Survey of Optimum Resource Allocation in OFDM Communication System

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ABSTRACT
Orthogonal Frequency Division Multiplexing (OFDM) has the properties of being robust to interference and frequency selective fading and the various multiplexing techniques for the 4th generation wireless network systems. In wire-free system, resources such as power, bandwidth are limited, thus intelligent allocation of these resources to users are necessary for having the best possible quality of services. In this paper various algorithms have been discussed such as Root Finding Algorithm, Multi user PSO, Fuzzy Rule Base System, PSO for resource allocation.

General Terms
Orthogonal Frequency division Multiplexing i.e OFDM, Particle swarm Optimization i.e PSO and Fuzzy Rule Base system i.e FRBS, Rooting finding, MOPSO .

Keywords
Power Allocation, Fuzzy, PSO, Code rate, Modulation.

1. INTRODUCTION
Orthogonal Frequency Division Multiplexing (OFDM), which is multicarrier modulation (MCM) techniques, offers a considerable high spectral efficiency multipath delay spread tolerance, resistance to frequency selective fading channels and power efficiency [1], [2]. As a result, OFDM has been selected for high data rate communication and has been used 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 would not be beneficial since sub-channels may need different power. This situation demands adaptive resource allocations for an optimum utilization.

The optimal power allocation and user selection solution was derived based on Lagrange dual decomposition proposed by [3] for maximizing the system energy efficiency. A low complexity algorithm for proportional resource allocation in OFDMA system was proposed in [4], where linear method and root finding algorithm were used to allocate power and data rates to users. A gradient based method was proposed by [5], for downlink OFDM wireless systems an 96.6% serviceableness 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 proposed by [7]. In this paper it has shown that MOPSO power optimization is better than 3GPP LTE and NSGA II Algorithm.

Atta-ur-Rahman et. al. in [8] proposed a Fuzzy Rule Base System(FRBS) and particle swarm optimization(PSO) to change the code rate, modulation symbol and power according to varying channel conditions.

This paper consists of three sections. Section 1 consists of A Low Complexity Algorithm for Proportional Resource Allocation in OFDMA Systems. Section 2 consists of OFDM Systems Resource Allocation using Multi-Objective Particle Swarm Optimization. Section 3 consists of Optimum Resource Allocation in OFDM Systems using FRBS and Particle Swarm Optimization.

2. ROOT FINDING ALGORITHM

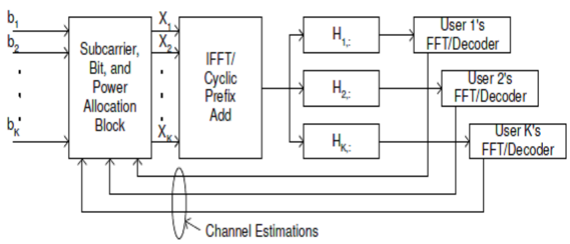

Figure 1: OFDM system model for K user

Root Finding Algorithm maximizes the total capacity instead of maximizing the minimum user capacity. By developing a subcarrier allocation scheme proposed in [4] that linearize the power allocation problem while achieving approximate rate proportionality. The resulting power allocation problem was thus reduced to a solution to simultaneous linear equations. In this paper root finding algorithm solves the non-linear equations, which requires computationally expensive iterative process. It provides probabilistic solution of power allocation depending how many users are accessing the channel.

The steps performed in Root Finding Algorithm were

Step 1- Number of subcarriers per user

Step 2 - Subcarrier assignment

Step 3- Power allocation among users

Step 4- Power allocation across subcarriers per user.

In Root Finding Algorithm, iteration methods for root finding were still needed. Thus motivates a different approach to the resource allocation problem..

3. MODIFIED GA AND MULTI OBJECTIVE PSO

Particle swarm optimization is proposed in [9] and compared it with modified Genetic Algorithm. In PSO, each particle flies in the search space with a velocity which is dynamically adjusted according to its own flying experience and its companions flying experiences. It was widely reported that PSO algorithm is very easy to implement to solve real world optimization problems and has fewer parameters to adjust when compared to other evolutionary algorithms. The information sharing mechanism among the particles in PSO is significantly different from the information sharing among the chromosomes in GAs. In GAs, the entire group moves towards an optimal solution area. However, in PSO only the global best or local best solution is reported to other particles in a swarm optimization. Therefore, evolution only looks for the best solution and the swarm tends to converge to the best solution quickly and efficiently. The swarm tends to converge to the best solution quickly and efficiently. Gheitanchi et al. [10] has applied PSO for subcarrier allocation in OFDMA systems with significant reduction of computational complexity and increase flexibility compared to conventional techniques.

