Fast Dynamic Channel Allocation Algorithm for TD-HSPA System

Haidong Li, Hai-Lin Liu, and Xueyi Liang

School of Applied Mathematics, Guangdong University of Technology,
Guangzhou 510520, China
hlliu@gdut.edu.cn

Abstract. In order to make full use of channel, a new dynamic channel allocation algorithm for TD-HSPA system is proposed. The proposed algorithm gives priority to consider the time slot distribution in uplink channels. This paper uses low order modulation coding in uplink channels, but uses high order modulation coding in downlink channels. The transmission rate of uplink and downlink are asymmetric. In his paper, we propose a criterion sharing channel for each other through main and auxiliary frequency when the voice channel is idle. As a result, the system capacity is increased 50% larger than the past. Simulation results show that the proposed algorithm can decrease the call blocking ratio and dropping packet rate of data service, improve the channel utilization efficiency, and increase the number of data users dramatically.

Keywords: TD-HSPA, asymmetric transmission, frequency sharing, dynamic channel allocation.

1 Introduction

The fast DCA (Dynamic Channel Allocation) algorithm, which can dynamically adjust the channel resource, allocates channel resources to the user according to telecommunication network. The resource of wireless channel includes carrier, slot, and spreading codes in TD-HSPA (Time Division-High Speed Packet Access) system. The DCA algorithm searches the channels which have smaller interference and which can provide stable service to supply the users. The TD-HSPA system has three kinds of key techniques which include AMC (Adaptive Modulation and Coding), HARQ (Hybrid Automatic Repeat reQuest) and FPS (Fast Packet Scheduling), which can better support asymmetric data transmission[1-6]. The existing fast dynamic channel allocation algorithms mainly include MRG MB DCA, PCR MB DCA algorithm[7-11], etc. Literature [8] makes data business be able to use idle speech channel through a movable boundary method, which reduces the data service loss rate of packet and the average waiting time. The paper [9] sets a different priority for voice users and reserves parts of channels for high precedence voice users based on the paper [8] to reduce call blocking rate of handover voice users. However the paper [9] does not consider the data slots allocated in uplink time slots, allocated and transmitted method in the case

M. Kurosu (Ed.): Human-Computer Interaction, Part V, HCII 2013, LNCS 8008, pp. 82–91, 2013.

of asymmetric transmission, and frequency sharing (Main and auxiliary carrier can borrow channel resources from each other).

This paper proposes a new algorithm for the three key techniques in TD-HSPA. Firstly, we give priority to the uplink time slot and allocate a data slot in the uplink time slot for data transmission. Secondly, we transmit different rate of data service when uplink time slots and downlink time slots are asymmetric. we use low order modulation to transmit low speed data service in uplink time slots and use high order modulation to transmit high speed data service in downlink time slots for achieving the maximization of channel utilization efficiency. Thirdly, we propose a criterion based on BRU number when main and auxiliary frequency borrow channel resources from each other. We can fast determine data channel which can borrow idle voice channel of main frequency or auxiliary frequency. More users get system service by way of frequency sharing that main and auxiliary frequency can borrow channel resources from each other. We will ensure more users to access the system through the switch which is from 3G to 2G when the volume of service is very large. The proposed algorithm is called TD-HSPA MB (movable boundary) DCA algorithm in this paper. Simulation results show that the proposed algorithm can decrease the call blocking ratio and increase the performance of data service and the number of data users dramatically.

2 Resource Allocation

I In the time slot of the main and auxiliary frequency, the channel with SF (Spreading Factor) 16 can be looked upon as one BRU, twhich means one time slot is composed by sixteen BRU (Basic Resource Unit). In TD-HSPA system, resource allocation mainly involves the allocation of the BRU made up of carriers, time slots and channel codes. Transmission rate of voice service, HSUPAHigh Speed Uplink Packet Accessdata service, stream data service, browser data service and interactive (background) data service are 12.2kbit/s, 32kbit/s, 64kbit/s, 128kbit/s and 384kbit/s,respectively. And the corresponding numbers of BRU are 2, 4, 8, 16 and 48[12].

