REDUCING PACKET LOSSES DURING HANDOVER PROCESS VIA SIMPLE ADAPTIVE RSS THRESHOLD CONCEPT

Muhammad Ariff Baharudin[1]*, Eiji Kamioka[2]

[1] Electrical Engineering Faculty, Universiti Teknologi Malaysia

[2] Graduate School of Engineering and Science, Shibaura Institute of Technology

mariff@utm.my, kamioka@shibaura-it.ac.jp

ABSTRACT When a mobile host (MH) is moving towards the boundary of its current connected network, a handover process is needed to maintain the MH's connection to the Internet. A duration of time is needed to resolve this process. For a handover to be successful, the handover process should complete within this time duration. If this condition is not met, a handover failure will occur and this will incur a very huge delay and packet losses. In most existing handover method, static threshold is usually used to trigger the handover process. However, a static threshold configured for low velocity MH is not suitable for high velocity MH. To overcome this issue, the proposed concept adapts the handover threshold according to the MH's velocity and the end-to-end delay of MH's current serving network. The existing methods use very complex computation and only shows empirical analysis in terms of handover failure probability. In this paper, the proposed concept is evaluated using simulation approach and the evaluation is done in terms of packet loss percentage. The result shows that the proposed concept can maintain low percentage of packet loss for all considered velocity.

1. INTRODUCTION

The wireless access technologies have advanced tremendously within the recent decades. New radio access technology (RAT) such as WiMAX and Long Term Evolution (LTE) have been introduced and deployed in the real world together with existing RAT such as Wireless LAN (WLAN) and 3G, creating a heterogeneous environment. During the same decade, the mobile device technology has also advanced in parallel; currently, devices with computation power that are on a par with desktop computers can be obtained at an affordable price. Thus, the number of devices connected to the wireless network is increasing. This scenario becomes more critical with the advent of Internet of Things (IoT), where all devices and appliances are wirelessly connected to the Internet. Hence, effective network selection and handover schemes are paramount in the current and future wireless network scenario in order to provide Always Best Connectivity (ABC) (Gustafsson et. al. 2003) to these mobile devices.

The handover process is important since it will affect the connection continuity, the quality of service (QoS) as well as the quality of experience (QoE) received by the users. Disruptions and connection loss may occur during the handover process. This fact is particularly important for real-time applications since it is greatly affected by the end-to-end delay and packet loss. Generally, the Received Signal Strength (RSS) is used in classical approach to trigger the handover. However, within the current and future context, users are becoming more mobile; for example, a user who rides a high speed train. Other parameters, velocity in particular, are also important for a more efficient handover trigger timing. Normally, static RSS threshold or RSS comparison is used to trigger the handover process. Some approach combines several parameters such as static RSS and QoE threshold to trigger the handover process; however, these approaches may not be suitable for users with high velocity. Thus, a suitable handover scheme that can adapt to the mobile host (MH) velocity is needed to improve the efficiency of the handover process and avoid disruptions, packet losses and connection losses.

The proposed method in this paper was derived from the Travel Distance Estimation (TDE) from (Yan et. al., 2008, Abrar et. al. 2012, and Riaz et. al., 2012). Yan et. al. (2008) has proposed the unnecessary handover avoidance method based on the RSS and the TDE to decide whether the MH should handover or avoid handing over to a network available to the MH. Riaz et. al. (2012) on the other hand predicts the MH's dwell time within the current network and the target network using the TDE to avoid unnecessary handover. Meanwhile, Abrar et. al. (2012) proposed a handover trigger based on the probability of the MH departing from the current cell. These proposed methods have shown improvements compared to existing methods. However, the calculation needed to determine the handover trigger is complex and the effectiveness was shown in terms of handover failure probability and number of handover failures instead of performance in terms of QoS or QoE. In this research, a simple velocity-adaptive RSS threshold approach is introduced and the performance of the proposed method in terms of packet loss, which signifies the QoE, will be discussed.

