A Fast Handover Scheme Using Exponential Smoothing Method

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Summary
Development of high-speed internet service and the increased supply of mobile devices have become the key factor for the acceleration of ubiquitous technique. WiBro system, formed with Backbone Network based on IP, is a MBWA technology which provides high-speed multimedia service in a possibly broader coverage than Wireless LAN can offer even when mobility. Wireless telecommunication environment needs not only mobility support in Layer 2 of Wibro system but also mobility management protocol in Layer 3 and has to minimize handover latency is necessary in order for the user to be provided with seamless service while mobility. Thus, this thesis suggests a scheme to reduce delay in handover in WiBro environment based on IPv4. The following suggestion applies fast handover scheme based on Cross-Layer which is measured on the basis of the estimated value of signal strength that a Mobile Station receives and it is calculated by Exponential Smoothing Method. Simulation will compare as well as analyze the existing scheme and the suggested one in order to prove the saving of handover latency.
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Key words:
Handover, Cross-layer, WiMAX.

1. Introduction

While the Mobile WiMAX standards activity has been progressing, equipment suppliers have been aggressively developing equipment that is IEEE802.16d/e [1], [2] compliant. Offering VoIP services on IEEE 802.16 networks is considered problematic due to very long handover latency both in layer 2 (i.e., IEEE 802.16e Air Interface) and 3 (i.e., Mobile IP). The handover latency resulting from standard Mobile IP procedures is often unacceptable to real-time applications. Furthermore, the strict separation between IEEE802.16e MAC and Mobile IP handover scheme has negative consequences for total handover latency.

Recently, techniques based on cross-layer design have attracted wide spread interest in reducing built-in delay of Mobile IP. The protocols [3], [4] enable a mobile station (MS) to quickly detect that it has moved to a new subnet by providing the new access point and the associated subnet prefix information when the MS is still connected to its current subnet. L2 trigger is early notice of an upcoming change in the layer-2 point of attachment of the MS to the access network. L2 trigger can be utilized by the MS to start layer-3 handover-related activities in parallel with or prior to those of layer-2 handover.

In this paper, we propose a cross-layer handover scheme based on movement prediction for mobile WiMAX networks. Movement prediction is achieved by simple exponential smoothing method. We measure the signal strength between mobile users and base stations (BS's) continuously and find out coefficients for exponential smoothing method. With the help of the prediction, layer-3 handover activities are able to occur prior to layer-2 handover, and therefore, total handover latency can be reduced.

The rest of this paper is organized as follows. We first briefly describe exponential smoothing method. We then present the fast handover method based on exponential smoothing method together with experimental results. Finally, conclusions follow.

2. Exponential Smoothing Method

Exponential Smoothing method is a very popular scheme to produce a smoothed Time Series. Whereas in Moving Averages the past observations are weighted equally, Exponential Smoothing assigns exponentially decreasing weights as the observation get older. In other words, recent observations are given relatively more weight in forecasting than the older observations. Linear Expoential Smoothing is better at handling trends without non-seasonal property. Double Exponential Smoothing is better at handling trends. Triple Exponential Smoothing is better at handling parabola trends.

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The prediction using Linear Exponential Smoothing is given by

$$F_{n+l} = 2SM_n - SM_n - SM'_n + \frac{\alpha}{1-\alpha}(SM_n - SM'_n)\cdot l \quad (1)$$

where, F_{n+l} is prediction value l-time ahead. The coefficient α is weighting factor and Z_n is observed value at time n. SM_n and SM'_n is given by

$$SM_n = \alpha Z_n + (1-\alpha)SM_{n-1} \quad (2)$$

$$SM'_n = \alpha Z_n + (1-\alpha)SM'_{n-1} \quad (3)$$

Single Smoothing does not excel in following the data when there is a trend. This situation can be improved by the introduction of a second equation with a second constant, which must be chosen in conjunction with α .

$$F_{n+l} = a_n + b_n \cdot l + \frac{1}{2}c_n \cdot l^2 \quad (4)$$

$$a_n = 3SM_n - 3SM'_n + SM''_{n-1} \quad (5)$$

$$b_n = \frac{\alpha}{2(1-\alpha)^2}[(6-5\alpha)SM_n - (10-8\alpha)SM'_n + (4-3\alpha)SM''_{n-1}] \quad (6)$$

$$c_n = \frac{\alpha^2}{(1-\alpha)^2}(SM_n - 2SM'_n + SM''_n) \quad (7)$$

$$SM''_n = \alpha Z_n + (1-\alpha)SM''_{n-1} \quad (8)$$

Note that the current value of the series is used to calculate its smoothed value replacement in double exponential smoothing.

3. Fast Handover Method

An MS scans neighbor BS's to determine their suitability, along with other performance considerations as a handover target. In general, MS obtains received signal strength indicator (RSSI) periodically through the scanning process. Without prediction method that we proposed in this paper, an MS may start handover process when the current RSSI value is below a certain handover threshold. This MAC-layer handover initiation may also trigger layer-3 handover process.

