A Multi-Factors Cell Selection Scheme for Heterogeneous Networks with Multimedia Traffic

Wen-Ching Chung, Chung-Ju Chang*, Chih-Yuan Hsieh, and Yung-Han Chen†

Department of Electrical and Computer Engineering
National Chiao Tung University
Hsinchu, 300, Taiwan, R.O.C.
*Email: cjchang@mail.nctu.edu.tw
†Industrial Technology Research Institute, Hsinchu, 300, Taiwan

Abstract— **In this paper, we propose a multi-factors cell selection (MFCS) scheme for heterogeneous networks with multimedia traffic. In heterogeneous networks, it is an important issue to determine a suitable access network for call request to support seamless service and high-speed connectivity. The MFCS scheme first chooses candidate cells for call request to satisfy the received signal strength constraint, cell loading constraint, and dwell time constraint. It then determines a target cell from candidate cells based on the QoS factor, loading factor, and mobility factor. Simulation results show that, the MFCS scheme reduces the handoff occurring ratio by 25.5 % and improves the overall system throughput by 15.9 % as compared to the utility and game-theory based network selection (UGNS) scheme [6].**

I. Introduction

The technique of heterogenous wireless access plays an important role to develop next-generation wireless networks [1], [2]. By using this technique, a mobile station (MS) has the ability of multi-mode access to simultaneously connect with multiple heterogeneous radio access networks (RANs), included wireless local area network (WLAN), wireless metropolitan area network (WMAN), and wideband code division multiple access (WCDMA) cellular network, and so on. Through a proper cell selection scheme, next-generation wireless networks can provide the service of seamless access and high-speed connectivity for call requests. However, the design of cell selection scheme is very complicated, since it should consider the different system characteristics of different RANs. On the other hand, it is an essential requirement to support the multimedia traffic in next-generation wireless networks. Each traffic has different quality-of-service (QoS) requirements. Therefore, how to develop an effective cell selection scheme for heterogeneous networks to support multimedia traffic becomes a challenging issue.

In the literature, the study of cell selection or network selection for heterogeneous networks has attracted a lot of attentions [3]-[6]. By combining non-compensatory and compensatory multi-attribute decision making algorithms, Bari and Leung [3] proposed a decision process to assist the terminal in selecting the top candidate network. In [4], Sehgal and Agrawal proposed a QoS-based network selection scheme for 4G networks to select an appropriate network during handoff based on user preferences and interests. Moreover, Pei et al. [5] proposed an access control mechanism to maximize network welfare or loading balance between CDMA networks and WLANs. By combining the utility function and the cooperative game, Tsai, Chang, and Chen [6] proposed a utility and game-theory based network selection (UGNS) scheme to achieve the loading balance and reduce the occurrence of handoff.

In this paper, we propose a multi-factors cell selection (MFCS) scheme for heterogeneous networks with multimedia traffic. The MFCS scheme takes multiple factors into account when it makes the decision for cell selection. It contains three stages, candidate cells determination (CCD), utility value assignment (UVA), and target cell selection (TCS). The CCD stage selects candidate cells by checking the received signal strength constraint, cell loading constraint, and dwell time constraint. The UVA stage assigns utility values to candidate cells by considering the QoS factor, loading factor, and mobility factor. Finally, the TCS stage determines the most suitable cell as target cell for call request. Simulation results show that, when the call arrival rate is larger than 0.7, the proposed MFCS scheme reduces the new call blocking ratio and the handoff call dropping ratio by 42.4 % and 44.4 %, respectively, as compared to the UGNS scheme [6]. Moreover, the MFCS scheme decreases the handoff occurring ratio by 25.5 % and enhances the overall system throughput by 15.9 % as compared to the UGNS scheme.

The remainder of the paper is organized as follows. The system model is introduced in Section II. Section III describes the design of the MFCS scheme. Section IV presents the simulation results for the performance analysis of the MFCS scheme. Finally, conclusions are given in Section V.

