Handover Management In Heterogeneous Networks

Geetika, Koushik Barman

Abstract— **The continuation of an active call is one of the most important quality measurement in cellular system. Handoff process enables a cellular system to provide such a facility by transferring an active call from one cell to another. In this paper a new vertical handoff decision algorithm, handover necessity estimation (HNE), is proposed to minimize the number of handover failure and unnecessary handover in heterogeneous wireless network. The traveling distance has been predicted and compared against the RSS based method to make a handover decision in order to minimize the probability of handover failures or unnecessary handovers from a cellular network to a WLAN. Simulation result shows that this method reduce the number of handover failures and unnecessary handovers up to 80% and 70%, respectively.**

Index Terms— RSS, HNE, WLAN IEEE 802.11, 4G network, VHD, MT, AP.

1 Introduction

In last few years, wireless technology has become very popular in all around the world. Cellular phones, cordless telephones, remote control, pagers, radio, and satellite TV are all examples of wireless communication systems used in our daily life. Everyone around the world would like to be connected seamlessly anytime anywhere through the best network. Wireless networks like 2G and 3G which provide ubiquitous coverage area but suffer from low data rates and on the other side 4G which combines all previous wireless technologies has ability to provide high data rates without dropping calls [1]. Heterogeneous networks are the wireless networks using different access technologies.

Various wireless technologies and networks exist currently that can satisfy different needs and requirements of mobile users. Since these different wireless networks act as complementary to each other in terms of their capabilities and suitability for different applications, integration of these networks will enable the mobile users to be always connected to the best available access network depending on their requirements [2]. This integration of heterogeneous networks will, however, lead to heterogeneities in access technologies and network protocols. To meet the requirements of mobile users under this heterogeneous environment, a common infrastrture to interconnect multiple access networks will be needed.

The change in connection may be initiated by the user or may be initiated by the network, transparent to the user.

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For example, a user may choose to access a wireless local area network (WLAN) to send a large data file, but may choose the cellular network to carry on a voice call.

On the other hand, a network may decide to hand off a stationary data user to a WLAN in order to increase bandwidth availability for mobile users in a 3G cellular network.

To achieve seamless mobility, network management operations must be conducted without causing degradation of services [3]. With this era of seamless mobility the users will be able to experience uninterrupted, easy, universal access to different networks. Different networks guarantees different Quality of Service and they satisfy different needs and requirements of the customers. One of the major challenges for seamless vertical mobility is vertical handover. In 4G, there are a large variety of heterogeneous networks. When connections have to switch between heterogeneous networks for performance and high availability reasons, seamless vertical handover is necessary. The requirements like capability of the network, handover latency, network cost, network conditions, power consumption and user's preferences must be taken into consideration during vertical handover. Traditional signal strength comparisons are not sufficient to make a handover decision, as they do not take into account the current context or the various attachment options for the mobile user. Thus, the vision of 4G requires investigation of a more adaptive and intelligent network approach to vertical handover. But as these networks have different capabilities and are different from application point of view thus it is needed to integrate these networks so as to utilize them in better way. By this the user will be able to be connected by the best available service or we can say user will always best connected to the best available access technology.

2 HANDOVER MANAGEMENT

Mobility Management emerges as one of the most important and challenging issue with the increasing number of mobile subscribers. Mobility management enables the serving networks to deliver the data packets to the correct location i.e. location management. There are two main areas for mobility management: location management and handover management [4].

2.1 Location Management

Location management enables the networks to track the locations of mobile nodes. Location management has two major sub-tasks: (1) Location registration, and (2) Call delivery or paging.

In location registration procedure, the mobile node periodically sends specific signals to inform the network of its current location so that the location database is kept updated. The call delivery procedure is invoked after the completion of the location registration. Based on the information that has been registered in the network during the location registration, the call delivery procedure queries the network about the exact location of the mobile device so that a call may be delivered successfully.

2.2 Handoff Management

When the person moves from one cell to another within call duration and the call is transfer to the new cell's base-station without any interruption, this process of changing the point of attachment is termed as handover or we can say that it is a process by which a Mobile Node keeps its connection active when it moves from one AP to another.

There are three phases in Handoff process [4]:

1. Handover initiation – A mobile terminal starts searching for new links. After neighboring networks are discovered, the mobile terminal will select the most appropriate network according to certain handover criteria and then handover negotiation will be underway [5].
2. Handover preparation– After a new network is selected; a new link between the mobile terminal and a base station located in the new network is setup [3].
3. Handover execution – After a new link is setup, all the communications associated with the old link are transferred to the new link. The control signals and data packets are allocated to the connection associated with the new base station or access point.

