Journal of Theoretical and Applied Information Technology
20th August 2013. Vol. 54 No.2

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

MULTI-CRITERIA VERTICAL HANDOVER DECISION ALGORITHM IN HETEROGENEOUS WIRELESS NETWORK

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ABSTRACT

Vertical handover is essential to ensure service continuity in a heterogeneous network. Multi-criteria decision is proposed to reduce handover rate and optimizing usage of network resource compared to the conventional handover decision, which used single criteria. The algorithm is evaluated by assessing the performance in terms of number of handoff, load balance index, and network blocking probability. By implementing the proposed handover decision algorithm, the number of handoff decreased up to 90.81%. The average blocking probability decreases by 23.20% and the load balance index was improved by 68.50%.

Keywords: *Vertical Handover, Heterogeneous Network, Multi Criteria, Handover Decision, Handover Algorithm*

1. INTRODUCTION

Evolution of mobile communication reached the Fourth Generation where the network provides seamless connection in terms of mobility. Trends of wireless communication are moving towards convergence. Accordingly, the concept of heterogeneous was emerged. Heterogeneous network is a convergent network which is built up from networks of different technologies. Those networks are interrelated to each other, even sometimes geographically overlapped. Figure 1 presents an illustration of heterogeneous network architecture. Certain network has unique characteristics, and heterogeneous network combines the advantages of each network to provide better service in terms of coverage, capacity and link performance.

In a heterogeneous network, handover process is classified into two categories: horizontal handover and vertical handover. Horizontal handover takes place when a mobile user moves from one network to another within the same network technology. Vertical handover happens when a mobile user moves from one network to another with different technology meanwhile horizontal handover happens within the same type of network.

Vertical handover decision together with horizontal handover is essential in heterogeneous network. To ensure continuous connection, mobile users must always be connected to the appropriate network. Vertical handover also plays a role in increasing network performance, especially balancing the load between corresponding networks.

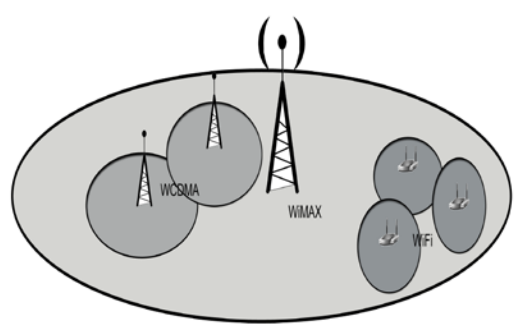

Figure 1: Heterogeneous Network

The handover process consists of three stages [1]: handover information gathering, handover decision and handover execution. In the first phase of information gathering, all the information is collected. This phase considered as handover initiation. Handover decision is a process when the handover decision algorithm is run to decide which network to be selected as a point of

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

attachment for mobile user. This is the main focus of our study. We emphasize our study in vertical handover decision algorithm. The last stage of handover process is handover execution, where involves the physical layers of corresponding networks to facilitate a smooth handover process over the network.

Decision in horizontal handover is different with decision of vertical handover, mainly because corresponding networks are different. The horizontal handover decision involves networks from the same link layer technology meanwhile vertical handover decision involves the network from different radio access technology (RAT). In horizontal handover, single parameter of RSSI is sufficient to trigger handover, but in vertical handover, more parameters are needed to decide handover accurately. Wrong handover decision, however, causes the higher cost on the network side in terms of signaling and switching resource.

Vertical handover decision algorithm using multi criteria is proposed as the handover decision using single criteria (RSSI) may result in inefficient handover and unbalanced load. To decide vertical handover more accurately, more parameters are needed. In our study, we propose four criteria to decide vertical handover. Those criteria are RSSI, type of traffic, speed and network occupancy. The first three criteria (RSSI, type of traffic and speed) are user-related parameter meanwhile network occupancy is network-related parameter.

2. RELATED WORK

There have been exhaustive numbers of study on vertical handover in a heterogeneous network. Conventional method of vertical handover decision relies on received signal strength indicator (RSSI) to estimate the networks availability and to trigger the handover mechanism [2] [3]. In those works, RSSI is the only parameter to decide vertical handover. In [4] signal strength adaptation is proposed to achieve improved performance in terms of signaling load, available bandwidth and packet delay. In the other work [2], performance of vertical handover decision based on RSSI in term of number of blocked users is evaluated.

Advance methods of vertical handover decision have been reviewed extensively in several works. Vertical handover decision methods are classified into 5 (five) categories [1]:

- Decision function-based strategies, where the network with the lowest cost is chosen as the target network. Number of cost functions in the algorithm depends on the number of parameters to be considered. User centric strategies cost of each network is calculated.

