International Journal of
Sensor Networks and Data Communications

Mustafa and Lohiya, Sensor Netw Data Commun 2015, 4:1
DOI: 10.4172/2090-4886.1000121

Research Article Open Access

Optimization of Resource Allocation in OFDM Communication System for Different Modulation Technique using FRBS and PSO

Farhana Mustafa* and Padma Lohiya

Department of E&TC, D.Y. Patil College of Engineering, Akurdi, Pune, India

Abstract

OFDM is technique that is chosen for high data rate communication and is important for 4th generation communication system. Resources such as power, bandwidth are limited, thus intelligent allocation of these resources to users are crucial for delivering the best possible quality of services. Fuzzy Rule Based System (FRBS) and Particle Swarm Optimization (PSO) algorithm are used for optimization of code rate, modulation and power. FRBS is used for adapting code rate and modulation size while PSO is used for power allocation.

Keywords: OFDM; PSO; FRBS; Optimization; Resource allocation

Introduction

Orthogonal Frequency Division Multiplexing (OFDM), offers a considerable high spectral efficiency multipath delay spread tolerance, immunity to frequency selective fading channels and power efficiency [1,2]. As a result, OFDM has been chosen for high data rate communication and is used for 4th generation technology. In Orthogonal Frequency Division Multiplexing (OFDM) technique, a single very high data rate stream is divided into several low data rate streams using Inverse Fast Fourier Transform (IFFT). Then these streams are modulated over different orthogonal subcarriers. This is to divide one large frequency selective channel into a number of frequency non-selective sub-channels. Moreover, addition of appropriate cyclic prefix (CP) and interleaver makes the system almost inter-symbol-interference (ISI) free. It has been widely deployed in many wireless communication standard such as based mobile worldwide interoperability for microwave access (mobile WIMAX), 3GPP long term evolution (LTE) based on OFDM access technology. In OFDM every sub channel experiences a different channel condition so the use of same modulation and code rate may not be suitable for all subcarriers. Also, flat power is not beneficial since sub-channels may need different power. This situation demands adaptive resource allocations for an optimum utilization.

Prior Work

In the optimal power allocation and user selection solution was derived based on Lagrange dual decomposition proposed by Wong et al. [3] for maximizing the system energy efficiency. A low complexity algorithm for proportional resource allocation in OFDMA system was proposed in ref. [4], where linear method and root finding algorithm were used to allocate power and data rates to users. A gradient based solution was proposed by Rajendrasingh et al. [5], for downlink OFDM wireless systems and a 96.6% utility was achieved. A Genetic Algorithm based adaptive resource allocation scheme was proposed by Reddy [6] to increase the user data rate where water-filling principle was used as a fitness function. The water filling theorem is based on a continuous relationship between the allocated power and the achievable capacity. OFDM Systems Resource Allocation using Multi-Objective Particle Swarm Optimization. Another paper with adaptive resource allocation based on modified GA and particle swarm optimization (PSO) for multiuser OFDM system was propose by Kennedy and Eberhart [7]. In this paper it has shown that MOPSO power optimization is better than 3GPP LTE and NSGA II Algorithm. An optimization problem for power constraints and use of GA algorithm to maximize the sum capacity of OFDM system with the total power constraint was investigated in ref. [8-11]. Also it was shown that GA is better than conventional methods. A scheme for resource allocation in downlink MIMO OFDMA with proportional fairness where dominant Eigen channels obtained from MIMO state matrix are used to formulate the scheme with low complexity in ref. [8], scheme provides much better capacity gain than static allocation method. A PSO based Adaptive multi carrier cooperative communication technique which utilizes the subcarrier in deep fade using a relay node in order to improve the bandwidth efficiency [9] where centralized and distributed versions of PSO were investigated. Atta-ur-Rahman et al. in ref. [10,11] , used GA and Water-filling principle in conjunction with FRBS for adaptive coding, modulation and power in OFDM systems, where GA was used to adapt the power.

The paper is organized as follows: section III deals with the Multi Modulation OFDM system where QAM modulation is taken in consideration with M=4, 16, 32, 64, 128, 256, system description is given in section III. FRBS and PSO aspects are discussed for FRBS rule are define in section IV. Section V describes the simulation and results for OFDM system. VI concludes the paper.