II. System Model

A. Heterogeneous Network

Consider a heterogeneous network is composed of K cells and can be divided into many subnetworks. Each subnetwork has the same network topology and is overlapped with each other. As shown in Fig. 1, the subnetwork of the heterogeneous

1550-445X/13 $26.00 © 2013 IEEE
DOI 10.1109/AINA.2013.69

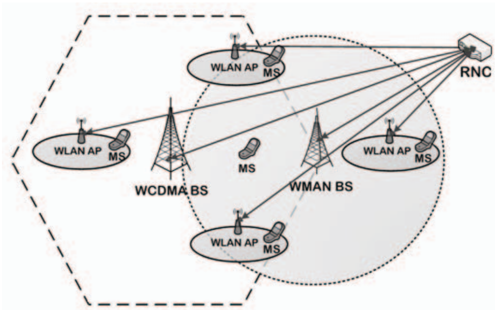

Fig. 1. The subnetwork of the heterogeneous network.

network contains one WCDMA cell, one WMAN cell, and four WLAN cells. All cells in the subnetwork are connected with a radio network controller (RNC) via backhaul. The RNC gathers information from base stations (BSs) of WCDMA and WMAN cells and access points (APs) of WLAN cells to make the decision for cell selection. The mobile station (MS) is supposed to have multiple radio transceivers and then can detect all radio interfaces simultaneously. Also, the MS with call request can only connect with one cell at the same time. The proposed MFCS scheme is implemented in the RNC to choose one suitable cell from K cells for call request.

1) WCDMA System

In the WCDMA system, the achievable bit rate for MS, denoted by *AR*, can be obtained by [7]

$$AR = \frac{W}{a \cdot (E_b/N_0)} \times \frac{RSS}{PI_t - RSS}, \tag{1}$$

where W is the chip rate, a is the activity factor of MS, E_b is the signal energy per bit, N_0 is the noise spectral density, *RSS* is the signal strength of BS received at MS, and PI_t is the total power including thermal noise power received at BS. Note that, (E_b/N_0) should be set to meet a predefined QoS requirement for MS.

2) IEEE 802.16 WMAN System

In the IEEE 802.16 WMAN system [8], the orthogonal frequency division multiple access (OFDMA) is adopted as a multiple-access method. The frame time is defined as T ms and is divided into N OFDMA symbols. Suppose each WMAN BS has Z sub-channels, and each sub-channel consists of q sub-carriers. Denote $b_{n,z}$ as the number of transmitted bits allocated to call request on sub-channel z at the nth OFDMA symbol. The allocated transmission bits for call request in this frame, denoted by B, is then obtained by

$$B = \sum_{z=1}^{Z} \sum_{n=1}^{N} q \cdot s_{n,z} \cdot b_{n,z}, \tag{2}$$

where $s_{n,z}$ is the allocation indication. If the resource on sub-channel z at the nth OFDMA symbol is allocated to this call request, $s_{n,z} = 1$; otherwise, $s_{n,z} = 0$.

3) IEEE 802.11 WLAN System

In the IEEE 802.11 WLAN system [10], the enhanced distributed channel access (EDCA) mode is adopted to transmit data. It allows the AP to initiate the duration of transmission opportunity in the contention period. Under the EDCA mode, a MS cannot transmit packets until the channel is sensed to be idle for a time period, which is equal to the arbitration interframe space (AIFS). When a MS detects the channel to be busy during the AIFS, the backoff time counter is triggered. Moreover, the WLAN system can provide up to four access categories and eight priorities to support differentiated QoSs.

B. Traffic Classes

The considered heterogenous networks can support four classes of traffic: conversational, streaming, interactive, and background. Each traffic has different QoS requirements. For conversational and streaming traffics, the QoS requirements are the required bit error rate (BER), the required (E_b/N_0), the maximum delay tolerance, and the maximum allowable packet dropping ratio. For interactive and background traffics, the QoS requirements have the required BER and the required (E_b/N_0). Therefore, the conversational and streaming traffics can be seen as the real-time traffic, while the interactive and background traffics can be seen as the non-real-time traffic.

