Abstract – Due to the limited transmission power at the user equipment (UE), 3GPP’s LTE (Long Term Evolution), uses a variation of OFDMA in the uplink called SC-FDMA (Single Carrier FDMA), to deal with the large signal variations observed in OFDMA and achieve a lower PAPR (Peak to Average Power Ratio). The introduction of SC-FDMA in LTE however, brings yet another challenge, since the allocation of resources is restricted to contiguous bands in the frequency domain. We propose to research and compare sub-optimal algorithms for resource allocation under various but strict criteria such as limited power, QoS, fairness, etc. Furthermore, the aspect of resource allocation under ICI will also be addressed in this research.

Index Terms — SC-FDMA, LTE, uplink, resource allocation

INTRODUCTION

OFDMA (Orthogonal Frequency Division Multiple Access) is a multiple access scheme based on OFDM, which allows several users access to some network resource. Examples of Next Generation Wireless Networks standards that have adopted this MA scheme include Mobile WiMAX IEEE 802.16e and 3GPP’s LTE in the downlink [1].

OFDMA is highly efficient, since each adjacent subcarrier is orthogonal removing the need for guard bands. However, since each subcarrier is modulated independently the overall transmitted signal varies quite a lot leading to a high Peak to Average Power Ration (PAPR). This has an undesired effect that is specially felt in the uplink where the mobile devices have a limited amount of battery life

LTE deals with this problem in the uplink by using a DFT-precoded version of OFDMA called SC-FDMA. By doing this the output waveform behaves like a single carrier, without giving away the “beneficial” properties of OFDMA such as subcarrier orthogonality. With this scheme a lower PAPR is achieved which ultimately means that the mobile device will attain greater transmit power efficiency.

When multiple users are trying to access network resources, for instance bandwidth, there needs to be an efficient way of allocating these resources both in the time and frequency domains [2]. In this research we will only look at the frequency domain.

To optimally allocate resources, a “picture” of channel conditions is needed. This picture of the channel allows the system to take advantage of frequency diversity among the different users. What this means is that a user is allocated a sub-carrier that performs well for him and perhaps badly for the other users. In LTE, downlink direction, PRB’s (Physical Resource Blocks) can be allocated to users in an interleaved manner thus maximizing frequency diversity. However in the uplink only contiguous allocation of PRB’s is allowed, meaning that some of that frequency diversity is lost.

In this section OFDMA and SC-FDMA as used in the uplink were introduced. In section II we discuss the relevance of this research, in section III we discuss the related research being done, in section IV we present the research objectives and in section V we conclude.

RELEVANCE OF RESEARCH

The high availability of multimedia content and services in the Internet, and devices that support these applications has led to a sharp increase in data demand. This ultimately means that better techniques at the PHY and MAC layers need to be studied in order to achieve higher transmission capacity.

Thus, the main objective here is to research techniques that will allow users to meet their new expensive QoS requirements while minimizing the amount of energy used.

RELATED WORK

The quest for finding the most efficient way of allocating resources in Wireless Networks under the influence of various channel impairments has led to a large variety of algorithms being proposed. The possible outcomes of (users - resource allocations) are so many that finding the optimal solution is impractical under real world conditions. To circumvent this limitation, sub-optimal algorithms have been developed in order to find a “good enough” approximation, with “low enough” complexity to be considered practical [1].
In [2], 3 heuristic Frequency Domain Packet Scheduling (FDPS) algorithms are presented. The main focus of this paper is that of contiguous packet scheduling with proportional-fair criteria.

In [3], LTE uplink power control is discussed where both the open-loop and closed-loop components of power control are argued. A trade-off point is reached and the conclusion reached was that optimal power control involves both open and closed loop components.

In [4], an LTE uplink packet scheduling algorithm based on search trees is proposed. The algorithm proposed provides considerable throughput gain over LTE RAN under the proportional-fair criteria.

In [5], a distributive non-cooperative game is proposed to perform sub-channel assignment, adaptive modulation, and power control for multi-cell multi-user Orthogonal Frequency Division Multiplexing Access (OFDMA) networks taking into account ICI (Inter-Cell Interference).

PROBLEM DEFINITION AND RESEARCH OBJECTIVES

It is almost a certainty that at the end of a resource allocation research paper, the conclusion will state that some sort of gain or improvement has been achieved. However this does not have much meaning when each researcher has optimized the environment/model to perform well for his specific algorithm. So, when confronted with various algorithms each claiming to provide improvement over previous ones, how can you make valid comparisons when the initial assumptions and constraints for each algorithm vary? The idea is then to create strict scenarios with conditions under which the algorithms will be executed and compared to determine which has better performance.

It is important to also consider the fact that most algorithms studied for resource allocation tend to simplify the effect of the interference caused by frequency re-use in neighboring cells, by considering this effect as white noise [2-4]. In practice some gain in capacity and power efficiency can be achieved by considering ICI [5].

Thus, this research aims at finding the “best” performing resource allocation algorithm under restricted power allocation in the LTE uplink.

The expected deliverables of this research are:
- Comparison of different resource allocation algorithms in the uplink and the determination of best performing allocation algorithm,
- Development of a resource allocation algorithm (joint subcarrier and power) which takes into account inter-cell interference from frequency-reuse

CONCLUSION

A relatively extensive research on resource allocation for LTE uplink has been done, with some algorithms achieving improvements under certain conditions. However, no comparison has been done to determine which algorithm performs best under strict metrics of real case situations such as power constraints.

Furthermore, there is a lack of resource allocation algorithms for LTE uplink based on game theory, that take into account ICI.

This research proposes to address the above mentioned topics.

REFERENCES


Armando Ubisse received his undergraduate degree in 2009 from the University of Cape Town and is presently studying towards his Master of Science degree at the same institution. His research interests include power control, packet scheduling and resource management in Next Generation Wireless Networks.