- User-centric strategies, where a vertical handover decision is driven by user preferences, mostly in terms of monetary cost and QoS. In [5], cost function includes the time unit because accordingly it is related to the monetary cost paid by the customer.

- Multiple attribute decision strategies, where the decision is made using Multiple Attribute Decision Making (MADM) algorithms. MADM methods were made to make decisions between multiple and conflicting criteria. MADM methods include Linear Assignment Method (LAM), Simple Additive Weighting (SAW), Elimination et Choice Translating Reality (ELECTRE) and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [6].

- Fuzzy logic and neural network based strategies, usually combined with MADM strategies to decide best target network. This method has two stages: (1) the fuzzification and weighting procedures, and (2) the decision making [1].

- Context aware strategies, where the handover decision is based on the signal quality and additionally based on the knowledge about the context of mobile device and networks [7].

MADM method has been reviewed in [8] which compared the performance between algorithm methods of MEW (Multiplicative Exponent Weighting), SAW (Simple Additive Weighting), TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) and GRA (Grey Relational Analysis). Input parameter of the decision making included bandwidth, delay and packet loss. Traffic in the network was classified into 4 (four) QoS classes: conversational, streaming, interactive and background. This traffic classification complies with QoS classes of

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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

WCDMA (Wideband Code Division Multiple Access).

Comparison between MADM methods shows that the method of MEW, SAW and TOPSIS selected the same network in handover decision most of the time [8].

3. SIMULATION AND ALGORITHM

In our study, heterogeneous network consists of three networks from different link layer technology: WiFi, WCDMA and WiMAX. Simulation network topology is shown in Figure 2. Network with the largest coverage is WiMAX and network with the smallest coverage is WiFi. In between, there are WCDMA base stations across the simulation environment.

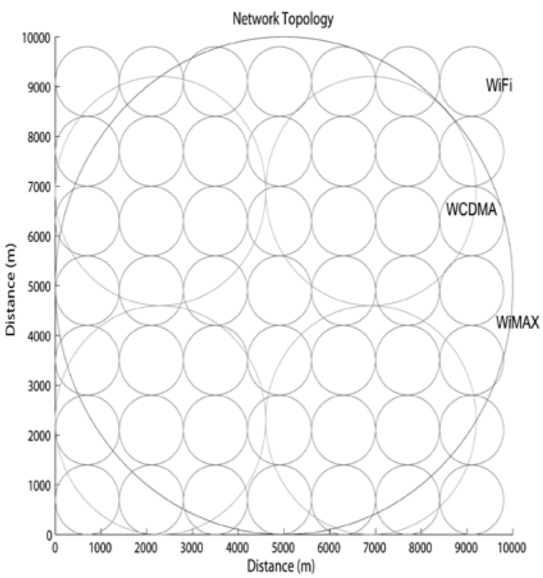

Figure 2: Network Topology

Parameter setting of BS (Base Station) and MS (Mobile Station) for simulation environment is presented in Table 1.

Figure 3 presents simulation algorithm. Conventional method of vertical handover decision is included in the flowchart. In conventional vertical handover decision, RSSI was used as main attribute meanwhile in our proposed algorithm the attributes to decide handover are RSSI, speed class, traffic class and network occupancy.

RSSI is a main parameter in the handover decision because it decides the availability of the network. RSSI is associated with the distance between the mobile station and the base station. It is a radio power which is measured at the user's terminal. In our simulation, RSSI value is obtained by subtracting transmit power with a path loss which depends on the distance between the base station and the mobile station.

Table 1: Simulation Parameter Setting

	Parameter	**Network Type**		
		WiMAX	***WCDMA***	***WiFi***
BS	Operating Frequency (MHz)	3500	2100	2450
	Transmit Power (dBm)	48	15	20
	Antenna gain (dB)	15	6	3
	Loss (cable, combiner) (dB)	-3	-3	-3
	EIRP (dBW)	60	18	20
	Cell Radius (km)	5	2.3	0.7
	Antenna Gain (dB)	3	3	3
	Available Bandwidth (kbps)	15000	10000	3000
MS	Receiver Sensitivity (dBm)	-100	-100	-118
	Cell Edge Receive Level (dBm)	-100.12	-100.45	-119.58

The propagation model used is COST 231 Walfisch-Ikegami, which is most widely used as an empirical model [9]. It is valid in the condition of transmitter height 4 to 50 m, receiver height 1 to 3 m, and the transmitter-receiver distance 0.02 to 5 km. The formula is as follows:

$$L = 42.6 + 26\log(d) + 20\log(f) \quad (1)$$

where d is distance from base station to mobile user in km, and f is operating frequency in MHz.