C. Mobility Model

According to the estimated velocity, the MS could be categorized as pedestrian, normal mobility MS, or high mobility MS. For the pedestrian and normal mobility MS, their speeds are assumed to be unchanged, but their direction of motion will be randomly changed in every fixed duration. For the high mobility MS, its estimated velocity and direction of motion are supposed to be unchanged. Figure 2 shows the model of dwell time for high mobility MS, where r_k is the radius of cell k, θ_k is the angle between the BS/AP of cell k and the moving direction of MS, $0 \leq \theta_k \leq \pi$, and $d_{r,k}$ is the distance between the BS/AP of cell k and the MS, $0 \leq d_{r,k} \leq r_k$. Therefore, the travel distance of MS in the cell k, denoted by $d_{t,k}$, can be obtained by [9]

$$d_{t,k} = \sqrt{r_k^2 - (d_{r,k} \cdot \sin\theta_k)^2} + d_{r,k} \cdot \cos\theta_k. \tag{3}$$

Here, $0 \leq d_{t,k} \leq 2r_k$. We then have the estimated dwell time of MS in the cell k, denoted by $T_{dw,k}$, by

$$T_{dw,k} = d_{t,k}/v, \tag{4}$$

where v is the estimated velocity of MS. In this study, the velocity of high (normal) mobility MS is set to be 80 (30) km/hr, while that of pedestrian is set to be 3 km/hr.

III. Multi-Factors Cell Selection Scheme

The proposed multi-factors cell selection (MFCS) scheme is composed of three stages, candidate cells determination (CCD), utility value assignment (UVA), and target cell selection (TCS). The detailed designs of the MFCS scheme are given below.

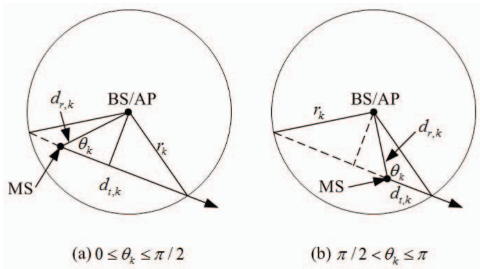

Fig. 2. The model of dwell time for high mobility MS in the cell k.

A. Candidate Cells Determination Stage

The CCD stage chooses the suitable cells as candidates based on the received signal strength constraint, dwell time constraint, and cell loading constraint. Only the cell satisfying these three constraints will be chosen as the candidate cell for call request.

1) Received Signal Strength Constraint

In order to provide a sufficient link quality, the received signal strength of pilot/beacon from cell k at the MS with call request, denoted by RSS_k, should exceed a predefined signal strength threshold for cell k, denoted by $RSS_{th,k}$. We then have the received signal strength constraint as

$$RSS_k \geq RSS_{th,k}. \tag{5}$$

In this paper, the $RSS_{th,k}$ is set to be the received signal strength of pilot/beacon from cell k at its boundary.

2) Dwell Time Constraint

If the high mobility MS is allowed to access a small cell, it might pass through this cell quickly and perform the handoff procedure frequently. Hence, we utilize the dwell time constraint to reduce the occurrence of handoff. Let $x_k = T_{dw,k}/T_{max,k}$ be the dwell time factor of call request in the cell k, where $T_{max,k} = 2 \cdot r_k/v$. The dwell time constraint can then be written as

$$x_k \geq x_{th,k}, \tag{6}$$

where $x_{th,k}$ is a predefined threshold for the dwell time factor of cell k. If $x_k \geq x_{th,k}$, the dwell time of MS in the cell k would be long enough to provide a certain period of service.

3) Cell Loading Constraint

The cell loading constraint is used to guarantee the admission of call request will not influence the QoS requirements of existing connections, given by

$$\rho_k + \Delta\rho_k \leq \rho_{th,k}, \tag{7}$$

where ρ_k is the loading intensity of cell k before admitting the call request, $\Delta\rho_k$ is the increment of loading intensity when the call request connects to the cell k, and $\rho_{th,k}$ is a predefined threshold for loading intensity of cell k.

For the WCDMA cell k, the $\Delta\rho_k$ is defined as [7]

$$\Delta\rho_k = (1+\eta) \cdot \frac{1}{1 + W/(a \cdot R \cdot E_b/N_0)}, \tag{8}$$

where η is the ratio of the interference from other cells (inter-cell interference) over the interference from own cell (intra-cell interference), and R is the bit rate of call request. For the WMAN cell k, the mean capacity can be estimated as $4 \cdot q \cdot Z \cdot N/T$ (bps). Hence, the $\Delta\rho_k$ is defined as

$$\Delta\rho_k = \frac{a \cdot R}{4 \cdot q \cdot Z \cdot N/T}. \tag{9}$$

For the WLAN cell k, the measurement-based cell loading intensity estimation is adopted. Let $T_{b,k}$ be the busy time of cell k during an observation duration, denoted by T_o. The loading intensity of the WLAN cell k can be estimated by $\rho_k = T_{b,k}/T_o$. The WLAN cell k is said to satisfy the cell loading constraint if $\rho_k \leq \rho_{th,k}$.

