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Comparing Between WSM and TOPSIS Based Cell Selection Scheme for Mobile WiMAX Network

Mohammed Awadh Ben-Mubarak

Abstract**—**Handover is an important element in Mobile WiMAX because it is supposed to support user mobility of up to vehicular speeds. However, the selection of the appropriate target BS (TBS) that meets the end-user QoS requirements for handover remains an unresolved issue whereas the conventional cell selection scheme is merely based on the signal quality, i.e. Received Signal Strength (RSSI) which does not provide a complete picture. This paper compare between the WSM and TOPSIS multi-criteria decision making (MCDM) approaches for TBS selection to meet the user application requirements in WiMAX network. In this research the MCDM methods are based on a collection of criteria such as CINR, bandwidth (BW) and congestion delay to select the TBS.

Index Terms**—**Mobile WiMAX, Handover, MCDM, TOPSIS, WSM.

I. Introduction

Nowadays with the variety of the user application and their requirements, the new 3G/4G systems have to consider many applications such as voice calls, video streaming/conference, online gaming, peer-to-peer application and many other application and their different requirements as shown in Table 1 [10-11], [1]. Cell selection is one of the main phases which may affect the user requirements after the handover process. The conventional cell selection scheme in Mobile WiMAX is based on signal quality, i.e. the nBS that has the best signal quality in terms of Received Signal Strength, will be considered as the TBS for the coming handover [2]. However, a single criterion like signal quality is not sufficient as a basis to choose the best BS for different end user application's requirements.

As an illustration in Figure 1, suppose the MS is in an overlapping area of two or more BSs that have similar signal quality, there will be an ambiguity on which one will the MS choose for different user application requirements? Putting a cell selection criterion on signal quality entirely may make an MS choose a TBS with a good signal quality but one which may incur higher delay or smaller bandwidth, this may affect some real-time applications.

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Table I: WiMAX Application Types

Application	Type	Bandwidth	Delay
Multiplayer Interactive Gaming	Real-time	50-85 kbps	<100 ms
VoIP & Video Conference	Real-time	4-64 kbps (VoIP) 32-384 kbps (Video call)	<150 ms
Streaming Media	Real-time	5-128 kbps (music) 20-348 kbps (video clip) >2 Mbps (movie streaming)	<300 ms
Web Browsing & Instant Messaging	Non real-time	<250 kbps (instant messaging) >500 kbps (email/web browsing)	N/A
Media Content Downloads	Non real-time	>1 Mbps	N/A

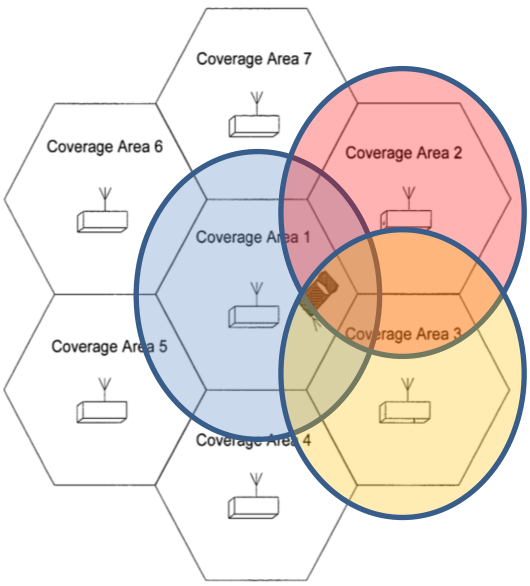

Fig. 1 Cell selection

The 802.16 standard [8] defines the receive signal strength indicator (RSSI) or carrier-to-interference plus noise ratio (CINR) as the handover trigger factor and cell selection scheme whereas WiMAX supports many multimedia data services therefore, it is not sufficient to let the signal strength be the only reference criteria. Authors in [8], [3], [4] proposed that the cell or the target BSs are chosen before the scanning operation. However, choosing the TBS before the scanning could lead to an incorrect decision because the MS does not know all the information of the channel condition, QoS, and other physical information of the nBSs. On the other hand, the authors in [5], [6], [7] introduced an enhanced handover target cell selection algorithm for WiMAX network based on the effective capacity estimation and neighbour

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advertisement. This paper compares WSM and TOPSIS as a smart way for selecting the right TBS based on a set of multiple decision criteria such as CINR, delay, and bandwidth.