According to the changes of wireless channel, TD-HSPA uses AMC technique to select the appropriate modulation and coding mode, which makes users use network in most effective way. In uplink time slot, base station sends data to the user by using low-level modulation and low-rate channel coding, which ensures the quality of communication. Difference from the way of uplink time slot, the user receives data from base station by using higher order modulation and high-rate channel coding so that they have a high transmission rate in downlink time slot. TD-HSPA uses HARQ technology to ensure the reliability of data transmission. TD-HSPA FPS is transferred to the base station from the radio network controller. Furthermore, scheduling signaling can be transmitted directly between base stations and mobile terminals, so it reduces the scheduling time. FPS makes the resource allocation of base station be more flexible and rapid, and increases the cell throughput.

3 Fast Dynamic Channel Allocation Algorithms

In the view of the negative impact caused by the dropped calls or data traffic delay, it is important to reduce the rate of dropped calls and speed up data transmission. This can bring bilateral benefits for telecom operators and users.

To make use of system resources better, TD-HSPA MB DCA algorithm is proposed. It reduces call blocking rate and improves the performance of data service.

3.1 Chanel Modulation and Coding

In this paper, we should allocate two time slots for uplink channel and four time slots for downlink channel. Furthermore, in the uplink time slot, one time slot is allocated for voice service and the other is for data service. In the uplink and downlink time slot, we use the QPSK (Quadrature Phase Shift Keying) and 16QAM (Quadrature Amplitude Modulation) modulation, respectively. Base station transmits data with low speed 32kbit/s in uplink time slot. Meanwhile, uplink time slot resource is shared, which makes the uplink code channel be not restricted and maximize the total capacity of the channel. Base station transmits data with high speed in the downlink time slot, and AMC adjusts the modulation mode according to instantaneous changing of downlink channel. When current line-channel environment is very good, we use 16QAM modulation mode. However we use QPSK modulation when channel environment is poor or close to the edge of the cell. The ratio of uplink and downlink time slot is 2:4, so the transmission rates of uplink and downlink are different. To use time slots efficiently, data is transmitted with low speed in the uplink time slot and high speed data service in the downlink time slot.

Using PCR MB DCA algorithm [9], it allocates all two uplink time slots to voice service. PCR MB DCA algorithm model is shown in Figure 1.

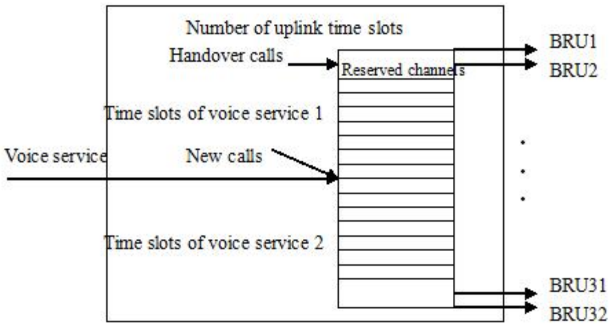

Fig. 1. PCR MB DCA algorithm model

Compared with PCR MB DCA algorithm using symmetrical transmission in uplink and downlink time slots, TD-HSPA MB DCA algorithm uses asymmetric transmission. Shown in Figure 2 and Figure 3TS is used to represent one time slot. And the arrow of towards up denotes the uplink time slot. Similarly, the arrow of towards down represents the downlink time slot), the utilization rate of downlink time slot for PCR MB DCA algorithm is half of the TD-HPSA MB DCA algorithm.

Fig. 2. Channel allocation model for PCR MB DCA algorithm

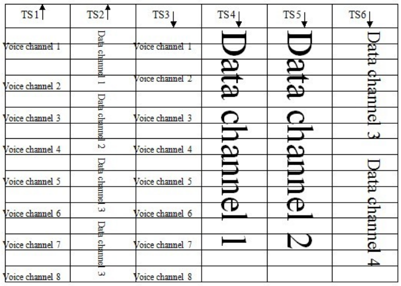

Fig. 3. Channel allocation model for TD-HSPA MB DCA algorithm

3.2 Borrowing Criterion of Main, Auxiliary Frequency Channel Resource

In TD-HSPA MB DCA algorithm, when the channel of main frequency is not enough to support data service, it uses free voice channel of auxiliary frequency. In time slots of main frequency, data service uses free voice channel. When there is no free voice channels in main frequency the algorithm borrows free voice channels from auxiliary frequency. Since voice service has a high priority, voice service can occupy the channel used by data services when new voice calls arrive.

