RSS Based Adaptive Hysteresis Vertical Handoff Decision Algorithm between WiMAX and LTE to Reduce Ping-Pong Effect

Smita Ramsey, Mr. Ravi Shankar Shukla, Mr. Zubair Khan

Abstract—In the next generation of wireless network such as long term evolution (LTE) and worldwide interoperability for microwave access (WiMAX), always best connected concept is required. However in many situation handoff failures and unnecessary handoff are triggered causing degradation of quality of service. In this paper our main focus is on the handoff decision problem which affects the number of handoffs which may result in ping pong effect. To overcome this problem we have proposed an RSS based vertical handoff decision (VHD) algorithm with adaptive hysteresis to prevent this ping pong effect and also avoid late handoffs.

Index Terms—Adaptive hysteresis, LTE, Ping-pong effect, Quality of service, RSS, Vertical handoff decision algorithm, WiMAX.

1 INTRODUCTION

A major challenge of the 4G wireless networks is seamless vertical handoff or inter-system handoff across the multi-service heterogeneous wireless access networks as vertical handoff is the basis for providing continuous wireless services to mobile users roaming across the heterogeneous wireless networks. Multimode mobile terminals will have to seamlessly roam among the various access networks to maintain network connectivity since no single network can provide ubiquitous coverage and high quality-of-service (QoS) provisioning of applications. Users will increasingly expect all their services to be accessible anywhere and from any device [1].

For the packet switched fourth generation heterogeneous wireless networks such as LTE and WiMAX it is a challenge to provide seamless vertical handoff across these networks. In such networks of heterogeneous nature, roaming users experience frequent handovers across network or cell boundaries. Such superfluous frequent handovers causes ping pong effect, wastage of network resources and interruption in service connectivity resulting in degradation of quality of service. An important issue that needs to be considered while providing seamless vertical handoff especially across these heterogeneous network boundaries is handoff decision, that is, the ability to correctly decides at any given time whether or not to carry out vertical handoff. A vertical handoff decision algorithm must be able to decide on the need to timely and reliably initiate a handoff, and determine and select the appropriate access network(s) when a user can be reached through several access networks. Using RSS based vertical handoff, a mobile device will handoff to another network, when it did not receive the pre-established minimum receiving power from the original network. Use of only RSS as the vertical handoff metric in RSS based vertical handoff between LTE and Wi-MAX networks to support multimedia services cannot provide the user with the desired service continuity. This may also result in premature handoffs for example when the user is forced to handover from LTE to Wi-MAX network because of the fluctuations in received signal strength, even though the user achievable data rate from LTE network might be still much higher than it may get from Wi-MAX network.

When the mobile station moves across the network boundary while moving from WiMAX to LTE and vice versa, the received signal strengths from the neararound base station of either of the two networks will be very close. In such a situation, the strength of signal will be more susceptible to shadowing effect, and be likely to cause handoff between the two base stations back and forth constantly, which is known as the ping-pong effect. By using a fixed hysteresis value the ping-pong effect can be significantly reduced. When the hysteresis value is higher, the handoff time will result in more delays, thus reducing the ping-pong effect but not satisfactorily because of the late handoffs issue which causes service degradation. Therefore, in this paper, the RSS-adaptive hysteresis vertical handoff algorithm has been presented to not only minimize unnecessary handoffs but also avoid the problem of late handoff.

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2 WI MAX AND LTE NETWORK

2.1. Wi-MAX

WiMAX is an acronym meaning Worldwide Interoperability for Microwave Access. It is part of the IEEE 802.16 standards and was developed by the Institute of Electrical and Electronic Engineers (IEEE).The current WiMAX release supports transfer rates up to 46 Mbps in downlink and 4 Mbps in uplink us-

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ing 10MHz system bandwidth. The WiMAX system supports scalable system bandwidth using time division duplex (TDD). Maximum coverage with the technology is 50 km for fixed usage and up to 5 km for mobile usage. WiMAX is a flat, all IP-based architecture. WiMAX supports quality of service (QoS). It is achieved by allocating bandwidth to users. WiMAX uses orthogonal frequency-division multiple access (OFDMA) in the downlink and in the uplink. WiMAX provides authentication which prohibits unauthorized users from using the network services. WiMAX also makes use of the multiple in, multiple out (MIMO) technology [2].

