A novel method for the efficient reduction of TDD based Electromagnetic Asymmetry with Demand based slot allocation scheme incorporating TD-SCDMA

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Abstract- Most mobile communications services such as high multimedia are Asymmetric. There is a great difference in their downlink & uplink requirement both in transmitted amount and transmitted rate.This paper discuss asymmetry between uplink and downlink in view of EM radiation, termed as electro-magnetic Asymmetry.The influence of surrounding environment caused by EM radiation is always a serious problem.Also in view of the fact that the wireless resource is limited and to mainly minimise the asymmetry in TDD and to effectively mitigate cross-slot interference an efficient scheme called Demand based slot allocation (DBSA) with reference to TD-SCDMA is proposed. Finally,the simulation result shows that DBSA strategy markedly minimize the Asymmetry leading to human safety and also improves the system performance leading to higher resource utilization.

Index Terms- Demand based slot allotment, electro-magnetic asymmetry, TD-SCDMA, cross-slot interference, Demand based slot allocation

I. Introduction

In view of the effects of electromagnetic radiation to human body,this paper discusses asymmetry between uplink and downlink in mobile communications system in a new aspect which is termed as Electromagnetic Asymmetry (EA). In the future, most mobile communications services will be asymmetric, such as high multimedia [1, 3]. The downlink of service requirement is much greater than the uplink both in transmission total amount and transmission rate. In this paper, we consider the asymmetric characteristic of uplink and downlink caused by electromagnetic radiation, which is termed as Electromagnetic Asymmetry (EA) between uplink and downlink. The influence on surrounding environment caused by electromagnetic radiation is always a controversial problem. With the large-scale application of mobile communications, the total amount of electromagnetic radiation will increase and people will have to re-evaluate the social effect of mobile communications [5]. The influence of electromagnetic radiation will be one of the most important elements which should be considered in the research and design of mobile communications system. This paper analyzes the asymmetric characteristics of mobile communications system influenced by electromagnetic radiation. And also because of the need of rich mobile communication services and the difference of the traffic volume requirement between uplink and downlink, the asymmetric traffic services now becomes an important feature for the mobile communication system. However ,the wireless resources is finite and the asymmetric traffic services varies from cell to cell. Demand based slot allocation (DBSA) is the most effective method proposed to settle these issues, and it plays an important role in TD-SCDMA network. DBSA can govern the overall service quality and offer flexible downlink and uplink capacity & if the technology of DBSA is applied to the mobile communication system in TD-SCDMA network, it will also raise the system capacity and get better the resource utilization.

II. ASYMMETRIC NATURE CAUSED BY ELECTROMAGNETIC RADIATION

It is notable that the mobile terminal is very close to human body, which is a small transceiver. The distance from mobile terminal to human body ranges from several centimeters to dozens of centimeters. In contrast to that, the distance from base station to human body is much longer, which ranges from dozens of meters to several kilometers. So the electromagnetic radiation impact on human body caused by mobile terminal is much more intense than that caused by base station.

(a) Radiation power of base station absorbed by human body

As there is a long distance from base station to human body, we can consider ideal LOS propagation environment.

(b) Radiation power of mobile absorbed by human body

The mobile terminal is close to human body and the radiation is inductive, so the free space propagation model above is not suitable. Here we introduce the concept of antenna propagation efficiency [6, 7].

To ignore the heat loss of mobile terminal itself, the total emission power of the antenna is

$$P_t = P_a + P_r \quad (1)$$

P_a is the power transmitted to faraway place, and P_r is the power absorbed by human.

There are many indexes used to evaluate the electromagnetic radiation influence upon human body. Among these, Specific Absorption Rate (SAR) is fundamental and widely used for analysis of electromagnetic radiation. The SAR means the power absorbed by unit weight of organism exposed to the electromagnetic fields.

$$SAR = (P_r / M) \quad (2)$$

where P_r is the power absorbed by human body, and M is the weight of the absorbing radiation part of human body.

We consider the SAR to human body caused by base station and mobile terminal.

1. SAR to human body caused by base station

As there is a long distance from base station to human body, the radiation distribution on each part of human body can be considered even.