In this paper, cross-frequency network is selected as a networking mode. Every cell has nine frequencies, which include three main frequencies and six auxiliary frequencies. We take a main frequency and an auxiliary frequency for example. In uplink time slots of main and auxiliary frequency, they both have 32 BRU. Voice service requires two BRU while data service (32kbit/s) requires 4 BRU. In the ith main frequency, when voice user x_i and data users y_i satisfy $0 \leq x_i \leq 8, 4 \leq y_i \leq 8$ and $2x_i + 4y_i \leq 32$, data service borrows the free voice channels from ith frequency of main frequency. Similarly, when voice user x_i and data users y_i satisfy $0 \leq x_i \leq 8, 8 \leq y_i \leq 12$ and $2x_i + 4y_i \leq 48$, data service borrows the free voice channels from ith frequency of auxiliary frequency.

When the free voice channels are borrowed by data service, they are divided into groups as follows. Data service (32kbit/s) requires 4 BRU, so we view 4 BRU as a unit. And the BRU resources of other data services are an integer multiples of the unit.

One group means that it can transmit data service with 32kbit/s. Within time slots of main frequency, if the data buffer queue is not empty and groups from 1to 4 are free, they are used to transmit data service of 128kbit/s TV or two-way data service of 64kbit/s stream service of 64kbit / s or four-way data service of 32kbit/s HSUPA service. Similarly, if the 1th, 2th and 3th groups are free, they are used to transmit corresponding data. By this method, the probability of borrowing free voice channels is increased greatly.

If data channels of main frequency are not enough, it can borrow free voice channels from auxiliary frequency. Moreover, if voice channels of auxiliary frequency are still not enough, the TD-HSPA system switches to 2G to ensure the data transmission. The Model of TD-HSPA MB DCA algorithm is shown in Figure 4.

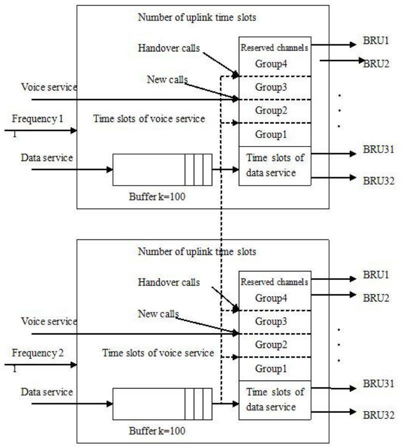

Fig. 4. Model of TD-HSPA MB DCA algorithm

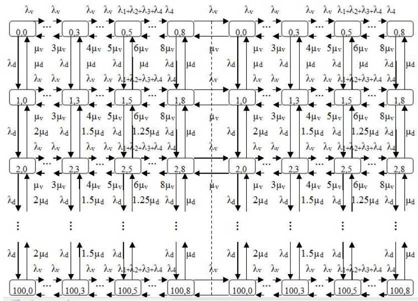

Fig. 5. Markov queuing model of TD-HSPA MB DCA algorithm

3.3 Performance Analysis for TD-HSPA MB DCA Algorithm

Suppose that packet arrival rate, the average time of transmission and the intensity of data traffic are λ, $\frac{1}{\mu_d}$ and $a_d = \frac{\lambda_d}{\mu_d}$ respectively. Let the total arrival rate of voice service be λ_ν containing λ_n (new arrival rate of voice calls) and λ_h (arrival rate of handover voice calls). Set the arrival rate of VIP high-speed handover voice calls, VIPlow-speed handover voice calls, ordinary high-speed handover voice calls and ordinary low-speed handover voice calls to be $\lambda_1, \lambda_2, \lambda_3$, and λ_4 .The average duration of voice calls is $\frac{1}{\mu_\nu}$, and the traffic intensity of voice calls is $a_\nu = \frac{\lambda_\nu}{\mu_\nu}$.

In main frequency, voice service requires two BRU, and each time slot contains sixteen BRU. The number c of voice traffic channel is set to be 8. Data service using free voice channels borrows the 1th, 2th, 3th and 4th group each of which represents 0.25 time slot. The number of data slot d can be 1, 1.25, 1.5, 1.75 and 2 when the queue length of data buffer k is 100.