3 CLASSIFICATION OF HANDOVER

An illustration of a handover scenario is depicted in Figure 1, where a mobile station (MS) travels from base station (BS) A to BS B. The overlap between the two cells is the handover region in which the mobile may be connected to either BS A or BS B.

Some of the popular classifications of handover are discussed below:

1. Horizontal or Homogeneous Handover

This is a kind of handover within single network i.e. when user switches between different base stations of the same access network. Thus it has localized mobility [3].

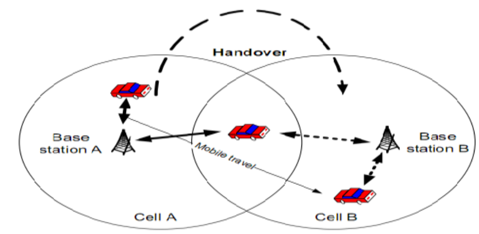

Fig. 1. Handover Scenario

2. Vertical Handover or Heterogeneous Handover

This is a kind of handover across different networks i.e. it represents mobility between different access networks.

These are described in Figure 2.

Vertical handovers are generally of two types namely, upward and downward handovers. An Upward vertical handover is a handover to a wireless overlay with a larger cell size and generally lower bandwidth per unit area. So, an upward vertical handover makes a mobile device disconnect from a network providing faster but smaller coverage (example WLAN) to a new network providing slower but broader coverage. A downward vertical handover is a handover to a wireless overlay with a smaller cell size, and generally higher bandwidth per unit area. A mobile device performing a downward vertical handover disconnects from a cell providing broader coverage to one providing limited coverage but higher access speed [6].

3. Hard Handover

It is type of handover in which the channel in the source cell is released and only then the channel in the target cell is engaged.

4. Soft Handover

It is handover type the channel in the source cell is retained and used for a while in parallel with the channel in the target cell.

5. Mobile-controlled (MCHO), Network-controlled (NCHO) and Mobile-assisted Handover (MAHO)

Under network-controlled handover, the network makes the decision for handover, while under mobile-controlled handover; the mobile node must make the handover decision on its own.

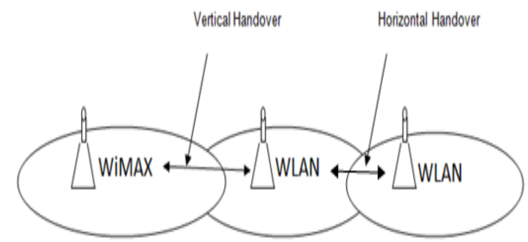

Fig. 2. Horizontal and Vertical Handover in Heterogenous Networks.

4 Vertical Handover Decision Algorithm

VHD Algorithms are classified as:

1. **RSS Based Algorithms**

   RSS is used as the main handover decision criterion in this group. Various strategies have been developed to compare the RSS of the current point of attachment with that of the candidate point of attachment [7, 8].

2. **Bandwidth Based Algorithms**

   Available bandwidth for a mobile terminal is the main criterion in this group. In some algorithms, both bandwidth and RSS information are used in the decision process [9]. Depending on whether RSS or bandwidth is the main criterion considered, an algorithm is classified either as RSS based or bandwidth based.

3. **Cost Function Based Algorithms**

   This class of algorithms combines metrics such as monetary cost, security, bandwidth and power consumption in a cost function and the handover decision is made by comparing the result of this function for the candidate networks [10]. Different weights are assigned to different input metrics depending on the network conditions and user preferences.

4. **Combination algorithms**

These VHD algorithms attempt to use a richer set of inputs than the others for making handover decisions. When a large number of inputs are used, it is usually very difficult or impossible to develop analytical formulations of handover decision processes. Due to this reason, researchers apply machine learning techniques to formulate the processes. Literature survey reveals that fuzzy logic and artificial neural networks based techniques are popular choices. Fuzzy logic systems allow human experts' qualitative thinking to be encoded as algorithms to improve the overall efficiency. If there comprehensive set of input desired output patterns available, artificial neural networks can be trained to create handover decision algorithms. It is also possible to create adaptive versions of these algorithms. By using continuous and real-time learning processes, the systems can monitor their performance and modify their own structure to create highly effective handover decision algorithms.

5 Vertical Handover Decision Algorithm: Handover Necessity Estimation (HNE)

In this section a new vertical handoff decision algorithm handover necessity estimation (HNE), is proposed to minimize the number of handover failure and unnecessary handover in heterogeneous wireless networks [11]. This decision algorithm is based on two parts: traveling time estimation and time threshold calculation. Handover decision is taken i.e. to decide when to perform the handover and to which access network. Several parameters have been proposed in the research literature for use in the vertical handover decision (VHD) algorithms like Handover Delay, Number of handovers, handover failure probability, throughput etc.