2. SAR to human body caused by mobile terminal

The radiation of mobile to human body differs from that base station to human body. It is inductive close field radiation and its intensity decreases rapidly when the distance increases. The influences of electromagnetic radiation on human body mainly focus on human parts close to mobile terminal. In this paper, two using mobile modes are considered:

A. Mobile near the ear. This is a common mode of calling, the radiation on human body mostly focuses on head.

B. Mobile terminal is in the same height with person's eyes and the distance between them is about 50 cm. This mode corresponds to high downlink services such as video on demand or online game. In this mode, the radiation mostly focuses on head and parts of chest.

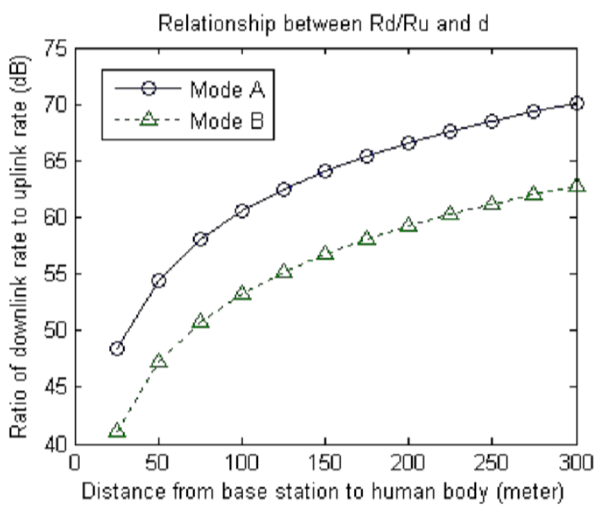

Figure 1: The relationship between ratio of downlink rate to uplink rate (dB) and distance form base station to human body (meter).

Under the constraint of electromagnetic radiation, we can find using Matlab simulation that the downlink transmission rate is much higher than that of uplink in mobile communication system. In mode A, the ratio of maximum rate of downlink and uplink is more than 10^5 times, which shows the asymmetric transmission characteristic of uplink and downlink. The uplink is much easier to reach transmission capacity saturation for one user, while there is much transmission rate and transmission power margin in downlink. So we call it Electromagnetic Asymmetry (EA) between uplink and downlink.

III THE THEORY OF DBSA INCORPORATING TD-SCDMA

For the mobile communication system in TD-SCDMA network, a physical channel is indicated by a combination of its carrier frequency, time slot, and spreading code. The sub-frame is shown in Figure 2. The length of the sub-frame is 5ms.Each sub-frame is divided into 7 main time slots (TSO- TS6)and 3 special time slots: downlink pilot time slots (DwPTS), guard period (GP) and up link pilot time slots (UpPTS) The length of each main time slot is O.675ms, where in TSO is a downlink time slot, TS 1 is a uplink time slot, while the remaining main time slots can be configured flexibly to be used for uplink or downlink according to the system demand. A switch point is set between the uplink slots and downlink slots. In the mobile communication system, Demand based slot allocation changes the switch point between downlink and uplink slots adaptively according to the rate of asymmetry traffic in a cell, and maximize the resource utilization.

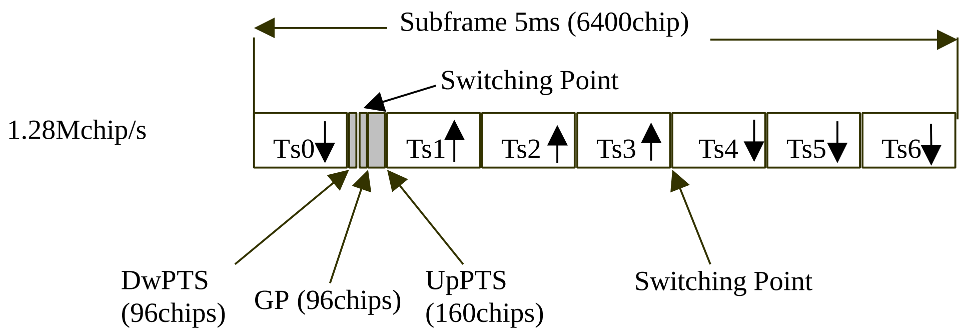

Figure 2: A sub-frame structure of the system

As the name implies, TD-SCDMA combines two leading technologies: an advanced TDMA/TDD [17] system with an adaptive CDMA component operating in synchronous mode. Code Division Multiple Access (CDMA) in combination with Time Division Duplex (TDD) significantly improves the network performance by radio network resources to process network traffic in both uplink and downlink directions.

