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Resource Management for Wireless Systems under Assignment Methods and Optimization Algorithms: Survey

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ABSTRACT: This article describes the different methods and rules for managing resources radio sources radio resource management (RRM). We wish by this present study to achieve a twofold objective to create an analytical model of the problem of optimization radio resources and highlight recommendations for the management of resources in terms of frequency and power of a transmission network based on one of the most used modulation techniques such as OFDM.

KEYWORDS: OFDM, OFDMA, Radio Resources, Random and Adaptive Allocation, Optimization Algorithms.

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I. INTRODUCTION

In fact, it begins with a semantic interpretation of the term Radio Resource Management (RRM). The word resource management in a communication system has no bearing on the content or value of the management. It's all about allocating resources at the physical level, using frequency and power. Two categories of assignments are considered in this article paper. In the first part of this, we will introduce randomization methods that use one of the most promising access technologies for 4G access networks. (IEEE 802.11, WiMax, LTE) known as OFDMA. In the second part of this work, the details of the investigation of various methods of assignment of adaptive resources are presented.

II. RELATED WORK

In this section, we review the optimization based wireless network resource management techniques and discuss the open issues.

II.1 Network Resource Usage Optimization

Optimization based approaches are widely utilized to improve the performance of network systems. Network Utility Maximization (NUM) has been one of the most notable techniques in network optimization, since it was first introduced in the 1960s. Kelly et al. [6] further extended NUM by introducing a pricing mechanism for resource management. This pricing approach is used in network congestion control optimization, such as [9, 10, 11]. NUM tries to capture the network dynamics by embracing user objectives (the utility function) and resource sharing constraints. Usually, NUM defines a utility function based on the types of optimality and fairness the algorithm wants to achieve. The utility function should be concave and second order differentiable. The optimization framework incorporates network dynamics like capacity, scheduling and power constraints, by formulating them as constraint inequalities. Solution to the optimization problem can be obtained via primal, dual or primal-dual algorithms. Since its birth, NUM has gained tremendous success in resource management for both wire-line and wireless networks. Other optimization techniques, like multi-objective optimization involving the user objective and operator objective, and game theorem based optimization [3] are also effective techniques in optimizing resource management.

In wireless resource optimization problems, the major difference from wire-line networks is the resource sharing mechanism, which is constrained by the interdependencies among wireless links: when one link is used, the links in the same channel and within the interference range of this link cannot be active. Therefore the formulations of wireless optimization problems usually rely on some interference models, for instance, the conflict graph [12].

II.2 Channel Assignment and Scheduling

Optimization algorithms on channel assignment and scheduling focus on improving the quality of service by controlling media access, like wireless link access [3, 12, 13, 14, 15, 16], channel usage [1], etc. A notable scheduling policy is the well-known throughput optimal scheduling [30]: Maximal Matching Scheduling, which is used by many existing works like [2, 7, 8] and [18]. The capacity of wireless networks can be greatly extended by using multi-channel multi-radio (MC-MR) interfaces. Each radio can switch between several orthogonal channels to avoid interference. The work of [1] proposes a robust resource provision channel assignment algorithm for MR-MC wireless networks. The solution provides guaranteed QoS under channel variability and external interference. The Max-Weight algorithm [17] is a popular scheduling strategy, which determines the transmission priority based on the product of queue length and current channel rate.Max-Weight involves both user demands and channel variation, and was considered to provide throughput optimality. However, the work in [19] proves that Max-Weight is not always throughput optimal under certain flow-level dynamics.

II.3 Routing

Generally, routing is a mechanism used to find the path(s) from a source to a destination in a network, which can also be formulated as optimization problems. The algorithms solving these problems usually claim analytical properties like resource utilization optimality and throughput fairness [5].

Optimal routing under conflict graph [11] is a throughput optimal routing strategy. It relies on a conflict graph model: the link dependencies in a wireless network can be modelled by a graph, in which the interference between two links is mapped to an edge of graph. A throughput optimal routing algorithm is derived from a multi-commodity flow problem, in which the graph model is used to formulate the constraint set.

Wireless networks are often constrained by the power of wireless clients. The power aware routing [4] aims at finding the most energy-efficient route. It employs energy opportunistic weighted minimum energy routing strategy based on the energy consumption model to maximize the total revenue of a network.

II.4 Congestion Control

Congestion control algorithms adapt the sending rates at the source nodes to avoid traffic congestion in networks. Since the seminal work by Kelly [6], congestion control problems have been investigated under the optimal resource allocation framework. Algorithms in this class explore how to maximize network utility under the constraint of network capacity by allocating sending rates and meanwhile maintain fairness among the competing flows, such as the max-min fairness and the proportional fairness. To this end, many existing works [9, 10, 20] adopt an optimization variable called price that reflects the demand-supply relationship between the available network resource and bandwidth utilization. Since the achievable capacity of wireless networks is not explicit, Xue et al. [10] use maximal clique to model the resource sharing of wireless nodes. In the contention graph of a wireless network, wireless links are mapped to the vertices and the interference between two links is mapped to an edge in the graph. In a maximal clique of the contention graph, any two vertices are connected, so only one link in the clique can be active at any time, thus the contention graph can be mapped to a set of cliques. Then each clique is associated with a shadow price: the charge for a unit flow to use a link in the clique.

