POWER ALLOCATION WITH AND WITHOUT SOFT HANDOVER ON THE DOWNLINK INTERFERENCE OF WCDMA NETWORK

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Abstract: *Power control is one of the technologies used to utilize the radio resources as efficient as possible in WCDMA network. The transmission power is adjusted to transmit with the lowest power level possible while the required received signal quality is maintained. Since there is large variation in channel quality over time, the power has to be adjusted to compensate for these variations. During moments of bad channel conditions a high transmission power has to be used which will to a greater extent interfere with other users in the system. This work emphasis relative down link power measurement at various distances and various angles under various radio environment conditions. Also calculate required the down link power by both with and without soft handover condition.*

Key Words: *Wideband Code Division Multiple Access (WCDMA), Base Stations (BSs), Soft Hand Over (SHO), Radio Resource Management (RRM), and Quality of Services (Q_0S).*

1. Introduction

A mobile radio network has to guarantee, together with the functions strictly related to the set up and to the drop of radio channels, a set of functionality, which takes into account the user mobility. The main requirement is to ensure continuity to connections, despite of situations of discontinuity due to cellular coverage [1]. Handover deals with the mobility of the end users in mobile network and it guarantees the continuity of the wireless services when the mobile user moves across the cellular boundaries. This provides the link level performance analysis of soft handover in terms of total power consumption and required down link power for a user is measured with soft handover and without soft handover at various radio environment. If power requires less at soft handover state, then interference created by this user for other user is decreased in so handover state [2]. Quality of services is very important for mobile users. This work describes the effect of soft handover on Q_oS. WCDMA is intended for wideband multimedia services and support for bit rates of at least 384 kbit/s with good coverage and full mobility. Up to 2 Mb/s can be supported with one 5 MHz carrier with local coverage. The access scheme of WCDMA is Direct-Sequence Code Division Multiple Access (The name “direct sequence CDMA” means that a code sequence is directly used to modulate the transmitted radio signal) with information spread over approximately 5 MHz bandwidth. The basic chip rate is 3.84 Mcps which leads to a carrier spacing of around 5MHz. There is a flexible carrier spacing in order to allow for different carrier spacing dependent on the actual need for separation [3, 5]. This work investigate relative down link power measurement by both with and without soft handover condition. The calculations are based on certain assumptions, chosen as realistic as possible.

2. Soft Handover Effects on Downlink Interference

Interference is the term for signal power that interferes with our signal. To guarantee the QoS, the BS needs to allocate the proper amount of power to each mobile to compensate for the interference. If the mobile is not in soft handover status, as mobile 1 shown in Fig.1 (a) one downlink channel is set up interference between the mobile and its serving BS1 according to the service requirement and the total downlink

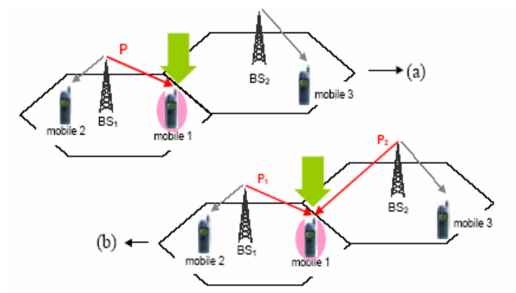

Fig. 1 Soft hand over effects on the downlink

interference received by mobile 1 (which is denoted by I_0) power (p) is allocated to the downlink channel between the mobile and BS1. This channel acts as interference source for other users. This channel acts as intra-cell interference and inter-cell interference to mobile 2 and mobile 3 respectively [1].

If mobile 1 is in soft handover status, it communicates with BS_1 and BS_2 simultaneously. Two downlink dedicated channels are set up to support the soft handover, as shown in Fig. 1(b). Let P_1 and P_2 represent the power allocated to channels from BS_1 and BS_2 separately and P_1 and P_2 both are source of interference of other users. P_1 acts as intra-cell interference to mobile 2 and inter-cell interference to mobile 3 and P_2 acts as inter-cell interference to mobile 2 and intra-cell interference to mobile 3.