Under the premise of the criteria for borrowing main and auxiliary frequency resources and the performance analysis of TD-HSPA MB DCA algorithm, we create the Markov queuing model in figure 4[13, 14]. In this figure, the left part of the dotted line represents the Markov queuing model of main frequency A, and the right part represents the Markov queuing model of auxiliary frequency B. This figure shows that Markov queuing model of main frequency A and auxiliary frequency B borrow resources from each others. In this figure, each small rectangle node (m, n) denotes one system state, where m represents the number of packets in the buffer and n represents the number of voice calls serviced. Figure 4 shows that free voice channels can be borrowed by data service of main and auxiliary frequency from each other[13, 14].

3.4 The Formula of TD-HSPA MB DCA Algorithm

When the uplink time slots have two time slots, one slot is allocated to voice service and the other for data service. The utilization rate of uplink channel is

$$\eta = \frac{a_\nu(1-p_c)/8 + a_d(1-p_{pd})}{2}. \tag{1}$$

When the voice call channels is fully occupied, the voice call blocking ratio is

$$\eta = \frac{\frac{a_\nu^c}{c!}}{\sum_{k=0}^{c} \frac{a_\nu^k}{k!}}. \tag{2}$$

When the data buffer is full, the new arrival data service will be refused. The packet loss rate of data services is

$$P_{pd} = \sum_{n=0}^{8} p(100, n). \tag{3}$$

When data channels and voice channels are utilized fully, the new arrival data service will be queued in the buffer. Queue length L of packet and average waiting time W of packet are

$$L = \sum_{m=0}^{100} \sum_{n=0}^{8} mp(m,n), \quad W = \frac{L}{\lambda(1-P_{pd})}. \tag{4}$$

Reselection from TD-HSPA to GSM is a switching process in different systems. In the mobile communication network, the measurement system can be opened or closed by setting the parameters, which controls cell reselection among disparate systems [15].

4 Simulation Results

In this paper, we compare TD-HSPA MB DCA algorithms with PCR MB DCA algorithm from several aspects such as number of data users, channel utilization efficiency, call blocking rate, loss rate of data packet and average waiting time of data packet. The parameters of computer simulation are set as follows. Given a main frequency and a auxiliary frequency in a cell, there are six time slots with the time slot rate 0.5 of uplink and downlink in one frequency. A time slot is composed by sixteen BRU. Voice service requires two BRU and the data service with 32kbit/s, 64kbit/s and 128kbit/s requires the corresponding numbers of BRU are 4, 8 and 16. The arrival rate of voice service is set to be 0, 30, 60, 90, 120 and 150 call/h. And about 40% to 50% of voice service involves handover service [16]. Arrival rate of voice handover service is 0, 10, 20, 40, 50 and 60 call/h, and arrival rate of data service is 0, 12, 24, 36, 48, 60 packet/s [17]. Average waiting time of voice call is 90 seconds, while average transmission time of data packet is 0.1068 seconds, 0. 0534 seconds, 0.0267 seconds. The voice time slot ratio of uplink and downlink service is 1:1, while the ratio of data service is 1:3. A main and an auxiliary frequency can borrow four BRU from each other, and handover rate from 3G service to 2G service is 5% [15, 18]. Arrival of voice calls and data packets obeys the Poisson distribution, while the duration time of the voice calls and transmission time of data packet obey the negative exponential distribution.

Using the above parameters, the simulation results PCR MB DCA and TD-HSPA MB DCA algorithm are shown from figure 6 to figure 12.

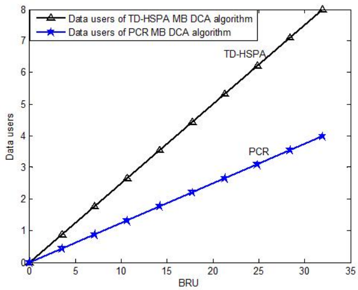

Fig. 6. Available data service users of TD-HSPA MB DCA algorithm and PCR MB DCA algorithm

In figure 6, we can see that the data user number of TD-HSPA MB DCA algorithm is two times of PCR MB DCA algorithm. Because uplink channel coding of TD-HSPA uses low-level modulation, it can transmit low-rate data service and make the uplink code channel be not restricted. Furthermore, uplink channel resource can be shared. Hence, it increased the uplink capacity greatly

