Chapter 5

Conclusion and Future Research

This thesis has described some promising techniques for RRM to be implemented in the future IMT-Advanced systems, highlighting the impact of these techniques in the LTE system architecture, which consists of OFDMA-based system.

First we start with GSM, CDMA overview and learn some important concept about their architecture. Then we go deep into physical layer. After GSM and CDMA radio architecture and procedures, we worked on different RRM techniques and at the end we analyze two power control algorithms to understand and get some practical experience of actual RRM strategies, because power control is the important most and critical part of RRM techniques due to interference limited nature of CDMA systems.

Performance of FCA and DCA is evaluated. The blocking and dropping probabilities are calculated for reservation of channels for handoff calls. From the analysis and simulation carried out, it can be concluded that dropping probability for HO-reservation of 15% channels is best. The results of simulation and an analytical model indicate that as there is increase in percentage of priority channels, the handoff dropping probability reduces.

The analysis of the optimum power and rate allocations in a CDMA-based cognitive wireless network with spectrum underlay is done.

Our analysis indicates that there is a limit on the interference threshold beyond which the secondary link transmission rate cannot be increased by increasing the interference threshold. Furthermore, the increase of the secondary user transmission rate
will consume extra power from the primary user, and the same amount of power increase from the primary users can support higher rate of the secondary links using proportional rate allocation, compared to using equal rate allocation among the secondary links.

Different radio resource scheduling algorithms have also been studied. These algorithms include round robin, algorithm based on maximum interference, algorithm on proportional fairness, and algorithm based on softer frequency reuse. Radio resource scheduling scheme, based on cyclic switching scheduling scheme offers the best performance compared to the other schemes.

All aspects are considered while scheduling resources, like the throughput, needs of the user, channel condition, available resources, and the location of the user in the cell. It is the major factor of partial isolation inter-cell interference coordination scheme.

Thus, simulation is extended to find out throughput analysis for both static and dynamic frequency resource allocation schemes. Also blocking rate for different frequency allocation schemes for partial and full isolation is simulated (CSSS).

An adjustable fairness scheduler is also proposed, that allows specifying a desired fairness constraint. A general formulation is proposed and it is specialized to the needs of LTE. The scheduler solves a sum utility maximization problem. The utility of a user is measured by means of the \( \alpha \)-fair utility functions. In order to set a desired fairness we propose an algorithm that predicts the required \( \alpha \) from the observed pmf of achievable user rates per resource. The performance of this prediction scheme is demonstrated by means of LTE link level simulations. Already after few channel realizations the predicted \( \alpha \) converges, closely achieving the desired fairness.

Finally, for LTE-A, which is one of the candidates of 4G, a comparison to a rate maximizing scheduling strategy is carried out by simulation. Our scheduler achieves better results for small user numbers, while for large user numbers also the performance is similar. Subsequently we show how the proposed framework can be used to implement other schedulers. We have compared several schedulers in terms of achieved throughput and fairness by simulations. These show that proportional fair and resource fair schedulers deliver a good conciliation between and throughput and fairness which are
very much supportive for allocation of Radio Resources in LTE.

So the main conclusion of all above analysis is that a fast and accurate power control for RRM is necessary to run the operations smoothly, to maintain the network coverage according to the planning and to provide services with better quality of service to make customer happy.

**Future Research**

There is still much work to be done in the area of 4G. As 3GPP LTE proposes that the radio resources must be scheduled every 1ms which is also called TTI in scheduling, this will place a lot of processing on the eNodeBs. The ways to speed up this scheduling process must be found.

3GPP LTE also recommends the use of higher order modulation schemes like 64QAM which will enhance the system throughput to a greater extent but it will also place a lot of processing on both ends of transmission. Its performance should also be investigated. Deployment of higher order modulation techniques may also suffer from the noise created by the processing in both ends of the transmission. So, this noise behavior should also be investigated.

This thesis also deliberates resource allocations of cognitive radio networks in a CDMA-based scenario. All simultaneous transmissions cause interference to one another, and transmission power management is the major factor that affects former aspects of the network performance.

There are more practical and interesting topics on resource allocation that should be studied for CRNs. In this work, single cell environment in the primary network and a single CRN is studied. When multiple CRNs coexist in a cellular network with multiple radio cells, resource management becomes more complicated, yet more transmission opportunities can be explored for the CRNs. Resource management in multihop ad hoc CRNs should also be studied to extend the current work, which is based on single hop
transmissions. In our current work, we have assumed the assumption of stationary traffic load in the primary network.

When there is major jitter or the traffic load exhibits heavy tail distribution, the current admission control for long term throughput assurance may not be valid, and other methods should be explored to predict the resource availability in the CRNs.

Further work can be done for supporting variable rate traffic, maximizing a certain system utility function, such the throughput, subject to providing the users with a certain fairness, supporting user mobility, etc.
Publication from the Thesis

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