Comparing the two cases, soft handover effects on the downlink interference are quite complicated. Without soft handover, mobile 1 contributes power (P) to the total downlink interference. With soft handover, the total contribution is the sum of P_1 and P_2. The increment of the interference due to mobile 1 has influence on all the other active mobiles within the system: all these mobiles need to adjust their channel power to meet the change in the interference. This, in return, changes the total interference received by mobile 1, resulting the alteration of P or P_1 and P_2 (SHO case). This circulation repeats until the system reaches a new balance. In CDMA systems, power control is the functionality responsible for this adjustment. Because of the interference limited feature, experiencing less interference is always the main principle of the radio resource allocation in CDMA systems. Therefore, whether soft handover leads to lower interference than the conventional hard handover or not, depends intimately on the value of P, P_1 and P_2. These powers are related to certain facts, such as the location of the mobile, the radio attenuation [1].

3. Downlink Power Allocation

Power allocation is a very important procedure for WCDMA cellular systems. The total transmits power of the BS is composed of two parts. One part is for the downlink common control channels, such as the common pilot channel (CPICH) and the synchronization channel (SCH) and other part power is allocated for users as dedicated downlink channels.

Normally, the power for common control channels represents about 20-30% of the total BS transmits power. In order to minimize the interference and the radio resource consumption, the system tries to allocate as little power as possible to each dedicated channel for individual users, but this does depend on the Q_oS requirement. Under perfect downlink power control, the received bit energy-to-interference power spectral density ratio E_b/I_0 of all mobiles is kept at the target value. When the mobile is only linked to one BS, only one downlink dedicated channel is active to this mobile, but when the mobile is in soft handover status, at least two BSs are involved in the power allocation. These two situations are analyzed below separately [1].

3.1 Power Allocation without SHO

Consider the mobile located at (r_1,θ_1) shown in Fig. 2. Without soft handover, the mobile only communicates with one BS at a time.

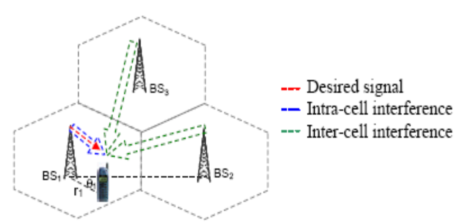

Fig. 2 Downlink interference

Assuming BS_1 is its serving BS, the mobile received E_b/I_0 can be expressed as:

$$\frac{E_b}{I_0}=\frac{W}{VR}\frac{P_s r_1^{-\alpha}10^{\zeta_1/10}}{P_{T1}(1-a)r_1^{-\alpha}10^{\zeta_1/10}+\sum_{i=2}^{19}P_{Ti}r_i^{-\alpha}10^{\zeta_i/10}} \quad .... (1)$$

Where, W is the chip rate; R is the service bit rate and v is the activity factor; Here, the thermal noise is ignored. Thus, in order to keep the QoS meeting the target, the required transmit power of the downlink channel Ps can be derived from equation (1) as:

$$P_s = \frac{VR}{W}\left(\frac{E_b}{I_0}\right)\left[P_{T1}(1-a) + \sum_{i=2}^{19} P_{Ti}\left(\frac{r_i}{r_1}\right)^{-\alpha} 10^{(\zeta_i-\zeta_1)/10}\right] \quad ..\ (2)$$

W same assumptions of the last section that the load is distributed evenly across the system, all BSs here $(E_b/I_o)t$ is the target value of E_b/I_0. The value of $(E_b/I_0)t$ is decided by RNC [1]. Using the same assumption amount of power (Ps) can then be rewritten as:

$$P_s = \frac{VR}{W}\left(\frac{E_b}{I_0}\right)_t \left[1-a+\sum_{i=2}^{19}\left(\frac{r_i}{r_1}\right)^{-\alpha} 10^{(\zeta_i-\zeta_1)/10}\right]\cdot P_T = \beta_1 \cdot P_T \ldots.\ (3)$$

Factor β_1 shows the relative strength of the required power for the mobile located at (r_1,θ_1) without soft handover [1].

3.2 Power Allocation with SHO

When a mobile is in the soft handover status, all the BSs in the active set needs to allocate proper power for the downlink channels linked to this mobile. Here, 2-way soft handover are considered.

