A new code allocation scheme for UMTS system

Thamer Al-Meshhadany[1] and Khaldoun Al Agha[1,2]
[1]Laboratoire de Recherche en Informatique (LRI)
Bât 490 Université Paris Sud
91405 Orsay Cedex, FRANCE
phone (33)(0)169156591; fax (33)(0)169156586
[2]Institut National de Recherche en Informatique et en Automatique (INRIA)
Domaine du Voluceau - B.P.105
78153 Le Chesnay Cedex, FRANCE
email: {thamer,alagha}@lri.fr

Abstract—**Third generation wireless system is based on the CDMA access technique. In this technique, all users share the same bandwidth simultaneously but with different codes. This sharing generates interferences that can reduce the system's capacity when using a weak code allocation algorithm. In this work, we analyze the WCDMA capacity as a function of the type and the number of allocated codes. We also study the way used to assign codes to users. Finally we propose a new scheme that assigns the code allocation according to the type of the user's application. Simulation model and results are provided in this paper.**

Keywords—**WCDMA, control power, resource allocation.**

I. Introduction

The data modulation in the UMTS system consists of a sequence of two stages: spreading and scrambling. In the first stage, we spread the user's information over a bandwidth that is large but constant. We replace the 1's bit (or symbol) of the user's information by the chip code and the 1-complement of this chip code if the bit is 0. We provide different data rate by replacing each bit with a variable-size chip code in respect to the fixed spreading chip rate [1].

The Orthogonal Variable Spreading Factor (OVSF) that is used in this stage provides variable size code and zero cross correlation. Every user transmits data on one or multiple channels according to the information quantity and to the delay required. Thus, every channel can spread the data transmitted with different codes. This code is called "the channelization code". The second stage is the scrambling in which we sum all the channels of the first stage to constitute one data flow that is multiplied by a unique scrambling code. The scrambling codes are generated from the Gold and Kasami sequences [2], [3], [4] that use pseudo-noise sequences. These sequences are not orthogonal but they provide excellent quality of auto and cross correlation properties. Thus, It is obvious that the scrambling codes generate more interference than the orthogonal codes.

Our analysis for the resource allocation mechanism in the 3rd generation was based on three essential points: how we can reduce the interference generated from the using of scrambling codes in order to increase the system capacity? Secondly, how we separate the different services taking into account the delay and the Quality of Service (QoS)? Finally, how we simplify the algorithm of the resource allocation?

When evaluating the UMTS mechanism [5] by studying points described above, we can observe that firstly, this mechanism multiplexes all the active user's services to constitute the data flow. This flow is transmitted by using one or several physical dedicated channels after multiplying every channel by an orthogonal code, then we sum these channels and multiply the result by the scrambling code that is designed by the base station. The combination of the real time (RT) services and the non real time services in the same multiplexer can reduce the performance of the RT service transmission (the delay of transmission for the RT services may be augmented).

Secondly, the user transmits in fact two or up to three services simultaneously. The UMTS offers one scrambling code and a tree of channelization codes for every user. Consequently, The code utilization is not optimized because the majority of the OVSF tree codes are unused. Thus, on the basis of the UMTS spreading principles, we propose a new strategy of service management and code allocation that reduces the aggregate number of used scrambling codes in the system. Consequently, the interference will be moderated and the system capacity is improved.

Our proposition (called OSSC [6]: One Service, One Scrambling Code) consists of grouping the users that use the same service under the same scrambling code by assigning to each user the adequate channelization code for his active service. The base station indicates on the broadcast channel the assignment of this scrambling code. Each user using the announced service makes synchronization and asks the base station about his channelization code. After the assignment of the OVSF code to this user, he spreads and modulates his data for transmission.

This work is organized as follow, Section II presents the UMTS and OSSC code allocation schemes; Section III describes simulation model and provides simulation results.

II. The OSSC and UMTS models

A. The UMTS code allocation scheme

Figure 1 depicts the UMTS code allocation [5] in a cell where every user can transmit his data in one or several channels after multiplying each channel by an orthogonal code. We sum all these channels to constitute the data flow that is multiplied by the unique scrambling code assigned to the user by the base station.

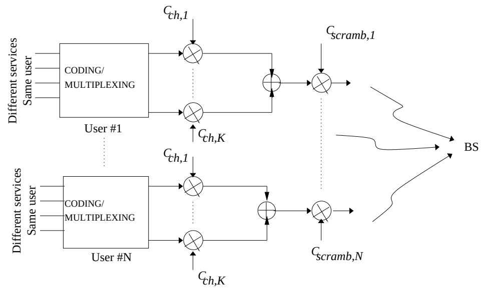


Fig. 1. UMTS system model.