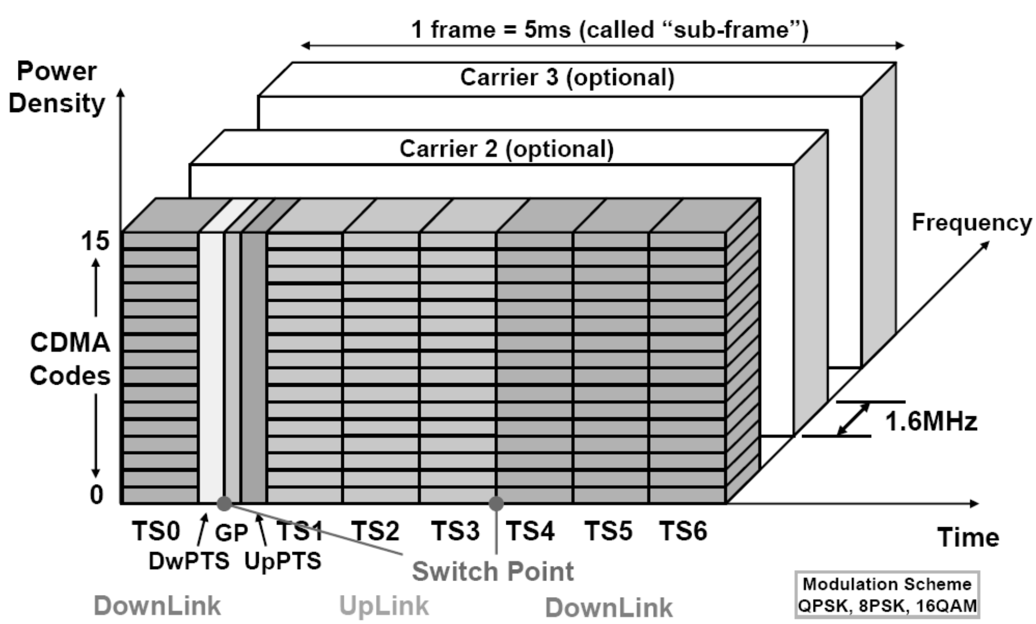

Figure 3: TD-SCDMA Resource Structure

The frame structure for each sub-frame is shown in Figure 2. Every sub-frame includes 7 traffic time slots and 3 special ones. The length for each traffic time slot is 864 chips duration. Among the 7 traffic time slots, Ts 0 is always allocated as a downlink while Ts 1 is always allocated as an uplink. The switching point is used here for separating the time slots for the uplink and the downlink. Using this kind of frame structure, TD-SCDMA can operate on both symmetric and asymmetric modes by moving the switching point and configuring the number of uplink and downlink time slots. For symmetric services used during telephone and video calls (multimedia applications), where the same amount of data is transmitted in both directions, the time slots are split equally between the downlink and uplink. For asymmetric services used with Internet access (download), where high data volumes are transmitted from the base station to the terminal, more time slots are used for the downlink than the uplink.

IV THE PROBLEM OF ASYMMETRY & CROSS-SLOT INTERFERENCE

(A.) *Asymmetry*

Mitigating the Asymmetry and resource utilization [11] to scale the performance of the system, we will define two variables namely, Slot asymmetry **(γ)** and traffic asymmetry factor **(δ) :**

$$\gamma = (\text{the number downlink slots / the number of uplink slots}) \quad (3)$$

$$\delta = (\rho_d / \rho_u) \quad (4)$$

ρ_d & ρ_u denote the accumulated traffic load (measured in bits/sec) by all users in a cell on downlink and uplink.

The offered load in a cell between downlink and uplink is determined at a time. As the sub-frame structure of the communication system in TD-SCDMA network is showed in Fig .l, and TSO is used for the downlink communication services, the value of slot asymmetry factor in this system will be l:5, 2:4, 3:3, 4:2, 5:l. It is determined by the position of switch point. In order to acquire maximum utilization of resource, DBSA changes the switch point between downlink and uplink to discover the most appropriate value of slot asymmetry factor.

(B) *Cross-slot interference*

In multi-cell environment, we must consider that the degree of traffic asymmetry generally varies from cell to cell. In this case, to maximize resource efficiency, one can use unequal γ for each cell, but now the cross-slot interference is generated for different slot allocation among cells.

