OPTIMAL POWER CONTROL IN RAYLEIGH – FADING HETEROGENEOUS WIRELESS NETWORKS

[1]T. Sudha, M.Phil Scholar, Bharathiyar Arts And Science College For Women, Deviyakurichi, Thalaivasal, Salem,
[2]R.Radha, Asst. Professor, Bharathiyar Arts And Science College For Women, Deviyakurichi, Thalaivasal, Salem.

Abstract:

A basic question in wireless networking is how to optimize the wireless network resource allocation for utility maximization and interference management. How can we overcome interference to efficiently optimize fair wireless resource allocation, under various stochastic constraints on quality of service demands? Network designs are traditionally divided into layers. How does fairness permeate through layers? Can physi- cal layer innovation be jointly optimized with network layer This monograph provides a comprehensive survey of the models, algorithms, analysis, and methodologies using a Perron-Frobenius the- oretic framework to solve wireless utility maximization problems. This approach overcomes the notorious non-convexity barriers in these prob- lems, and the optimal value and solution of the optimization problems can be analytically characterized by the spectral property of matrices induced by nonlinear positive mappings. It also provides a systematic way to derive distributed and fast-convergent algorithms and to eval- uate the fairness of resource allocation. This approach can even solve several previously open problems in the wireless networking literature.

Keywords: Perron, Fairness, Physical layer, algorithms.

1. INTRODUCTION

The demand for broadband mobile data services has grown significantly and rapidly in wireless networks. As such, many new wireless devices are increasingly operating in the wireless spectrum that are meant to be shared among many different users. Yet, the sharing of the spectrum is far from perfect. Due to the broadcast nature of the wireless medium, interference has become a major source of performance impairment. Current systems suffer from deteriorating quality due to a fixed resource allocation that does not adequately take interference into account. As wireless networks become more heterogeneous and ubiquitous in our life, they also become more difficult to design and optimize. How should these large complex wireless networks be analyzed and designed with clearly-defined fairness and optimality in mind? In this regard, wireless network optimization has become an important tool to design resource allocation algorithms that can realize the untapped benefits of co-sharing wireless resources and to manage interference in wireless networks. In wireless network optimization, the performance objective of a wireless transmission can be modeled by a nonlinear utility function that takes into account important wireless link metrics. Examples of these wireless metrics are the Signal-to-Interference-and-Noise Ratio (SINR), the Mean Square Error (MSE) or the transmission outage probability. The total utility function is then maximized over the joint solution space of all possible operating points in the wireless network. These operating points are realized in terms of the powers and inter- ference at the physical link layer. As such, wireless network optimization can be used to address en- gineering issues such as how to design wireless network algorithms or analyzing the tradeoffs between individual link performance and overall system performance. It can even be useful for understanding cross-layer optimization, for example, how these algorithms interact between dif- ferent network layers, such as the physical and medium access control layers, in order to achieve provable efficiency for the overall system. It also sheds insights on how fairness permeates through the network lay- ers when interference is dominant. This can open up new opportunities to jointly optimize physical layer innovation and other networking con- trol mechanism that lead to more robust and reliable wireless network protocols.

2. RELATED WORK

The main challenges in solving these wireless utility maximization problems come from the nonlinear and coupling depen- dency of link metrics on channel conditions and powers, as well as the interference among the users. In addition, these are non convex prob- lems that are notoriously difficult to solve optimally. Moreover, designing scalable and distributed algorithms with low-complexity to solve these nonconvex problems is even harder. In fact, there are several important considerations to algorithm de- sign in wireless networks. First, algorithms have to adapt the wire- less resources such as the transmit power and to overcome interference based on locally available information. This means that the algorithms have to be as distributed as possible. Second, the algorithms are practical to deploy in a decentralized manner, i.e., the algorithms have minimal or, preferably, no parameter tuning by a controller. Third, the algorithms have good convergence performance. This is especially important since wireless users can arrive and depart in a dynamic set- ting. Henceforth, wireless resources need to be adapted fast enough to converge to a new optimal operating point whenever the network conditions change. This can be particularly challenging for some kinds of wireless networks such as wireless cognitive radio networks due to the tight coupling in the transmit powers and the interference temper- ature constraints between the primary users and the secondary users.Whatever the algorithms may be, the algorithm design methodology is intrinsically driven by the theoretical approach used in analyzing the optimization problems. Finding an appropriate theoreti- cal approach to study wireless network optimization is thus important.

These works demonstrated that the optimal solution to vari- ous widely-studied max-min optimization problems, e.g., the max-min SINR and max-min rate problems, can be characterized analytically and, more importantly, can be efficiently computed by iterative algo- rithms that can be made distributed. We introduce and present some of these work using the nonlinear Perron-Frobenius theory approach in this monograph. The Perron-Frobenius theory introduced in this monograph is a new theoretical framework for analyzing a class of nonconvex optimization problems for resource allocation in wireless networks. Essentially, this framework provides a convenient suite of theories and algorithms to solve a broad class of wireless network optimization problems opti- mally by leveraging on the recent developments of the nonlinear Perron- Frobenius theory in mathematics.

3. PROPOSED SYSTEM

In this section, we introduce the system models for the wireless network utility maximization problems considered in the monograph. There are primarily two different kinds of system models - one that considers a static transmission channel (i.e., frequency-flat fading) and one that considers stochastic channel fading. Whenever applicable, we will em- phasize the system model to avoid confusion. Let us first introduce the static transmission channel for modeling a wireless network by the Gaussian interference channel. There are altogether L links or users (equivalently, transceiver pairs) that want to communicate with its desired receiver. Due to mutual interfering channels, each user treats the multiuser interference as noise where Glj are the channel gains from the transmitter j to the receiver l and nl is the additive white Gaussian noise (AWGN) power for the lth receiver. For brevity, we collect the channel gains in the channel gain matrix G, and the channel gains take into account propagation loss, spreading loss and other transmission modulation factors. Notice that the SINR is a function in terms of the transmit powers.

