Recently, a drastically change has been witnessed in the mobile network, due to the unrelenting increase in bandwidth demanding application, such as video streaming, and social networking. According to Cisco Visual Networking Index [1], the number of mobile-connected devices will surpass the world’s population in 2013, and the global mobile data traffic per month will exceed 10 Exabyte in 2017. The cellular networks which were initially designed for voice and low data rate transmission cannot fulfill the users’ requirements. Thus, improved technologies or new strategies are needed. Meanwhile, studies from ABI research show that over 50% of voice calls and over 70% of data traffic will be from indoor users in the near future and 30% of businesses and 45% of household users experience poor indoor coverage with cellular technology [2]. Moreover, researches [3] show that a 1600 times gain can be obtained through small cell size and reduced transmit distance, because of higher area spectral efficiency and QoS enhancement for indoor users. These changes are shifting the conventional cellular industry from voice-centric homogeneous, one-tier network to the data-oriented, distributed and heterogeneous network, which consists of small entities and functionalities. One of typical technologies in the heterogeneous network is femtocell.

Femtocell is a short range, low power, plug and play base station that is usually deployed by the end-users to support the communication in an indoor area. It connects with a cellular network through a broadband link such as Digital Subscriber Line (DSL). It can help to drop off data traffic from the macrocell and thus benefit the macrocell to support more outdoor users’ communications. The indoor customers’ QoS are improved with the reduced transmission range from the base station and the total energy consumption of the network system is decreased with lower transmission power from femtocell. Furthermore, with femtocell, there is no need to establish new base stations or upgrading the current network infrastructures. Hence, femtocell is viewed as a cost-effective way for both end-users and operators to provide higher data rates and better indoor coverage. Meanwhile, three access strategies are prepared for femtocell: closed access, open access and hybrid access. In closed access, a particular number of users are allowed to connect with the femtocell. In open access, femtocell provides service to every user who is passing by. While in hybrid access, the femtocell subscribers and a fixed set of macrocell users can be supported by the femtocell. In any case, the interference problem is a non-negligible.

Using partition dedicated operating spectrum from macrocell, the interference which is introduced to the system is relatively less. However, it is not economic because of the scarce availability of radio resource. For cellular operators, universal frequency reuse is a preferable choice. But, in close access, the co-channel interference is sever. In open access, the handoff overhead and security problem is introduced. Hybrid access can balance the benefit of both closed access and open access. But the improvement is depending on the portion of spectrum and power that femtocell wants to share with the non-subscribers. Thus, efficient resource management is desired.

In this dissertation, we take account of the coordination of macrocell and femtocell in the case of orthogonal multiple access scheme such as OFDMA and we develop an optimal hybrid access strategy for the Macro Cell-Edge User (MCEU) through efficient resource allocation from the femtocell. We assume the resource of both femtocell and MCEU are limited and both of them are selfish. Game theory helped us to build the hybrid access strategy as it is an effective tool for making decisions according to the choices from both players. Furthermore, to satisfy the guarantee throughput of new accessed MCEUs in a femtocell, a Lagrange based optimal resource allocation scheme is introduced. In the following, I will introduce the details in each chapter.

In chapter 1, I briefly introduced the basic concept of femtocell. At first, I analyzed the current situation of wireless communication system. The development of new generation devices and new applications facilitate modern people’s life, but also propose challenge to the current cellular network. Femtocell is proposed as a preferable approach to meet this challenge. The history of femtocell was described to show the femtocell technology evolution process. A comparison of femtocell and Wi-Fi was given to declare the benefits of femtocell. After that, we examined the key technical challenges encountering in a practical femtocell deployment, including access strategies, co-channel interference, security, handoffs and mobility issues and so on. Then, the characteristic, especially the co-channel interference problem in the heterogeneous network was introduced. The work that I have
done to improve the system performance is stated. At last, I listed the organization of the dissertation.

In chapter 2, the basic knowledge of Radio Resource Management (RRM) is overviewed. First, I introduce the objective of RRM, the importance of RRM and the main issues in RRM. Then, I describe current OFDMA systems and present RRM for these systems. The resource allocation problems in OFDMA system and the main techniques that we used during this thesis are described. OFDMA technologies were considered in this thesis because OFDMA is air interface technology for 4G networks. The main technical algorithms that we used are optimization and game theory. For optimization and resource management, I introduce dual optimization and the Lagrangian duality theory. For game theory, a brief introduction and its applications in telecommunications are listed.

In chapter 3, a game theory based hybrid access scheme was given out to improve the throughput of MCEUs in a macro-femto network. In this chapter, we consider the scenario in which the FBS allows the hybrid access of MCUEs on the condition that the MCEUs rent the power resource from it. However, the FBS is power limited. If almost all of its power is used to serve the MCEUs and its original Femtocell User Equipments (FUEs), when newly authorized FUEs are switched on, there will be little power left to serve these newly authorized FUEs. In this situation, the FBS can select one MCEU as a relay to coordinate its information transmission to the FUE. To reward the cooperation of the MCEUs, the FBS will agree to support the service of MCEUs without charging. Game theory is used to find the optimal power and price value for this procedure. An MCEU relay selection criterion is proposed for the FBS. The optimal power that the MCEU can obtain from the FBS and the power that the MCEU can obtain from the FBS and the power that the MCEU can share with the FUEs are obtained. The simulation results show that the throughputs of both the FUEs and the MCEUs are improved.

In chapter 4, the cell selection and resource allocation problem for the MCEUs were addressed in the heterogeneous macro-femto network. An FBS is allowed to lease its idle resource to the nearby MCEUs on the condition that the MCEUs are willing to pay for the resource usage. The cost of the transaction between the MCEUs and the FBS is expressed as the proportional throughput relationship between the users. A Lagrange based binary integer programming algorithm is proposed. An MCEU first chooses the sub-channels that can provide it with the highest throughput improvement in one of the FBSs. Then optimal power allocation is performed under the constraint of the MCEUs’ throughput requirements in the FBS. The simulation results validate that our proposal can effectively allocate power and channel resource to the MCEUs and achieve improved throughput compared to the case when the MCEUs are served by a MBS. In addition, the fairness among these MCEUs based on their throughput requirements in each FBS is satisfied.

In chapter 5, I concluded the dissertation and stated the future work.

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