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Inter-Carrier Interference Reduction in Broadband Wimaxand LTE using Improved Firefly Method

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Abstract:
Wireless broadband access development OFDM has several disadvantages that may arise from Carrier Frequency Offset (CFO), including Intercarrier Interference (ICI). Existing projected cancellation and self- cancellation strategies are commonly used to counter the effects of CFOs. These two technologies enhance productivity at the cost of decreased data rates and are far from optimal after compensation. This paper analyzes the OFDM scheme with a CFO and suggests a blind technique for cancellation using the analytical results that turns the ICI cancellation issue into a traditional optimization issue. A metaheuristic elevated efficiency algorithm, the Firefly algorithm, is frequently used to tackle the optimization problem. We introduce an improved firefly algorithm in this paper to select and adjust parameters in a normal firefly algorithm. The suggested firefly algorithm introduces an altered exploring and growth structure with adjustable randomness and absorption factors. The suggested technique utilizes time/randomness modification and absorption coefficients.

Keywords: *firefly algorithm, WiMAX, LTE, ICI, CIR.*

I. INTRODUCTION

The most prominent multi-carrier method so far has been orthogonal frequency division multiplexing (OFDM) with a linear suffix (CP) [1]. Due to its intrinsic propagating robustness and it's very easy equalisation (one complicated coefficient per subcarrier) OFDM is used, for example, by the standards of the local wireless network (WLAN) as well as digital broadcasting(DAB, DVB) and by evolving technologies such as LTE, WiMAX[2]. To enhance the effectiveness of the OFDM scheme, several assessment and compensation algorithms have been created. The CFO assessment models are divided into practice-oriented and blind models depending on the requirements of pilots. A study of these estimates and compensation algorithms is held out. The method of OFDM is capable of handling ISI efficiently as the subcarrier bandwidth generated is less than the coherencebandwidth [3].

OFDM also has a strong spectral efficiency by orthogonally intersecting [4, 5]. For example, [6] the CFO is 300 Hz for a frequency oscillator with an accuracy of up to 0.1 ppm (parts per million) and a frequency band of 3 GHz. Several ICI mitigation techniques have been investigated, including the ICI Self Cancellation [7]. The drawback of this technique, however, shows poor spectral efficiency, as only half the bandwidth can be used to transmit data. Estimate oriented methods estimation the flight signal quality of CFO and assess the ICI compensation[8]. A method relying on the firefly algorithm for the joint estimation of the CFO and the stream is suggested in [9]. An alternative effective ICI cancellation method uses blind cancellation systems that use the characteristic function of the obtained message to assess the CFO and withdraw its recipient impact. Furthermore, the PEKF (Planar EKF) method [10] is implemented, which improves scheme gains. This approach improves the difficulty of overcoming ICI. A blind CFO compensator using the cyclic prefix redundancy for calculating CFO can be presentedin [11]. In [12] a CFO compensator has been suggested to formulate the cost function of the steady modulus signalling scheme OFDM, on the premise that signal reaction varies progressively over neighbouring sub-carriers

This paper, therefore, models the ICI cancellation issue in OFDM as the standard optimization problem and a firefly algorithm [13] [14] for the best possible alternative. Due to the typical design of the objective function, ICI cancellation is used to achieve powerful original fireflies with a decreased quantization rate and standard FFA parameter sets are selected properly for quick convergence and enhanced precision.

II. OFDM SYSTEM MODEL

The parameters for the development of an effective CFO estimate algorithm, therefore, include estimate range, estimate precision and computational complexity. Although several standard methods for CFO estimates are accessible, problems with restricted CFO estimates or elevated computational complexity are present. Therefore, it is critical to investigate the creation of an effective CFO algorithm with a wide frequency acquisition region and a small computational complexity. The offsets between the transmitter's location and the receiver produce ICI, which in effect degrades OFDM's efficiency. Different researchers have created numerous methods to mitigate frequency offsets in order to decrease the ICI as shown in figure.1.

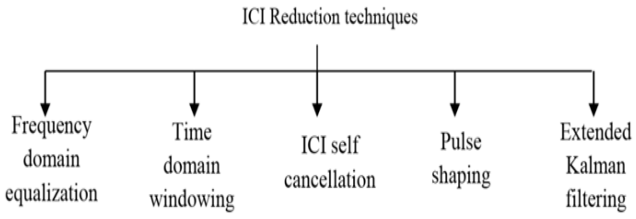

Fig.1.ICI reduction techniques

Consider an OFDM System with N subcarriers. Let denotes the data symbols to be transmitted. An N point FFT process is conducted to modulate data symbols on subcarriers to obtain

$$y = F_N^H x \qquad (1)$$

Where F_N is NXN DFT matrix the elements present in theDFT matrix as formulated as

$$[F]_{l,m} = e^{-j2\Pi lm/N} \text{ for } l,m = 0,1,\ldots\ldots..N-1 \qquad (2)$$

As $y$is attached with cyclic prefix (N_{cp}) communicatedwiththe$L$tap multipath channel ($L<N_{cp}$) having an impulse response $h = [h_0, h_1,\ldots\ldots.,h_{L-1}]^T$

