# Slow Adaptive OFDMA Systems Through Chance Constrained Programming

**N. Revathy[1], T.Guhan[2]**

**[1]Assistant Professor,
Department of Computer Applications, Karpagam College of Engineering,
Coimbatore, TamilNadu – 641 032, India.**

**[2]Assistant Professor,
Department of Computer Applications, Sri Ramakrishna Engineering College,
Coimbatore, TamilNadu – 641 022, India.**

**Abstract**

Adaptive orthogonal frequency division multiple Access (OFDMA) has recently been recognized as a promising Technique for providing high spectral efficiency in future broadband Wireless systems. The research over the last decade on Adaptive OFDMA systems has focused on adapting the allocation Of radio resources, such as sub carriers and power, to the instantaneous Channel conditions of all users. However, such "fast" adaptation requires high computational complexity and excessive signalling overhead. This hinders the deployment of adaptive OFDMA systems worldwide. This paper proposes a slow adaptive OFDMA scheme, in which the sub carrier allocation is updated on a much slower timescale than that of the fluctuation of instantaneous channel conditions.

Meanwhile, the data rate requirements of individual users are accommodated on the fast timescale with high probability, thereby meeting the requirements except occasional outage. Such an objective has a natural chance constrained programming formulation, which is known to be intractable. To circumvent this difficulty, we formulate safe tractable constraints or the problem based on recent advances in chance constrained programming. We then develop a polynomial-time algorithm for computing an optimal solution to the reformulated problem. Our results show that the proposed slow adaptation scheme drastically reduces both computational cost and control signalling overhead when compared with the conventional fast adaptive OFDMA.

Our work can be viewed as an initial attempt to apply the chance constrained programming methodology to wireless system designs. Given that most wireless systems can tolerate an occasional dip in the quality of service, we hope that the proposed methodology will find further applications in wireless communications.

***Keywords:*** *Adaptive orthogonal frequency division multiple access (OFDMA), chance constrained programming, dynamic resource allocation, stochastic programming.*

## 1. Introduction

Future wireless systems will face a growing demand for broadband and multimedia services. Orthogonal frequency division multiplexing (OFDM) is a leading technology to meet this demand due to its ability to mitigate wireless channel impairments. In the existing literature, adaptive OFDMA exploits time, frequency, and multi user diversity by quickly adapting sub carrier allocation (SCA) to the instantaneous channel state information (CSI) of all users.

The allocation decisions are fixed for the duration of an adaptation window, which spans the length of many coherence times. By doing so, computational cost and control signalling overhead can be dramatically reduced. Slow adaptation schemes have recently been studied in other contexts such as slow rate adaptation, and slow power allocation. Random channel parameters are replaced by their mean values, resulting in a deterministic rather than stochastic optimization problem.

By doing so, quality-of service (QoS) can only be guaranteed in a long-term average sense, since the short-term fluctuation of the channel is not considered in the problem formulation. The resource allocation problem can easily become infeasible. Even if the problem is feasible, the resource utilization is inefficient as most system resources must be dedicated to provide guarantees for the worst-case scenarios.

In this paper, we propose a slow adaptive OFDMA scheme and MPT (Multipath Power control Transmission) that aims at maximizing the long-term system throughput while satisfying with high probability the short-term data rate requirements.

The key contributions of this paper are as follows.

- We design the slow adaptive OFDMA system based on chance constrained programming techniques. Our formulation guarantees the short-term data rate requirements of individual users except in rare occasions. To the best of our knowledge, this is the first work that uses chance constrained programming in the context of resource allocation in wireless

Copyright (c) 2012 International Journal of Computer Science Issues. All Rights Reserved.

systems. We exploit the special structure of the probabilistic constraints in our problem to construct safe tractable constraints (STC) based on recent advances in the chance constrained programming literature.

- We design an interior-point algorithm that is tailored for the slow adaptive OFDMA problem, since the formulation with STC, although convex, cannot be trivially solved using off-the-shelf optimization software. Our algorithm can efficiently compute an optimal solution to the problem with STC in polynomial time.