This method determines the necessity of making a handover to an available network. The inputs include: the AP power level, RSS samples, the radius of the network, the velocity of the MT, the handover latency, and the handover failure and unnecessary handover probability requirements as shown in Figure 3. An output describes of '1' means a handover is necessary, and an output of '0' means the handover is not necessary.

The Fig. 4 shows a MT moving in an area having cellular service and is also partially covered with a WLAN cell. The MT enters and exits the WLAN cell at P_i and P_o and M is the middle point. Dashed area is called as boundary area with R and r as outer and inner circle radii and d_R and d_r represent the half length of the trajectory segments inside the outer and inner circles respectively. B is the intersection point of the trajectory and the inner circle.

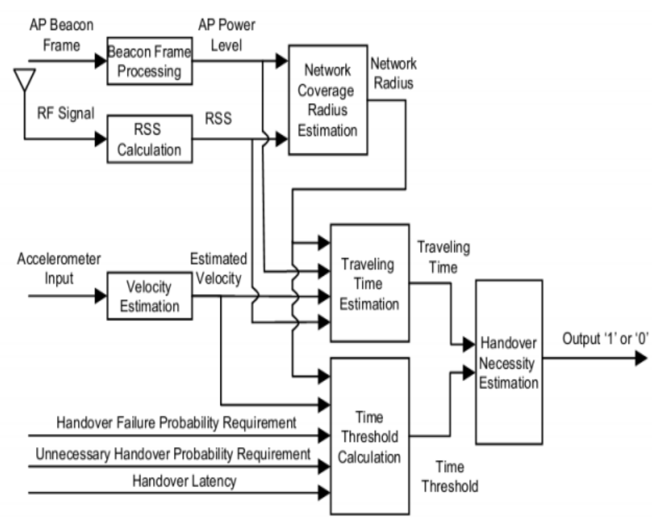

Fig. 3. Block diagram of Handover Necessity Estimation [11].

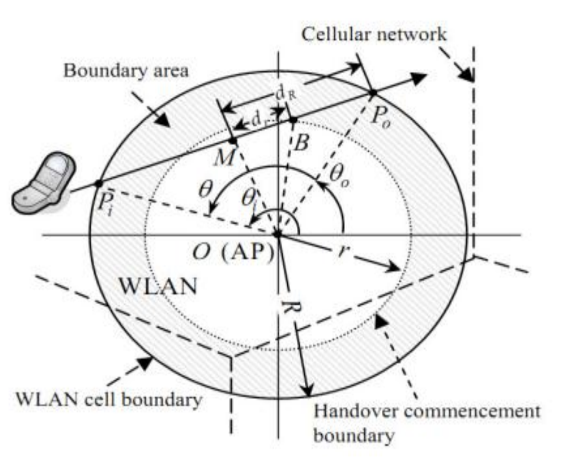

Fig. 4. Scheme diagram of WLAN to cellular network handover necessity estimation mechanism [11].

The HNE relies on the algorithm which relies on the prediction of travelling time by using successive RSS measurement. The algorithm works under following assumptions:

1. WLAN cell has circular geometry.
2. The MT is moving in a straight lineand with a constant speed as shown in Fig. 4.
3. It is assumed that the MT is receiving sufficient strong signals at point P_i and the signal strength drops as it gets close to P_o.

6 Analysis of HNE

6.1 Handover Failure Probability

The handover failure probability for the fixed RSS threshold based method is given by

$$P_{f\ fixed} = \begin{cases} 1, & v\tau_i > 2R1_{fixed}, \\ \frac{2}{\pi}\sin^{-1}(\frac{v\tau_i}{2\,R1_{fixed}}), & 0 \le v\tau_i \le 2R1_{fixed} \end{cases}$$

$R1_{fixed}$ is the distance between the MT location and the AP of the WLAN cell when a handover into the WLAN occurs in the fixed RSS threshold based method. It is calculated by

$$R_{1fixed}=10^{[(E_t-RSS_{1fixed})/(10\,\beta)]}$$

Where β is the Path Loss Exponent, τ_i is handover delay from cellular network to WLAN, v is the velocity of the mobile terminal.