As the channel introduces CFO $\in$on the transmitted and thereafterthe received undergoes CP removal processas to formulated as

$$r = \varphi H y + w \qquad (3)$$

Where $H$is $N\times N$circulant matrix

W is AWGN with zero mean and variance σ_w^2

φ is diagonal CFO matrix

$$\varphi = diag\left(e^{-j2\Pi\varepsilon m/N}\right) \text{for } m = 0,1,\ldots\ldots..N-1 \quad (4)$$

The received signal after DFT processing is given as $R = F_N r = S\Lambda X + W$

(5)

$W$is AWGN in the frequency domain

Λ is diagonal matrix

$S$is circulant interference matrix $S = F_N \varphi F_N^H$ (6)

As noted that the frequency domain (W_{eq}) equalization, the transmitted symbol can be calculated using Zero Forcing or MMSE to compensate for the channel

$$\hat{X} = W_{eq} R \tag{7}$$

Substitute eqn. (5) in eqn. (7) we get

$$\hat{X} = W_{eq} S \Lambda X + W^{l} \tag{8}$$

Eqn.(8) is used asa decision about transmitted data ICI cancellation based on uniform quantization.

The orthogonality of the supposed interference matrix S is used to cancel its impact on the receiver as

$$\tilde{R} = S^H R \tag{9}$$

$$= \Lambda X + S^H W \tag{10}$$

The quantization is done for M spaced values to estimate and distance as

$$\in_k = k\Delta \in \; k = 0,1,\ldots\ldots M-1 \tag{11}$$

Where $\in = \frac{\left(\in_{\max} - \in_{\min}\right)}{M}$

The estimate of CFO matrix can be computed by the eqn.11

$$\varphi_k = diag\left(e^{-j2\Pi\varepsilon_k m / N} \right) \text{for}\, m = 0,1,\ldots\ldots..N-1 \tag{12}$$

To determine the respective S_k interference matrix, eqn (8) is replaced for the equalization and decision-making of information element estimates $\tilde{X}_k$ as

$$\tilde{X}_k = dec\left(W_{eq} S_k^H R\right) \; k = 0,1,\ldots\ldots M-1 \tag{13}$$

Where dec (x) is the choice on the comment x

We now have M projections of transmitted data from which the eqn (14) feature is minimized $f\left(\in_k\right)$ is considered to be an optimal solution.

$$f\left(\in_k\right) = \lVert S_k \Lambda \tilde{X}_K - R \rVert^2 \tag{14}$$

For instance deliberated in [12], an increase in the number of quantization levels is not expected to increase the accuracy of the estimate consistently. The Firefly scheduling method concentrated on the algorithm is therefore described in this work, which will converge to optimum value and also in the minimum amount of iterations to an optimum valuation.

III. FIREFLY ALGORITHM

There are two significant problems, light intensity variation and attractiveness formulation. The FFA used guidelines depending on the bio-light interaction occurrence of fireflies. Firefly, regardless of sex, will be drawn by other fireflies. Attraction is equal to its luminosity and reduces as the range between them rises. The landscape of the objective function determines the luminosity of the firefly. Two significant problems, such as light variability and the formulation of attractiveness, exist in the firefly algorithm.

The flash frequency (r) reduces as range (r) rises with that of the equation intermediate

$$I\left(r\right) = I_0 e^{-\gamma r^2} \tag{15}$$

Attractiveness (β) is described in the chart with an absorption coefficient (γ) and range (r) as

$$\beta\left(r\right) = \beta_0 e^{-\gamma r^2} \tag{16}$$

The Cartesian distance between and two i^{th}andj^{th}fireflies at $x_i$andx_j respectively, the Cartesian distance is determined by

$$r_{ij} = \sqrt{\sum_{k=1}^{d} \left(x_{i,k} - x_{j,k}\right)^2} \tag{17}$$

Where $x^{i,k}$is the k^{th} element of the x of i^{th} firefly d space coordinate, the number of dimensions is. The firefly movement happens if it is drawn to another (brighter) j^{th} firefly that is defined by the equation.

$$x_i = x_i + \beta_0 e^{-\gamma r_{ij}^2}\left(x_j - x_i\right) + \alpha \in \tag{18}$$

$\beta_0 e^{-\gamma r_{ij}^2}\left(x_j - x_i\right)$ is due to attraction. $\alpha\epsilon$ is due to randomization.

$\alpha$is the randomization parameter.

$\in$isa vector of random numbers drawn from Gaussian or uniform distribution.

IV. PROPOSED FIREFLY ALGORITHM

It eradicates Firefly's vulnerability through improved exploration and screening capabilities and decreased algorithm randomness and improved mutual firefly movement. It improves the value of the algorithm's exploitation by decreasing randomness gradually and incorporating the social dimension of each firefly (global best). In this case, the randomization parameter α was maintained and decreased from α_0 to $\alpha_\infty$with iterations in linear order. The α_0 *and* α_∞ are the start and end values, where α provides the best global search capability in the early stages and α better convergence in the subsequent phase.