II. Handover Cell Selection Criteria

In the conventional scheme of cell selection in Mobile WiMAX, the nBS which has the best signal quality (ex. RSSI or CINR) will be considered as the TBS for the coming handover [2, 8]. As highlighted earlier, this is inefficient because besides the signal quality each user's application has their own respective QoS requirements. In paper, two types of application are studied; VoIP as an example of real-time applications, and Media Content Downloads as an example of non real-time application [2]. VoIP is a latency or delay sensitive application with low data rate demand. On the other hand, Media Content Download is a delay-tolerant application and generally demand high bandwidth. Thus, there are some other criteria that need to be considered when the cell selection decision is to be taken. Thus, in this paper, three criteria will be considered; they are CINR, BW, and congestion delay. CINR is the best indicator for the signal quality compared to the RSSI, because the MS could receive a good RSSI but with high inference or signal noise. BW is a good criteria for demaning high bandwidth application while the congestion delays are good indication for delay sensitive application.

III. Multi-Criteria Decision Making Methods

The cell selection problem is about selecting one BS for handover among limited number of candidate BSs with respect to a set of different criteria. This is a typical MCDM problem. In the study of decision making, terms such as MCDM is the problem of choosing an alternative solution from a set of alternatives, which are characterized in terms of their attributes [9]. The most popular classical MCDM methods are:

WSM (Weighted Sum Model): the overall score of a candidate BS is determined by the weighted sum of all the attribute values.

TOPSIS (Technique for Order Preference by Similarity to Ideal Solution): the chosen candidate BS is the one which is closest to ideal solution and the farthest from the worst case solution.

In this paper, we use TOPSIS as alternative score ranking based cell selection scheme and compare it with WSM. Cell selection could be considered as an MCDM problem. For the limitation of the conference paper length, all the details about the MCDM formula and equations can be found in [9].

IV. Simulation Results

Qualnet 5.0 simulation tool has been used to evaluate the performance cell selection schemes. The simulated network topology consists of nine BSs. Initially, different number of MSs are attached to each BS. The total number of MSs is sixty as shown in Figure 2. The MSs are randomly moving along the BSs and is handed over between the nine BSs. In this scenario, two MSs will be monitored, one running real-time application, VoIP and the other one running non real-time application, FTP. The two-ray path loss model, Channel BW is 10 MHz, Frame length 20ms, Handover threshold is -78 dBm, Handover margin is 3dBm and 2.5 GHz operating frequency are used in this simulation as shown in Table 2.

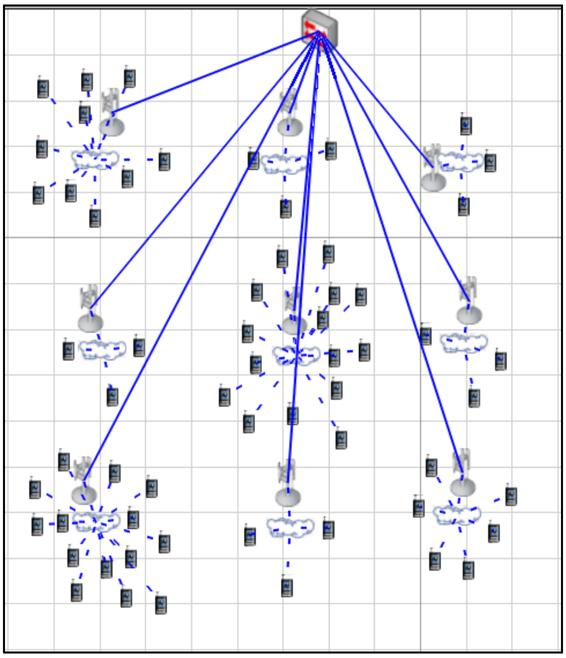

Fig. 2 Simulation scenario topology

TABLE II: Simulation parameters

Parameters	Value
Number of BSs	9
Number of MSs	60
Frequency	2.5 GHz
Channel Bandwidth	10 MHz
Duplexing Scheme	TDD
Path loss model	Two Ray
Frame length	20 ms
FTT size (OFDMA)	1024
Transmission power	20 dBm
HO threshold	-78 dBm
HO margin	3 dB