B. Utility Value Assignment Stage

The UVA stage calculates utility values for candidate cells by considering the loading factor, QoS factor, and mobility factor. The utility value is the degree of suitability for a candidate cell. Suppose there are J candidate cells for call request selected by the CCD stage. Denote C_j as the jth candidate cell and $\mathbf{C}$ as the set of candidate cells, where $\mathbf{C} = \{C_1, \cdots, C_j, \cdots, C_J\}$. The utility value of candidate cell C_j, denoted by U_j, is defined as a linear combination of three factors given by

$$U_j = w_1 \cdot L_j + w_2 \cdot Q_j + w_3 \cdot M_j, \tag{10}$$

where L_j is the loading factor of C_j, Q_j is the QoS factor of C_j, M_j is the mobility factor of C_j, and w_1, w_2, w_3 are the weights of loading, QoS, mobility factors, respectively, with $w_1 + w_2 + w_3 = 1$. In this paper, we set $w_1 = w_2 = w_3 = 1/3$.

1) Loading Factor

The loading factor L_j is used to measure the cell loading difference between two cells in $\mathbf{C}$ after the call request is accepted by C_j. When a call request arrives at the RNC, the MFCS scheme prefers to arrange it to the cell which can improve the loading balance among candidate cells. This can also enhance the number of accommodated calls. The loading factor L_j is designed as

$$L_j = \frac{1}{1 + L_{1,j} + L_{2,j}}, \tag{11}$$

where $L_{1,j} = \sum_{i=1,i\neq j}^{J} \sum_{i'=1,i'\neq i,i'\neq j}^{J} |\rho_i - \rho_{i'}|$, $L_{2,j} = \sum_{i=1,i\neq j}^{J} |\rho'_j - \rho_i|$, and ρ'_j is the loading intensity of C_j after it accepts the call request. The $L_{1,j}$ shows the total of the cell loading difference between two cells in $\mathbf{C}$ except for C_j. The $L_{2,j}$ represents the total of the cell loading difference between C_j and other candidate cell. If the L_j is larger, it means the C_j can achieve a better loading balance among candidate cells.

2) QoS Factor

The QoS factor Q_j is used to measure the QoS satisfaction level of call request accepted by C_j. Let A_j, B_j, and D_j be the average packet dropping ratio, allowed data rate, and average packet delay, respectively, measured in C_j. The QoS factor of C_j is designed as

$$Q_j = Q_1(A_j) \times Q_2(B_j) \times Q_3(D_j), \tag{12}$$

where $Q_1(A_j)$, $Q_2(B_j)$, and $Q_3(D_j)$ are the normalized QoS satisfaction functions of packet dropping ratio, data rate, and packet delay, respectively, for C_j. Note that, for the interactive and background traffics, $Q_{A,j} = Q_{D,j} = 1$, since they do not have the QoS requirements for packet dropping rate and transmission delay. If a cell can guarantee the QoS requirement for call request, the corresponding QoS satisfaction value is designed to have an exponential relationship with the measured QoS metric; otherwise, it is set to be zero.

The QoS satisfaction function of packet dropping ratio for C_j is given by

$$Q_1(A_j) = \max\{1 - e^{\beta_{1,j} \times A_j - \alpha_{1,j}}, 0\}, \tag{13}$$

where $\alpha_{1,j}$ is the requirement parameter for A_j and $\beta_{1,j}$ is the elasticity parameter for A_j. The larger value of $\alpha_{1,j}$ means that the call request has a higher allowable packet dropping rate. The larger value of $\beta_{1,j}$ means that the $Q_1(A_j)$ is a steeper curve and has a less elasticity in the packet dropping ratio. In this study, we set $\alpha_{1,j}$ ($\beta_{1,j}$) = 7 (700) and 5 (500) for the conversational and streaming traffics, respectively.