An example is given in the Figure 3(a) where three users are actives in the cell. Each user transmits on a unique scrambling code Sc_i. All services (voice, data or both) are multiplexed on the scrambling sequence by using separate OVSF codes.

B. The OSSC code allocation scheme

The OSSC [6] (One Service One Scrambling Code) consists of allocating a scrambling code for each supported service in a cell. The base station indicates on the broadcast channel the assignment of this scrambling code. Each user using the announced service makes synchronization and asks the base station about his channelization code. After the assignment of the OVSF code to this user, he spreads and modulates his data for transmission. This user processing is illustrated in Figure 2. By using this mechanism, we multiplex all homogeneous services on the same scrambling code and apply the same service requirement on all user flows. Since mixing all users on the same scrambling code, this procedure allows also a best utilization of the scrambling code and reduces consequently the interference between codes assigned in the given cell.

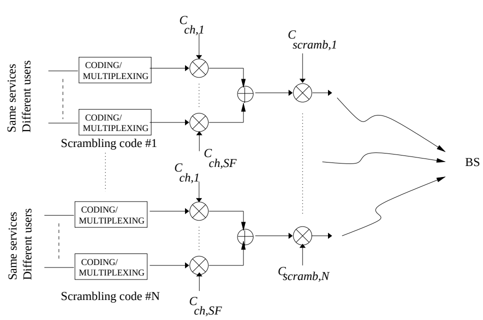
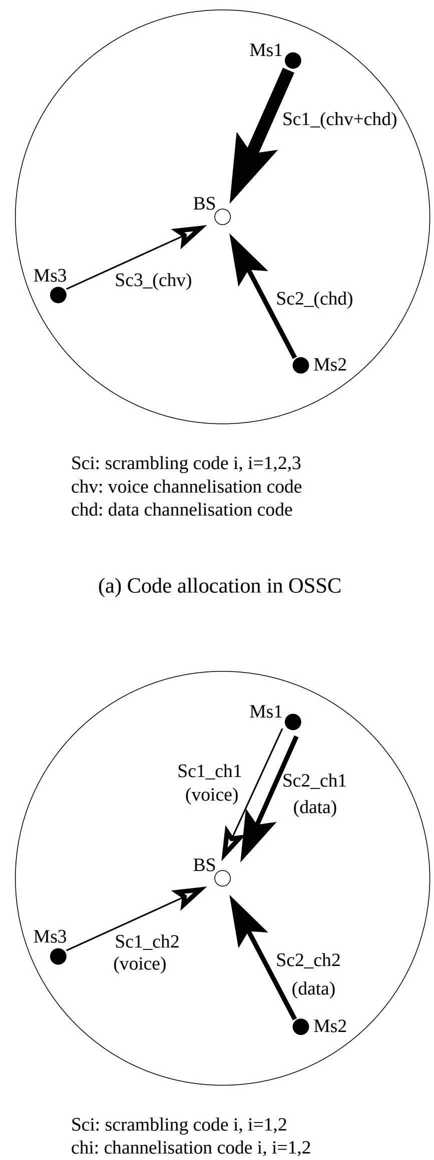


Fig. 2. OSSC system model.

Figure 3(b) shows the same example of Figure 3(a) by using the OSSC scheme: each service has its scrambling code SC_i and users transmit data or voice by using different OVSF codes.

In [6], the OSSC is studied analytically and compared to the WCDMA code allocation scheme. The uplink WCDMA scheme employs an opposite method than OSSC. It assigns on scrambling code to each user and then, the user, on this scrambling code, multiplex his services by using OVSF tree. These OVSF codes are orthogonal and generate a cross correlation equal to zero. Figure 3 illustrate code allocation in WCDMA and OSSC.



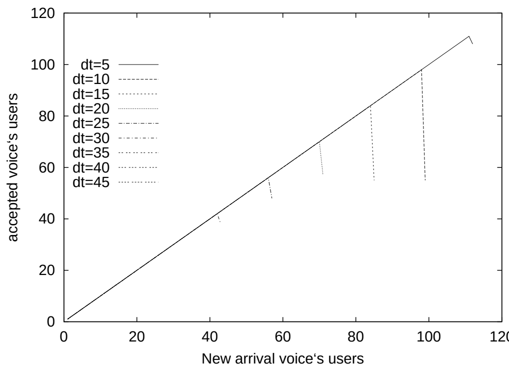
(a) Code allocation in OSSC

(b) Code allocation in UMTS

Fig. 3. OSSC system model.