With 2-way SHO, assuming BS_1 and BS_2 are the mobile's serving BSs, the desired signals from the two BSs are combined together. Different combining schemes can be used, but here, maximal ratio combining is considered here. The received E_b/I_0 of the mobile can be expressed as:

$$\frac{E_b}{I_0} = \left[\frac{E_b}{I_0}\right]_1 + \left[\frac{E_b}{I_0}\right]_2$$

$$= \frac{W}{VR}\left[\frac{P_{s1} r_1^{-\alpha} 10^{\zeta_1/10}}{P_{T1}(1-a) r_1^{-\alpha} 10^{\zeta_1/10} + \sum_{i=2}^{19} P_{Ti} r_i^{-\alpha}} + \frac{P_{s2} r_2^{-\alpha} 10^{\zeta_2/10}}{P_{T2}(1-a) r_2^{-\alpha} 10^{\zeta_2/10} + \sum_{\substack{j=1 \\ j=2}}^{19} P_{Tj} r_j^{-\alpha} 10^{\zeta_j/10}}\right] \quad ...(4)$$

Where, r_1= Represent the distance from the mobile to BS_1

r_2= Represent the distance from the mobile to BS_2

Ps_1= Represent the transmit power from BS_1 and

Ps_2= Represent the transmit power from BS_2

During the soft handover process, two power control loops are active. As well as the inner closed loop power control, an adjustment loop is employed for balancing the downlink power among active set cells during macro diversity. This power control strategy avoids power drifting that leads to increased transmission power and stability problems. In the perfect situation, $Ps_1=Ps_2$. Using the same assumption, the transmit power for each downlink channel can be expressed as

$$P_{s1} = P_{s2} = \frac{\frac{VR}{W}\left(\frac{E_b}{I_0}\right)_t P_T}{\frac{1}{1-a+\sum_{i=2}^{19}\left(\frac{r_i}{r_1}\right)^{-\alpha} 10^{(\zeta_i-\zeta_1)/10}} + \frac{1}{1-a+\sum_{\substack{j=1 \\ j\neq 2}}^{19}\left(\frac{r_j}{r_2}\right)^{-\alpha} 10^{(\zeta_j-\zeta_2)/10}}}$$

Therefore, the total power needed for supporting this mobile is

$$P_{s1} + P_{s2} = \frac{2\frac{VR}{W}\left(\frac{E_b}{I_0}\right)_t P_T}{\frac{1}{1-a+\sum_{i=2}^{19}\left(\frac{r_i}{r_1}\right) 10^{(\zeta_i-\zeta_1)/10}} + \frac{1}{1-a+\sum_{\substack{j=1 \\ j\neq 2}}^{19}\left(\frac{r_j}{r_2}\right)^{-\alpha} 10^{(\zeta_j-\zeta_2)/10}}} \cdot P_T$$

$$= \beta_2 . P_T \quad ...(5)$$

Factor β_2 =Represent the relative strength of the total required power for the mobile under soft handover [1].

4. Analytical Result with SHO and Without SHO

The power allocated to a certain user acts as interference for other users. β_1 indicates the relative power for without SHO, while β_2 represent relative power for with SHO. Therefore β_1 β_2 also indicate how much interference is being brought by the mobiles in different situation. At first to measure power on mobile users at various distances under handover condition of a WCDMA network, consider a hexagonal cell that serving BS along the line AB in the cell (without shadow condition) which is shown in fig. 3. Here it's observe that in all location in the cell, $\beta_1 < \beta_2$ i.e. without SHO requires minimum power in all position. This means more power is needed to support soft handover to keep the same E_b/I_o target. This more power occurs more interference to other users. Hence, soft handover has no benefit in without shadow condition. But this type of radio environment is practically rare.