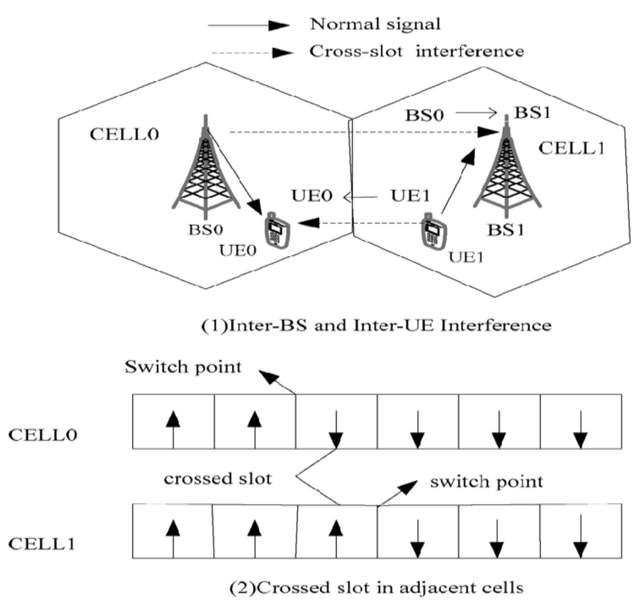

Figure 4 : The interference caused by crossed slot between cells

$$U = \Sigma u_i \quad \text{where } i = 1 \text{ to } 2 \quad (5)$$

Since TSO is reserved for common channels, we only use the rest 6 time slots to allocate to consumers. To make the utilization of resource better, the switch point in CELLO is between TS2 and TS3 while in CELL I it is between TS3 and TS4, and thus cross-slot is TS3.When in TS3, BSO (BS, Base Station) sent a signal to UE, and at the same time ,UEI sent a signal to BS I ,then the inter-BS interference and inter- UE interference[12] are produced.

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V SOLUTIONS TO THE PROBLEMS

To cut down the interference of cross-slot discussed before,[13] and [14] recommend the same slot allocation (thus, the same γ). However, for various multimedia services and traffic asymmetry in the mobile communication system, the method will debase resource efficiency .We should find out a way to reduce the interference of cross-slot and increase the utilization of resource.

If the time slot of the high transmit power BS or UE is the uncross-slot, and the lower transmit power BS or UE is cross-slot, it will have lower interference. The status of the system will be greatly improved. As illustrated in Fig.3, [15] and [16] divided the cell into two zones: the inner region near to the base station and the outer region that enclose the first one. The crossed-slots can be allocated only to UEs in the inner region for both links. This way can abstain the appearance of cross-slot interference and reduce the blocking probability and heighten the resource utilization.

Thinking of one-to-multipoint communication mode in the mobile communication system, if one of the called is blocked, it will do not influence the system communication. But if it is the call blocked, the whole of group-uses will not communicate normally. For the purpose of improving the mobile communication system performance, we should try to allocate the uncross-slot to the group-uses, whether they locate in the inner or the outer region.

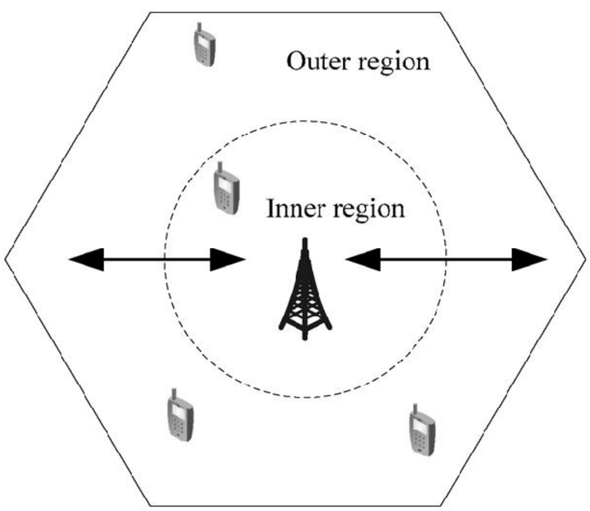

Figure 5 : The division of a cell

VI STATERGY OF TD-SCDMA AND ITS SIMULATION

Figure 2.4 shows the generation of the TD-SCDMA signal of a user (reverse channel). Quadrature phase-shift keying (QPSK) modulation is used for the RF carrier. Base-band filtering is defined in the TD-SCDMA standard in terms of a digital finite impulse (FIR) filter.

