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Group Cell Architecture for Cooperative Communications

Springer

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Foreword

For the past decades, cellular network architectures have achieved great success during the development of mobile communications. However, today cellular network architectures encounter some unprecedented challenges, which include higher data rate, higher carrier frequencies, smaller coverage area, and stronger BS processing abilities. What changes will occur in future mobile network architecture? How to improve the network architecture?

In 2001, Prof. Xiaofeng Tao et al. proposed the Group Cell architecture for the first time in order to solve the mentioned challenges. The Group Cell architecture is based on distributed cellular architecture with multi-antenna techniques for cooperative communications, which can increase the coverage area and employ the advantages of multi-antennas techniques. Group Cell architecture also has an enhanced flat (not traditional hierarchy) network architecture for IP services. Moreover, Group Cell has covered the scenarios of Coordinated Multiple-Point Transmission and Reception (CoMP), which was proposed in April, 2008 for 3GPP LTE-Advanced as a tool to improve the cell-edge throughput and increase system capacity.

Since 2001, the authors had performed plenty of research about Group Cell for cooperative communication. Based on the Group Cell architecture, the authors studied capacity analysis, slide handover and power allocation in Group Cell, etc. Furthermore, the authors developed the first 4G TDD Trial system for Group Cell and completed the validation of the above key technologies in 2006. Up-to-date, based on the investigations of Group Cell, they have made some good achievements including publications and patents. In this book, the authors share their main findings.

With a balanced blend of theoretical analysis and system verification, this book provides researchers and practitioners with basic properties of Group Cell architecture for cooperative communication and system development. All the techniques introduced in this book are quite new. In addition, this book makes an easy-to-follow presentation and is ideal for graduate students.

Hequan Wu
Academician, Chinese Academy of Engineering

Preface

The reason for writing this book started 11 years ago, as a result of an innovative idea on the cell architecture in mobile communication network. At that time, there was a growing tendency for high speed wired and wireless data rates. The data transfer bottleneck occured at the interface between Radio Access Network (RAN) and the Core Network (CN) as they converged at the Base Station Controller (BSC) via different Base Stations (BSs). An ideal solution is to bypass the BSC and connect the BSs directly with the CN avoiding the possible bottleneck. Control entities resided in traditional BSCs are directly incorporated to the CN, which resulted in a prototype of LTE network structure of nowadays.

Meanwhile, future mobile communication systems will continue to have higher carrier frequencies, smaller coverage area, and stronger BS processing abilities. Thus, the future scenario that multiple distributed AUs (antenna units, antenna elements / antenna arrays) are connected to the same BS would likely be realized soon. We first proposed the Cooperative Communication Oriented Group Cell Architecture in 2001, by combining the technologies (available at that time) such as transmit diversity, micro cells, joint transmission, and MIMO.

The fundamental idea of Group Cell is to convert the traditional hierarchy RAN architecture into an enhanced flat one in which BS will access the CN directly, without the support of BSC. Group Cell is characterized by several adjacent cells in order to serve a certain MT (mobile terminal) in an efficient way. In Group Cell, the physical layer technology greatly affects the way signals are transmitted. For instance, using distributed antenna technique, the same signals can be transmitted by different transmitting AUs, whereas in case of joint transmission, each transmitting AU may send different signals. Group Cell can be formed by adaptive AU selection at physical layer, in which AUs can be selected from both intra BSs and inter BSs, or even from heterogeneous BSs. Moreover, contrary to the traditional static cells, Group Cells are not stationary anymore. They can move together with the moving MT, thus MT will always be located in the center of a Group Cell. By employing this, cell edge problem can be avoided and the handover probability can also be reduced significantly. This also constitutes a prototype of CoMP in 4G networks.

The trial systems with Group Cell Architecture for Cooperative Communications were implemented under the support of the Chinese NSFC and MOST 863 high-tech program in 2006. To the best of the authors' knowledge, these were the first trial systems ever attempted that included features such as 4G TDD, CoMP, mobile Internet with IPV4/IPv6. The 4G TDD and CoMP features were never implemented before. The integration of 4G TDD and IPv6 was also a first attempt of its kind. The 4G TDD feature also supported multi-BS multi-user handover in multi-cell, single-frequency networking,high vehicular speed, and low BER (less than 10^{-8}). The CoMP feature supported multi AUs cooperation in transmit/receive signals. The standardization of technologies mentioned above is in progress, some of which has already been standardized.

In 2009, with lots of preliminary works on cooperative communication in Group Cell, the author carried out further research in Stanford University. After analyzing the capacity of single user, multi-user diversity and ergodic capacity in Group Cell, the author proposed the Slide Handover and fast group cell selection scheme, and evaluated their performances. The authors also studied the energy conservation problem in Group Cell, including ICIC-based downlink resource allocation and downlink power allocation for capacity maximization.

In 2011, under the support of *Prof. Sherman Shen* and *Springer Press*, we decided to publish our research work carried out during the past 10 years. All comments and suggestions for improvements of this book are welcome.

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