3.1 Resource Allocation Using Mopso

In paper [7], authors considered a multi-user OFDM system with N sub channels and K users with total transmitted power of P-total, to optimize the subcarriers and power allocation in order to achieve the highest capacity under the total power constraint. For the joint allocation of bits and power, the swarm particles position and velocity was defined. Therefore, a channel matrix H of K rows and N columns, each of the elements showing the channel gain was generated.

$$H = \begin{pmatrix} p_{11} & \cdots & p_{1n} \\ \vdots & \ddots & \vdots \\ p_{k1} & \cdots & p_{kn} \end{pmatrix} \quad (1)$$

From matrix H, velocity is initially set to zero and the initial value of the channel gain assigned to the particle position. Bits were allocated to the subcarriers depending to the respective the fitness value and channel gain value for the capacity and allocated power was computed.

Authors represented the positions of the particles by non-dominated vector and stored in the external archive A. The crowding distance values of each non dominated solution in archive A were then calculated and the non-dominated vectors were sorted in descending orders to select a set of leaders. At each generation, for each particle, a leader was selected and the flight was performed. The velocity and position of each particle was updated as follows

$$v_i = w \times V_{(i)} + r_1 \times [PBEST(i) + r_2] \times A[GBEST] - P(i)$$
$$x_i(t) = x_i(t-1) + v_i \quad (2)$$

The PBEST and GBEST were thus determined. The non-dominated vectors were stored in archive A. The crowding distance of each non dominated particle was determined. Mutation operation is then applied so as to promote diversity within the population. Then the particle is evaluated and its corresponding PBEST was updated. A new particle replaces the PBEST particle usually when this particle is dominated or if both were incomparable (i.e., they are both non-dominated with respect to each other). After all the particles are upto-dated, the set of leaders were updated too. The steps of the MOPSO algorithm were iteratively repeated until the termination criterion is met such as maximum number of generations or when there has been no change in the set of non-dominated solutions found for a given number of generations. The output of the MOPSO method is the set of non-dominated solutions stored in the final archive.

In this paper it was shown that MOPSO power optimization is better than 3GPP LTE and NSGA II Algorithm.

4. FRBS and PSO

Atta-ur-Rahman et. al. in [8] proposed a Fuzzy Rule Based System (FRBS) for adaptive coding and modulation in OFDM systems where convolutional codes were used as forward error correction (FEC) codes. In [11], same authors proposed FRBS for Product codes as FEC. In both of these papers, power was kept constant while code rate and modulation was adaptive. In [12], same authors 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. In [13] author proposed a Fuzzy Rule Base System (FRBS) and PSO to adapt the code rate, modulation symbol and power according to the varying channel conditions.

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

Where k= 1, 2, 3, 4, 5, ………. N, 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 was assumed that signal transmitted on the kth subcarrier was propagated over Rayleigh at fade channel and each subcarrier faces a different amount of fading independent of each other. The proposed adaptation model is given in Fig- 2.

Steps performed by author in FRBS and PSO are given as

- CODED MODULATION:

Performance of standard modulation and codes being used in IEEE 802.11 n1g/b was analyzed in terms of bit error rate (BER) and SNR. Calculation of coding scheme, modulation scheme and channel is estimated.

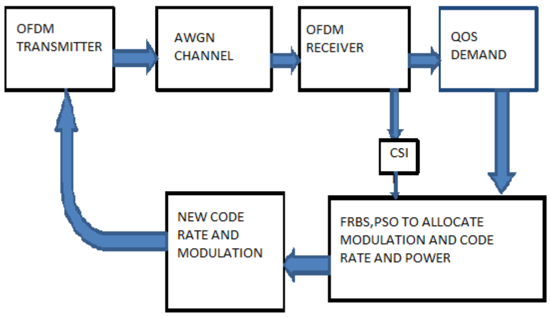

Figure 2: OFDM model for FRBS and PSO

4.1 Fuzzy Rule base System

FRBS was designed for optimum selection MCP per subcarrier based upon received SNR and QoS. The steps involved in creation of FRBS was described below

i. Data Acquisition

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

ii. Rule Formulation

Rules for every pair were obtained by the appropriate fuzzy set used.

iii. Elimination of conflicting rule

This was used for eliminating conflicting rules. e.g. 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.

iv. Completion of Look Up Table

If complete numbers of IO pairs was not present, then those parts were 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.

v. Fuzzy rule base creation

The input output pair for design of FRBS was of the form

$$(x_{1s}, x_{2s}, y_s); s = 1, 2, 3, ...S \quad (3)$$

Where X_{1s} represents received SNR X_{s2} , represents BER(QOS) and Ys represents the output MCP Suggested by FRBS so the rule was given as {If (X1 and L1 and X2 is Q7 and Y is p2)}

