VOL. 10, NO. 2, FEBRUARY 2015 ISSN 1819-6608

ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

HARD HANDOVER OPTIMIZATION USING TIME WINDOW BASED HANDOVER ALGORITHM

Nagy F. Merghani[1], Rania A. Mokhtar[1], Raed A. Alsaqour[2] and Rashid A. Saeed[1]
[1]College of Engineering, Sudan University of Science and Technology (SUST), Khartoum, Sudan
[2]School of Computer Science, Faculty of Information Science and Technology, Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia
E-Mail: raed.ftsm@gmail.com

ABSTRACT

This paper shows and solves a handover problem occurring with current power control mechanisms in co-channel Wideband Code Division Multiple Access (WCDMA) heterogeneous networks. The problem is the mismatch between the required uplink transmits power when a user is communicating to a small cell and an underlying microcellular base-station. This paper introduces Time Window Handover (TWHO) algorithm to adapt the transmit power of the small cell users during the handover regime to prevent such Signal to Interference plus Noise Ratio (SINR) drops.

Keywords: femtocells, small cells, handover optimization, uplink power control, WCDMA, co-channel operation, heterogeneous networks.

INTRODUCTION

With the massive growth in mobile data applications and resultant broadband traffic has placed severe pressure on mobile operators. But simply, 3G networks are completely overloaded, especially in high-density environments such as urban centers, transport hubs and public locations [1]. Today, with network capacity being stretched to the limit, causing degradation in the service experience for millions of users and Signal to Interference Ratio (SIR) falling, the mobile operators must adopt a new network model such as small cells. Since small cells are considered as an integrated part of the operators' network, seamless handovers between the small cells and the underlying macrocell network is considered as a key advantage when compared against other alternatives such as WiFi-based solutions. Additionally, while operating small cells on a dedicated frequency is a pragmatic possibility, co-channel operation with an existing macrocellular network is technically far more challenging, but is also more rewarding for the operators due to the potentially significantly increased spectral efficiency through spatial frequency re-use [2].

This paper introduces a challenging problem that is associated to the power control mechanism during the handovers between the co-channel small cells and macrocells in WCDMA networks. As confirmed by simulations, if not addressed appropriately, the problem can result in significant performance degradation and major increase of dropped calls during handovers. As a result, a practical solution for adapting the power control mechanism is introduced and evaluated through a simulation study. Existing literature has been mainly focused on optimization of soft-handovers for traditional macrocell networks without addressing the issues related to the emerging heterogeneous networks [3, 4]. Park et al. in [5] proposed a power control scheme during soft-handovers to reduce the error rate of downlink power control commands. Similarly, Tamilselvan in [6, 7] introduced downlink power control method for soft handover regimes in that the power of each base-station in the active set is proportional to the radio channel between the user and base-stations. Finally, a modified signaling flow when handovers between small cells and macrocells is introduced in [8].

In WCDMA, the uplink inner-loop power control adjusts the User Equipment (UE) transmit power, PUE, in order to keep the received uplink SIR on that frequency at a given SIR Target SIRT). The base-station estimates the SIR of the received uplink Dedicated Physical Control Channel (DPCCH). Then, it generates Transmit Power Control (TPC) commands and transmits the commands to the UE once per time slot. Normally, the TPC commands are binary quantities that are set to '1' if SIR < SIRT and to '0' otherwise.

In hard handover, after the UE establishes a connection to the new cell, it adjusts its power using the open loop power control to communicate to the target cell. The UE's initial transmission consists only of the DPCCH. The details of the initial power configuration after the handover are described in [9]. Adapting the UE's transmit power in that way is not problematic in traditional networks, consisting only of macrocells. The reason for that is because the UE's transmit power is not expected to vary radically after the handover, that itself is due to insignificant difference between the path-loss from the source and target macrocell Node-Bs. In addition, since macrocells are usually serving relatively large number of users compared to small cells, the increase of a single user's transmit power may not significantly vary the overall interference at a neighboring base-station.