In this section, the effect of cell selection scheme in WiMAX network will be evaluated in terms of delay, throughput. The simulation results are compared between the proposed schemes WSM, TOPSIS, the conventional signal strength-based cell selection and BW based cell selection scheme in [7]. Figure 3 and Figure 4 show the system end-to-end delay for real-time application during the simulation time with different MS velocities, which are 15 m/s in Figure 3 and 30 m/s in Figure 4 respectively. The proposed scheme reduced the average end-to-end delay by 41.87%, 30.29% and 19.15% compared to the conventional, signal strength-based cell selection, BW-based cell selection and WSM method respectively when the MS velocity is 15 m/s. The enhancement stems from the fact that the proposed scheme takes into the consideration the cell congestion delay before choosing it, while the conventional scheme simply chooses the BS that has better signal quality over that of the SBS only and the BW-based cell selection consider the BW only beside the signal quality. Although the WSM also considers the cell congestion delay before choosing it, the TOPSIS based method is more sensitive to the weighting score over that of WSM. Moreover, when the MS velocity increases to 30 m/s, the number of handovers will increase which leads to higher end-to-end delay. In Figure 4, it could be observed that the proposed scheme managed to reduce the average end-to-end delay by 34.76%, 24.05% and 13.39% compared to the conventional, signal strength-based cell selection. BW-based cell selection and WSM methods respectively.

Figure 5 shows the BS throughput over the simulation time for all the schemes -- the TOPSIS based method against the conventional, signal strength-based cell selection and WSM method. During the simulation run, the MS is handed over to subsequent BSs which lead to system throughput degradation from time to time. Choosing the BS that offers better throughput to meet the user application requirement will optimize the system throughput. In Figure 5, it could be seen that the proposed scheme enhanced system throughput by 55.20%, 16.38% and 8.43% compared to the conventional, signal strength-based cell selection, BW-based cell selection and WSM methods, respectively.

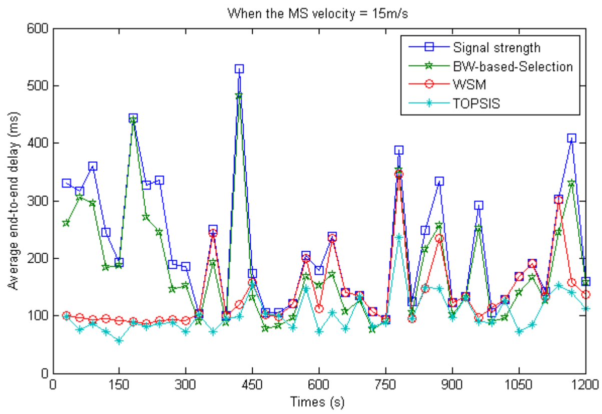

Fig. 3 The average delay when the MS velocity = 15 m/s

The enhancement stems from the fact that the proposed scheme takes into account the available BW in the BS before choosing it, whereas the conventional scheme chooses the BS based on signal quality only. For the BW-based cell selection scheme, it introduced a good performance comparing to the conventional scheme, because it considered the available BW too. Although the WSM also considers the available BW in the BS, the proposed TOPSIS based scheme is more sensitive to the weighting score over that of the WSM.