Multi-Modulation OFDM System

The system model considered is OFDM equivalent baseband model with N number of subcarriers. It is assumed that complete channel state information (CSI) is known at receiver. The frequency domain representation of system is given by

$$r_k = h_k \sqrt{P_k} X_k + Z_k ; k = 1,2,3 \ldots N \quad (1)$$

where amplitude, transmit symbol and the Gaussian noise of sub carrier k=1, 2,…, N respectively. The overall transmit power of the system and the noise distribution is complex Gaussian with zero mean and unit variance. It is assumed that signal transmitted on the k^{th} subcarrier is propagated over Rayleigh at fade channel and each

***Corresponding author:** Farhana Mustafa, Department of E&TC, D.Y. Patil College of Engineering, Akurdi, Pune, India, Tel: 02027421095; E-mail: farhanabhatt23@gmail.com

Received May 27, 2015; **Accepted** May 29, 2015; **Published** June 11, 2015

Citation: Mustafa F, Lohiya P (2015) Optimization of Resource Allocation in OFDM Communication System for Different Modulation Technique using FRBS and PSO. Sensor Netw Data Commun 4: 121. doi:10.4172/2090-4886.1000121

Citation: Mustafa F, Lohiya P (2015) Optimization of Resource Allocation in OFDM Communication System for Different Modulation Technique using FRBS and PSO. Sensor Netw Data Commun 4: 121. doi:10.4172/2090-4886.1000121

subcarrier faces a different amount of fading independent of each other. This can be given mathematically

The proposed adaptation model is given in Figure 1.

Coded modulation

Performance of standard modulation and codes being used in IEEE 802.11n1g/b are analyzed in terms of bit error rate (BER) and SNR. Calculation of coding scheme, modulation scheme and channel is estimated. The code rate are taken from the set C

$$C = \{\frac{1}{4}, \frac{1}{3}, \frac{1}{2}, \frac{2}{3}, \frac{3}{4}\} \quad (2)$$

Modulation symbol are taken from

$$M = \{2, 4, 8, 16, 32, 64, 128\} \quad (3)$$

Total number of MCPS can be given by

$$P = C \times M \quad (4)$$

Fuzzy rule Base System and Practicle Swarm Optimization

Fuzzy rule base system

To maximize the data rate FRBS is used for optimum selection of code modulation pair (CMP) per subcarrier based upon received SNR and QoS. The steps involved in creation of FRBS are described below

Data acquisition: The information about SNR and BER obtained from Coded Modulation can be expressed as "for a given SNR and specific QOS which modulation code pair can be used.

Rule formulation: Rules for every pair are obtained by the appropriate fuzzy set used.

Elimination of conflicting rule: This is used for eliminating conflicting rules.eg If there are two different pairs with same throughput like [2,1/2] and[4,1/4], both have same throughput i.e.1×1/2=0.5. Thus [2,1/2] is chosen since it have less modulation/ demodulation, coding/ decoding cost.

Completion of Look up Table: If complete numbers of IO pairs are not present, then those parts are filled by heuristic or expert knowledge. Example a modulation code pairs is suggested by rule for a certain SNR and QOS. Then that rule can also be used for slightly above SNR and poor QOS (Table 1).

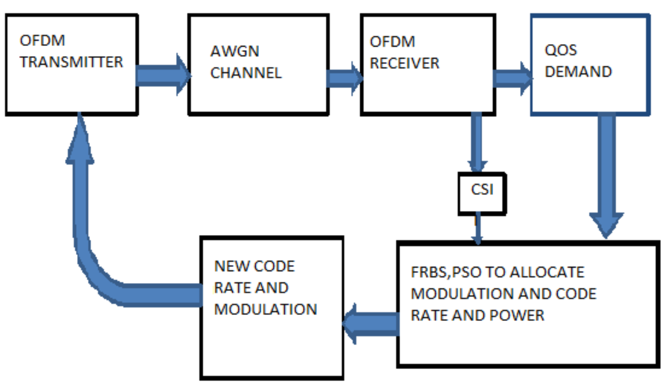

Figure 1: OFDM model with FRBS and PSO.

SR. NO.	PARAMETERS	VALUES
1	NO. OF SUBCARRIERS	52
2	CODE RATE	½ , ¼
3	MODULATION	16, 32, 64, 128,256
4	CHANNEL	AWGN
5	BER	10E-2,10E-3,10E-4,10E-5,10E-6, 10E-7

Table 1: Parameters.

For instance [64, 1/2] is suggested for 20dB SNR and SER=10^{-2} then this pair can be used for 21 to 25dB SNR at 10^{-1} SER

Fuzzy rule base creation: The input output pair for design of FRBS are of the form

$$(x_1^s, x_2^s, y_3^s); s = 1, 2, 3, \ldots S \quad (5)$$

where x1s represents received SNR, x_2^s represents BER (QOS) and y3s represents the output MCP.