2.2. LTE

Long Term Evolution also known as LTE was developed by the 3rd Generation Partnership Project (3GPP). It was released in the 4th quarter of 2008. LTE supports peak data rates of 100 Mbps in downlink and 50 Mbps in uplink, both reached with 20 MHz spectrum. LTE uses also orthogonal frequency-division multiple access (OFDMA) in the downlink, but it uses single carrier frequency-division multiple access (SCFDMA) in the uplink. LTE has also some power-saving mechanisms to turn off the transmitter whenever there is no data to transmit or receive. Same as WiMAX, LTE also offers quality of service. To achieve that, it uses reservation-based access as well and creates time frames. LTE provides similar security mechanisms to WiMAX such as using security keys between transmitter and receiver to ensure a secure connection and encrypting the communication. MIMO techniques are also used in LTE [2].

3 VERTICAL HANDOVER

3.1. Handover Management Process

Handover management process in a mobility scenario is the procedure to maintain continuous connection in active mobile terminal while moving from one access link (base station or access router) to another. Handover management process has been described in several works which involve three phases [3] as shown in Figure 4:

a. Handover Information Gathering

It is used to collect all information desired to initiate the handover. Also known as system discovery or handover initiation phase.

b. Handover Decision

It is used to determine when and how to perform the handover by selecting the best access link available and by giving instructions to the next phase (i.e. handover execution). Also known as system or network selection.

c. Handover Execution

It is used to change channels conforming to the details resolved during the decision phase.

3.2. RSS based VHD algorithm

Many VHD algorithms have been proposed in the research literature, most of them have designed their VHD algorithms depending on the signal strength received by the mobile terminal, where handover decisions are made by comparing the received signal strength with the preset threshold values. These algorithms which use signal strength as their basic handover decision indicator are called Received Signal Strength (RSS) algorithms. RSS based VHD algorithm occurs when the mobile terminal receiving power approaches the threshold value regardless of the QoS needed, thus rendering RSS-based VHD not to support user's QoS requirement[3]. This leads to premature handoffs resulting in ping pong effect thus degrading service quality because of networks resources wastage, huge power consumption which is the life of a mobile terminal as well as interrupted data transfer. The metrics for performance evaluation of VHD algorithm are [4]:

a.Handover delay

It refers to the duration between the initiation and completion of the handover process. Handover delay is related to the complexity of the VHD process, and reduction of the handover delay is especially important for delay-sensitive voice or multimedia sessions.

b. Number of handovers

Reducing the number of handovers is usually preferred as frequent handovers would cause wastage of network resources.

c. Handover failure probability

A handover failure occurs when the handover is initiated but the target network does not have sufficient resources to complete it, or when the mobile terminal moves out of the coverage of the target network before the process is finalized.

4 RELATED WORK

Zahran and Liang [5] proposed RSS based VHD algorithm using lifetime metric which reduced number of superfluous handovers and improves average throughput for the users. Its drawback is long packet delay.

Mohanty and Akyildiz [6] proposed RSS based VHD algorithm comparing the current RSS and a dynamic RSS threshold. This algorithm reduced the false handover initiation and handover failure probabilities. Its drawback is wastage of network resources.

Yan et al. [7] developed an RSS based VHD algorithm that takes into consideration the time the mobile terminal is expected to spend within a WLAN cell. This method minimized handover failures, unnecessary handovers and connection breakdowns. Its drawback is extra handover delay.

Lee et al. [8] devised a bandwidth based VHD algorithm which gave high system throughput and low handover latency for real time transmission. Its drawback is difficulty in acquiring available bandwidth information and increased new application blocking rate.

Yang et al. [9] presented a bandwidth based VHD method using Signal to Interference and Noise Ratio (SINR).Its drawback is excessive handovers.

In [10], Chi et al. proposed a VHD heuristic based on the wrong decision probability (WDP) prediction. This algorithm reduced unnecessary handover probability and balanced the traffic load. Its drawback is increased connection breakdown

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probability without considering the RSS.