The situation is slightly different when considering soft handovers. When the user is already connected to all base-stations in the active set, its transmit power is continuously modified through inner-loop control. Since the conservative power control keeps the transmit power of users at a minimum level during the soft handover regime, once the link to the serving small cell base-station is removed, the UE will suddenly need to increase its power. Given that the inner-loop power control modifies the transmit power in small steps, it may take a while before the UE can reach an appropriate power level and hence degradation of the user's Quality of Experience (QoE) and dropped calls are possible. While, the solution proposed in this paper addresses the problem associated to hard, the paper focus mainly on the hard handover case since currently there is no soft-handover support in most small cells products [9].

PROBLEM FORMULATION

The recent advancement of femtocell technology has emerged in cellular wireless networks and rapidly taken its place in the cellular industry. The principle of femtocell is to reduce the network operation cost as well as extend indoor coverage, which is also considered as a promising path way toward the Fixed Mobile Convergence (FMC) goal. Femtocell intends to serve a small number of users, i.e. four users with the coverage of approximate thirty meter square similar to existing WiFi access points [10].

For heterogeneous networks, small cells are deployed within the coverage area of macrocells as shown in Figure-1, if user move from femtocell to macrocell, this user increase its power to performed handoff to serving the macrocell.

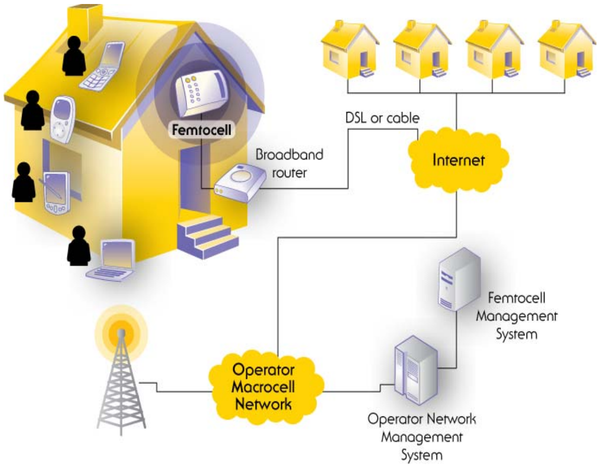

Figure-1. Macrocell network.

In WCDMA, handovers are assisted by measurement reports from UEs. The common measurement quantity that is used to trigger handover events is CPICH Ec/No. Once the CPICH Ec/No quantity associated to the small cell falls below that of the macrocell by at least a Handover Threshold (HT) and stays there for a minimum of a Time to Trigger (TTT) period, the handover occurs. Over time, the small cell base-station is capable of estimating the Ec/No level at which handovers are performed as shown on Figure-2.

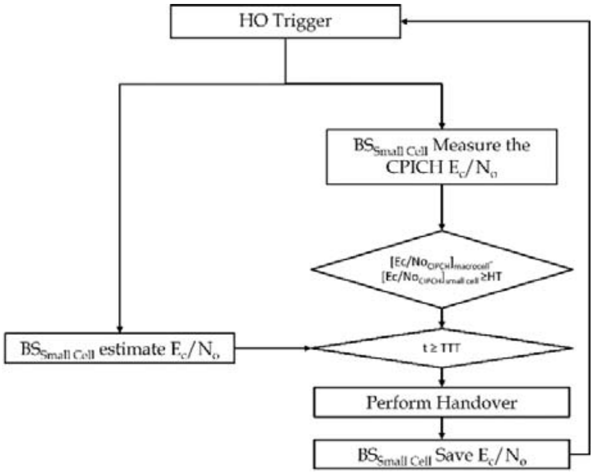

Figure-2. WCDMA handover flowchart.

We refer to this quantity as the Handover Ratio (HR). By introducing another threshold level as 'Potential Handover Threshold (PHT), the small cell base-station can be prepared to face a likely handover. The Critical Ratio (CR) is then defined as

$$CR = HR + PHT \tag{1}$$

If no handover is performed, the user introduces significant uplink interference to the remaining small cell users.

TIME WINDOW BASED HANDOVER (TWHO) ALGORITHM

In practice, once the CPICH Ec/No falls below CR, the small cell base-station records the current transmit power of the UE noted as P_{start}. It then commands the UE to adjust its power level P_{UE} such that by the time of the handover, the UE is already at the approximate power level required to communicate to the target macroell base-station as shown on Figure-3. We shall refer to this power level as P_{target}. In this way, the small cell base-station assures that significant rise of the transmit power and sudden decrease of the SIR for the existing small cell users are avoided. Moreover, P_{target} does not need to be estimated accurately as the finer inner-loop power control mechanism after the handover will adjust any offset. P_{target} can be simply estimated by the small cell base-station or more accurately by the UE via path-loss estimation to the target macrocell. Ideally, the users transmit power, P_{UE}, should be set to P_{target} when CPICH Ec/No equals HR (i.e. when handover is executed).