- We design the slow adaptive OFDMA system based on chance constrained programming techniques. Our formulation guarantees the short-term data rate requirements of individual users except in rare occasions. To the best of our knowledge, this is the first work that uses chance constrained programming in the context of resource allocation in wireless systems.

- We exploit the special structure of the probabilistic constraints in our problem to construct safe tractable constraints (STC) based on recent advances in the chance constrained programming literature.

- We design a polynomial time algorithm that is tailored for the slow adaptive OFDMA problem. MPT utilizes this property to provide “multipath macro-diversity.” Specifically in MPT, the source node transmits the same packet along multiple paths to the same destination.

The transmission power at each intermediate node along each path is controlled by the source nodes based on the path characteristics.

## 2. Related works

We discuss some relevant work on multipath routing as well as packet combining. Multipath routing has drawn extensive attention in wireless sensor networks. The dense node deployment in wireless sensor networks makes multipath routing a natural and promising technique to cope with the unreliable network environments.

Research efforts have been made using multipath routing to improve the robustness of data delivery to balance traffic load and power consumption among nodes to reduce end-to-end delays and the frequency of route discoveries and to improve the network security etc.

The focus of our work in this paper is not to propose a new multipath routing protocol. Instead, our research leverages existing multipath routing protocols to make end-to-end transmission more energy-efficient. The basic idea of packet combining is to combine multiple corrupted copies of one packet to recover the original one.

Here we propose a way to merge two or more non-coded packets to correct errors. It is shown that with packet combining at the receiver side, the original packet can be correctly recovered even if every individual received copy of this packet is corrupted. The authors of extend the packet-combining scheme into multihop scenarios and investigate its performance in wireless sensor networks. Through experiments, they show that the packet-combining scheme can achieve promising results even in multihop wireless networks.

The authors propose a multipath packet-combining scheme for wireless multihop networks. Based on an analysis on the delay characteristics of multipath transmission, they show that the optimal number of paths exists that minimizes the average end-to-end packet error rate under certain delay constraints. In our work, we also propose a simple packet-combining strategy for our MPT scheme.

SCA decisions are made based on instantaneous channel conditions in order to maximize the system throughput. slow adaptive OFDMA systems rely only on the distributional information of channel fading and make an SCA decision for each window. Short-term QoS can often tolerate an occasional dip in the instantaneous data rate. The short-term data rate requirement is satisfied with sufficiently high probability.

## 3. Methodology

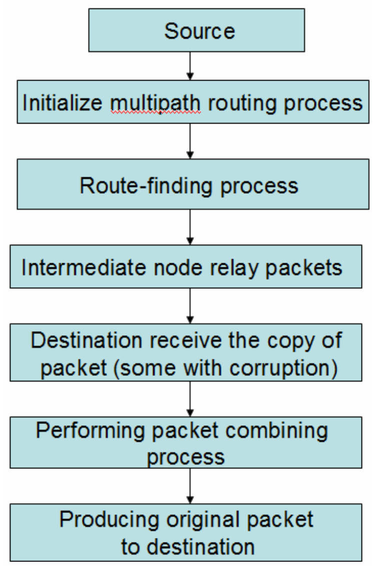
We then develop a polynomial-time algorithm for computing an optimal solution to the reformulated problem. In this section, we propose an algorithm for solving Problem. the principles of the algorithm as follows.

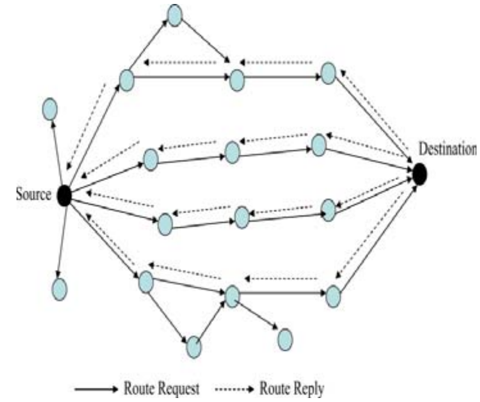
A. The Cutting-Plane-Based Algorithm

$$\max_{\{x^t, s^t\}} \sum_{m=1}^{M\,i} \log s_M{}^i$$

B. Global Convergence Complexity

Copyright (c) 2012 International Journal of Computer Science Issues. All Rights Reserved.




