RELAY SELECTION AND SCHEDULING SCHEME IN MOBILE WIRELESS CELLULAR NETWORK

Hoang Xuan Thiem, Mui Van Nguyen, Choong Seon Hong, Sungwon Lee
Department of Computer Engineering, Kyung Hee University

E-mail: thiemhoangvn@gmail.com, {nvmui, cshong, drsungwon}@khu.ac.kr

Abstract

In this paper, we consider relay selection problem for two-tie mobile wireless networks for remote Macro cell User Equipments (MUEs). In order to maximize throughput of the system, MUEs perform the Femtocell Base Station (FBS) selection to find the best that achieves the highest end-to-end Signal-to-Noise Ratio (SNR). In this regard, we propose a selection scheme in which each timeslot is divided into three phases so that two first phases is reserved for relay and the chosen FBS will transmit its own data on the last phase.

I. Introduction

Demand for high data rate communication in wireless networks such as LTE, Wimax, HSPA,… is dramatically increasing. However, remote MUEs couldn't have transmitted successfully their data to Macro cell Base Station (MBS) because of severe fading. Nowadays, wireless communication Wi-Fi Mesh Network (WMN) [1], [2], [3], [4] which has been developing provides some distributed services with high data rate. In order to improve its performance compared with such a WMN, Femtocell plays an important role in helping MUEs to relay to MBS with some technologies including frequency reuse and cooperation. So that mobile service cellular data system can compete with WMN in terms of high data rate. In this paper, we consider the mobile wireless system with a MBS serving some remote MUEs and several FBSs distributed around MBS.

When a MUE is very far from MBS, it must increase its power to keep ongoing communication out of outage with MBS. This will cause more interference to other terminals in the system and as a result MUE spends more energy. In this paper, we propose a solution that there is a FBS to relay signal from MUE to MBS. This mechanism brings more spectrum opportunities for femtocells in transmitting their data into the third phase of each time slot.

II. System model

We consider the mobile wireless system as shown in Figure 1. Some of Femtocells belong to a Macro cell. In this model, femtocell will relay signal from Macro-User Equipment (ME) to Macro cell-BS (MBS) to increasing data rate uplink from ME.

In this model, we propose that time is divided into slots as illustrated in Figure 2 and each slot includes 3 phases. The first phase, denoted by T_1, is the time for MUE to transmit to the best FBS while the second phase, denoted by T_2, is the time for the chosen FBS to transmit to MBS using AF. The third phase, denoted by $T_{3,}$ is the time for FBS to transmit to its users.

We assume that during T_1 and T_2 the transmit power is very enough low so that the other FBSs can still have chance to transmit its data. In this regard, FBSs in the system must compute if their transmission can cause an excess interference to ongoing communications. Then, those FBSs which don't affect the ongoing communications during T_1 and T_2 and achieve the highest throughput will be scheduled to transmit. Thereby, the overall throughput will significantly increase.

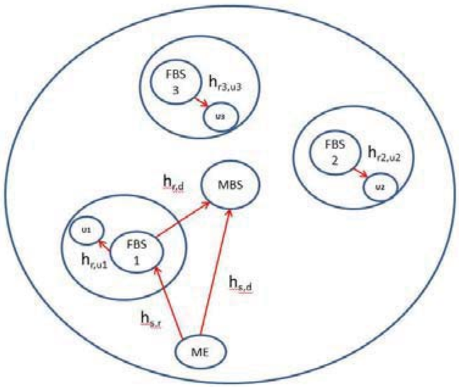

Figure 1: An example of two-tie wireless networks

III. Relay selection and Scheduling Scheme

1. Relay selection

In this case, MUE is too far from MBS and need a FBS to relay its data for increasing uplink rate as well as save its energy. As aforementioned, this system has many FBSs co-exist with MBS, and MUE must be chosen one of them for relay work. In order to select a best one, we compare the value end-to-end sink SNR value from MUE to MBS via FBS_i.