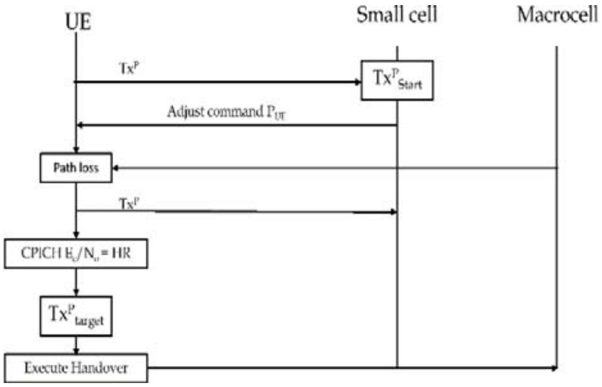

Figure-3. Practical handover flowchart.

To avoid unnecessary increase of the transmit power; a timer is activated after the CPICH Ec/No falls below the CR threshold. Then, if no handover is performed within a predefined time-window, T_w, the power control will gradually be set back to its normal procedure and the timer is reset, this allows static users at the edge of the small cell coverage to transmit at their normal power and eliminates the need for unnecessary power increase. Figure-4 shows the procedure of TWHO algorithm.

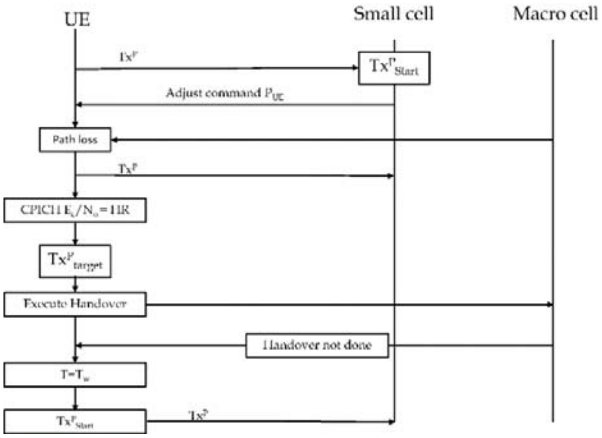

Figure-4. TWHO algorithm flowchart.

In Open loop power control, UE use the below equation to adjust its power:

$$P_{UE} = P_{Offset} - CPICH\,(RSCP) \tag{2}$$

where P_{UE} is the user equipment power and P_{offset} is Power Offset

$$P_{offset} = \\ CPICH^{Tx}_{power} + UL_{inter} + SIR + 10log\,(SF) \tag{3}$$

In this paper UE use the below equation to adjust its power:

$$P_{UE} = \left(\frac{P_{target} - P_{start}}{PHT}\right)\left(CR - \frac{\mathrm{Ec}}{No}\right)^{m} + P_{start} \tag{4}$$

where Ec/No is the carrier energy to noise density and its equal to:

$$\frac{E_c}{N_0} = RSCP - RSSI \tag{5}$$

where the uplink interference UL_{inter} is:

$$UL_{inter} = RSCP_{U1} + RSCP_{U2} + \ldots + RSCP_{U3} \tag{6}$$

And the CPICH received code power:

$$CPICH\,(RSCP) = CPICH^{Tx}_{power} - PL \tag{7}$$

where SF is the spreading factor, m is the mapping order
The small cell path loss:

$$PL_{SC} = 30.52 + 36.7\log(d) \tag{8}$$

The macrocell path loss:

$$PL_{MC} = 11.81 + 38.6\log(d) \tag{9}$$

Finally, the signal to interference ratio of one the remaining users:

$$SIR = \frac{RSCP}{ISCP} + SF \tag{10}$$

SIMULATION SETTING AND RESULTS

In this paper, we compare between the SIR of one of remaining user that use the open loop power control and SIR of one of remaining user that use the TWHO algorithm.