*Basic procedure of multipath routing.*

In the following, we investigate the convergence properties of the proposed algorithm. As mentioned earlier, when the polytype is too small to contain a full-dimensional closed ball of radius $\alpha > 0$, the potential value will exceeds a certain threshold. Then, the algorithm can terminate since the query point is within a distance of $\alpha > 0$.

MPT can be divided into the following three parts: multipath routing, source initiated power-control transmission, and destination packet combining. First, the source node (any underwater sensor node in our network model can be a source node) initiates a multipath routing process to find paths from the source to the destination. Through this route-finding process, the source will get to know some network parameters such as path length and the number of available paths. Based on this knowledge, the source node selects some paths and calculates the optimal transmitting power for each node along the selected paths. Then, it sends the same packet along the selected paths. Intermediate nodes on these selected paths will relay the packet with specified transmitting power parameters (carried in the packet header). When the destination receives all copies of the packet (some copies may get corrupted), it performs packet combining to recover the original packet.

**A.Multipath Routing**

"Route Request" message to the destination. Any intermediate nodes who receive this "Route Request" for the first time will forward it. When the destination receives "Route Request" messages, it will reply with "Route Reply" messages reversely along the paths of the corresponding "Route Request" messages. The destination can also make path selection.

"Route Request" message to the destination. Any intermediate nodes who receive this "Route Request" for the first time will forward it. When the destination receives "Route Request" messages, it will reply with "Route Reply" messages reversely along the paths of the corresponding "Route Request" messages. The destination can also make path selection.

**B.Source-Initiated Power-Control Transmission**

In this phase of MPT, the same packets sent from the source node are transmitted by the intermediate nodes along all the selected paths using the specified transmission power. The source node should also include power parameters in the packet header. These parameters specify the required power level that every intermediate node should use to relay the packet. In addition, we assume some coding schemes with strong error correction capability, such as forward-error coding (FEC), are used in the header of every packet. In this way, the header part of every packet can be decoded correctly with high probability. Since the packet header is usually much smaller than the data part.

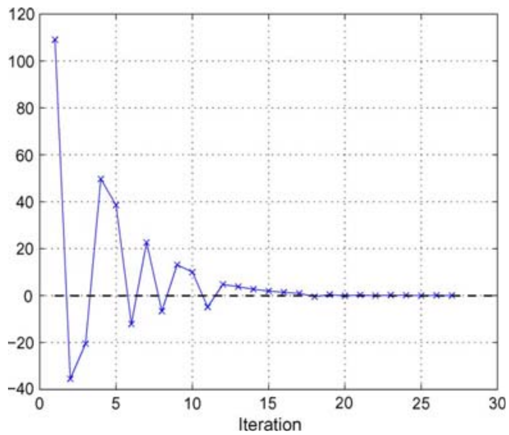
**C. Destination Packet Combining**

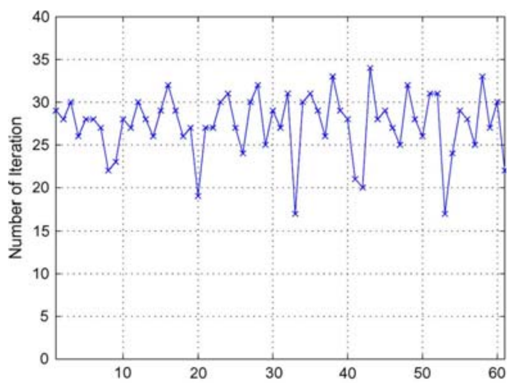
When the destination receives a copy of the original packet from one path (the data part of this copy may be corrupted during the transmission process), it first checks whether this copy is correct or not. If there is no error with this copy, the destination successfully receives the original packet. Otherwise, the destination will keep this corrupted copy in its buffer. After multiple corrupted copies of the original packet are received, the destination will combine them to recover the original one.