The rest of this paper is organized as follows. The proposed method is discussed in Section 2. Then in section 3, the results will be reported and discussed and will be concluded in the final section.

2. SIMPLE VELOCITY-ADAPTIVE RSS THRESHOLD APPROACH

2.1 Travel Distance Estimation

For ease of discussion, the TDE method used in (Yan et. al., 2008, Abrar et. al. 2012, and Riaz et. al., 2012) is discussed in this subsection. The TDE concept is derived from the topology in Fig. 1. The list of notations on Fig. 1 is as follows:

AP Access Point.
Pi The point where MH enters the cell.
Po The point where MH leaves the cell.
s A point within the cell after MH has moved for a certain duration.
m A point at the center of the MH's travel distance (half of Pi-Po distance).
a The critical point based on the RSS threshold where MH should start the handover process. The position of A on the Pi-Po line is determined by the value of dcrit which is calculated based on the proposed ART.
l_{os} Distance between point o and point s. This value changes with the RSS since its calculation is based on the current RSS.
l_{om} Distance between point o and point m. This value is the perpendicular distance from point o to the Pi-Po line.
l_{oa} Distance between point o and point a. This value is based on dcrit, which is calculated based on the proposed adaptive RSS threshold (ART).
d_{crit} The critical distance, which is the minimum distance between the cell edge and the point where MH should start the handover process.

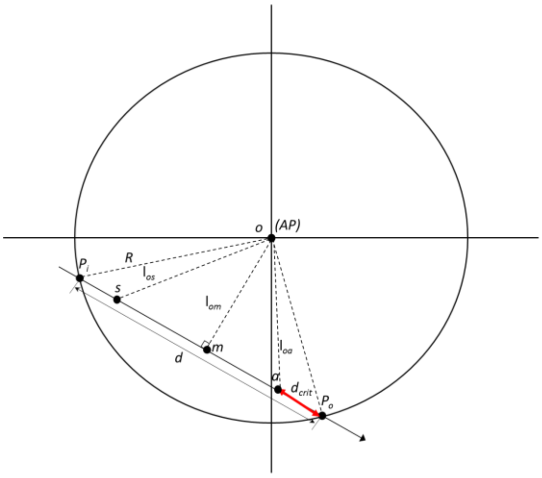

Fig. 1 Geometrical model for TDE concept based on (Yan et. al., 2008); assuming that the cell has a circular shape and MH is moving in a straight line with constant speed, the distance Pi-Po can be estimated.

The equation derived from Fig. 1 is with the assumptions that the wireless cell has a circular shape with the AP at the center of the circle labelled *o*, and the MH is moving in a straight line from its entry point, Pi to its exit point, Po with constant speed, and the MH will cover the travel distance, *d*. This distance can be estimated and is useful in determining the necessity of performing handover and in finding the critical threshold in avoiding handover failure.

When the MH enters the AP coverage area, the radius of the cell, R, can be estimated using a propagation path loss model. In this case, the Free Space Path Loss (FSPL) model is used for simplicity of its calculation. Take note that this method is not limited to just FSPL; other propagation path loss models are also applicable. The value of R can be obtained from the following equation:

$$R \cong \sqrt{\frac{P_T \lambda^2}{P_{P_i} 16\pi^2}} \tag{1}$$

R Radius of AP's cell.
P_T Transmission power of the AP.
P_{Pi} Power received by MH at point Pi.
λ Wavelength (speed of light/carrier frequency)