There is a strong need of performance modelling which should be able to take care of not only the pure perform- ance but also the availability and reliability model of the system. But most of the performance models will con- sider this contention and generally over estimate the sit- uation and will not consider the failure–recovery of the systems resources in turn the traditional availability mo- dels are not considering the performance metrics. There is a need for a composite model which will work on fail- ure recovery model. Researchers have achieved success in developing tech- niques for modelling the performance, availability and reliability of communication systems in a unified way. There are good number of approaches that have proved the need of unified performance model and availability models of any stochastic system under study. In this pa- per we have proposed composite Performance and Avai- lability models and are evaluated using the stochastic petrinet.

4. ANALYSIS

In this paper we propose a novel analytic performance model admission control mechanism for reducing the call blocking probability there by increasing the resource utilization. This would achieve the objective of guaran- teeing the user QoS requirements. The proposed model is able to handle three types of traffic considered for the study includes conversation traffic, interactive traffic and background traffic. All of this traffic represents different QoS service class of traffic with the following QoS pa- rameters. The conversational traffic is sensitive to transfer delay and jitter.

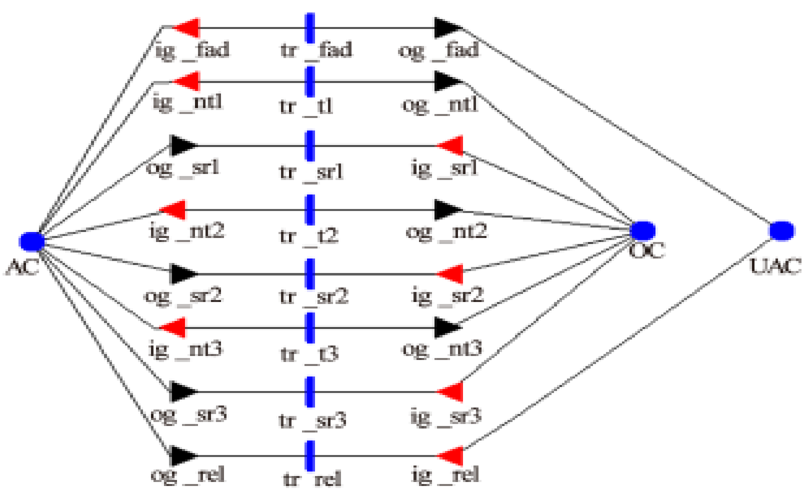

Fig.1. Performance model

It demands guaranteed bit rate and low bit er- ror rate. The examples of the applications belonging to this category are video-conferencing and audio confer- encing. The interactive traffic is a QoS class that is not sensitive to transfer delay and Jitter but demands low bit error rate. The applications of this QoS class do not need guaranteed bit rate for example web browsing, interac- tive chats and interactive games. The background traffic QoS class is not sensitive to transfer delay and jitter but needs low bit error rate from the network. The proposed model is developed keeping in mind the WCDMA, WiFi, and WiMax. The CAC mechanism proposed is focused only on the system's ability to ac- commodate newly arriving users in terms of the total channel capacity which is needed for all terminals after the inclusion of the new user. In the case when the chan- nel load with the admission of a new call was precom- piled (or computed online) to be higher than the capacity of the channel the new call is rejected, if not, the new call could be admitted. The decision of admitting or re- jecting a new call in the network will be made only based on the capacity needed to accommodate the call.

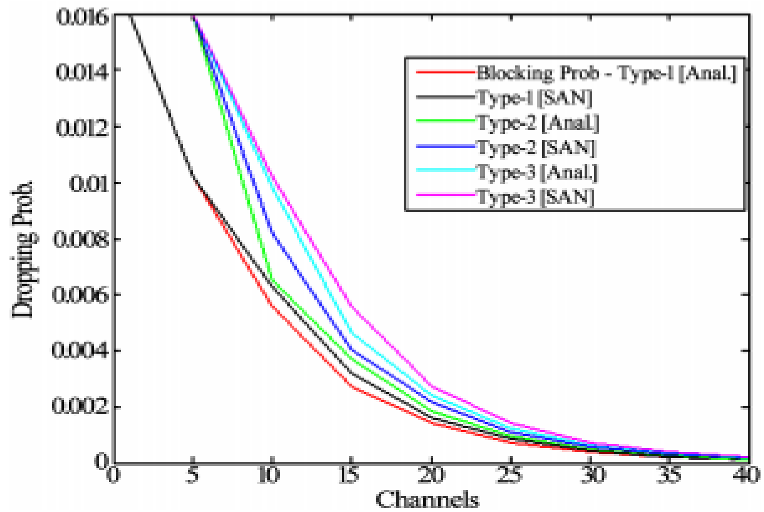

Fig.2.Analysis

The second set of experiments conducted will present the numerical results and compare the call blocking pro- babilities of the different types of traffic obtained for performance-capacity model and the analytical model. The proposed a performance-availability model for call admission control mechanism in the heterogeneous RATs environment is analysed for the call blocking pro- bability, by having variation.

CONCLUSION

In this paper, the performance of analytical model for CAC system for next generation networks is compared and validated with the system performance-capacity mo- del developed using SAN. The Performance of both call admission control models in the heterogeneous RATs are studied pitching upon the call blocking probability by varying the number of channels. The increase in number of channels in the system decreases the call blocking probability of all traffic types. The results obtained for analytical model is in line with the performance model results where both the models behave in the similar fashion in the experiments conducted.

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