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Cross Layer Resource Allocation Design for video Uplink OFDM Wireless Systems

Kartik Sharma[1],Vivek Sharma[2]

[1]Student, [2]Assistant Professor,
Bahra University Shimla Hills,Waknaghat , India
[1]kartiks913@gmail.com

Abstract- Cross-layer design approaches are critical to efficiently utilize radio resources. Resource allocation decision is made by assuming a single user. Multiple access scheme used is an Orthogonal Frequency Division Multiple Access (OFDM). With the goal of choosing best error detection technique, various techniques are compared. A resource allocation algorithm is required to efficiently allocate power and subcarriers. Water filling charts show the final results for initial power allocation and final power allocation.

Key terms: Cross-layer design, OFDM, Water Filling Algorithm.

1. INTRODUCTION AND BACKGROUND

Communication system has played a key role in the evolution of the human race. In last few decades, the wireless communication system has grabbed the attention of public and media [1]. At present there are lot of wireless communication users and are expected to increase in number in near future. OFDM is wideband digital modulation scheme. In this scheme data is encoded on multiple carrier frequencies [2]. Without any complex time domain equalization, it is capable of adapting to worst channel conditions. It has efficient implementation using FFT. For time synchronization errors, it shows low complexity [3]. This technology is used in digital television, power lines and 4G mobile communications. Allocation of limited resources among the users is a difficult task. According to the present scenario wireless communication users are increasing day by day and with this radio resources are also decreasing. Cross layer resource allocation is an important task in resource allocation process [10]. Traditional layer architectures follow strict layer principles. But the limit of co-ordination between the layers limits the performance in such architecture. Cross-layer design was proposed to overcome such limitations. It allows co-ordinations, interaction and joint optimization [3]. Water filling algorithm is used to maximize the capacity of frequency selective channel. Total bandwidth is divided into N sub-channels. Water filling algorithm provides more power to the subcarriers which experience good conditions while don't assign any power to the subcarrier with deep fade. Initial power is allocated to every subcarrier. Now there can be subcarriers which are facing deep fade. To allocate power to these subcarriers would be wastage of power. So water filling algorithm determines the sub-carriers with deep fade. Then reallocation of power takes place. The subcarriers with very deep fades are rejected and no power is assigned to these sub-carriers.

The adaptive subcarrier, bit and power allocation for multiuser OFDM networks to minimize the total transmit power, the multiuser OFDM subcarrier, bit and power allocation algorithm developed is explained in [2]. A cross-layer iterative resource allocation algorithm for transmitting video in an uplink multiuser OFDM setting is explained in [3]. A resource allocation scheme for coexistence of future unlicensed users with existing licensed users is explained in [4]. The theoretical and practical framework for the cross-layer optimization for OFDM wireless networks is explained in [5] [6]. The problem of minimizing the overall system power consumption (including the power consumption in the BBU pool, the fibre links and the RRHs) in a C-RAN, such that the cross-layer QoS and per-RRH power constraints are satisfied is explained in [7]. To minimize the the transmission power considering support of QoS parameters is explained in [8]. The fundamental performance limit of cross-layer wireless resource allocation is explained in [9]. Quality of service (Qos) is the major challenge in multimedia services over CDMA cellular networks [10]. As compared to old circuit switched voice service in 2G CDMA, Qos model required for heterogeneous multimedia application in present IP based CDMA networks is much complex and need sophisticated management of radio resources is explained in [10]. The rest of the paper is organized as follows: section II presents system model and

2. SYSTEM MODEL AND PROBLEM FORMULATION.

(A) System model

A raw video data is taken as input to the system. The raw video is first converted into frames. Every frame is converted into bits. For every frame bits are QAM modulated and fed to the channel. In communication channel the signal is influenced by multipath and fading. Then channel estimation is required. Channel estimation helps to calculate channel state information. With the help of channel estimation water filling for power allocation is done. After power allocation to improve performance, subcarrier reassignment is done. Hence performance of system is improved. Procedure is repeated for all the frames.
MATLAB communication system toolbox is used to simulate the system model. Communications System Toolbox provides algorithms and applications for the analysis, design, end-to-end simulation, and verification of communications systems in MATLAB simulation software. Toolbox algorithms, including channel coding, modulation, MIMO, and OFDM, enable you to compose a physical layer model of any system. System can be modelled to measure performance. The block diagram of system model is shown in Figure 1.