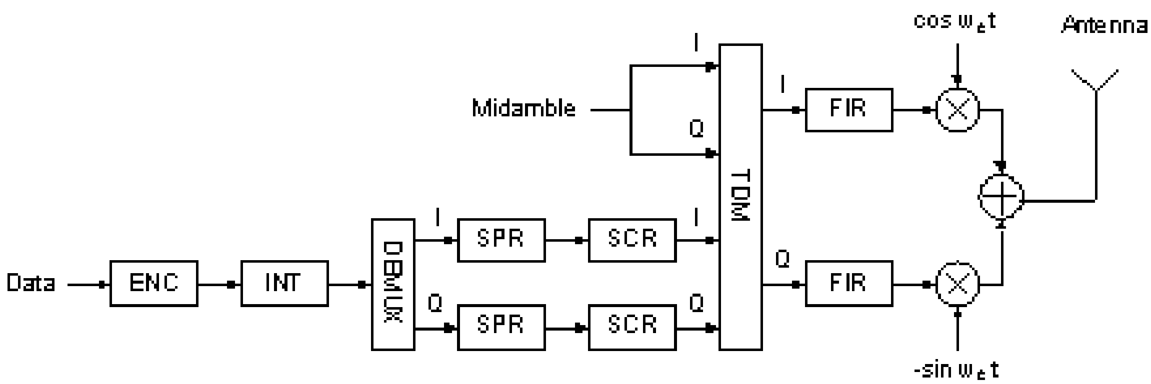

Figure 6 : Generating the Signal for TD-SCDMA Standard

(a) *The TD-SCDMA Signal Equivalent Mathematical Model*

TD-SCDMA adopts time division multiplex (TDD) operation instead of the frequency division multiplex (FDD) of W-CDMA, which may be considered a major difference between these two systems. In TDD mode, a 5ms frame is subdivided into 7 time slots, which can be flexibly assigned to either several users or to a single user who may require multiple time slots. Within one time slot, the system uses CDMA (Code Division Multiple Access) to further increase the capacity of the radio interface. Therefore, the TD-SCDMA system's mathematical model can be separated into TDMA and CDMA two processes.

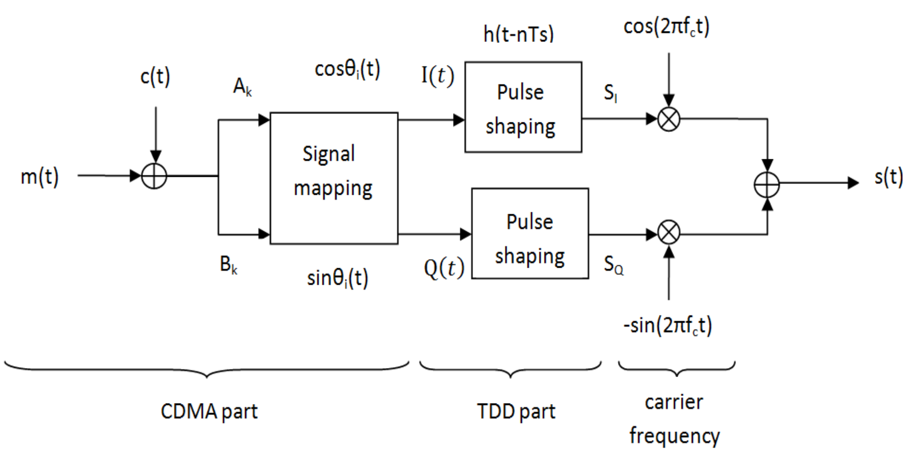

Figure 7 : Signal Modulation Procedure of TD-SCDMA math model

(b) *The Power Spectrum Density (PSD) of TD-SCDMA Signal*

In [18], the spread spectrum signal $f(t)$ will be a band-limited Gaussian stochastic process with zero mean, so the general expression for the PSD of a digital signal $f(t)$ is

$$P_f(f) = \begin{cases} \frac{N_0}{2}, & |f| \le B \\ 0, & |f| > B \end{cases} \qquad (6)$$