4.2 Particle Swarm Optimization (PSO)

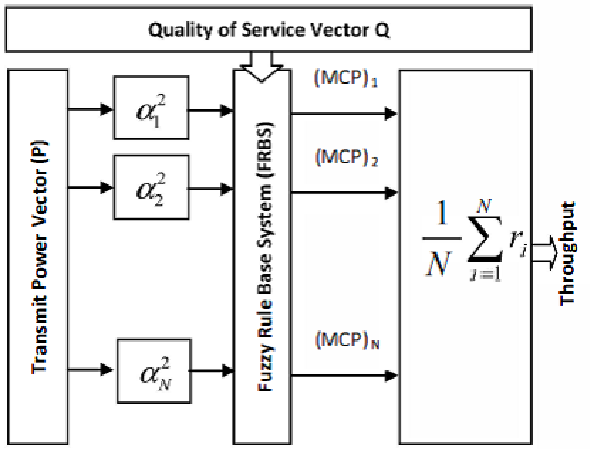

Figure 3: Fitness Block

PSO is a population- based stochastic optimization technique developed by Eberhart and Kennedy inspired by the social behaviour of flocks of bird. Each particle was represented in [13] by a position and velocity vector.

Dimensions of position and velocity vectors are defined by the number of decision variables in optimization problem. In [13] 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. The fitness block for local and global particles was given in fig 3.

5. CONCLUSION

In this Paper various techniques for resource allocation have been discussed. Root Finding algorithm solves non- linear equations in OFDMA system, which requires computationally expensive iterative operation when it's computed with Linear Method and suitable for cost effective time implementation. Root finding algorithm depends upon various parameters such as subcarrier allocation per user, power allocation, sub-channel SNR and Capacity per user. But Capacity per user is lower than linear method.

MOPSO Algorithm depends on following parameters: position xi(t), Velocity Vi, PBEST, GBEST, while as NSGAII depends upon crossover and mutation operation for total generation, number of equation for selection. Thus MOPSO is more efficient than NSGAII as it required less number of functions to reach a specified target value.

In FRBS-PSO with addition to power allocation it also allocates code rate and modulation pair in OFDM system. It depends on following parameter such as number of subcarrier per user, Fitness function of PSO based on FRBS and QoS.

6. REFERENCES

[1] Y.Wu and W.Y.Zou,"Orthogonal frequency division multiplexing : A multi-carrier modulation scheme,"IEEE Trans.Consumer Electonics, vol.41,no. 3, pp. 392-399, Aug. 1995.

[2] W.Y. Zou and Y.Wu,"COFDM: An overview", IEEE Trans.Broad-casting, vol.41, no. 1,pp.1-8, Mar. 1995.

[3] Derrick Wing Kwan Ng, Ernest S. Lo, and Robert Schober, "Energy-Efficient Resource Allocation in Multiuser OFDM Systems with Wireless Information and Power Transfer" University at Erlangen-N¨urnberg, Germany, 2010

[4] Wong, I.e.; Zukang Shen; Evans B.L., Andrews lG. , "A low complexity algorithm for proportional resource allocation in OFDMA Systems", Dept. of Electr.& Comput. Eng., Texas Univ., Austin, TX, USA, 2004.

[5] Wong, I.e. ; Zukang Shen; Evans B.L., Andrews lG. ,"A low complexity algorithm for proportional resource allocation in OFDMA systems ", Dept. of Electr. & Comput. Eng., Texas Univ., Austin, TX, USA, 2004

[6] Reddy, Y.B . ; Gajendar, N . ; Taylor, Portia; Madden, Damian," Computationally Efficient Resource Allocation in OFDM Systems:Genetic Algorithm Approach ", Dept of Math & Comput. Sci., Grambling State Univ., LA, 2007, pp 3 6 - 41 .

[7] Rajendrasingh Annauth1 , Harry C.S.Rughooputh," OFDM Systems Resource Allocation using Multi-Objective Particle Swarm Optimization", International Journal of Computer Networks & Communications (IJCNC) Vol.4, No.4, July 2012

[8] Atta-ur-Rahman, Qureshi I.M., Malik A.N., "A Fuzzy Rule BaseAssisted Adaptive Coding and Modulation Scheme for OFDM

[9] Systems", J. Basic Appl. Sci. Res. Vol. 2(5), pp. 4843-4853, 2012.

[10] J.Kennedy and R.C.Eberhart, "Particle Swarm Optimization", Proceedings of IEEE Conferenceon Neural Networks, Pages 1942-1948, 1995.

[11] S.Gheitanchi et al., "Particle Swarm Optimization for Resource Allocation in OFDM", Proc. International Conference on digital Signal Processing, 2007.

[12] Atta-ur-Rahman, Qureshi I.M. and Muzaffar M.Z. "Adaptive Codingand Modulation for OFDM Systems using Product Codes and Fuzzy Rule Base System". International Journal of Computer Applications (IJCA), Vol. 35(4), pp. 4 1 -48, December 2011.

[13] Atta-ur-Rahman, Qureshi T.M., Malik A.N.,"Adaptive Resource Allocation in OFDM Systems using GA and Fuzzy Rule Base System", World Applied Sciences Journal, Vol. 1 8(6), pp. 83 6-844S