The QoS satisfaction function of data rate for C_j is given by

$$Q_2(B_j) = \max\{1 - e^{\alpha_{2,j} - \beta_{2,j} \times B_j}, 0\}, \tag{14}$$

where $\alpha_{2,j}$ ($\beta_{2,j}$) is the requirement (elasticity) parameter for B_j. The larger value of $\alpha_{2,j}$ means that the call request has a higher data rate requirement. The larger value of $\beta_{2,j}$ means that the $Q_2(B_j)$ is a steeper curve and has a less elasticity in the data rate requirement. In this study, we set $\alpha_{2,j}$ ($\beta_{2,j}$) = 5.5 (0.5), 3.75 (0.05), 0.45 (0.005), and 0, (0.0005) for the conversational, streaming, interactive, and background traffics, respectively.

The QoS satisfaction function of packet delay for C_j is given by

$$Q_3(D_j) = \max\{1 - e^{\beta_{3,j} \times D_j - \alpha_{3,j}}, 0\}, \tag{15}$$

where $\alpha_{3,j}$ ($\beta_{3,j}$) is the requirement (elasticity) parameter for D_j. The larger value of $\alpha_{3,j}$ means that the call request has a higher maximum delay tolerance. The larger value of $\beta_{3,j}$ means that the $Q_3(D_j)$ is a steeper curve and has a less elasticity in the delay tolerance. In this study, we set $\alpha_{3,j}$ ($\beta_{3,j}$) = 8 (0.2) and 10 (0.1) for the conversational and streaming traffics, respectively.

3) Mobility Factor

The mobility factor M_j considers the dwell time of MS in C_j and the relative position between the BS/AP of C_j and the MS. The proposed MFCS scheme favors to arrange a high mobility MS to a large cell to avoid frequently handoff. Denote T_{avg} as the average dwell time of candidate cells for the MS with call request. Let $y_j = T_{dw,j}/T_{avg}$. If y_j is less than one, it indicates that the MS has a high probability to initiate handoff when it enters C_j. Therefore, the mobility factor considering the dwell time, denoted by $M_{dw,j}$, is given by

$$M_{dw,j} = \begin{cases} 0, & \text{if } y_j \le 0.25, \\ y_j - 0.25, & \text{if } 0.25 < y_j \le 1, \\ 0.75 + (y_j - 1), & \text{if } 1 < y_j \le 1.25, \\ 1, & \text{if } y_j > 1.25. \end{cases} \tag{16}$$

On the other hand, if the MS is nearer to the BS/AP of C_j, the C_j will be more suitable as target cell. Therefore, the mobility factor considering the relative position, denoted by $M_{rp,j}$, is given by

$$M_{rp,j} = \begin{cases} 1, & \text{if } d_{r,j} \le r_{th,j}, \\ \frac{r_j - d_{r,j}}{r_j - r_{th,j}}, & \text{if } r_{th,j} < d_{r,j} \le r_j, \\ 0, & \text{if } d_{r,j} > r_j, \end{cases} \tag{17}$$

where $d_{r,j}$ is the distance between the BS/AP of C_j and the MS, r_j is the cell radius of C_j, and $r_{th,j}$ is the predefined threshold for $d_{r,j}$. Finally, the mobility factor M_j can be obtained by averaging $M_{dw,j}$ and $M_{rp,j}$; that is,

$$M_j = \frac{M_{dw,j} + M_{rp,j}}{2}. \tag{18}$$

C. Target Cell Selection Stage

The TCS stage chooses the cell with maximum utility value as the target cell for call request. If a candidate cell has a larger utility value, it means this cell has a higher probability to satisfy the QoS requirements for call request, maximize the number of accommodated calls, and minimize the number of handoff. Let j^* be the index of target cell in **C**. The target cell for call request, denoted by C_{j^*}, can then be obtained by

$$j^* = \arg \max_{1 \le j \le J} \{U_j\}. \tag{19}$$

IV. Simulation Results

A. Simulation Environment

In this simulation, the heterogenous network is considered to contain 7 subnetworks. The system parameters for the WCDMA, WMAN, and WLAN systems are listed in Table I. The wireless fading channel is composed of large-scale fading and small-scale fading. The large-scale fading is caused by path loss and shadowing effect, while the small-scale fading is caused by multipath reflection. The path loss is modeled as $128.1 + 37.61 \times \log d_{r,k}$ (dB) [11]. The shadowing from the BS/AP is log-normal with zero mean and standard deviation of 8 dB. The small-scale fading channel is simulated by the Jakes model [12]. Moreover, the channel is assumed to be fixed within one frame and varies independently from frame to frame.