6.2 Unnecessary Handover Probability

The unnecessary handover probability for the fixed RSS threshold based method is given by

$$P_{u\ fixed} = \begin{cases} 1, & v(\tau_i + \tau_0) > 2R1_{fixed}, \\ \frac{2}{\pi}\sin^{-1}(\frac{v(\tau_i + \tau_0)}{2\,R1_{fixed}}), & 0 \le v(\tau_i + \tau_0) \le 2R1_{fixed} \end{cases}$$

Here τ_0 is handover delay from WLAN to cellular network.

7 Simulation

Under this section the proposed method, HNE, is compared with the fixed RSS threshold based method [12] in which handovers between the cellular network and the WLAN are initiated when the RSS from the WLAN reaches a fixed threshold. MATLAB was used for the experimental work.

The probability of handover failures and unnecessary handovers of the RSS threshold based (R_{1fixed} = 150 m) and HNE methods are shown in Fig. 7 and Fig. 8. The Fig. 5 describes the algorithm to be followed for the HNE method and Figure 6 describes the flowchart of the MATLAB code for HNE based method.

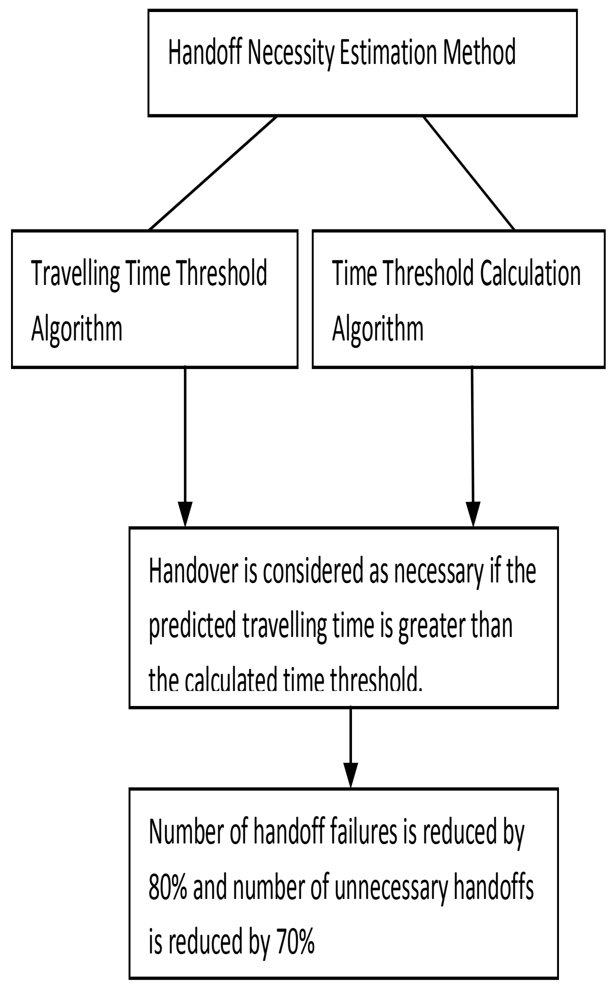

Fig. 5. Steps of Handover Necessity Estimation Method.

To analyze the probability of handover failures and unnecessary handovers for different handover decision methods, we assume that the target P_f and P_u are 0.02 [14] and 0.04, respectively, path loss exponent β is 3.5, and the handover latencies from the cellular network to the WLAN and from the WLAN to the cellular network, $\tau_i = \tau_o$, are both 2s.

From the figures it can be seen that, with HNE, handover failures and unnecessary handovers are kept under very low value, respectively. The probability of failures declines with the increasing velocity of the MT. In the RSS threshold method, the probability of handover failures and unnecessary handovers increase sharply as the velocity increases. HNE is able to reduce the number of handover failures and unnecessary handovers up to 80%, when the velocity of the MT is up to 100 km/h.