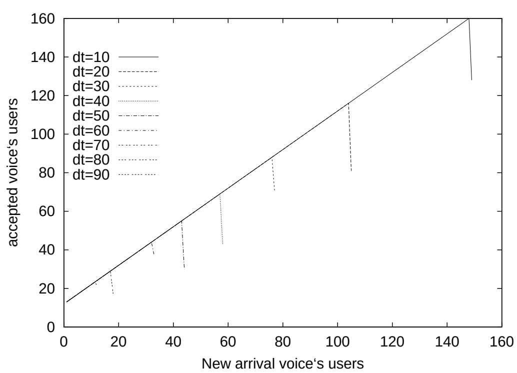
The study, shown in [6], exhibits the performance optimization of the cell capacity when using an OSSC mechanism. Figures 4 and 5 illustrate the system capacity in term of the maximum number of users accepted in the system for WCDMA and OSSC respectively.

Figure 4 exhibits the number of accepted voice users versus the total number of new users. Several curves are depicted. Each curve is related to the number of active data user in the cell. The value of the factor of orthogonality is $\alpha = 0.3$. All curves are superposed until the system capacity reaches its maximum. The maximum reached depends, of course, on the number of active data users. When the active data users are high, the number of voice users accepted decreases.



$\alpha = 0.3$*, number of multiple-service users=12, dt: number of data's users*

Fig. 4. UMTS anaylitical system capacity.



$\alpha_{orth} = 0.1, \alpha_{scramb} = 0.4$*, number of multiple-service users=12, dt: number of data's users.*

Fig. 5. OSSC analytical system capacity.

In Figure 5, same results are illustrated. Comparing to Figure 4, the gain obtained by using the OSSC was augmented. Thus, between 17 and 50 more voice users are accepted depending on the number of data active users. In the same way, the number of active data users can be augmented.

In short, the gain by using the OSSC scheme varies between 31% and 77%. Other parameters were used to study the behavior of the two schemes. These parameters are: α and the number of active multi-user.

III. Simulation model

The used simulation model consists of a cluster of 64 hexagonal shaped cells where a sample is shown in Figure 6. Edge effects to handoffs at the cluster boundary are handed by wrapping then around thereby assuming that handoff arrival rates and handoff departures rates from cluster to cluster are equivalent. Among the assumptions made in the study the call duration is exponential with a mean value of 120s. The cell dwell time (time a mobile spends in a cell) is also assumed exponential with mean value 50s. Two types of traffic are considered: voice and data. Voice and data users represent 70% and 30% respectively. Arrivals are modeled by Poisson distribution with mean λ. Two E_b/I_0 values are considered to distinguish voice from data users. Simulation parameters are the same of the analytical model in [6]. Table I show values of these parameters.

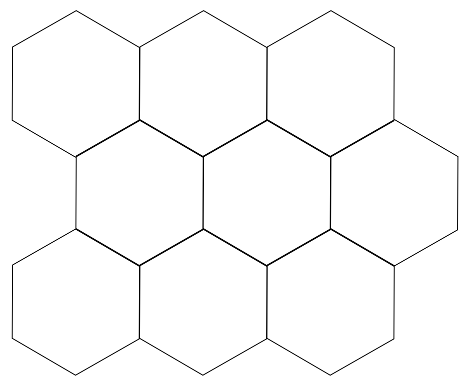
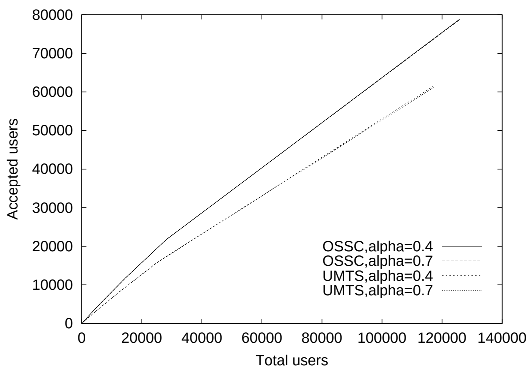


Fig. 6. System layout.