Then after some interval *t*, another sample is taken at point *s*, where the distance between AP and *s*, l_{os}, is estimated as:

$$l_{os} \cong \sqrt{\frac{P_T \lambda^2}{P_s 16\pi^2}} \tag{2}$$

Next, let *m* be a point at the center of *d* and perpendicular to *o*. From the geometric configuration in Fig. 1, applying the Pythagoras Theorem, the values of l_{os} and l_{om} can be calculated as:

$$l_{os}^2 = l_{om}^2 + \left(\frac{d}{2} - \upsilon t^2\right) \tag{3}$$

$$l_{om}^2 = R^2 + \left(\frac{d}{2}\right)^2 \tag{4}$$

After that, substituting equation 4 into equation 3, the value of *d* can be estimated as:

$$d = \frac{R^2 - l_{os}^2 + \upsilon^2 t^2}{\upsilon t} \tag{5}$$

2.2 Velocity-adaptive RSS Threshold

The concept here is to use the values obtainable from TDE with an estimated critical distance, d_{crit}, which is the distance that will be covered by the MH during the handover process, assuming that the velocity of the MH is static during the handover process. Further assuming that the duration of the handover process equals to a round-trip time (*rtt*) for the handover request and reply process to complete (two times end-to-end delay), d_{crit} can be calculated as:

$$d_{crit} = \upsilon(rtt) \tag{6}$$

where v is the velocity of the MH.

Using the value of d_{crit}, the value of l_{oa}, which is the distance between the AP and the point where MH should execute handover, a, can be estimated as:

$$l_{oa} = \sqrt{l_{om}^2 + \left(\frac{d}{2} - d_{crit}\right)^2} \tag{7}$$

Finally, the critical RSS threshold, assuming the free space path loss, RSS_{crit} can be calculated as:

$$RSS_{crit} = \frac{P_T \lambda^2}{16\pi^2 l_{oa}^2} \tag{8}$$

This RSS_{crit} is the RSS threshold that have been adapted to the MH's velocity. As long as the MH starts the handover process when RSS ≥ RSS_{crit}, handover failure can be avoided with assumption that the end-to-end delay does not increase drastically and the connection to the current network is not lost during the handover process.

2.3 Simulation Settings

The topology in Fig. 2 is used for the simulation. The simulation was done using OMNeT++ with the inetmanet module. For this experiment only one scenario is considered. More scenarios will be considered in future works. For this simulation, the value of l_{om} is set to 20 meters, the cell radius is set to 177 meters, the power transmitted by the AP is set to 2mW and the end-to-end delay is set to be 450ms. The MH is programmed to move according to the dotted arrow. Fig. 3 shows RSS threshold adapted to the MH's velocity for this scenario. The blue line denotes the estimated critical RSS while the green dotted line is the fitted line and the equation shown on the graph is the fitted equation of the adapted RSS threshold. As can be seen from Fig. 3, when the velocity increases, the RSS threshold becomes higher. This means that when the MH moves at a higher velocity, it will start the handover process earlier, compared to when it is moving at lower velocity. This is to ensure that the MH can complete the handover process before losing its connection to the current network.

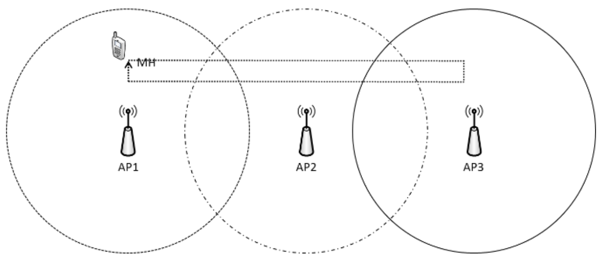

Fig. 2 The simulation topology.

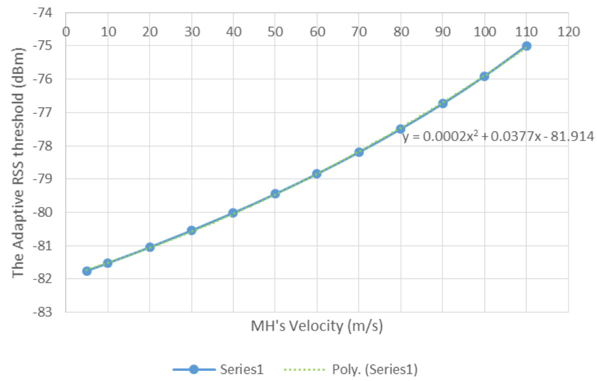

Fig. 3 An example of the adapted RSS threshold calculated using the proposed scheme.