Fuzzy set: Input for Fuzzy inference system is given as SNR and BER or minus log BER.

$$MLBER = -\log(BER) \quad (6)$$

$$BER = 10^{-q} \quad (7)$$

$$MLBER = -\log(10^{-q}) = q \quad (8)$$

where q is 0 to 10, there will be one output as MCP. Where BER is $\log_2(\frac{1}{M})$ of SER

Membership function: Membership function used in FIS (fuzzy inference system) is triangular. Triangular membership function is simple to implement as well as calculation of arithmetic operation is easier than Bell, Sigmoidal ,Gaussian.

In FIS system AND is used for MIN and OR as MAX.

Rule base: 7 sets of SNR and 10 sets MLBER are taken. Total number of rules taken is 70 that will be used in FIS system.

De-fuzzifier: Standard Center Average Defuzzifier (CAD) is used for defuzzification. CAD is to perform a linear combination over the computed weights at the fuzzy inference engine and then modify this combination by novelization. CAD provide continuity and homogeneity and has less computational complexity.

Particle Swarm Optimization

Particle Swarm Optimization is a stochastic optimization technique developed by Eberhart and Kennedy inspired by the social behavior of flocks of bird. Each particle is represented by a position and velocity vector. Let Dimensions of position and velocity vectors are defined by the number of decision variables in optimization problem. Soft PSO has been utilized for finding the optimum power vector for all the sub carriers depending upon the channel conditions and their QOS demand. Each sub-channel have different channel condition so different channel should have different power allocation depending upon the channel condition. Power allocation will be done with the help of PSO. Different power allocation is done for different users and thus the optimization of Power is done for different users in OFDM system.

Let $\bar{x}_i(t)$ represents the position particle p_i at time t, then it is given as

$$\bar{x}_i(t) = \bar{x}_i(t-1) + \bar{v}_i(t) \quad (9)$$

The position of p_i is then changed by adding a velocity $\bar{v}_i(t)$.

Each particle know its best position (p-best) and global best (g-best).Thus the particle will tend to attain its g-best at final iteration. g-best will give the optimum allocated power

$\bar{v}_i(t) = \bar{v}_i(t-1) + C_1 r_1(\bar{x}_{pbest} - \bar{x}(t)) + C_2 r_2(\bar{x}_{gbest} - \bar{x}(t))$ where C_1 and C_2 are constants and is normally equal to 2.0. r_1 and r_2 are random variables.

Simulation Results

Simulation is performed to have optimal power allocation.

Simulation parameters

Results

OFDM system with different code rate and modulation are simulated. Input of this graph is given to Fuzzy inference system and PSO for optimization of code rate and modulation Figure 2.

In Figure 3 Symbol Error Rate vs Signal to Noise Ratio are calibrated for different modulation QAM techniques such as 4, 16, 32, 64, and 128 with code rate ½, where EbN0 is taken from 0:33. This represents SER decrease exponentially with respect to EbN0 for different modulation.

Figure 4 represent SER vs SNR plot with respect to each modulation such as 16, 32,64,128 with code rate as ¼ . SER decrease exponentially with respect to EbN0 for different modulation.

Figure 5 shows the impact on throughput for different values of SNR and QoS demand after incorporating the constraint. In this diagram a higher numbered CMP reflects a high throughput.

Using FRBS in OFDM system it will give optimum modulation and code rate represented by Figure 5.

Power allocation with respect to noise interface is shown in Figure 6. This figure indicates that the 3rd user has less interference thus less power will be allocated.

Conclusion

In this paper FRBS and Particle swarm algorithm are used for optimization of code rate and modulation. FRBS are used for

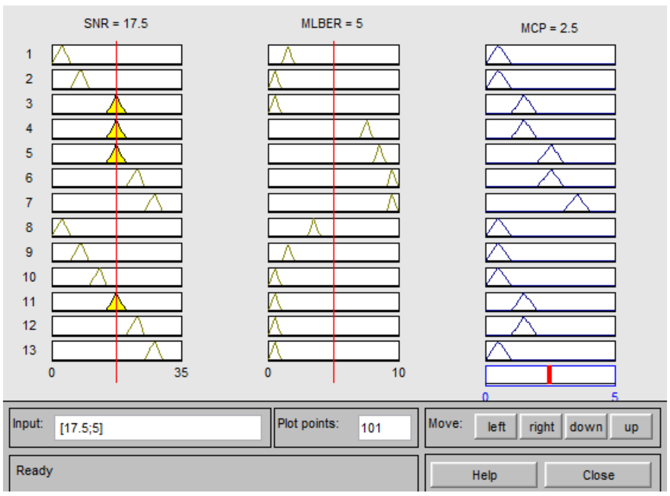

Figure 2: Fuzzy rules.