Multi-traffic networks classify transmitted traffic to ensure optimum quality for each user. Traffic classes related to the handling priority of the packets sent over the network. Certain typed of

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traffic requires different approaches in the network switching.

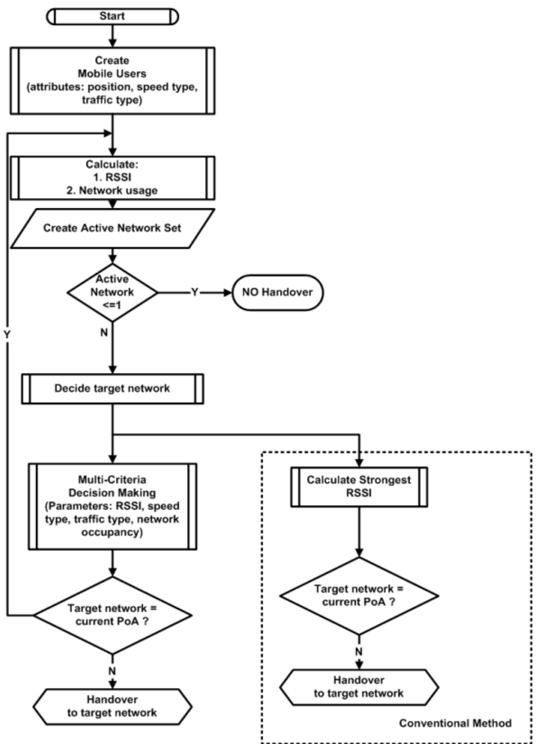

Figure 3: Simulation Flowchart

Our heterogeneous network was built up by networks of different standards and consequently there are certain traffic classes for each type of network. WiFi network classified its traffic into four QoS classes: voice, video, background and best effort. WCDMA and WiMAX standard also defined four traffic classes. Traffic service in WCDMA is categorized into conventional class, streaming class, interactive class and background class [10], meanwhile in WiMAX network, traffic is categorized into four QoS classes: Unsolicited Grant Service (UGS), Real-time polling service (rtPS), Non-real-time polling service (nrtPS) and Best effort (BE) service [11].

As our simulation environment is a heterogeneous network, we propose another traffic class that may accommodate different networks involved in this heterogeneous network. We classify the traffic into 3 (three) classes: conventional service, streaming service and best effort service. The conventional service includes voice calls, where the traffic has low tolerance for delay but high tolerance for bit error. Best effort service may have a relatively high delay, but it is strictly needed to be accurate in term of low bit error rate. Streaming service compromises those two extremes and provides service with average delay and bit error. In this simulation, bit rate for conventional service is 32 kbps, meanwhile it is 512 kbps and 128 for streaming and best effort service respectively.

WiFi network is a priority network for best effort services such as email and web browsing. Voice calls are preferred to be handled by WCDMA network as streaming traffic is preferred to be served by WiMAX network.

Mobility is crucial in deciding handover on heterogeneous environment. In our study, we include speed as a criterion in handover decision. Movement of a mobile user may effect on choosing the suitable network as a point of attachment.

Heterogeneous network combine several networks with different strength. Each network is suitable for certain type of velocity. WiFi, for example, is suitable for the users with low velocity or stationary because of its small coverage. On the other hand, WiMAX network is preferable for users with high velocity (i.e. vehicular speed) because of its big coverage. Suitable choice of handover decision may reduce the number of handoff. Optimum number of handoff may increase the optimization of network resource usage.

The work on the influence of mobile velocity to network performance was presented in [12]. Accordingly, in our study we classified mobile users into 4 (four) speed class:

- Stationary mobile users.
- Mobile users with a velocity of 1.3 m/s which are considered as pedestrians.
- Mobile users with a velocity of 3 m/s, where it is the average speed of a public bus in urban condition at peak hours.
- Mobile users with velocity of 4.7 m/s, the average speed of a public bus during off-peak hours.

Compared to previous criteria which are users based (speed, type of traffic, and RSSI), network occupancy is a criterion which is network

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based. Network occupancy is dependent on the traffic served by each base station.

Network occupancy is an important parameter in the handover decision because our objective is to achieve satisfaction for mobile users and optimizing the usage of network resource. By using network occupancy as a parameter, the total load of this entire heterogeneous network may be shared to each different network. As the load increase, the performance of a network decrease. By distributing the load evenly, the performance of each network may be maintained at a satisfactory level for each type of network.

4. RESULTS

Performance parameters of this simulation are number of handoff, load balance index and blocking probability. These parameters are calculated for both conventional and proposed algorithm.