the envelope of the TD-SCDMA signal can be expressed as,

$$P_g(f) = \frac{N_0}{2} R_c |H(f)|^2 \quad (7)$$

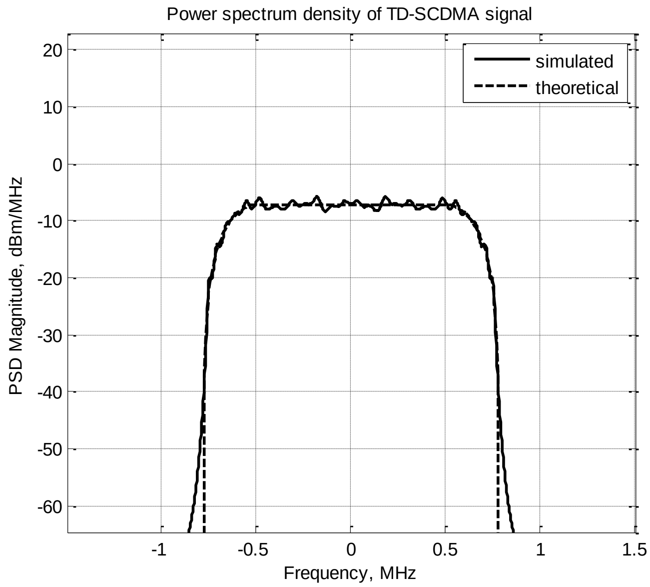

Figure 8 : PSD of TD-SCDMA signal

VII THE STRATEGY OF DBSA & SIMULATION OF RESULTS

To reduce the asymmetry and also to improve the capacity of communication service and allocate the limited resource effectively in the mobile communication system based on TD-SCDMA network, we can allocate the channel dynamically by the condition of traffic load between downlink and uplink to find out the optimal time slot allocation. Then divide a cell into two zone to minimize the cross slot interference. The specific implementing strategy of DBSA in this system as follows:

a) The initialization of a system. Under the value of traffic asymmetry factor in a cell, we can find out the optimal slot allocation and determine the value of the slot asymmetry factor to get the max. utilization by.

b) According the allocation of time slot between uplink and downlink, we find out the number of cross-slot and uncross-slot. Depending on the value of them, we can divide the cell into inter and outer region.

c) Access of consumers and detect the position of them.

d) In the service of consumers in mobile communication, the uncross-slot should be allocated. If the consumers belong to inner region, it will allocate the cross- slot, and the outer region customs will be allocated the uncross-slot. If the cross-slot (uncross-time) is distributed over, the uncross-slot (cross-slot) will be instead. If there are not any available resources remained, the new customs will be blocked. Wait for the update at next time.

e) When the traffic load between uplink and downlink is changed in the next time ,the allocation of resource should be renewed. The implementing returns to a.

The simulation scenario is illustrated in Figure 4. We presume two cells and each of them have a group-use. We give the value of traffic asymmetry factor of each cell in ten testing times as Table 1.

From the Table 1, we can detect the value of traffic asymmetry factor of the two cells is equal in some times (e.g,4),but it is unequal in other times(e.g,l).In a cell, sometimes the traffic load of downlink is equal to the uplink's, but in other time the value of downlink is higher than uplink. It fit the mobile communication condition. So the result which is gotten by using MATLAB software shows the advantage of the DBSA strategy applied in the mobile communication system. We should allocate the channel dynamically and renew the dividing line in Figure 5 in the light of the mutative traffic asymmetry factor.

Times	1	2	3	4	5	6	7	8	9	10
Cell 0	0.5	1	1.5	2	2.5	3	3.5	4	5	6
Cell 1	1.5	3	2.5	2	1.5	4	2.5	1	2	3.5

Table 1 : The value of traffic Asymmetry factor

To reflecting the advantage of DBSA, We take two strategy to allocate the channel in the mobile communication system: same slot allocation and dynamic slot allocation. The simulation result will concern the average resource utilization of the two cells by (5), and compare the two methods function.