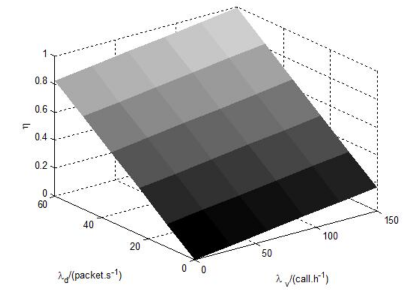

Fig. 7. The channel utilization efficiency of PCR MB DCA algorithm

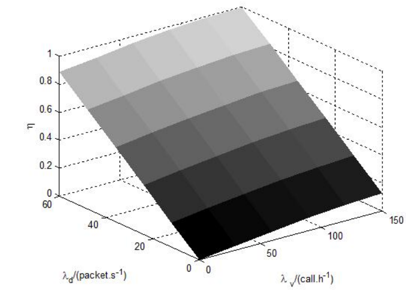

Fig. 8. The channel utilization efficiency of TD-HSPA MB DCA algorith

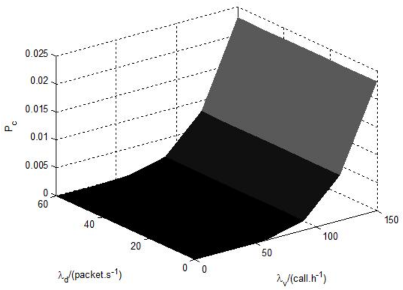

Fig. 9. The voice call blocking rate of PCR MB DCA algorithm

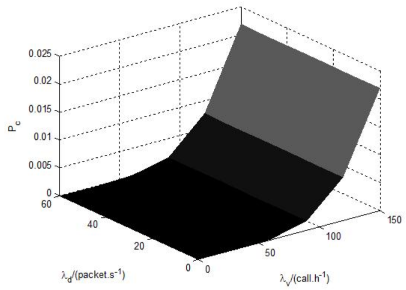

Fig. 10. The voice call blocking rate of TD-HSPA MB DCA algorithm

and service for more users with adding a small amount of system signaling overhead, which can be accepted by the system. Comparing figure 7 with figure 8, when the arrival rate of data and voice service is high and low, respectively, the channel utilization efficiency of PCR MB DCA algorithm is 0.83, but that of TD-HSPA MB DCA algorithm is 0.87, increased by 4.8%. With high arrival rate of data service and voice service, the channel utilization rate of PCR MB DCA algorithm is 0.980, while that of TD-HSPA MB DCA algorithm is 0.995, increased by 1.53%. In TD-HSPA MB DCA algorithm, the channels of main and auxiliary frequency can be borrowed from each other, and downlink time slots of high order modulation and the channel coding of high speed can utilize the time slot resources effectively, so the total channel utilization rate is increased. Similarly, comparing figure 9 with figure 10, call blocking rate of voice services of TD-HSPA MB DCA algorithm is lower by 5% than that of PCR MB DCA algorithm, which is caused by voice handover from TD-HSPA system to GSM system. Compared with the packet loss rate of PCR MB DCA algorithm in figure 11, the packet loss rate of TD-HSPA MB DCA algorithm is reduced by 5%. The reason is that, in uplink time slots of TD-HSPA MB DCA algorithm, it uses the low order modulation mode and low speed channel coding for ensuring the

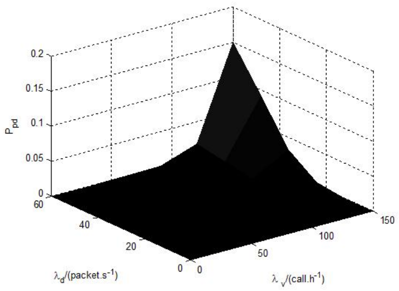

Fig. 11. The channel utilization efficiency of TD-HSPA MB DCA algorithm

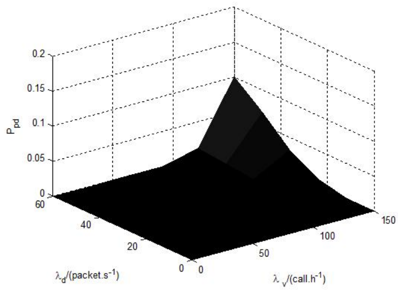

Fig. 12. Data packet loss rate of TD-HSPA MB DCA algorithm

communication quality, and it uses AMC technology to ensure the reliability of the transmission in the downlink time slots of TD-HSPA MB DCA algorithm. FPS of TD-HSPA system makes scheduling period become smaller base station allocate resource more flexibly and rapidly. In summary, TD-HSPA MB DCA algorithm is effective to the cells with asymmetry time slot of uplink and downlink and many voice users, especially for the cells possessing a large number of data users. Meanwhile, it increased the system capacity significantly.

