UTILIZATION OF MACRODIVERSITY FOR THE IMPROVEMENT OF SYSTEM CAPACITY IN UMTS

Thomas Brüggen, Jochen Trenzinger

Institute of Communication Systems and Data Processing (ind)
Prof. Dr.-Ing. Peter Vary
Aachen University, 52056 Aachen, Germany
brueggen@ind.rwth-aachen.de

INTRODUCTION

In the digital communication system UMTS (Universal Mobile Telecommunication System) [1], the system capacity depends on the Radio Resource Management (RRM) [2]. The RRM handles, e.g., the dynamic allocation of transmit powers for the individual users.
Macrodiversity in UMTS allows a mobile station (MS) to be connected to more than one single base station (BS). With dedicated RRM strategies, the transmit power necessary for the MS can be partitioned to the different radio links in the downlink. In addition, the "soft handoff" [2, 3] and load distribution between adjacent cells can be realized by macrodiversity.
In this paper, a system-immanent effect influencing system capacity and a new dedicated downlink RRM function with power partitioning considering macrodiversity are presented. Their effects on the system capacity defined as number of mobile stations being connected to a BS is examined by the "UMTS System Level Simulator" which we developed at our institute [4].

SYSTEM-IMMANENT EFFECTS AND POWER PARTITIONING

The graphical output of the simulator illustrates a network with MSs and BSs in an area of, e.g., 2.5 x 2.5 km. The simulator is used to observe the behavior of a UMTS network for various traffic situations and RRM strategies.
With macrodiversity, the Radio Resource Management has to handle the power partitioning between the different links from the base stations to the mobile station. One reasonable goal of RRM strategies is, e.g., a balanced traffic load of all base stations.

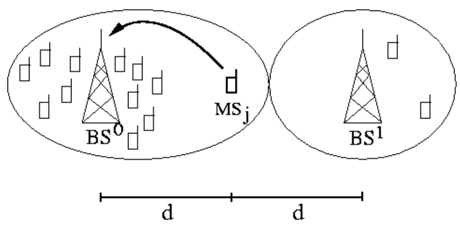

Fig. 1: MS in the center between two BSs connects to the full cell with BS^0

Some system-immanent effects which we examined with the UMTS System Level Simulator can reduce the system capacity [4, 5]. For example, Fig. 1 shows two cells and the mobile station MS$_j$ in the middle between the base stations BS^0 and BS^1. The left-hand cell contains many mobiles causing intense traffic. In contrast, the right-hand cell is nearly empty. At the beginning of the scenario, MS$_j$ wants to establish a radio link to the BS with the lowest interference and calculates the signal to interference ratio (SIR) of the pilot channel of BS^0:

$$SIR^0 = \frac{P^{0,pilot}}{P^{1,signal} + P^{1,pilot}}$$

with the pilot channel power $P^{0,pilot}$ of BS^0, the interference power of the other BS's pilot channel, $P^{1,pilot}$, and the total interference power $P^{1,signal}$ from BS^1 to the MSs in the neighboring cell excluding the pilot power. The MS_j also calculates the pilot channel SIR of BS^1 with the same Equation but exchanged indices 0 and 1.
Assuming that the pilot channel powers are equal in both cells, SIR^0 and SIR^1 differ only by the interference power $P^{1,signal}$. If MS_j logged on to the right-hand BS^1, MS_j would receive the interference from all mobiles in the left-hand cell due to the different scrambling codes used by BS^0 and BS^1. However, if the MS logged on to the left-hand BS^0, only the few mobiles in the right-hand cell would cause interference. As a result, the MS_j connects to BS^0.
In order to improve system capacity, we introduce the novel mechanism „power partitioning" to balance the traffic load and therewith to balance the transmitted powers of all BSs in the network, and describe its effect on the capacity. The power transmitted to a specific MS_j by, e.g., two base stations BS^0 and BS^1 can be subdivided with this control mechanism into all possible ratios P^0/P^1, not necessarily $P^0/P^1 = 1$ (with P^0 and P^1 denoting the power fraction transmitted by BS^0 and BS^1, respectively, to MS_j). The power partitioning algorithm exploits the total powers of the BSs to determine the distribution of the powers transmitted on the different links to MS_j in the macrodiversity area. The downlink power to be transmitted on each link of MS_j is calculated with the ratio of the total powers by the bases stations connected with MS_j. A higher loaded BS transmits a smaller part of the total power for MS_j than a less loaded BS. In addition, the power control for the pilot channel determines the size of the cells and of the macrodiversity areas. With these mechanisms, the RRM can avoid cell overload, and extreme interference peaks.

CONCLUSIONS

Our statistical system-level simulations confirm the increase of the cell capacity by the presented RRM strategies. Table 1 shows an example of the simulation results. The second column indicates the total number of MSs in the system. The last two columns give the total number of unconnected MSs without (third column) and with Rayleigh fading (fourth column). The scenarios no. 1 and 2 are simulated without and with macrodiversity, but without any RRM strategies. In scenario no. 3 power partitioning and pilot power control are simulated together. With these two RRM strategies, 22 additional MSs can be linked to a BSs, and the number of MSs without radio coverage is diminished significantly.

Table 1: Simulation results: example with 8 base stations

No.	Scenario	# MS	# $MS_{no\ link}$	# $MS_{no\ link}$, fading
1	no macrodiversity, no RRM	220	1	54
2	macrodiversity, no RRM	220	2	57
3	macrodiversity + RRM	242	0	47

REFERENCES

[1] B. Walke, *Mobile Radio Networks*, Wiley, 2002.
[2] N. D. Tripathi, J. H. Reed and H. F. VanLandingham, *Radio Resource Management in Cellular Systems*, Kluwer Academic Publishers, 2001.
[3] H. Holma and A. Toskala, *WCDMA for UMTS*, John Wiley & Sons, Ltd., 2000.
[4] J. Trenzinger, Effect of Macrodiversity on the Capacity of the UMTS Mobile Communication System, Diploma Thesis (in German), Institute of Communication Systems and Data Processing, RWTH Aachen, 2001
[5] T. Brüggen, M. Werner, Y. Vasseur, J. Trenzinger and P. Vary, *Capacity Improvement in UMTS by Dedicated Radio Resource Management*, in Proc. VTC Fall, Vancouver, September 2002