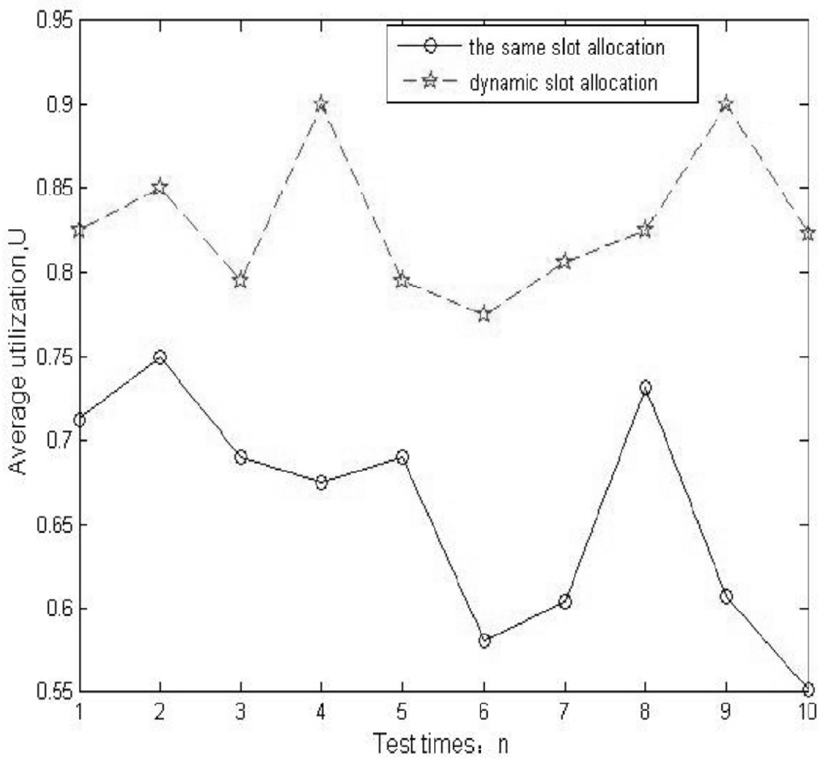

Figure 9 : The average utilization of the two cells

The result of simulation is showed by Figure 9. From Figure 9, it shows the average resource utilization of the two cells which have variable traffic asymmetry factor value. We can clearly see that the average resource utilization of the two cells by the strategy of dynamic slot allocation is higher than the method of same slot allocation.

Although the traffic load is asymmetric between uplink and downlink and it also is different from cell to ceIl, the average resource utilization tested is around 0.85 by dynamic resource allocation, approximately 0.15 higher than the way of same resource allocation. It reflects the strategy of DBSA which is introduced above is favorable for the mobile communication system in TD-SCDMA network to allocate resources and it obviously reform the communication performance.

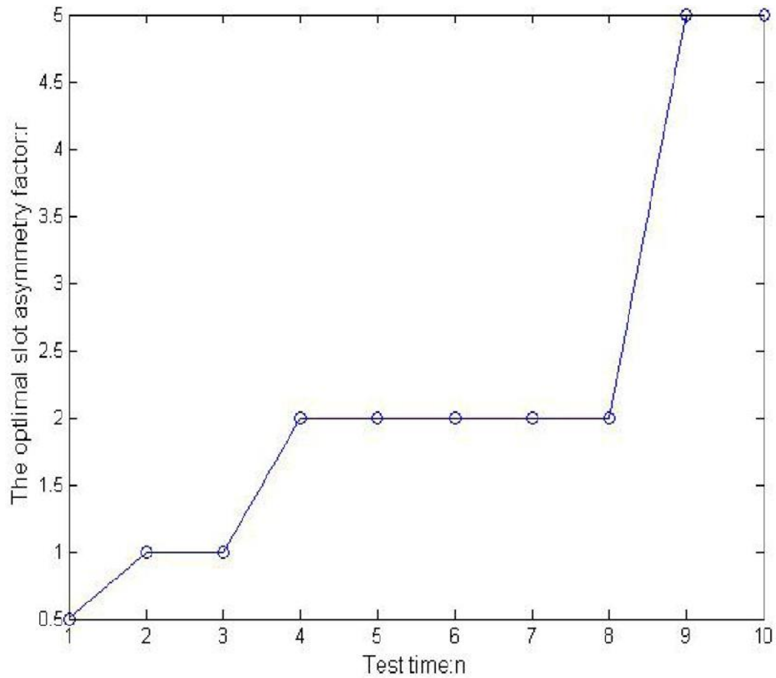

Figure 10 : The optimal slot allocation of CELL O

In Figure 10, we count the optimal slot asymmetry factor to maximize the utilization of CELLO. In the CELLO, the value of slot asymmetry factor increased gradually with the traffic asymmetry factor over time. We can find that the optimal slot asymmetry factor is approach the value of traffic asymmetry factor. And even the value of the two factors is not equal, we can choose one of two adjacent possible values, which maximizes the utilization, as an optimal one.