The simulation scenario was built with small cell radius about 30m and there are three users noted as User 1 (u1), User 2 (u2) and User 3 (u3), respectively. When one of these users move from small cell to macrocell, a drop happened in the value of SIR of the remaining users according to power increment if handover is not performed.

When u2 move from small cell area to macrocell area, this user must handoff to serve macrocell Based Station (BS). Here, if handover is not performed, u2 cause interference to the other users, we calculate the

SIR of u1 to show the performance when we apply open loop PC and when we apply TWHO algorithm.

Open loop PC

Here we use first open loop PC mechanism to show the effect of handover problem on SIR of u1. Figure-5 show that the SIR of u1 in open loop PC fall down (when u2 is the user that causes interference to other users) moves out to macro and come back.

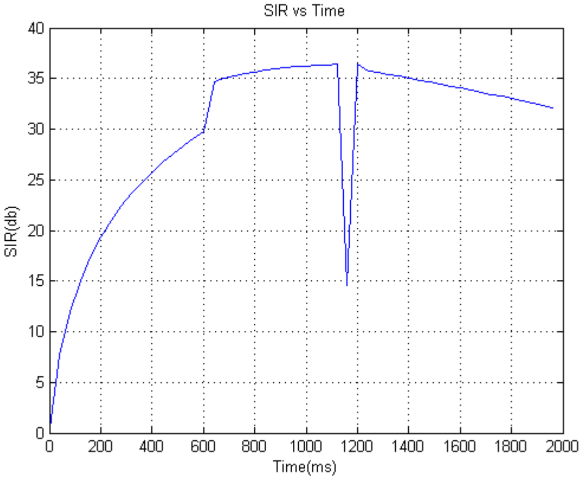

Figure-5. SIR of open loop PC.

TWHO algorithm

Here, TWHO algorithm was used to show the effect of handover problem on SIR of u1 on different Time Window (TW) as shown in Figure-6 (TW = 70ms), Figure-7 (TW = 190ms) and Figure-8 (TW = 10us).

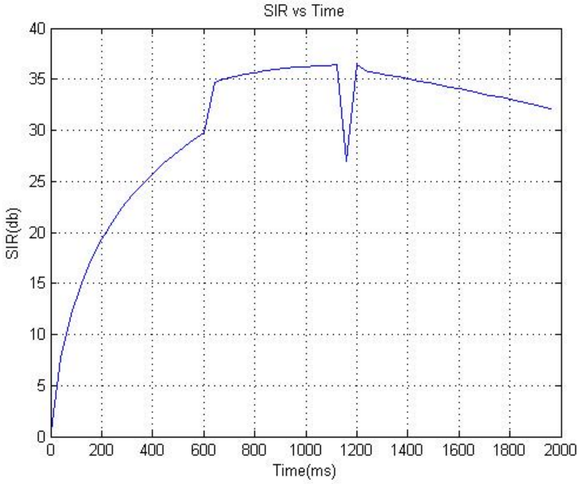

Figure-6. SIR of TWHO (TW = 70ms).

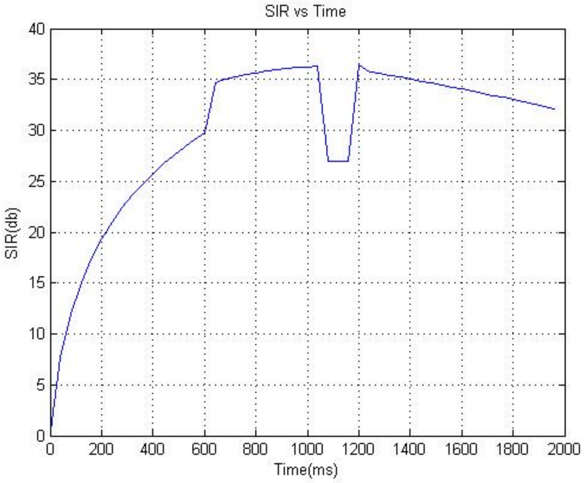

Figure-7. SIR of TWHO (TW = 190ms).