5 PROPOSED WORK

5.1 Ping-pong effect

Typical radio propagation environment is characterized by fluctuations in the received signal power due to slow fading caused by buildings and obstructions as well as fast fading resulted from multiple propagation paths the receivers exposes. Handover theoretically deals with these variations in the cells boundary where there is a signal decrease from one cell and increase of the other cell. As results of user mobility in the cell boundary, being these fluctuations fast and occur in frequent increase and decrease of signal strength. These signal fluctuations will lead to many handovers if a user is going to simply handover to a cell which provides a better quality of signal, when the user is moving from one cell to another. This impact, very significant around the cell boundary, forces the user to handover forth and back between two cells. This normally is referred to as Ping-Pong effect [11].

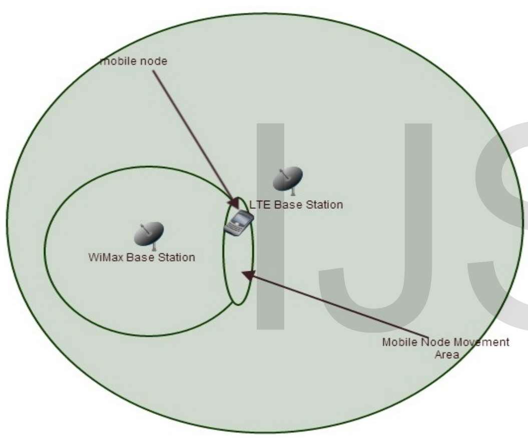

Fig.1 Mobile node movement area is the cell boundary where ping pong effect occurs.

Figure 1 shows the vertical handover between WiMAX and LTE networks and at the cell boundary of WiMAX the ping pong effect occurs due to fluctuations in RSS.As a result of user mobility in the cell boundary, being these fluctuations fast and occur in frequent increase and decrease of signal strength of both networks. This leads to superfluous handovers which increases ping pong effect. The RSS based VHD algorithm is used for handoff between these two networks. However this algorithmis not adequate enough because if we consider only RSS as the handoff metric it results in premature handoffs thus increasing the ping pong effect. To solve this issue a hysteresis value is added with the RSS of old base station then this value compared with the RSS of new base station.

5.2 RSS based Fixed Hysteresis Vertical Handoff Decision Algorithm

In a handoff, to reduce ping-pong effect a fixed hysteresis h can be added in the handoff decision by,

$$RSS_{new\_bs} > RSS_{old\_bs} + h \, , \qquad \text{(i) [12]}$$

In equation (i), h is the hysteresis value. If the handoff condition is satisfied, the call is handed over to the adjacent cell with the largest RSSnew_BS. The handoff will not occur unless the RSS from an adjacent BS is greater than that from the serving BS by the hysteresis value h. If h is set too high, the ping-pong effect can be reduced. But the handoff delay may result in a dropped-call or low quality of link. On the contrary, if h is too small, unnecessary handoffs might get increased [12].

5.3 RSS based adaptive hysteresis vertical handoff decision algorithm

The proposed adaptive hysteresis method would be superior to fixed hysteresis method due to the adaptivity on the value compared to the larger fixed hysteresis value thus effectively reducing number of handoffs preventing ping pong effect leading to better communication quality. This method uses the received signal strength difference between the LTE and WiMAX network as the hysteresis value along with a scaling factor, hysteresis value is defined as,

$$h = \frac{abs(RSS_{LTE} - RSS_{WiMAX}) + \gamma}{2} \text{(ii)}$$

In equation (ii),$(\mathrm{RSS_{LTE}} - \mathrm{RSS_{WiMAX}})$ represents the difference between received signal strength's of LTE and WiMAXand vice-versa. γis the scaling factor. In this algorithm, RSS with a hysteresis value is taken as an input parameter. The hysteresis value adapts according to the network conditions and thus is called as adaptive hysteresis value. Once the hysteresis value calculated and set for vertical handover decision making the change in that value made only if the next calculated value is greater than previous. The RSS of WiMAX and LTE is calculated on the basis of the mobile terminal velocity, a time counter and slow fading and fast fading calculations of both networks. Then the difference of RSS of both networks along with a scaling factor is calculated by the adaptive hysteresis formula and then the RSS of new base station (BS) is compared with the RSS of old BS and adaptive hysteresis value. A handoff clock is also set. If the RSS of new BS is greater than the RSS of old BS with hysteresis then only handoff is triggered.

The flowchart for the proposed algorithm has been shown in Fig. 2.