II.5 Cross-Layer Optimization

The cross-layer control algorithms have been popular in wireless resource management. Examples include joint congestion control and scheduling, joint congestion control and routing, and joint congestion control and power control. The idea of cross-layer optimization is motivated by the inherent nature of wireless resource sharing: feasible rate region are not explicitly measurable due to wireless interference [7], therefore the optimal resource allocation could hardly be achieved from a single layer.

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II.6 Dynamic-Aware Network Resource Management

Resource management in wireless networks can be further complicated by external dynamics such as time-varying channel and feedback delay. Recently, providing dynamic-aware resource management has attracted a lot of research attention. Time delay problem is notoriously intricate in the area of networking: the out-dated feedback information could raise various problems such as inaccurate rate/scheduling adjustment, bandwidth under/over utilization and system instability. Therefore, investigating network performance under time delay has been a long lasting research focus, either within the context of wire-line networks [9, 21], or wireless networks [22, 23] and [24].

III. RESOURCE ALLOCATION

In the first part, the allocation of resources is considered at the level of the physical layer (frequency and power allocation). This article is devoted to the study of several OFDM resource allocation techniques that allow, depending on the quality of the requested service, to ensure optimal system performance, assuming that the information on the channels corresponding to the subsystems carriers are available. As a result, two alternatives are considered. The first deals with the problem from the point of view, while the second has an adaptive aspect. These last two will be the main focus of our study.

III.1 Random allocation method

This is to describe how the optimal number of subcarriers has been affected. Each user is charged. To achieve this, we consider a number as a subcarrier common for all users. Namely, two hypotheses are considered: A subcarrier can be assigned only to a single user (hypothesis 1) or to two users (hypothesis 2). The probability *P* (*i*) that the users *i* select the same sub-carrier is given by the following expression [33]:

$$P(i) = C_{i-1}^{K} p^{i-1} (1 - p)^{K-1} \quad \textbf{(1)}$$

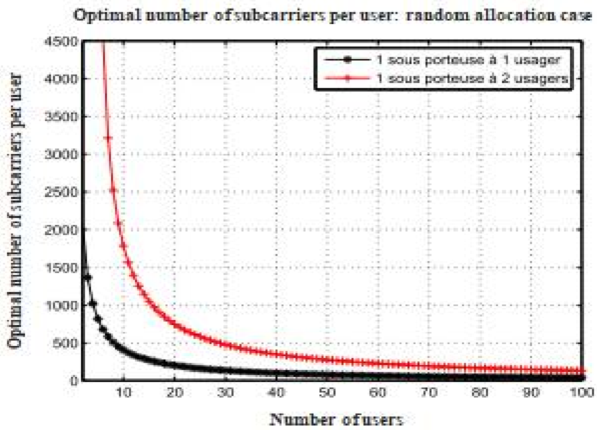

Fig.1: Optimal number of subcarriers per user

Figure 1 shows the variation of the optimal number of subcarriers per user. It should be noted that the larger the number of users sharing the same subcarrier, the larger the optimum number of subcarriers selected per user. This applies to the two hypotheses mentioned above. Therefore, in order to solve the problems of the collision or the rejected subcarriers, it is necessary to reduce the number of subcarriers selected by a user, since the number of collisions increases as the number of user's increases. In the following, delete the user with the lowest number of among carriers that can collide with the total number of users. And the same thing the procedure applies to the remaining users. Each time a user is eliminated, the number of users present in the system will be reduced in turn, and consequently, the number of subcarriers will collide. Hence the application of successive interference cancellation (SIC). N is the number of subcarriers over which the data is modulated, and the number of subcarriers assigned to each user, and a variable number K of users. The number of subcarriers usefulness for each user is described by the following relationship [33]:

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$$n_{SIC} = \frac{1}{K}\sum_{k=1}^{K} n_u = \frac{1}{K}\sum_{k=1}^{K} n*(1-\frac{n}{N})^{K-1} \quad (2)$$

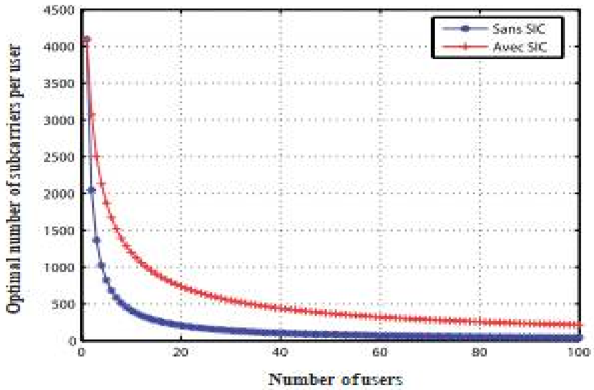

Fig.2: Optimal number of subcarriers per user with or not SIC

From Figure 2 it can be seen that the number of a for the user using the SIC algorithm exceeds this number in the absence of SIC. This brings us to a higher user capacity and thus to a higher return important.