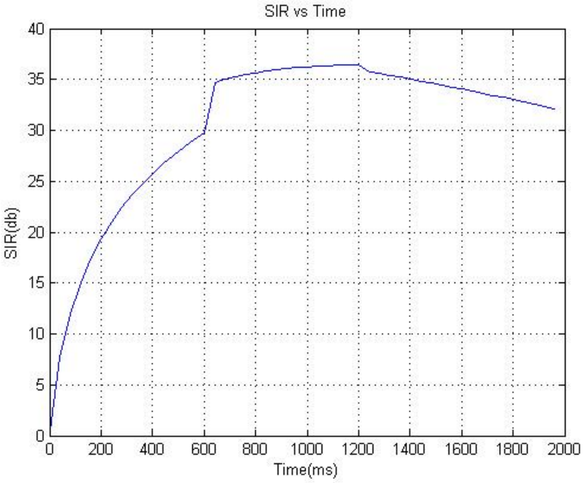

Figure-8. SIR of TWHO (TW=10us).

The SIR in TWHO algorithm reduce uplink interference to the remaining small cell users when applying short time window (TW), the uplink interference to the remaining small cell users effect increase with TW decrease and vice versa. In Figure-7, u1 SIR drop until 190ms (TW=190ms), this long time may be causing drop to the call, by decrease TW as shown on Figure-6 (TW=70ms) and 8 (TW=10us) the drop of SIR take short time, this time has a legal effect on SIR value.

CONCLUSIONS

This paper investigates a handover problem occurring with current power control during the handover for the co-channel WCDMA heterogeneous networks. The problem is associate with the mismatch between the required uplink transmit power when a user is communicating to small cell and an underlying microcellular base-station. It was shown that the sudden increase of transmit power after the handover causes severe degradation of uplink SINR for existing small cell users.

ACKNOWLEDGEMENT

The authors gratefully acknowledge the support of this work by the Centre for Research and Instrumentation Management (CRIM), University Kebangsaan Malaysia UKM), Malaysia. Grant numbers: FRGS/1/2012/SG05/UKM/02/7 and UKM-GUP-2012-089.

REFERENCES

[1] M. Tolstrup. 2011. Indoor Radio Planning: A Practical Guide for GSM, DCS, UMTS and HSPA and LTE: John Wiley and Sons.

[2] H. Claussen. 2007. Performance of macro-and co-channel femtocells in a hierarchical cell structure. In: IEEE 18th International Symposium on Personal, Indoor and Mobile Radio Communications, PIMRC 2007. pp. 1-5.

[3] I. Forkel, M. Schinnenburg and B. Wouters. 2003. Performance evaluation of soft handover in a realistic UMTS network. In: The 57th IEEE Semiannual Vehicular Technology Conference. VTC 2003-Spring. pp. 1979-1983.

[4] C. Werner, J. Voigt, S. Khattak and G. Fettweis. 2007. Handover parameter optimization in WCDMA using fuzzy controlling. In: IEEE 18th International Symposium on Personal, Indoor and Mobile Radio Communications, PIMRC 2007. pp. 1-5.

[5] S. Park, D. K. Sung, C. S. Kang and S. M. Shin. 2001. Uplink transmit power control during soft handoff in DS/CDMA systems. In: IEEE VTS 53rd Vehicular Technology Conference, 2001. VTC 2001 Spring. pp. 2913-2917.

[6] S. Tamilselvan, N. Thyagarajeswara Naidu and K. Manivannan. 2008. Optimization of SHO margin in WCDMA network. In: Annual IEEE India Conference, 2008. INDICON 2008. pp. 333-337.

[7] S. Tamilselvan and K. Manivannan. 2010. Optimisation of soft handoff margin in WCDMA cellular system. International Journal of Communication Networks and Distributed Systems. 4: 254-264.

[8] S. Yi, S. Chun, Y. Lee, S. Park and S. Jung. 202. Radio Resource Control (RRC). Radio Protocols for LTE and LTE-Advanced. pp. 47-85.

[9] R. Razavi, C. Androne and H. Claussen. 2012. Handover optimisation for co-channel WCDMA heterogeneous networks. In: 2012 IEEE 23rd International Symposium on Personal Indoor and Mobile Radio Communications (PIMRC). pp. 905-909.

[10] M. K. Hasan, R. A. Saeed, A. H. A. Hashim, S. Islam, R. A. Alsaqour and T. A. Alahdal. 2012. Femtocell Network Time Synchronization Protocols and Schemes. Research Journal of Applied Sciences, Engineering and Technology. 4: 5136-5143.