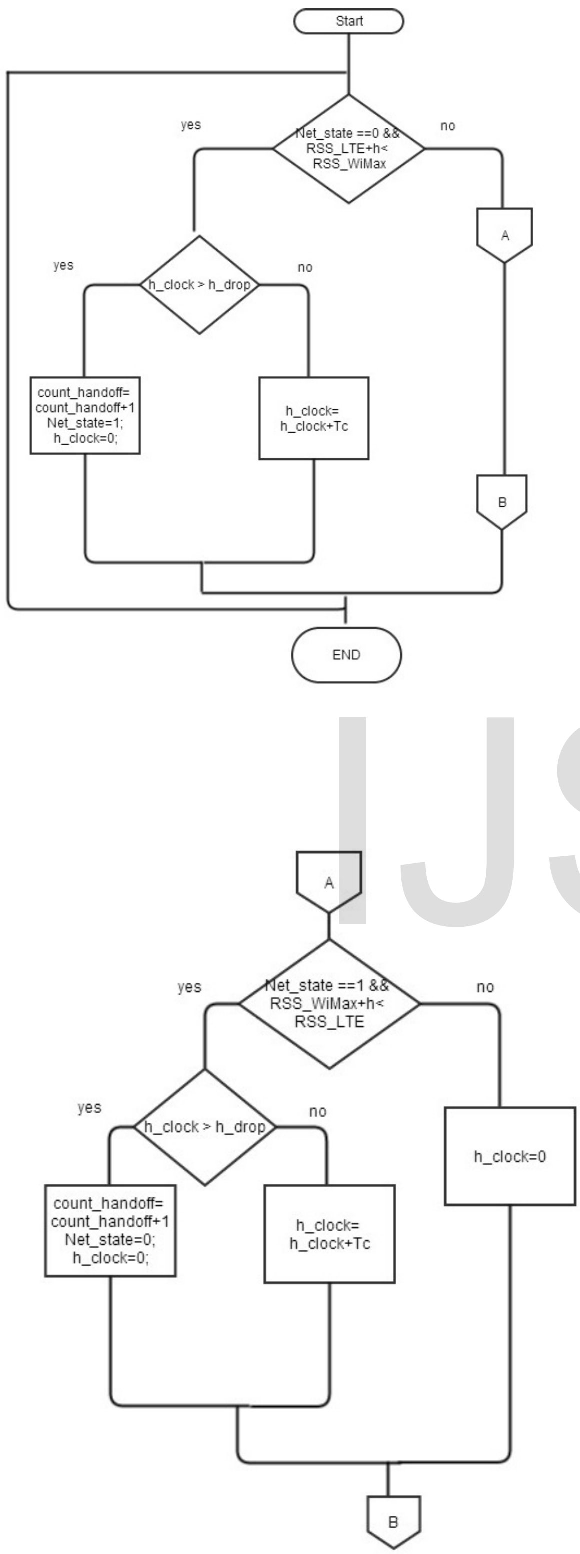

Fig.2 Flowchart of RSS based vertical handoff algorithm with hysteresis

6 SIMULATION AND RESULTS

For simulation we create an environment in Matlab R2010a. For developing such an environment we have created an LTE base station which has a coverage area of radius 1000 meters and a WiMAX base station which has a coverage area of radius 300 meters. WiMAX base station lies in the coverage area of LTE network. It has a mobile node which is moving in back and forth position at the cell boundary of WiMAX as shown in fig.1.

Table 1 for Simulation Parameters

Parameter	Value
Mobile station speed	10 m/s
Frequency of LTE	2000*10^6 Hz
Frequency of WiMAX	2500*10^6 Hz
Time Interval	0.5 s
Fast fading	Jakes model
Fixed hysteresis (h)	3
Simulation time	200 s
Handoff drop for handover decision	1 s
Distance between base stations	600 m
RSS	dBm

During simulation first we use RSS based VHD algorithm without any hysteresis value. Because of the back and forth movement of mobile node at cell boundary the received signal strength increases and decreases continuously. Fig. 3 shows the RSS received from both networks during simulation time period.