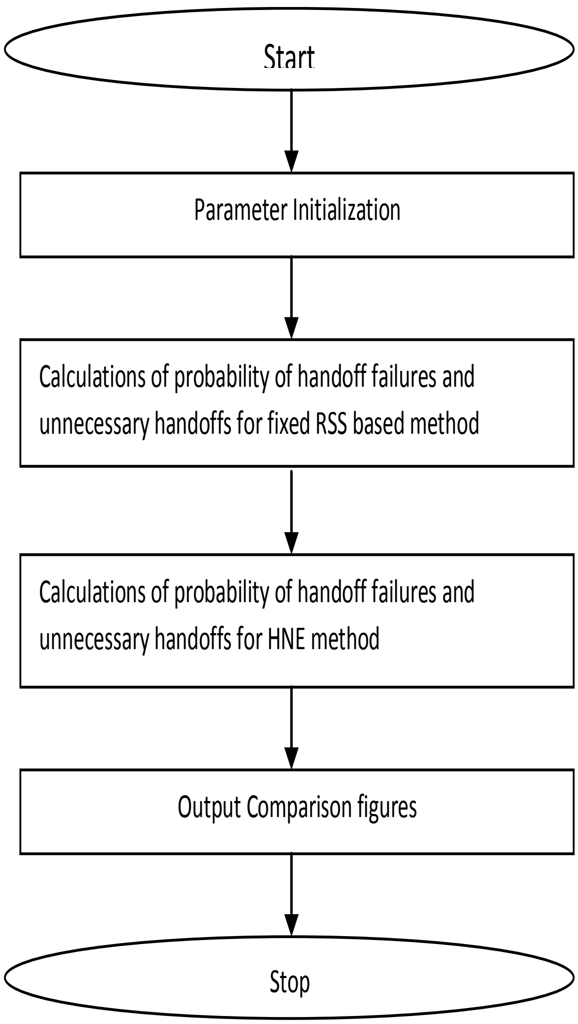

Fig. 6. Flowchart of the MATLAB program for HNE.

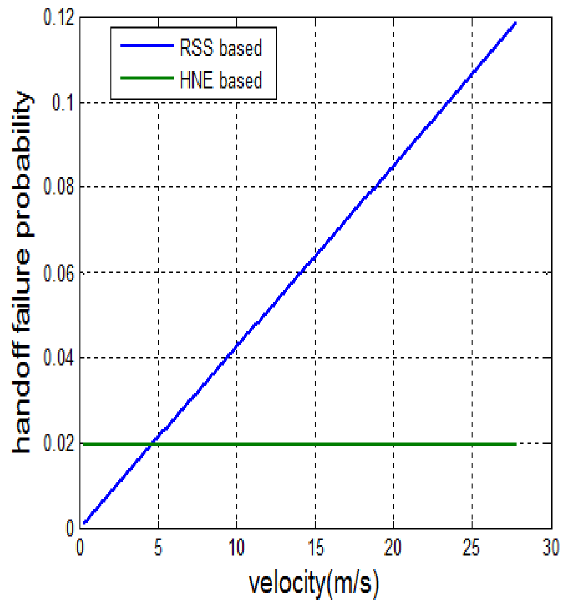

Fig. 7. Handover failure probability comparison between RSS based method and Handover Necessity Estimation method.

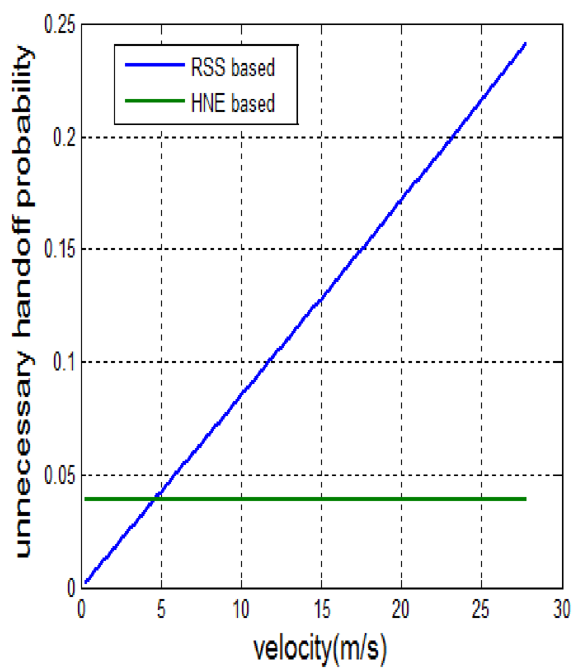

Fig. 8. Unnecessary handover probability comparison between RSS based method and Handover Necessity Estimation method.

8 Conclusion

In this paper, we introduced an overview on the concept of Handover. After that, a method to estimate the handover necessity into a WLAN cell has been proposed. The proposed method has two parts- (i) Traveling time estimation and (ii) Time threshold calculation. The traveling time estimation relies on the RSS measurements and the speed of the MT. The time thresholds are calculated based on various network parameters such as tolerable handover failure probability or unnecessary handover probability, the radius of the WLAN cell and the handover latency. This method is able to reduce the number of handover failures and unnecessary handovers up to 80% and 70%, comparing with the conventional RSS threshold based. HNE yields much better performance than the other methods. A possible improvement to the scheme is to periodically sample the RSS, recalculate the estimations for v to improve the performance, and eliminate the assumption that the MT's speed remains fixed inside the WLAN cell.

Acknowledgment

I would like to thank friends Toshar Sharma, Anjali Koranga, and Ekta Balotra.

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