APPENDIX

```
clear all;
close all;
%configurations
Rc=1.28*1.0e6;   %chip rate
Ts=1/Rc;   %Sample period
N_frame=3;  %No. of simulated frames
Range=8;  %Range to the magnitude of filter output signal
%TD-SCDMA procedures
PN_starting=zeros([1,16]);
SF=16; %spreading factor
Data_Out=[];
Data_In=[];
for j=1:N_frame
   %time slot 1
   ovsf_No=3;  %No. of the user.
   info=Data(44);
```

```
    Data_In=[Data_In,info];   %Ramdomly generating data scource
    conv=Conv_Encoder(info);   %Convolutional Encoding
    qpsk=Qpsk_Mod(conv);  %QPSK
    ovsf_mod=Ovsf_Mod(ovsf_No,qpsk);   %OVSF
    PN_mod=PN_Mod(ovsf_mod);   %Add PN
    Data_Out=[Data_Out,PN_mod];

    %time slot 2
    ovsf_No=4;  %Second user in the simulated frame
    info=Data(44);
    Data_In=[Data_In,info];
    conv=Conv_Encoder(info);
    qpsk=Qpsk_Mod(conv);
    ovsf_mod=Ovsf_Mod(ovsf_No,qpsk);
    PN_mod=PN_Mod(ovsf_mod);
    Data_Out=[Data_Out,PN_mod];

end

Data_Out=Symmetricize(Data_Out);
%do the pulse shaping filter and over sample by 3 times
fc=1/Ts;
delay=20;
R=0.22;  %roll off factor is 0.22
Fs=4*fc;
Ct_Out_0=rcosflt(Data_Out,fc,Fs,'fir/sqrt',R,delay); %raise cosine filter
freq_offset_1=1/3;
freq_offset_2=2/3;
for i=-30:30
  W_1(i+31)=sin((i+freq_offset_1)*pi)/((i+freq_offset_1)*pi);
  W_2(i+31)=sin((i+freq_offset_2)*pi)/((i+freq_offset_2)*pi);
end
%Over sample 1
Ct_Out_1=zeros(1,length(Ct_Out_0));
for i=1:length(Ct_Out_0)
    for j=-30:-1;
        if(i+j)>0
            Ct_Out_1(i+j)=Ct_Out_1(i+j)+Ct_Out_0(i)*W_1(j+31);
        end
    end
    for j=0:30
       if(i+j)<=length(Ct_Out_0)
          Ct_Out_1(i+j)=Ct_Out_1(i+j)+Ct_Out_0(i)*W_1(j+31);
       end
    end
end

%Over sample 2
Ct_Out_2=zeros(1,length(Ct_Out_0));
for i=1:length(Ct_Out_0)
    for j=-30:-1;
        if(i+j)>0
          Ct_Out_2(i+j)=Ct_Out_2(i+j)+Ct_Out_0(i)*W_2(j+31);
        end
    end
    for j=0:30
       if(i+j)<=length(Ct_Out_0)
          Ct_Out_2(i+j)=Ct_Out_2(i+j)+Ct_Out_0(i)*W_2(j+31);
       end
```

```
    end
end
Ct_Out=zeros(1,3*length(Ct_Out_0));
for i=1:length(Ct_Out_0);
   Ct_Out((i-1)*3+i)=Ct_Out_0(i);
   Ct_Out((i-1)*3+i+1)=Ct_Out_1(i);
   Ct_Out((i-1)*3+i+2)=Ct_Out_2(i);
end
%preparation for plotting the psd
 IP3=5;  %db
 a3=-2/3*10^(-IP3/10);  %amplifier
 B=0.8;  %bandwidth
 N=256;
 Res=B/N;
 L=length(Ct_Out);
 P0=0;  %power
Amp_Out=Ct_Out_1+a3*Ct_Out_1.^3;  % amplified signal
 P0=Amp_Out*Amp_Out';
 P0=(P0/L);
 %plot the simulated PSD
[PSD_non_Amp,freq]=pburg(Ct_Out_1,64,2048,1.28*4,'twosided'); %  Plot PSD
PSD_non_Amp=fftshift(PSD_non_Amp);  %Shift zero-frequency component to center of spectrum
PSD_non_Amp=10*log10(PSD_non_Amp);  % change to log scale
freq=freq-1.28*4/2;
figure;
plot(freq,PSD_non_Amp);grid on;
title(['Power spectrum density of TD-SCDMA signal'],'Color','b');
xlabel('frequency  MHz');ylabel('PSD Magnitude dBm/MHz');
```

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