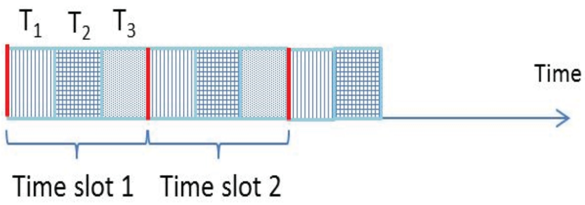

Figure 2: Cooperation structure of time

Received signal at FBS is $y_r = h_{s,r}x + n_r$ where $h_{s,r}$ is channel coefficient of the link ME to FBS, and n_r is additive white Gaussian noise (AWGN). And received signal at MBS is $y_d = Gh_{r,d}h_{s,r}x + G\, h_{r,d}\, n_r + n_d$ where n_d is AWGN at MBS.

According to [5], end-to-end SNR can be computed by:

$$\gamma d = \frac{G^2 |h_{r,d}|^2 |h_{s,r}|^2 P_S}{G^2 |h_{r,d}|^2 N_0 + N_0}$$

We compare end-to-end SNR γ_d to all of FBSs in the system and select the best FBS with the highest SNR.

2. Femtocell Scheduling

2.1 Phase T_1 is the time ME transmit to the selected FBS and the others are free. In this case, all of remain FBSs have chance to transmit their data. To guarantee the QoS of transmit from MUE to selected FBS the power of other FBSs must be limited and interference from other FBS transmission to selected FBS must be less than threshold ϵ. Interference from FBS_i to selected FBS can compute by $I = h_{s,i}\, P_i$ with $h_{s,i}$ is the channel coefficient of the link FBS i to selected FBS. With above formula, we compute interference I and we can select a list of candidate FBSs have chance to transmit to theirs users at phase T_1 based on interference threshold ϵ. To maximize utility of spectrum is the responsibility of femtocell in the list of candidate of FBSs. We thus select one of FBSs, which have highest capacity to maximum system throughput.

Capacity of FBS is computed by Shannon formula [6], [7], [8],[9], [10]:

$$C = Blog_2(1 + SNR)$$

We assume that there are m FBS in the system and W is the group of candidate FBSs which have chance to transmit data to its users. We further assume that there are n users in W. Femtocell Scheduling algorithm is described as follows:

```
Cmax=0;
For I = 1 to m-1;
    Ii = hs,i Pi;
    If Ii < ϵ;
            Channel I added to set W;
    Else
            I = I +1;
    End if
End for
For   j = 1 to n;
    Cj = Bj log2(1+SNRj);
    If   Cj − Cmax > 0;
            Cmax = Cj ;
            j = j + 1 ;
    End
End for
```

We run this algorithm to select the best FBS simultaneously transmit their data with the main transmission from MUE to the selected FBS in the phase T_1. In this phase T1, there are have two transmissions in the system, hence it can increase the capacity the overall throughput.

2.2 Phase T_2 is the time for transmission from selected FBS to MBS. In this time, it is similar to the phase T_1, the other FBSs also compete for a chance for transmission their data. In this phase, receiver is MBS, so that if others FBS want to transmit there data to its users, the power of the transmission must be limited for maintaining the ongoing links' QoS.

In phase T_2, we also compute interference from the other FBSs to MBS and choose the best one to maximize system capacity. In this regard, we run scheduling algorithm 1 to find the best FBS with an interference $I_i = h_{m,i}\ P_i$ where $h_{m,I}$ is the link coefficient from FBS_i to MBS.

2.3 Phase 3 is the time for the relay FBS to transmit to its users. This is a spectrum opportunity after finishing the relay task.

During phase T1 and T2, remaining femtocell can transmit their data in a limited power in order to protect ongoing communication from interference.

However, transmission inside femtocell with short distance will distribute a high value to total.

IV. Numerical Results

We evaluate the capacity of the system with and without relay to demonstrate that best effect of femtocell relay on the total throughput of mobile wireless cellular system.

In order to numeric capacity of system, the model has one MBS locates at (0,0), and there are five FMSs allocate around MBS allocate at [30 40; 50 40; 50 70; 30 60; 40 60], and we calculate capacity of system when MUE move far from MBS with ten different locations following [10 5; 20 20;30 20;30 30;40 30; 60 30;50 50; 70 40; 80 40; 90 40]. We assume that power of MUE is constant and equal 0.01w, bandwidth of channel is 0.5 MHz, Additive White Gaussian noise is 10^{-10} and threshold of SNR from MUE to MBS is 50.