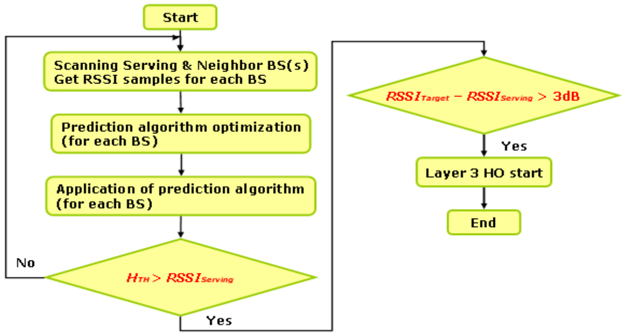

Fig. 1 Fast Handover Method.

In our work, we propose a prediction-based handover scheme. The flowchart for the proposed method is depicted in Fig. 1. Using the obtained RSSI samples, the MS obtains Exponential Smoothing Model parameters and predicts the future RSSI values between the MS and neighbor BS's.

4. Simulations

In this section the performance evaluation of the proposed prediction scheme is presented in terms of total handover latency. WiMAX Forum has proposed system evaluation methodology for simulating mobile WiMAX performance [5]. We have performed experiments on an example network (illustrated in Fig. 2) with system parameters and path loss model (i.e., The COST 231-Hata model) defined in [5]. The COST 231-Hata propagation model is based on empirical results in the 2GHz band and tends to make very conservative prediction for 2.5GHz. The simulation conditions used in the experiments are summarized in Table 1.

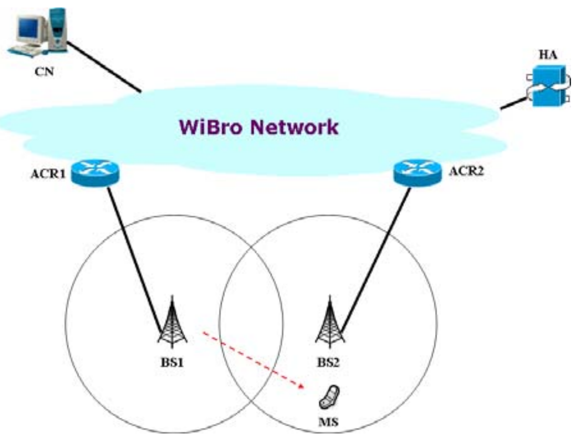

Fig. 2 Network Topology for Simulations.

As shown in Fig. 2, BS1 and BS2 are connected to the different access router AR1, and AR2. Therefore, when an MS moves from BS1 to BS2, corresponding layer-3 handover is required. In our simulation the MS moves from the edge of the Cell 1 to the center of the Cell2. Once the MS learns that it is going to move to different subnet, the next challenge is to estimate the right time to start Mobile IP registration.

Table 1: Summary of experiment conditions

Parameters	Value
Operating Frequency	2500 MHz
BS Height	32 meters
Mobile Terminal Height	1.5 meters
Shadowing Model	Log-Normal
Shadowing Mean	5.56 dB
Penetration Loss	10 dB

We use recent 30 samples for obtaining Exponential Smoothing parameters and predict the future RSSI value 1 second ahead. When an MS stops, we get less than 0.7% prediction error, while an MS moves we get less than 6.83% prediction error rate. As a simulation tool, we used commercial network level simulator, Qualnet 4.0.

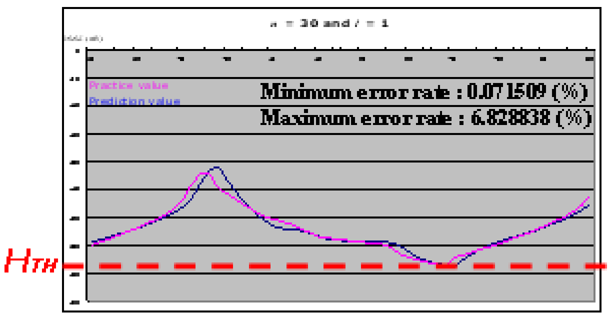

Fig. 3 Comparison practice value with prediction value about RSSI

Fig. 3 shows the measured RSSI values and predicted RSSI values together. The predicted values are derived from Exponential Smoothing method using recent 30 samples. The graphs show that the RSSI values from the serving BS decrease according to the MS movement to the target BS. When the measured RSSI value is less than the predefined handover threshold H_{TH}, then handover procedure starts and the RSSI values from the new serving BS increase.

Through the simulation, we find out that the prediction error increases when the gradient changes from positive to negative or negative to positive. When the signal strength has a steady trend, then the accuracy of the prediction is quite high. We has changed several prediction parameters such as prediction interval l and number of samples n, and we monitored the false L2 Trigger probability is always less than 1%.

Fig. 4 and 5 show that the cross-layer handover delay obtained through Qualnet 4.0 simulator. When we use the proposed L2 Trigger scheme, we reduce the total handover delay around 1 sec.

Fig. 4 Handover latency: Application of existing method

Fig. 5 Handover latency: Application of Low-Latency handover scheme

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5. Conclusions

Mobile WiMAX is a promising wireless communication technology for ubiquitous Internet access and personal communications as well. Fast handover technique is one of the most urgent issues for the successful WiMAX deployment. In this paper, we proposed prediction-based layer-2 trigger algorithm – Exponential Smoothing method. Our algorithm is applicable to the IETF cross-layer mobility frameworks. The proposed method is practical since the prediction model does not need to have any assumption on the statistical properties of user mobility patterns. The experiments conducted with system parameters and propagation model recommended by WiMAX Forum showed that the proposed scheme enables the total handover delay to be reduced by the amount of prediction interval.

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