can accurately estimate the next location to be visited by a mobile user, given a current and historical movement information. Each Base station (BS) calculates a combined weight value based on current Network Load , Received Signal Strength (RSS) and Power consumption of using the network access device. The home BS then selects an optimum attachment point for the Mobile station (MS) to perform handover, based on the sorted weight values. The effectiveness of the proposed algorithm has been verified by carrying out simulations. The results show that the proposed algorithm achieves 78.5% reduction in packet loss compared to Dynamic Decision Model (DDM). The increase in throughput is about 62.5 % compared to DDM.

Keywords: Heterogeneous network, Vertical Handoff, Handoff Decision, Hidden Markov Model.

1. INTRODUCTION

Next Generation wireless networks have been envisioned as an Internet Protocol (IP) based infrastructure with the integration of various wireless access technologies such as GSM, GPRS and UMTS for cellular networks and WLAN and WiMAX for broadband access networks. The trend of future wireless network is to provide accessibility for connecting to any network anywhere and anytime [1]. In such system, user will be roaming among different wireless access technologies which is known as Vertical Handoff/Handoff [2]. Several issues such as handoff metrics, handoff decision algorithms and handoff management are to be studied in order to achieve seamless handoff. .

In horizontal handoff which occurs between similar access 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 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 handoff decision algorithm is needed to improve the system performance.

Three main phases of vertical handoff namely system discovery, vertical handoff decision, and vertical handoff execution are discussed [4].

In the proposed work, the prediction of MN's mobility has been considered to enhance the HO strategy for ubiquitous wireless access. Knowing in advance where a MN is heading allows the system taking proactive measures. So, the unexpected impact of handoffs can be mitigated. Therefore It has been shown that the packet loss has been minimized and therefore maximizing throughput.

2. RELATED WORK

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 point of attachment with that of the candidate point of attachments. They are: Relative RSS, RSS with hysteresis, RSS with hysteresis plus dwelling timer method [5,6]. Relative RSS is not applicable for VHD, since RSS from different types of networks can not 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 criterian. 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. This excessive handoffs is 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 handoff 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 [11,12,13]. Different weights are assigned to different input metrics depending on the network conditions and user preferences. These papers have not considered other dynamic factors, such as velocity, and position of the MS.

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 but 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.

3. PROPOSED VERTICAL HANDOFF DECISION ALGORITHM

Sudden impacts of handoffs can be reduced by knowing in advance where the MN is heading which allows the system to take proactive measures. Prior information about mobile user's next destination can be much useful in handoff decision.

A method of mobility prediction, i.e., 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 node, 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.

A proactive handoff technique has been developed in which the Handoff Decision Controller (HDC) collects the following factors from the neighboring 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.

4. HIDDEN MARKOV MODEL (HMM)

A HMM is defined by a finite set of states, a set of state transition probabilities, an alphabet of output symbols (also referred to as emissions) and a set of emission probabilities which are indicated as the distribution of output symbols emitted from each state [16].

A hidden Markov model is a statistical Markov model where the state is not directly visible, but output, dependent on the state, is visible

In the proposed work, a HMM based prediction model is executed by each BS or AP in the network. Let us assume that each BS holds the list of other BSs and their locations. All the user movements are in the hidden state. The observed states are obtained from the received signal strength (RSS) values sent by each mobile node. The BS in which the mobile is currently residing is the home BS. The home BS predicts the list of possible BSs in the movement direction of a mobile station.

4.1 Selection of Optimum BS

The home BS sends a request to each predicted BSi, where i=1,2…v. On receiving the request BSi needs to calculate the Gain function. The Gain value is calculated by measuring the normalized values of load, RSS and the power consumed. Gain function Gi=f(L,P,RSS)

The Gain function is calculated by using Simple Additive Weight (SAW) algorithm.The Gain functions are calculated for BSs. The BSs send the calculated Gain functions back to the home BS. The home BS arranges the received weight values in their ascending order and selects the BS with minimum weight value. The details of the selected BS are sent to the mobile station so that the MN can move to that particular BS.

5. SIMULATION RESULTS

The proposed algorithm has been simulated using network simulator (NS2). In the simulation, mobile nodes (MN) and the base station (BS) are deployed in a 1000 x 1000 meter region for 50 seconds simulation time. It consists of 4 base stations among which, 2 are based on 802.16 WiMax and remaining 2 are based on 802.11 WLAN.

5.1 Performance Metrics

The proposed HMM based handoff decision algorithm has been compared with the Dynamic decision model (DDM) scheme where the weight value is calculated based on static parameters of the network and dynamic parameters such as velocity and position of the MS and no prediction method is used. The performance has been evaluated according to the following metrics:

Throughput: It is the average data received in Mbit/sec.

Packet Drop: It is the average number of packets dropped

5.2. Results

The speed of the mobile user is varied from 5m/s to 25m/s.

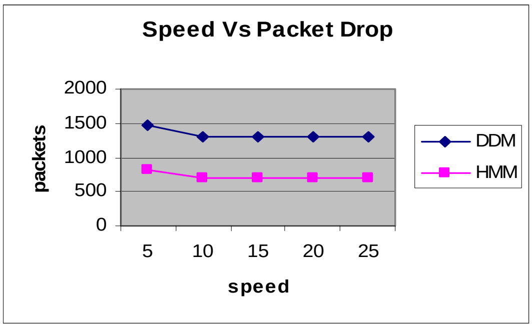

Figure 1: Speed Vs Packet Drop

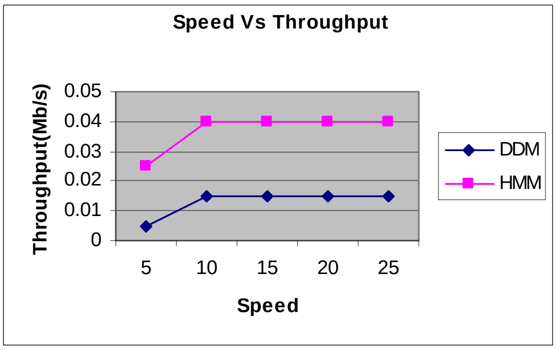

Figure 2: Speed Vs Throughput

Figure 1 and Figure 2 give the packets dropped and the throughput for the two schemes. As we can see from the figures, HMM scheme has more throughput with reduced packet drop, than the DMM scheme.

6. CONCLUSION

In this paper, an optimized algorithm for vertical handoff decision has been developed based on the mobility prediction. 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 sends 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. The algorithm has been implemented successfully using ns-2 simulator. The results show that the proposed algorithm achieves 78.5% reduction in packet loss compared to dynamic decision model(DDM).The increase in throughput is about 62.5% compared to DDM.

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