There are four classes of traffic in the heterogenous network, conversational, streaming, interactive, and background. The models of these four traffic classes can be found in [11], [13], and [14]. The QoS requirements for each traffic class are listed in Table II. We define the call arrival rate, denoted by *CAR*, as the number of arrival calls per second. For each cell, the new call arrival rates of conversational, streaming, interactive, and background traffics are set to be *CAR*, *CAR*/3, *CAR*/3, and *CAR*/6, respectively.

TABLE I

SYSTEM PARAMETERS FOR THE WCDMA, WMAN, AND WLAN SYSTEMS.

Parameters	WCDMA	WMAN	WLAN
Cell radius	2 km	2 km	0.1 km
Frame (slot) duration	10 ms	5 ms	9 us
Carrier frequency	2 GHz	2.5 GHz	2.4 GHz
Number of cells	7	7	28
Loading intensity threshold ($\rho_{th,k}$)	0.85	1	0.85
Dwell time factor threshold ($x_{th,k}$)	0.05	0.05	0.2
The other cell to own cell interference ratio (η)	0.55	——	——
Number of subchannels (Z)	——	4	——
Number of subcarries per subchannel (q)	——	48	——
Number of OFDMA symbols per frame (N)	——	16	——
Capacity	2 Mbps	3.69 Mbps	11 Mbps

TABLE II

QOS REQUIREMENTS OF EACH TRAFFIC CLASS.

Traffic class	QoS requirement	Value
Conversational (Voice)	Required BER	10^{-3}
	Required E_b/N_0	4 dB
	Max. delay tolerance	40 ms
	Max. allowable packet dropping ratio	1 %
Streaming (Video)	Required BER	10^{-4}
	Required E_b/N_0	3 dB
	Max. delay tolerance	100 ms
	Max. allowable packet dropping ratio	1 %
Interactive (HTTP)	Required BER	10^{-6}
	Required E_b/N_0	2 dB
Background (FTP)	Required BER	10^{-6}
	Required E_b/N_0	1.5 dB

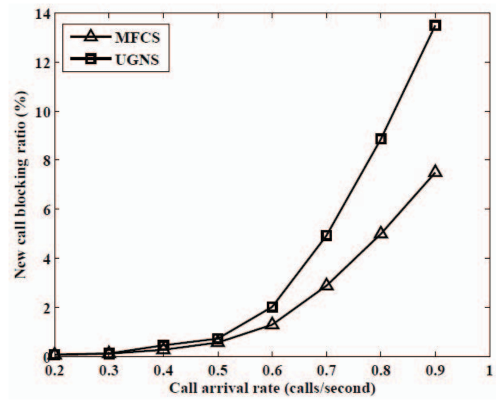

Fig. 3. New call blocking ratio.

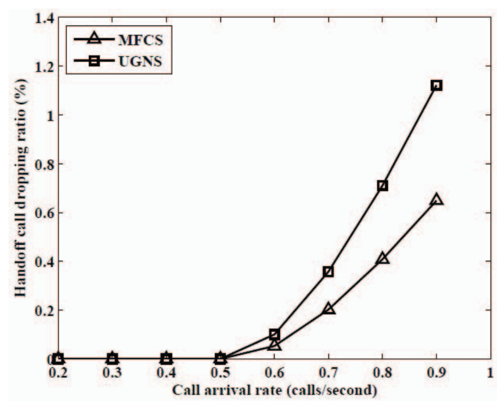

Fig. 4. Handoff call dropping ratio.

B. Performance Evaluation

The proposed MFCS scheme will be compared with the utility and game-theory based network selection (UGNS) scheme [6]. When a new call or handoff call arrives at the RNC, the UGNS scheme first chooses candidate cells by considering the signal strength constraint and network load constraint. It then calculates the utility value and preference value for each candidate cell based on the QoS satisfaction level and the cooperative game computation, respectively. Finally, the UGNS scheme selects the cell with the maximum linear combination of utility value and preference value as the most suitable cell for call request.