Number of handoff is a fundamental parameter in handover due to resource management. Unnecessary handover may reduce the network performance in term of throughput and occupancy because of wasted resources.

Numerical analysis on the number of handoff has been presented in [13] [14]. However our proposed method performance was obtained through simulation. The result, as shown in Figure 4 suggests that our proposed algorithm has significantly reduced the number of handoff 90.81% from 13 to 2. This number is obtained through simulation with 100 number of mobile, call duration of 180 seconds and 360 simulation samples.

Besides number of handoff, the performance of proposed algorithm also measured by calculating balance index. Balance index is defined as a value that is associated with load sharing and load balancing [15] [16].

Balance index value of 0 shows that the heterogeneous network is totally balanced. Higher value of balance index shows more unbalanced network. Multi-criteria handover decision method was able to improve the network balance compared to conventional method to 68.50%. Figure 5 presents balance index from the simulation of 100 number of mobile, 360 simulation time. Traffic model follows Poisson arrival with 0.5 arrival rate and 180 seconds mean duration.

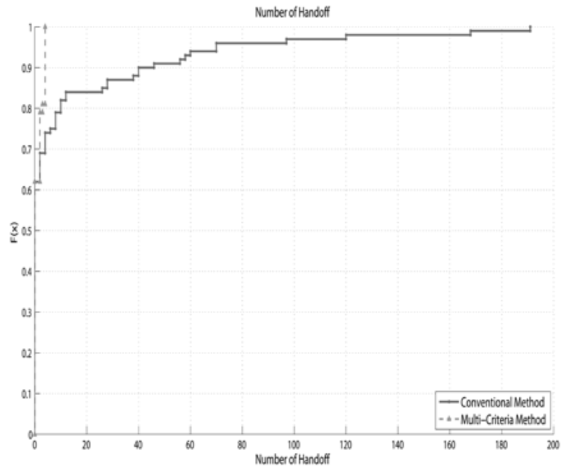

Figure 4: Number of Handoff

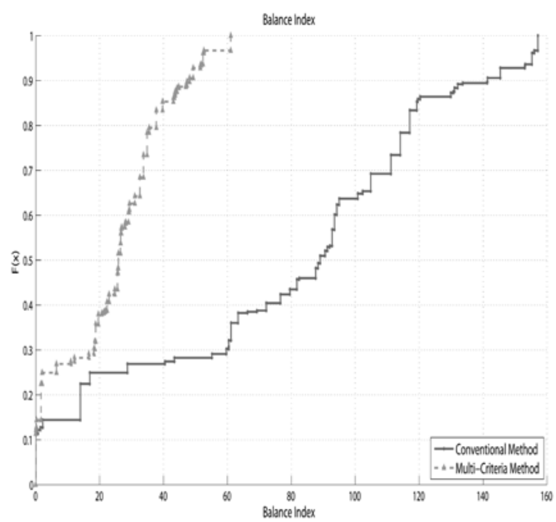

Figure 5: Balance Index

Blocking probability follows Erlang-B formula. By implementing multi-criteria handover decision, blocking probability of the all three networks has decreased 23.20% as presented in Figure 6.

5. CONCLUSION

Compared to single-criteria decision making, multi-criteria may increase the handover delay as it considers several parameter to decide the handover. However, the implementation of multi-criteria decision making in the vertical handover decision algorithm of a heterogeneous network

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

increases the network performance in terms of number of handoff and load balance index.

Furthermore, the handover decision algorithm may be modified using additional criteria. Performance measurement and performance analysis also may be improved by adding other performance parameters such as handover delay.

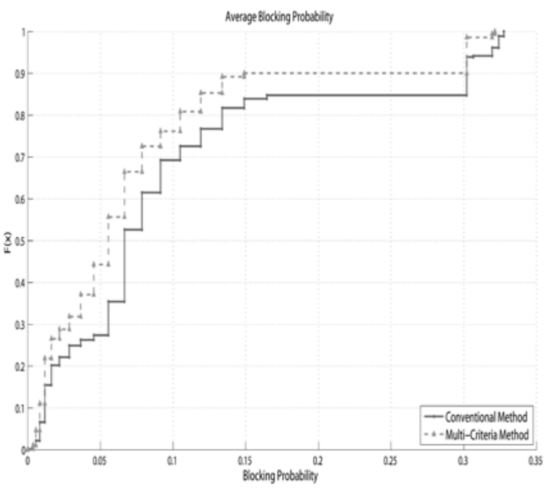

Figure 6: Blocking Probability

ACKNOWLEDGMENT

This paper is based on the project sponsored by Universiti Kebangsaan Malaysia project code OUP-2012-182. The authors wish to thank for their funding and support.

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