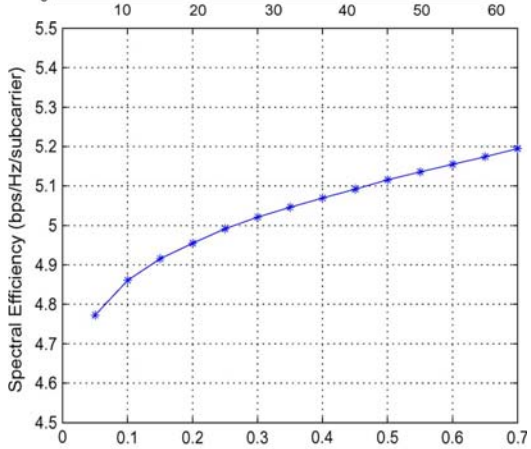
## 4. Experimental Results

In this section, we demonstrate the performance of our proposed slow adaptive OFDMA scheme through numerical simulations. We evaluate the performance of MPT through simulations.

Copyright (c) 2012 International Journal of Computer Science Issues. All Rights Reserved.




**A. Simulation Settings**

In this MAC protocol, when a node has packets to send, it first senses the channel. If the channel is free, it broadcasts the packets. Otherwise, it backs off.

**B .Overall Energy Distribution Process**

1) Through the source-initiated multipath routing process, the source node gets to know all needed information such as the number of available paths, the number of hops for each path, and the per-hop distance.

2) At the source node, the iterative algorithm is performed for multipath energy distribution. Then, for every selected path, the source node sends out messages with two additional fields in the packet header. One field is to specify the optimal overall energy along this path, and the other is to specify.

3) For each intermediate node along path, it has recorded its distance to its next hop in the path during the routing process.

## 5. CONCLUSION

This paper proposed a slow adaptive OFDMA scheme and multipath power-control transmission scheme, MPT, for time-critical applications that can achieve a throughput close to that of fast adaptive OFDMA schemes, while significantly reducing the computational complexity and control signalling overhead. Our scheme can satisfy user data rate requirement with high probability. MPT combines the power-control strategies with multipath routing protocols and packet recovery at the destination. In the future, it would be interesting to investigate the chance constrained subcarrier allocation problem when frequency correlation exists. In current MPT, multiple copies of the same packet are sent along multiple paths.

## REFERENCES

[1]. C. Y. Wong, R. S. Cheng, K. B. Letaief, and R. D. Murch, “Multiuser OFDM with adaptive subcarrier, bit, and power allocation,” IEEE J. Sel. Areas Commun., vol. 17, no. 10, pp. 1747–1758, Oct. 1999.

[2]. Y. J. Zhang and K. B. Letaief, “Multiuser adaptive subcarrier-and-bit allocation with adaptive cell selection for OFDM systems,” IEEE Trans. Wireless Commun., vol. 3, no. 5, pp. 1566–1575, Sep. 2004.

[3]. IEEE Standard for Local and Metropolitan Area Networks, Part 16: Air Interface for Fixed Broadband Wireless Access Systems, IEEE Std. 802.16e, 2005.

[4]. Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestial Radio Access Network (E-UTRAN); Overall Description: Stage 2 (Release 8) 3GPP TS 36.300 V 8.0.0, Apr. 2007.

[5]. I. C.Wong and B. L. Evans, “Optimal downlinkOFDMAresource allocation with linear complexity to maximize ergodic rates,” IEEE Trans. Wireless Commun., vol. 7, no. 3, pp. 962–971, Mar. 2008.