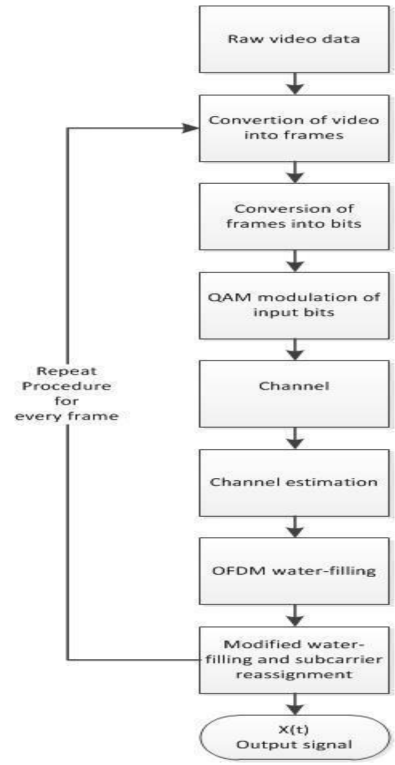

Figure 1 System model

(B) Problem Formulation

Choice of channel estimation technique: After transmission of data over a communication channel. The transmitted signal is affected by noise, fading and multipath. To find out their effect on signal, mean square error should be calculated. To calculate mean square error various techniques are used such as LS, MMSE, TD_MMSE etc. These techniques should be compared with each other for a specific value of energy per bit to noise.
The technique giving least value of mean square error should be used as channel estimation technique. Modification of water- filling algorithm: For efficient power allocation, water filling algorithm plays a key role. Zero power is allocated to the subcarrier with deep fade and power is given to sub-carriers that are performing much better. Moreover fading impact of channel can be decreased by increasing number of subcarriers as each sub-carrier is affected by fading differently. So increasing number of subcarriers may also decrease the impact of fading.

3. CROSS-LAYER RESOURCE ALLOCATION ALGORITHM

The idea behind cross-layer concept is that it maintains the functionalities of the original layer while allowing better co-ordination and interaction among the layers. It jointly optimizes the protocols crossing the layers. The cross-layer resource allocation is explained in Figure 2.
In Figure 2, temporary power is allocated to the subcarriers. According to water filling algorithm if positive power is allocated to subcarriers there would be efficient power allocation and would be less effect of noise on it. In case of positive power allocation, the noise to subcarrier ratio is low as compared to power allocated and no need of further power allocation. And if the power allocated is negative the noise to subcarrier ratio is high as compared to power allocated and there is need of further power allocation. Then according to water filling algorithm, the power allocated to subcarriers will be equal to zero. In this case another subcarrier is added to reduce the noise and multipath. The idea behind subcarrier reallocation is that every subcarrier is affected independently by noise and multipath. The reassigned subcarrier is again allocated initial power and whole process is again repeated. In worst case certain level of noise remains. This algorithm is just

an improvement of water filling algorithm.

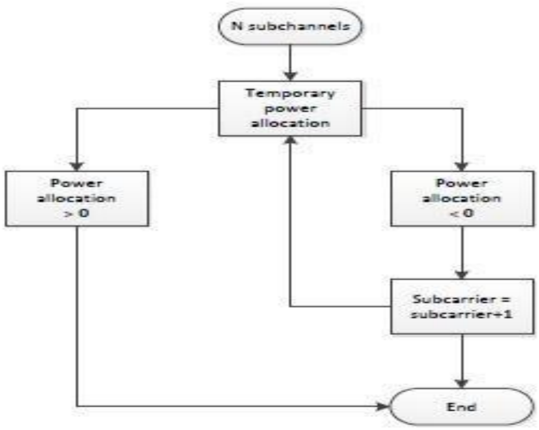

Figure 2 Cross-Layer algorithm.

4. SIMULATION RESULTS

In this section simulation results for first frame is presented which is extracted from raw video. For first frame the generated bit sequence is as follows

Frame 1: 10101110

This bit sequence is transmitted to channel by using QAM modulation. Then channel state information is calculated. This channel state information is used in modified water filling algorithm or cross-layer resource allocation algorithm. The output of water filling algorithm is shown in Figure 3.

Figure 3 shows the output of water-filling algorithm. Where noise to carrier ratio for 1st and 7th subcarrier is above power allocation level. For rest of subcarriers the power to subcarrier ratio is below allocation level which is much efficient. To improve performance of the system, the modified water filling algorithm is developed. With modified water filling algorithm the performance of the system is improved. Figure 4 shows the modified water filling algorithm. In this the power and subcarriers is reallocated to the system.

Hence after reallocation there is less impact of noise and multipath on subcarriers. For every subcarrier the noise to carrier ratio is less. Hence system performance is improved.

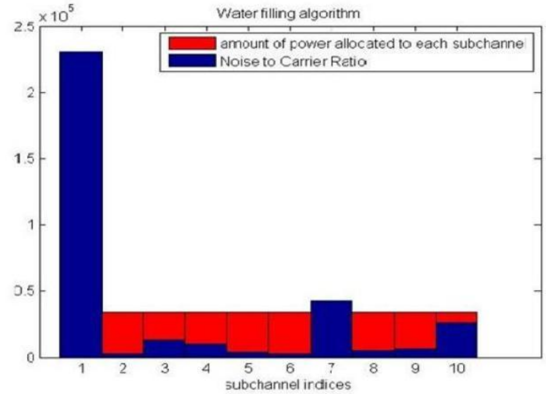

Figure 3 OFDM water-filling algorithm

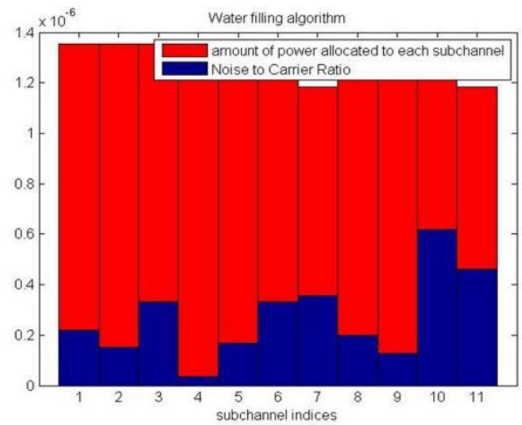

Figure 4 Modified water filling algorithm

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