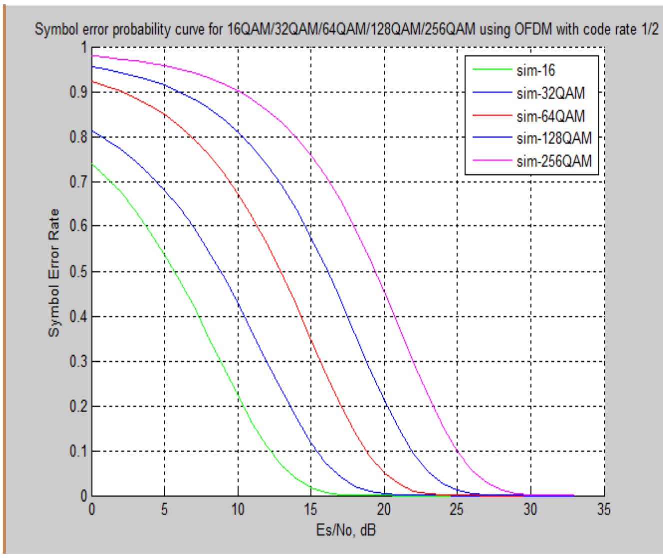

Figure 3: SER comparison of different QAM with code rate 1/2 code.

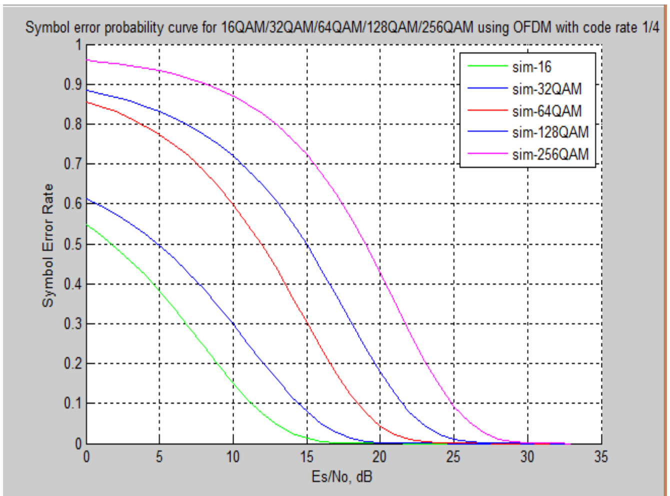

Figure 4: SER comparison of different QAM with code rate1/4 code.

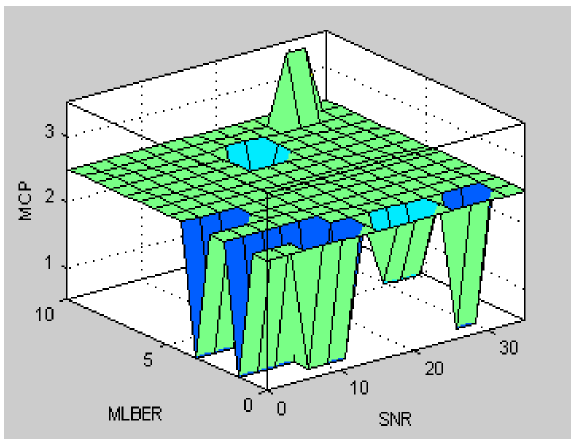

Figure 5: Rule surface.

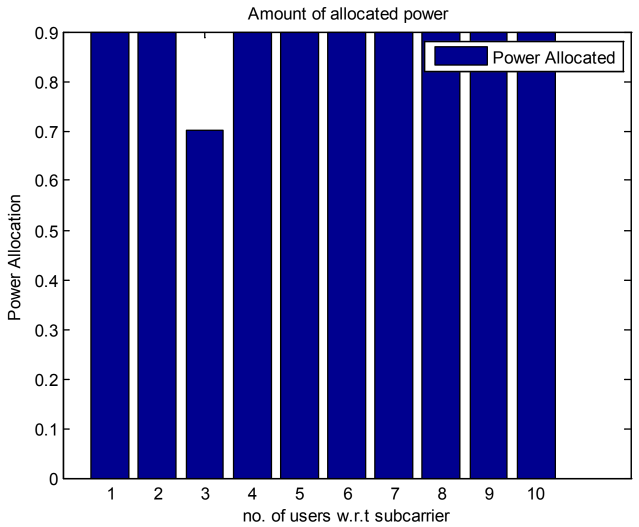

Figure 6: Power allocated by PSO algorithm.

optimization of code rate and modulation. Higher numbered CMP reflects a higher throughput. PSO is used for allocation of power for each sub-channel depending upon the channel condition. After using FRBS in OFDM system it will give optimal modulation and Code rate. Thus y using FRBS and PSO optimal power allocation can be done with specified modulation techniques for specified sub channel.

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