5 Conclusions

In this paper, TD-HSPA MB DCA algorithms are proposed. By asymmetric transmission rate of uplink and downlink, a reasonable arrangement for time slots and channels is obtained in uplink and downlink. For increasing the number of users and the system capacity, the main and auxiliary frequency borrow channel resources from each other. The proposed algorithm can decrease the call blocking ratio and the dropping packet rate of data service, and improve the channel utilization efficiency. Furthermore, TD-HSPA MB DCA algorithms provides some references for WCDMA-HSPA and TD-LTE systems.

Acknowledgment. This work was supported in part by the Natural Science Foundation of Guangdong Province (S2012010008813), and in part by the projects of Science and technology of Guangdong Province (2012B091100033),and in part by the projects of science and technology of the department of education of Guangdong province (2012KJCX0042), and in part by Zhongshan projects of science and technology (20114A223).

References

1. Peng, M., Wang, W., Chen, H.-H.: TD-SCDMA evolution. IEEE Vehicular Technology Magazine 5(2), 28–41 (2010)
2. Peng, M., Zhang, X., Wang, W., et al.: Performance of Dual-Polarized MIMO for TD-HSPA evolution systems. IEEE Systems Journal 5(3), 406–416 (2011)

3. Zhang, X., Wang, W., Li, Y., et al.: Performance analysis for dual polarization antenna schemes in TD-HSPA system. In: IEEE Personal Indoor and Mobile Radio Communications, September 26-30, pp. 2052–2056 (2010)
4. Peng, M., Wang, W.: A framework for investigating radio resource management algorithms in TD-SCDMA systems. IEEE Radio Communications, S12–S18 (June 2005)
5. Wang, L.-C., Huang, S.-Y., Tseng, Y.-C.: Interference Analysis and Resource Allocation for TDD-CDMA Systems to Support Asymmetric Services by Using Directional Antennas. IEEE Transactions on Vehicula Technology 54(3), 1056–1068 (2005)
6. Chang, K., Lee, K., Kim, D.: Optimal timeslot and channel allocation considering fairness for multicell CDMA/TDD Systems 33(11), 3203–3218 (2006)
7. Zhao, Y.Z.: Study on the Dynamic Channel Allocation Technology in TD-SCDMA System. Jilin University (2007)
8. Shi, W., Zhao, Y., Zhao, S.: A novel fast dynamic channel allocation scheme based on TD-SCDMA system. Journal of Jilin University (Engineering and Technology Edition) 38(4), 955–959 (2008)
9. Shi, W., et al.: Fast dynamic channel allocation algorithm based on priority channel reservation. Journal Communications 30(7), 59–66 (2009)
10. Chen, L., Yoshida, H., Murata, H.: A dynamic channel assignment algorithm for asymmetric traffic in voice/data integrated TDMA/TDD mobile radio. In: International Conference on Information, Communications and Signal Processing (ICICS), pp. 215–219 (1997)
11. Xu, J., Yao, F.: Dynamic channel allocation strategy between uplink and downlink for TD-SCDMA system. Journal of PLA University of Science and Technology (Natural Science Edition) 10(5) (October 2009)
12. 3GPP TSG UTRA TDD: Radio Transmission and Reception. 3GPP TS 25.105.2001
13. Sun, R., Li, J.: Basis Theory of Queuing. Publishing House of Science, Beijing (2002)
14. Shi, W., Zhang, L., Hu, K.: Communication Network Principle and Applications. Publishing House of Electronics Industry, Beijing (2008)
15. Zhao, S., et al.: Network deployment, operation and optimization practice in TD-SCDMA system. Publishing House of Electronics Industry, Beijing (2010)
16. Ismail, M., Aripin, N.: Downlink Soft Handover Performance for Different Cell Selection Schemes in WCDMA System. IEEE (2005)
17. Guo, S.: Radio resource management of TD-SCDMA system. ZTE Communications 5(12), 36–39 (2006)
18. Zhang, X., et al.: HSUPA/HSPA Network technology. Posts & Telecom Press, Beijing (2008)