III.2 Adaptive assignment method

Different Types of Optimization Problems There are several types of optimization problems in the literature; we will not fully illustrate them but confine ourselves to the problem of the type Rate Adaptive (RA). The following figure summarizes the different types of optimization issues available in the literature.
- Optimization problem, says in Rate Adaptive (RA),
- Optimization problem in Margin Adaptive (MA),
- Problems of justice,
- Failure problem.

In our study, we limit ourselves to the first type of optimization rate adaptation (**RA**).

III.2.1 Problem formulation of the optimization in RA

In the second part of this paper, we will present a detailed study of the algorithms proposed in the single-cell context of the descending path for an RA problem, as shown in [28, 26, 29, 30]. The fact that this type of problem is best suited to the problems of high-speed networks [31, 32, 25]. The main objective of the RA optimization problem is to maximize overall user throughput with limitations on maximum transmitted power (fixed power budget) and possibly minimal individual riffs u, b for each user.

$$\begin{cases} \max \sum_{b=1}^{B}\sum_{u=1}^{U} r_{u,b} \\ \text{with } P_{tr}^{(b)} < P_{tr,\max}, (1 \le u \le U), (1 \le b \le B) \\ and \ (r) \ge r^0 \end{cases} \quad (3)$$

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IV. PROPOSED APPROACHES FOR OPTIMIZATION ALGORITHMS

Two main applications in the literature they have been proposed as "Approach 1" and "Approach 2", each of which, despite some similarities, allows its own principal both approaches. The basic principle of Approach 1 is to consider that subcarrier assignment (step 1) and power assignment (step 2) are two steps that take place in a different way. For approach 2 they are performed simultaneously joint [31, 30]. We will limit ourselves to approach 1 in our study. Main optimization algorithms Assignment of subcarriers in approach 1 Subcarrier assignment is a process that consists of two sub-steps. The first is to allocate the band and the second to allocate the subcarriers. These last two can be done in a nested (option 1) or different way (option 2).

IV.1 BABS (Bandwidth Allocation Based on SNR) Allocation Algorithm

This algorithm begins by assigning each user the minimum number of subcarriers that they need. If the total number of sub-carriers requested exceeds the total number of sub-carriers ***N*** available, users are eliminated to the minimum of allocated sub-carriers. If you come to a number of subcarriers that are lower than ***N***, or if you have not gone through ***N***, you will begin assigning the additional subcarriers to the subcarriers. Users who actually add an extra subcarrier [30, 34, 27].

IV.1.1 Modified BABS allocation algorithm

A modification of the BABAS algorithm proposed (BABS modified). We become the main goal of the latter and consider the difference between BABS and the modified BABS. The idea with this algorithm is to eliminate the user whose a necessary number of subcarriers is closest to the difference between the number of subcarriers required (higher or equal) by the system and the available number [31, 33].

V. SIMULATION AND RESULTS

We consider in our simulations a mono-cellular context in which the users are evenly distributed. This cell consists of a base station (BS) and a U number of users. As far as the model of the considered channel is concerned, it is constituted N subcarrier. We have the same strategy as in [31]. That we led to the following simulation results.

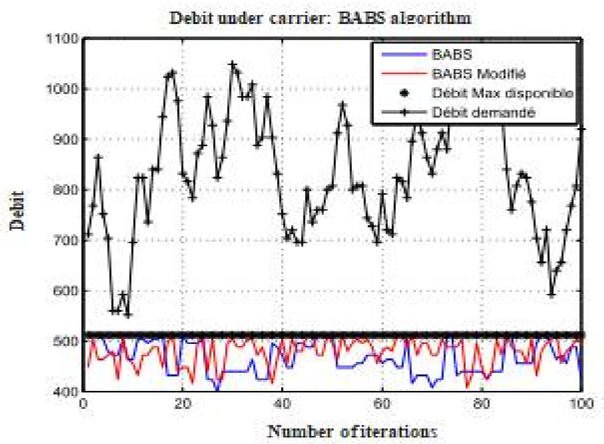

Fig 3: Flow per carrier: Application of the BABS algorithm

VI. CONCLUSION

In the first part, we introduced the principles of random methods for allocating OFDMA resources. Two main parameters are treated in our study. The number of useful subcarriers per user and the average capacity of the users. We have also highlighted the problem of troubleshooting with the algorithm successive interference cancellation (SIC),

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which improves the capacity and thus the load rate transmission. In calculating the number of subcarriers we have considered two approaches. The first is to think that the subcarrier can only be assigned to one user. While in the second, the subcarriers can be assigned by two users.

We will not limit ourselves to the different types of allocation In future studies, we will focus on other areas and approaches that will undoubtedly have advantages over the above methods. In contrast to the first type of assignment method, the second type is the adaptive allocation of radio resources.

In this second part of this article, we introduce the optimization problems that can occur when resource allocation is implemented in OFDMA, a promising access technique. It is mainly the subcarriers and the energy that is available to all users based on the so-called BABS optimization algorithm.

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