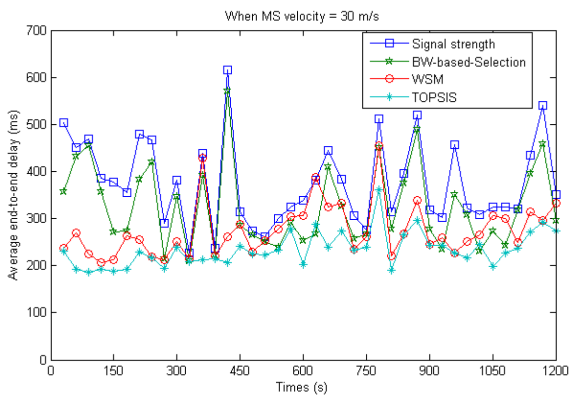

Fig. 4 The average delay when the MS velocity = 30 m/s

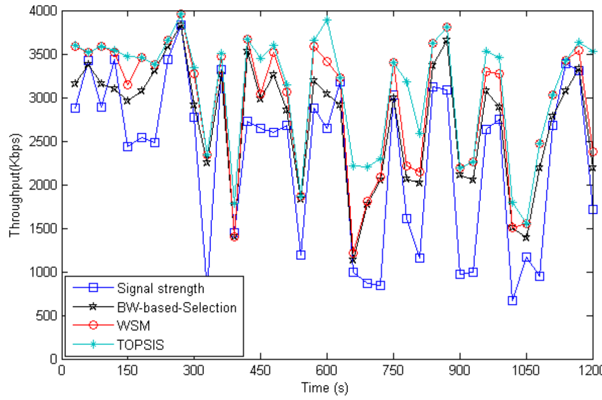

Fig. 5 System throughputs vs. simulation time

Usually, packets are dropped when they cannot meet the maximum end-to-end delay requirement due to queuing delays in a series of buffers. Figure 6 shows the effect of the MS velocity in terms of packet drop ratio for real-time applications, between the proposed scheme against the signal strength-based cell selection and WSM methods. Choosing a TBS that gives less congestion delay will reduce the packet drop ratio, because the BS will try to serve each packet before they reach the maximum delay threshold. From Figure 3 and Figure 4, it could be seen that the proposed scheme provides the best end-to-end delay compared to the conventional cell selection and WSM methods respectively, which also leads to smaller packet drop ratio. In Figure 6, the proposed scheme reduced packet drop ratio by 65.62%, 55.29 and 18.12% respectively compared to the conventional, signal strength-based cell selection, BW-based cell selection and WSM methods. Moreover, reducing the number of dropped packets will optimize the system throughput especially in TCP application.

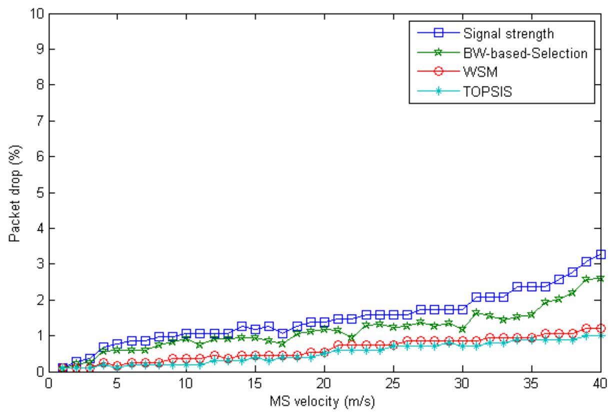

Fig. 6 Packet drops vs. MS velocity

V. Conclusion

The variety of user applications require different network characteristics. So, the handover mechanism and cell selection scheme have to be intelligent enough to meet the application need during and after the handover process. This paper has compared between two MCDM schemes, WSM and TOPSIS for selecting TBS in order to serve those needs. The TOPSIS scheme managed to reduce the average end-to-end delay by 48.87%, 30.29% and 19.15% respectively, compared to the conventional, signal strength-based cell selection, BW-based cell selection and

WSM methods, when the MS velocity is 15 m/s. When the MS velocity is 30 m/s this performance is improved by 34.76%, 24.05% and 13.39% respectively. Also, TOPSIS optimizes the system throughput by 55.20%, 16.38% and 8.43% and reduces the packet drop ratio by 65.62%, 55.20 and 18.12% respectively, respectively, compared to the conventional cell selection, BW-based cell selection and WSM method.

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