Figure 3 shows the new call blocking ratio versus the call arrival rate. When the call arrival rate is larger than 0.7, the MFCS scheme reduces the new call blocking ratio by more than 42.4 % as compared to the UGNS scheme. Reasons for this are as follows. In order to achieve the loading balance among candidate cells, the MFCS scheme assigns the call request to the cell, which can minimize the summation of cell loading difference, by using the loading factor. However, the UGNS scheme allocates the call request to the cell with the most resource. This might cause that non-real-time calls are blocked when the cell loading is close to the predefined threshold.

Figure 4 depicts the handoff call dropping ratio, which is defined as the probability that a call will be forced to terminate during the call holding time due to handoff. When the call arrival rate is larger than 0.7, the MFCS scheme decreases the handoff call dropping ratio by more than 44.4 % as compared to the UGNS scheme. The MFCS scheme utilizes the dwell time constrain to choose the cell with large dwell time. The MS with large dwell time may have enough time to complete handoff procedure. However, the UGNS scheme allows the high mobility MSs to enter and leave the WLAN cell quickly. Some of these MSs may have no enough time to complete handoff procedure due to contention and backoff.

Figure 5 presents the handoff occurring ratio, which is defined as the average of handoff that a call has experienced during the call holding time. The MFCS scheme reduces the handoff occurring ratio by more than 25.5 % as compared to the UGNS scheme. The reasons are given below. The MFCS scheme uses the dwell time constraint to exclude the cells with small dwell time and thus reduces the number of handoff. Moreover, the mobility factor in the MFCS scheme has a higher influence on the target cell decision than that in the UGNS scheme.

Figure 6 depicts the number of accommodated calls. The MFCS scheme increases the number of accommodated calls by 32.9 % as compared to the UGNS scheme. This is because the

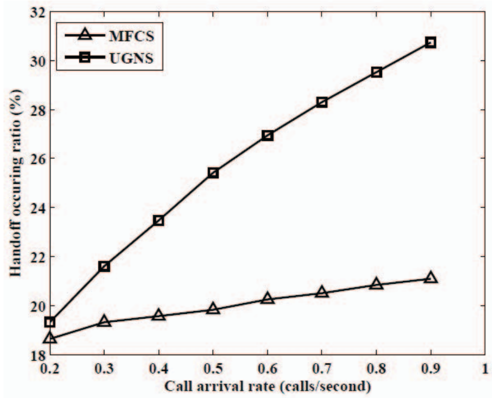

Fig. 5. Handoff occurring ratio.

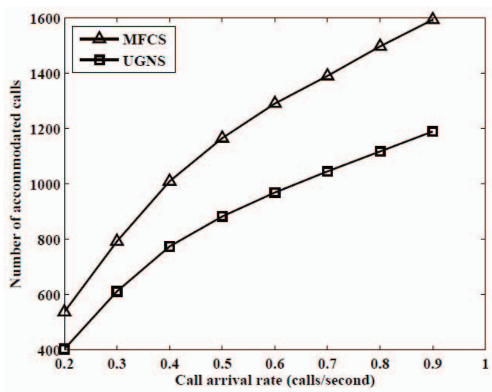

Fig. 6. Number of accommodated calls.

MFCS scheme has a lower new call blocking ratio and a lower handoff call dropping ratio than the UGNS scheme, as shown in Figs. 3 and 4, respectively. Therefore, the heterogenous network with the MFCS scheme can accommodate more calls than that with the UGNS scheme.

Figure 7 presents the overall system throughput. The MFCS scheme enhances the overall system throughput by 15.9 % as compared to the UGNS scheme. Since the MFCS scheme can accommodate more calls than the UGNS scheme, as shown in Fig. 6, this makes the MFCS scheme can transmit more data.