[6]. A. G. Marques, G. B. Giannakis, F. F. Digham, and F. J. Ramos, “Power-efficient wireless OFDMA

Copyright (c) 2012 International Journal of Computer Science Issues. All Rights Reserved.

using limited-rate feedback," IEEE Trans. Wireless Commun., vol. 7, no. 2, pp. 685–696, Feb. 2008.

[7]. A. Conti, M. Z. Win, and M. Chiani, "Slow adaptive -QAM with diversity in fast fading and shadowing," IEEE Trans. Commun., vol. 55, no. 5, pp. 895–905, May 2007.

[8]. Y. Li and S. Kishore, "Slow adaptive -QAM under third-party received signal constraints in shadowing environments," Rec. Lett. Commun., vol. 2008, no. 2, pp. 1–4, Jan. 2008.

[9]. T. Q. S. Quek, H. Shin, and M. Z. Win, "Robust wireless relay networks: Slow power allocation with guaranteed QoS," IEEE J. Sel. Topics Signal Process., vol. 1, no. 4, pp. 700–713, Dec. 2007.

[10]. T. Q. S. Quek, M. Z. Win, and M. Chiani, "Robust power allocation algorithms for wireless relay networks," IEEE Trans. Commun., to be published.

[11]. I. F. Akyildiz, D. Pompili, and T. Melodia, "Underwater acoustic sensor networks: Research challenges," Ad Hoc Netw., vol. 3, no. 3, pp. 257–279, Mar. 2005.

[12]. M. A. Bhatti, Practical Optimization Methods with Mathematical Applications. New York: Springer, 2000.

[13]. W. Cheng, A. Y. Teymorian, L. Ma, X. Cheng, X. Lu, and Z. Lu, "Underwater localization in sparse 3D acoustic sensor networks," in Proc. IEEE INFOCOM, Apr. 2008, pp. 236–240.

[14]. X. Cheng, H. Shu, Q. Liang, and D. H.-C. Du,"Silent positioning in underwater acoustic sensor networks," IEEE Trans. Veh. Technol., vol. 57, no. 3, pp. 1756–1766, May 2008.

[15]. M. Chitre, S. Shahabudeen, and M. Stojanovic, "Underwater acoustic communication and networks: Recent advances and future challenges," Marine Technol. Soc. J., no. 1, pp. 103–116, 2008.

[16]. J.-H. Cui, J. Kong, M. Gerla, and S. Zhou, "Challenges: Building scalable mobile underwater wireless sensor networks for aquatic applications," IEEE Networks., vol. 20, no. 3, pp. 12–18, May 2006, Special Issue on Wireless Sensor Networking.

**[1] Ms. Revathy N** had completed B.Sc., Computer Science in the year 2000 and Master of Computer Applications (MCA) in the year 2003 under Bharathiar University. Completed M.phil, Computer Science from Alagappa University in the year 2005. Currently pursuing Ph.d. and the area of research is Neural Networks. Other areas of interest are Mobile Computing, Data Mining and Artificial Intelligence At present working as an Assistant Professor in the Department of Computer Applications at Karpagam College of Engineering at Coimbatore-32 and published 3 papers in International Journals, presented 3 papers in International Conferences and 30 papers in National Conferences.

**[2] Mr. Guhan T** had completed B.Sc., Computer Science in the year 1999 and Master of Computer Applications (MCA) in the year 2002 under Bharathiar University. Completed M.phil, Computer Science from Alagappa University in the year 2006. Also completed M.E (Computer Science and Engineering) from Anna University in the year 2009. Currently pursuing PhD., and the area of Research is Data mining. Other areas of interest are Computer Graphics and Computer Networks. At Present working as an Assistant Professor in the Department of Computer Applications at Sri Ramakrishna Engineering College at Coimbatore-22 and presented 3 papers in International Conferences and 15 papers in National Conferences.

Copyright (c) 2012 International Journal of Computer Science Issues. All Rights Reserved.
IJCSI
www.IJCSI.org