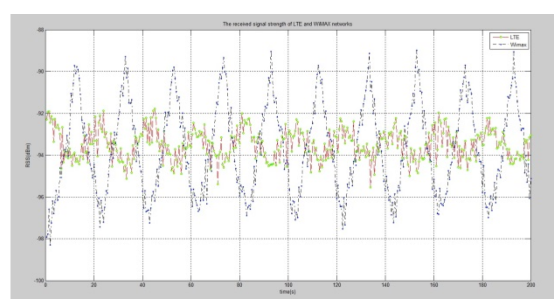

Fig. 3 Received signal strength of LTE AND WiMAX

Due to the fluctuations in RSS from both networks the handoffs occur frequently after each 10 sec approximately. As shown in fig. 4 below, the mobile node is showing the ping-pong effect indicated by the mark of network continuously changing network from WiMAX to LTE and from LTE to WiMAX in a very short period of time. There are 20 numbers of handoff that had occurred in a very short period of 200 sec when RSS based VHD algorithm without hysteresis value was used.

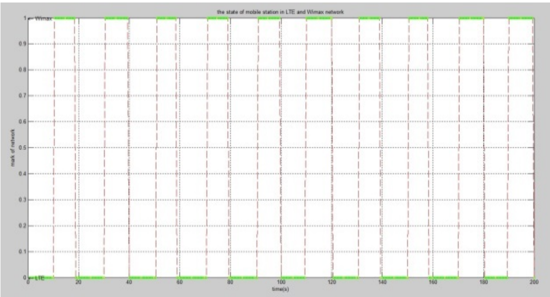

Fig. 4 RSS based VHD algorithm without hysteresis having ping pong effect.

To minimize these numbers of handoffs we then used the RSS with fixed hysteresis VHD algorithm. A fixed hysteresis value h=3 was added in RSS based VHD algorithm and then we evaluated the result. From fig. 5 it is shown that the number of handoffs reduced to 16 but this is not a satisfactory result.

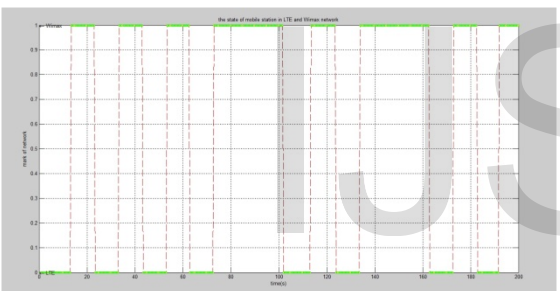

Fig. 5 RSS based VHD algorithm with fixed hysteresis, h=3.

To reduce the number of unnecessary handoffs finally we derived an adaptive hysteresis formulaand then used the value of adaptive hysteresis instead of fixed hysteresis in the RSS based VHD algorithm. The results are quite impressive as it reduced large number of unnecessary handoffs. From fig 6 it is finally shown that the number of unnecessary handoffs reduces to 4.Thus the proposed RSS based adaptive hysteresis outperforms the other two algorithms efficiently reducing the ping pong effect.

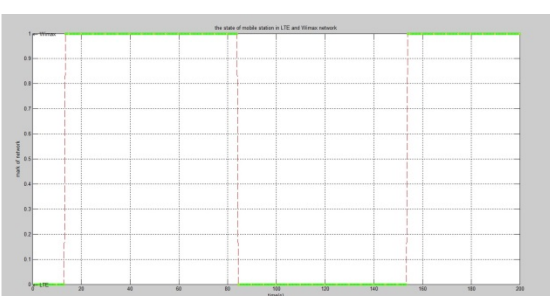

Fig. 6 RSS based VHD algorithm with adaptive hysteresis.

Simulation results have proved that RSS based adaptive hysteresis VHD algorithm reduced unnecessary (superfluous) handovers to 80% as compared to RSS based VHD algorithm and up to 64% as compared to RSS based fixed hysteresis VHD algorithm.

6 CONCLUSION AND FUTURE WORK

From this research work we can conclude that RSS based vertical handover decision algorithm with hysteresis provide greater efficiency to reduce the ping-ping pong effect and improve quality of service. The fixed hysteresis can be used but the adaptive hysteresis algorithm provides better results than fixed hysteresis algorithm.

In future work, vertical handoff decision algorithms such as SINR algorithm, Artificial Intelligence algorithm can be used to handle ping pong effect. The fixed and adaptive hysteresis values can be used with these algorithms to increase quality of service and minimize superfluous handoffs.

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