V. Conclusions

In this paper, we propose a multi-factors cell selection (MFCS) scheme for heterogeneous networks, where the multimedia traffic is considered. First, the MFCS scheme filters out unsuitable cells by checking the received signal strength constraint, cell loading constraint, and dwell time constraint. It then assigns utility values to candidate cells by considering the loading factor, QoS factor, and mobility factor. Finally, the MFCS scheme chooses the cell with maximum utility value as target cell for call request. Simulation results show that, when the call arrival rate is larger than 0.7, the MFCS scheme improves the new call blocking ratio and the handoff call dropping ratio by 42.4 % and 44.4 %, respectively, as compared to the UGNS scheme. Moreover, the MFCS scheme reduces the handoff occurring ratio by 25.5 % and enhances the overall system throughput by 15.9 % as compared to the UGNS scheme.

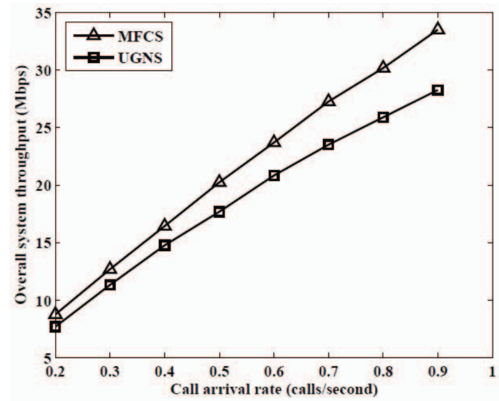

Fig. 7. Overall system throughput.

VI. Acknowledgments

This work was supported by the National Science Council of Taiwan, ROC, under contract number NSC 97-2221-E-009-098-MY3 and the Ministry of Education (MOE) under the Aiming for Top University plan.

References

[1] D. K. Kim, D. Griffith, and N. Golmie, "A new call admission control scheme for heterogeneous wireless networks," *IEEE Trans. Wireless Communications*, vol. 9, no. 10, pp. 3000-3005, Oct. 2010.

[2] W. Wang, X. Liu, J. Vicente, and P. Mohapatra, "Integration gain of heterogeneous WiFi/WiMAX networks," *IEEE Trans. Mobile Computing*, vol. 10, no. 8, pp. 1131-1143, Aug. 2011.

[3] F. Bari and V. C. M. Leung, "Automated network selection in a heterogeneous wireless network environment," *IEEE Network*, vol. 21, no. 1, pp. 34-40, Jan.-Feb. 2007.

[4] A. Sehgal and R. Agrawal, "QoS based network selection scheme for 4G systems," *IEEE Trans. Consumer Electronics*, vol. 56, no. 2, pp. 560-565, May 2010.

[5] X. Pei, T. Jiang, D. Qu, G. Zhu, and J. Liu, "Radio-resource management and access-control mechanism based on a novel economic model in heterogeneous wireless networks," *IEEE Trans. Vehicular Technology*, vol. 59, no. 6, pp. 3047-3056, Jul. 2010.

[6] T. L. Tsai, C. J. Chang, and Y. H. Chen, "Utility and game-theory based network selection scheme in heterogeneous wireless networks," *IEEE WCNC*, pp. 1-5, Apr. 2009.

[7] H. Holma and A. Toskala, *WCDMA for UMTS*, John Wiley and Sons, Ltd, 2004.

[8] IEEE Std. 802.16e, "IEEE standard for local and metropolitan area networks part 16: Air interface for fixed broadband Wireless access systems amendment for physical and medium access control layers for combined fixed and mobile operation in licensed bands," Oct. 2005.

[9] G. Ning, G. Zhu, Q. Li, and R. Wu, "Dynamic load balancing based on sojourn time in multitier cellular systems," *IEEE VTC*, vol. 1, pp. 111-116, May 2006.

[10] IEEE Std 802.11$^{\text{TM}}$-2007, "IEEE standard for wireless LAN medium access control (MAC) and physical layer (PHY) specifications: MAC sublayer functional description," June 2007.

[11] 3GPP TR 25.892, "Feasibility study for OFDM for UTRAN enhancement," 3rd Generation Partnership Project, Tech. Rep., 2004.

[12] G. L. Stüber, *Principles of Mobile Communication,* Kluwer Academic Publishers, 2000.

[13] 3GPP TS 23.107, "QoS concept and architecture," 3rd Generation Partnership Project, Tech. Spec., 2007.

[14] ETSI TR 101 112, "Selection procedures for the choice of radio transmission technologies of the UMTS," ETSI Tech. Rep., 1998.