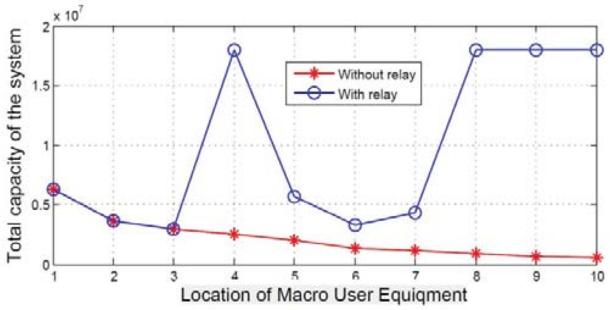

Figure 3: Capacity of the system

When MUE move far from MBS follow the predefined location, capacity of system is decreasing because of fading. In order to keep high data rate communication between MUE and MBS, we must use FBS to relay MUE's signal. According to numerical result on Figure 3, when MUE uses FBS to relay its data, the capacity of the system increasing although MUE continue move far from MBS. Moreover, the increasing of capacity because each time slot divide into 3 phases so that the remaining FBS can transmit their data simultaneously with ongoing communication during period T1 and T2 Thereby, the overall throughput will significantly increase.

V. Conclusion

This paper contribute to wireless cellular network another TDMA mechanism for transmitting to reach higher capacity and give more chance for secondary user can transmit their data. In this paper, we just concerned on one MUE in system for first part of this model. In the future, we will continue to develop this model with multiple MUEs and dynamic period phases.

VI. Acknowledgement

"This research was funded by the MSIP(Ministry of Science, ICT & Future Planning), Korea in the ICT R&D Program 2013". Dr. CS Hong is the corresponding author.

REFERENCES

[1] V. Chandrasekhar and J. G. Andrews, “Femtocell Networks: A Survey” IEEE Communications Magazine, Vol. 46, Iss. 9, September 2008.

[2] Ying Li ; Maeder, A. ; Linghang Fan ; Nigam, A.; Chou, J. “Overview of femtocell support in advanced WiMAX Systems” IEEE Communications Magazine, Vol.49, Iss.7 July 2011.

[3] M. V. Nguyen, C. S. Hong, S. Lee; “Cross-Layer Optimization for Congestion and Power Control in OFDM-Based Multi-hop Cognitive Radio Networks”; IEEE Transactions on Communications, vol. 60, no. 8, pp. 2101-2112, August 2012.

[4] M. V. Nguyen, C. S. Hong, S. Lee; “Joint Rate Adaption, Power Control, and Spectrum Allocation in OFDMA-Based Multi-hop CRNs”; IEICE Transactions on Communications, vol. E96-B, no. 01, Jan. 2013.

[5] T.Q. Duong, V.N.Q. Bao and H. J. Zepernick “Exact outage probability of cognitive AF relaying with underlay spectrum sharing” ELECTRONICS LETTERS, vol. 47, no. 17, August 2011.

[6] M. V. Nguyen, C. S. Hong; “Interference-Dependent Contention Control in Multi-hop Wireless Ad-hoc Networks: An Optimal Cognitive MAC Protocol”, Proceeding IEEE ICC 2013, 9-13 June 2013, Budapest, Hungary.

[7] M. V. Nguyen, C. S. Hong, L. B. Le; “Cross-Layer Cognitive MAC Design for Multi-hop Wireless Ad-hoc Networks with Stochastic Primary Protection”, Proceeding of IEEE WCNC 2013, 7-10 April 2013, Shanghai, China.

[8] M. V. Nguyen, T. Q. Duong, C. S. Hong; “Joint Optimal Rate, Power, and Spectrum Allocation in Multi-hop Cognitive Radio Networks”, Proceeding of IEEE ICC 2012, Ottawa, Canada, June 10-15, 2012.

[9] M. V. Nguyen, T. Q. Duong, C. S. Hong, S. Lee, Y. Zhang; “Optimal and Sub-Optimal Resource Allocation in Multi-hop Cognitive Radio Networks with Primary User Outage Constraint”; IET Networks, vol .1, no. 2, pp. 47-57, June 2012.

[10] C. T. Do, N. H. Tran, M. V. Nguyen, C. S. Hong, S. Lee, "Social Optimization Strategy in Unobserved Queueing Systems in Cognitive Radio Networks"; IEEE Communications Letters, vol. 16, no. 12, Dec. 2012.