3. RESULTS AND DISCUSSION

The proposed method is compared to conventional static threshold for the evaluation. The static threshold was set to -81 dBm. The result is as shown in Fig. 4.

From this figure, it can be clearly seen that when using static threshold, when the velocity of the MH is 40 m/s and above, the percentage of packet drops becomes higher with the increment of velocity, whereas when using the proposed method, the packet drop percentage can be maintained at a minimum level.

The results when using static threshold is obvious since a static RSS threshold is only suitable for certain scenarios. For example, low RSS threshold may be suitable for low MH velocity as shown in Fig. 4 for velocity below 40 m/s. However, it is not suitable for higher MH velocity as shown in Fig. 4 for velocity 40 m/s and above. Conversely, the static threshold may be set at a higher value, -70 dBm for example; however, it may not be the best solution if the target network has worse QoS and QoE level compared to the current network, since the handover process will be executed earlier. Thus, using the proposed method, the MH can adjust the most suitable

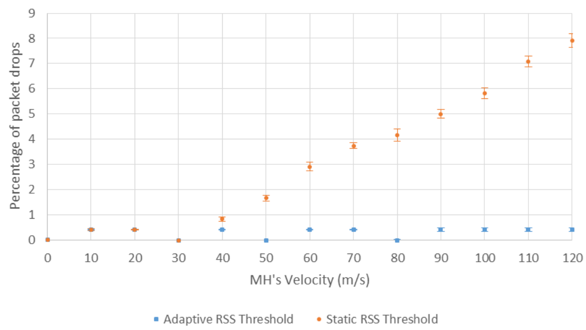

Fig. 4 The comparison between the proposed adaptive threshold approach and the static threshold approach (static at -81dBm).

RSS threshold to avoid handing over too early, or too late (which causes handover failure). The proposed method can be used as it is or combined with other more sophisticated handover scheme as a failsafe mechanism to avoid handover failure.

CONCLUSION

In this paper, a simple velocity-adaptive RSS threshold has been developed. The main target is to adapt the MH's RSS threshold to its velocity in order to ensure that the handover process can be completed before the MH leaves its current serving cell and avoid handover failure. With the utilization of the Travel Distance Estimation method, the proposed method is capable of estimating the critical RSS level; MH can avoid handover failure by triggering the handover when the current network RSS level is higher or the same as this critical value. The proposed method have shown better performance when compared with conventional static RSS threshold, and can maintain low percentage of packet loss for all tested velocities (10 m/s to 120 m/s)

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Muhammad Ariff Bin Baharudin obtained his B. Eng. (Hons) in Electrical Engineering in 2008, M. Eng. in Electrical (Telecommunications) in 2010 from Universiti Teknologi Malaysia (UTM), and a second M. Eng. in Telecommunications Engineering in 2011 from Shibaura Institute of Technology, Japan. Currently he is pursuing his Ph. D in the same institute. He is a staff of the Faculty of Electrical Engineering, UTM. His research interests includes network communication protocols, Smart Grid and optimization techniques.

Eiji Kamioka is a Professor at Shibaura Institute of Technology. He received his B.S. (1989), M.S. (1991) and D.S (1997) degrees in Physics from Aoyama Gakuin University. He also has other job experiences, working for SHARP Communications Laboratory (1991-1993), Institute of Space and Astronautical Science (ISAS) as a JSPS Research Fellow (1997-1998) and National Institute of Informatics (NII) as an Assistant Professor (1998-2006). His current research interests encompass mobile multimedia communications, ubiquitous computing eand context-aware applications.