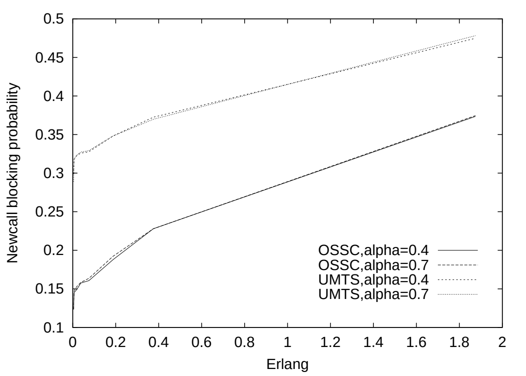
TABLE I
Implementation parameters.

item	value
Bandwidth	3.84Mcps
voice rate	15kbps
data rate	30kbps
$(E_b/I_0)_{voice}$	$5db$
$(E_b/I_0)_{data}$	$7db$
Max power transmitted	0.05W
Path loss	d^{-4}
Noise, η	$3.98 * 10^{-21}$

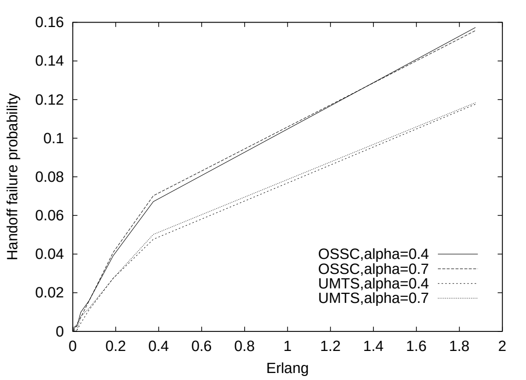
The simulation consists in accepting a user while conditions for a perfect power control is respected. First, the user enters in a cell. The power vector of all clients in the cell is recomputed. Users are invited to increase their power because of the additional interference generated by the new user. When the maximum power is reached, no new users are accepted. The handoff treatment is similar. Performances are calculated in terms of handoff dropping probability and new call blocking probability. All simulations are implemented by OPNET.



(a) Number of accepted users.



(b) New call block probability



(c) Handoff failure probability

Fig. 7. System performance.

The figure 7(a) exhibits the number of accepted users versus the total number of new users. Indeed, when the number of users exceeds 2000, the system capacity is obviously increased by 2% for a low system load and 8% for a high system load.

Figures 7(b) and 7.c compare the performance of UMTS and OSSC under two orthogonal factor values ($\alpha = 0.4$ and $\alpha = 0.7$. These figures show clearly a gain of 50% for new call probability and a gain of 20% of handoff failure probability when using the OSSC scheme. It obvious that this gain is obtained due to the interface reduced by maximizing orthogonal allocated codes and minimizing pseudo noise sequences.

IV. Conclusions

In this work, we have analyzed by simulations under OPNET the OSSC code allocation scheme FDD-WCDMA in the UMTS standard. We focused our study on the interference effects on the system capacity. This interference is related to the number of scrambling codes in each cell. The essential of our work separates the effect of the interference into two different sets: the interference that is generated by orthogonal codes and the interference that is generated by scrambling codes.

Simulation results show potential gain when using one scrambling code per service. The quantity of interferences is reduced on users communication and more users are accepted in the cell. Also, probabilities of new call block and handoff failure are reduced.

References

[1] TSG RAN WG1, "Spreading and modulation (FDD)," Tech. Rep. TS 25.213, 3GPP, mars 2000. http://www.3gpp.org.

[2] E. Dahlman, B. Gudmundson, M. Nilsson, and J. Sköld, "UMTS/IMT-2000 based on Wideband CDMA," *IEEE Communication Magazine*, vol. 36, pp. 70–80, Sep. 1998.

[3] W. M. Prodip Cnaudhury and S. Once, "The 3GPP proposal for IMT-2000," *IEEE Communication Magazine*, pp. 72–81, Dec. 1999.

[4] E. H. Dinan and B. Jabbari, "Spreading codes for direct sequence CDMA and Wideband CDMA cellular networks," *IEEE Commiunication magazine*, vol. 9, pp. 48–54, Sep. 1998.

[5] TSG RAN WG1, "Multiplexing and channel coding," Tech. Rep. TS 25.212, 3GPP, mars 2000. http://www.3gpp.org.

[6] T. Al-Meshhadany and K. A. Agha, "OSSC: A new scheme for code allocation in WCDMA," in *IEEE PIMRC2001*, (San Diego, USA), sep.-oct. 2001.