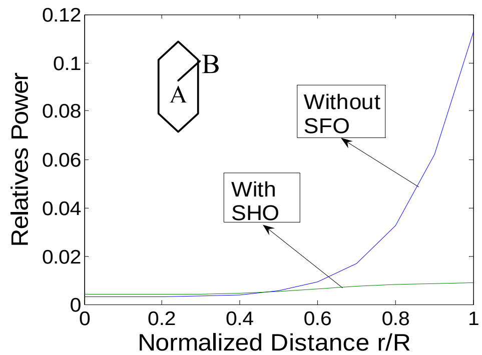

Fig. 3 Relative powers vs. mobile location

Another analytical result to measure the relative power β_1, β_2, for different distance from BS_1 along the line AB in downlink direction by considering the shadow effect. Shadowing occurs when there are physical obstacles including hills and buildings between the BTS and the MS. The obstacles create a shadowing effect which can decrease the received signal strength. When the MS moves, the signal strength fluctuates depending on the obstacles between the MS and BTS. In Fig. 4 it observes that without SHO less power is required to keep target E_b/I_o in the inner portion of cell than with SHO. So users near the BS_1 should be in without SHO state and this state it will create lower interference for other user. Also note that near the boundary region SHO needs less power to keep the target E_b/I_o.At this state it will create lower interference. So, this work it say that at normal environment, relative power β_1 for without SHO is less power in the inner portion of cell. Relative power β_2 for SHO is less in the near of the cell boundary.

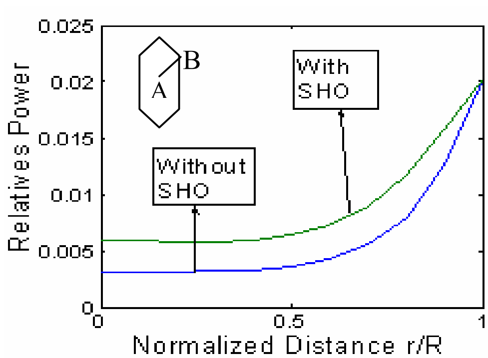

Fig. 4 Relative power vs. mobile location

In Fig. 5 shows the relationship between the values of β_1, β_2 in a two dimensional cell plane. Different colors correspond to different situation as shown in the caption. It is clear that soft handover can decrease the power required for the downlink channel by the mobiles at the cell boundary. This means the average downlink interference brought by these mobiles to other users is alleviated with soft handover. So, other user needs lees power to keep the same E_b/I_o also will crate less interference. Hence, there will go a circulation process until a new balance is obtained.

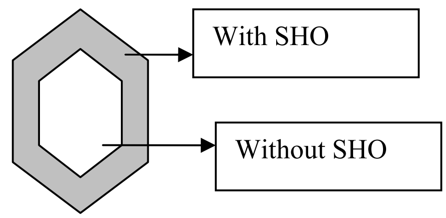

Fig. 5 Minimum relative powers vs. mobile location

Without implementing soft handover, in order to keep the E_b/I_o at the target value, the average downlink traffic channel power needed for the mobile at the cell boundary is very high and may be higher than the maximum power limit. At this situation the user may be either rejected or served with Q_OS under the target value. Soft handover can solve the problem by splitting power between the two BSs. For the mobile at the cell boundary, the E_b/I_o can be guaranteed to meet the target value without allocating high power to each downlink channel. When system is in low load, the power for the corner user might not be over the maximum power level even if soft handover is not supported. The point here is that soft handover reduces the probability of Q_OS deterioration. Another advantage of implementing soft handover is that the power floating due to shadowing loss is not as much as case with a single BS because the two signals being combined are transmitted through different radio channels.

5. Conclusions

WCDMA is interference-limited network and every additional user is seen as interference, which decrease the capacity of the network. Coverage and capacity are mutually dependent on each other in the WCDMA cellular network. In radio network planning, it is important to estimate correctly the capacity and plan for the coverage in a given geographically area. Optimum parameters responsible for functionality of the network which is needed to satisfy the above criteria. Power Allocation with and without soft handover on the downlink interferce WCDMA network is an important issues. In this work, it is emphasis that more power is needed to support soft handover to keep the same E_b/I_o target that causes more interference to other users. It also is pragmatic that the downlink power needed by the mobile unit at the cell boundary is decreased by introducing SHO. So, interference created by this mobile for other user is low in SHO state. SHO decreases the probability of over power and Q_OS deterioration for the user at the cell boundary in a cellular network.

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