

# Chapter 19

## Cross-Layer Optimization in OFDM Wireless Communication Network

**Babasanjo Oshin**

*Covenant University, Nigeria*

**Adeyemi Alatishe**

*Covenant University, Nigeria*

### ABSTRACT

*The wide use of OFDM systems in multiuser environments to overcome problem of communication over the wireless channel has gained prominence in recent years. Cross-layer Optimization technique is aimed to further improve the efficiency of this network. This chapter demonstrates that significant improvements in data traffic parameters can be achieved by applying cross-layer optimization techniques to packet switched wireless networks. This work compares the system capacity, delay time and data throughput of QoS traffic in a multiuser OFDM system using two algorithms. The first algorithm, Maximum Weighted Capacity, uses a cross-layer design to share resources and schedule traffic to users on the network, while the other algorithm (Maximum Capacity) simply allocates resources based only on the users channel quality. The results of the research shows that the delay time and data throughput of the Maximum Weighted Capacity algorithm in cross layer OFDM system is much better than that of the Maximum Capacity in simply based users channel quality system. The cost incurred for this gain is the increased complexity of the Maximum Weighted Capacity scheme.*

### INTRODUCTION

Describe the general perspective of the chapter. Toward the end, specifically state the objectives of the chapter.

The current visible trend in the current communication market is the increase in the wireless technology. Current phone manufacturer such as

Samsung and Nokia are daily increasing in the sales of smart phones and even PDAs. A number of these hand held devices come with one or more wireless technologies such as Bluetooth, WI-Fi or even connections to cellular mobile networks. Due to the continuous growth of the internet and its various applications, a lot of emphasis is the past years have being placed on satisfying the needs of mobile users.

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In order to satisfy the ever growing wireless users, a new paradigm, called cross-layer optimization was proposed. Cross-layer optimization exploits layer dependencies and thus allows the propagation of ambient parameter changes quickly throughout the protocol stack. Hence, it is well-suited for mobile multimedia applications where the characteristics of the wireless medium and the application requirements vary over time.

Wireless Local Area Networks (WLAN) can successfully transmit at data rates of up to a hundred megabyte currently; but its low range which is typically a few tens of meters makes it unsuitably for large scale deployments. High speed wireless communication systems would require a Metropolitan Area Network (MAN) infrastructure to provide efficient and scalable services. Designing a wireless communication system supporting data and real-time traffic using a packet switched approach and having a high spectral efficiency is difficult.

Orthogonal Frequency Division Multiplexing (OFDM) increases the efficiency of limited spectral resources available when compared with other multiplexing schemes such as Frequency Division Multiplexing (FDM) and Time Division Multiplexing (TDM) (Nicopolitidis, 2003). OFDM has gained a lot of interest to combat wireless link impairments and simultaneously offering flexibility at the link layer (Herrman, 1999). OFDM promises higher user data rate and great resilience to severe signal fading effects of the wireless channel at a reasonable level of implementation complexity. It has been taken as the primary physical layer technology in high data rate Wireless LAN/MAN standards. Furthermore next generation wireless communication systems uses OFDM technology (Muhammad, 2004).

Current wireless networks are said to be all IP based and using the standard protocol stack for example TCP/IP stack to ensure interoperability

(Jamalipour, 2001). The standard protocol stacks are architected and implemented in a layered manner and function inefficiently in mobile wireless environments (Xylomenos, 1999). This is due to the highly variable nature of wireless links and the resource-poor nature of mobile devices. Data communication over wireless connection can be improved by Cross-Layer Optimization or design (Shakkottai, 2003).

At the end of this work, we would have used cross-layer optimization techniques to:

- Improved Quality of Service (QoS) provisioning for multi-user wireless networks. Users of these networks want multimedia services with various QoS requirements. The cross-layer design used in this project is intended to balance delay, QoS and efficient resource utilization by exploiting the knowledge of channel and queuing states along with users' subjective performance metrics.
- Showed in this work that QoS delay for Real Time (RT), non-Real Time (nRT) and Best Effort (BE) traffic can be significantly reduced while ensuring a degree of fairness by using the Maximum Weighted Capacity (MWC) algorithm. This algorithm, using a joint physical and MAC layer optimization approach, addresses the requirements of the packet switched data sent from the base station to users. It uses information about the channel to allocate resource at the physical layer and schedule resources at the MAC layer to satisfy the data requirements.

A wholly physical layer system is compared to the MWC system in order to determine the amount of gains that has been achieved by it. The Maximum capacity (MC) algorithm is described

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