The distance function (r_i)put in the mathematical form as

$$r_{i,best} = \sqrt{\left(x_i - x_{gbest}\right)^2 + \left(y_i - y_{best}\right)^2} \tag{19}$$

The movement of i^{th} Firefly is determined by the equation

$$x_i = x_i + \left(\beta_0 e^{-\gamma r_{i,j}^2}\left(x_j - x_i\right) + \beta_0 e^{-\gamma r_{i,\mathrm{best}}^2}\left(x_{gbest} - x_i\right)\right) + \alpha \in + \lambda \in \left(x_i - g_{best}\right) \tag{20}$$

Where $\in = \left(rand - \frac{1}{2}\right)$

Herei^{th} because the firefly came up with the best solutions if there was no perfect local best solution in the neighbourhood. The suggested algorithm thus decreases the algorithm randomness so that convergence is achieved rapidly and affects fireflie's movement towards global optimal, thus decreasing the algorithm's probability of being caught in several local optima..

V. RESULTS AND DISCUSSIONS

OFDM system is modelled by MATLAB 2017b with a FFA-based suggested ICI cancelled system, and its efficiency is contrasted with the other complete ICI cancelled systems.

Parameters	Value
Number of subcarriers (N)	256
Channel	AWGN and Rayleigh
Modulation scheme	QAM
Equalization	MMSE
Cyclic prefix length	25
CFO range	-0.4 to 0.4
Population size	25
Randomization parameter	0.1
Cooling factor	0.95
Vector of random numbers	rand-1/2
Absorption coefficient	1
No. of iterations	1000

The simplest way to see the effectiveness of the proposed scheme is to apply a modified FFA based ICI cancellation scheme to estimate the value of CFO from the received OFDM signal. The plot of mean square estimation error with computational complexity for 64 QAM OFDM system in random CFO case is shown in Fig.2.

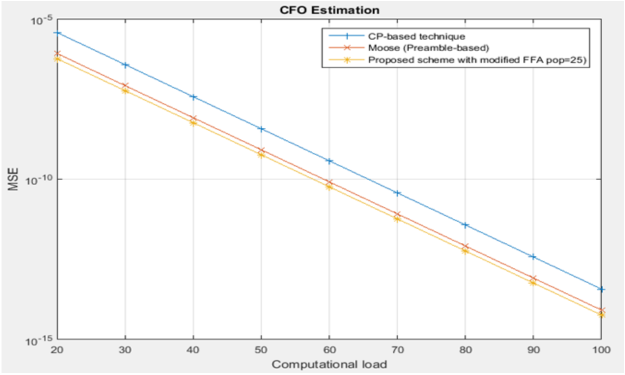

Fig. 2. MSE vs Computational load for 64-QAM OFDM at SNR=12dB

The original quantization rate and population density of figure.2 are combined continuous at 15 and 5 and varying maxgen. It can be concluded that the precision of the estimate originally improves as the computational load rises, and then stabilizes. Also, the computational load of the modified FFA scheme is the minimum of an estimated error, ensuring that the actual CFO value is converged early on compared to the total ICI cancellation scheme. It also shows that MSE estimates using conventional FFA and it is clear that the lack of changes, particularly initializing steps, in the case of conventional FFA results in performance degradation and thus validates the effectiveness of proposed modifications.

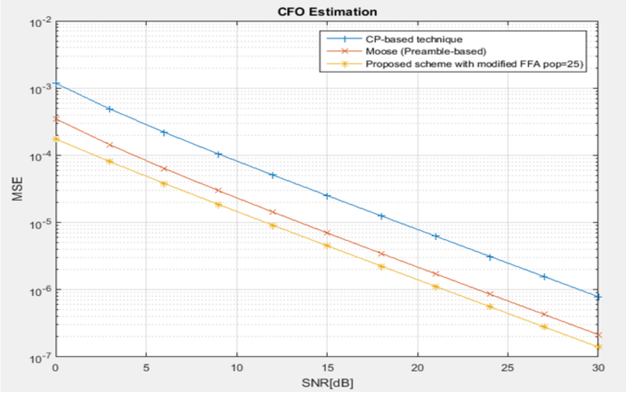

Fig. 3.MSEvsSNR (dB) for 64-QAM OFDM

The change in SNR average value assessment rate for the 64 QAM OFDM scheme is displayed in Fig.3. For the total ICI cancellation scheme the value of M is chosen as 30 while for modified FFA the total number of objective function evaluations is the same with M=15,pop=5 and maxgen=3. Although both systems are equivalent to lower SNR values, altered FFA results in an overall ICI cancelation system as SNR rises. Figure.3 also indicates the reliability of the proposed strategy with the FFA parameters M=10,pop=25and maxgen=4. As stated in the earlier paper, the original population size of the proposed system was inappropriately selected to cause an efficiency degradation.

VI. CONCLUSION

In general frequency synchronization and ICI rejection in OFDM, particularly for extremely portable applications, are significant issues for the communications system. This paper analyses the OFDM scheme in the existence of CFOs and models the standard ICI cancelation issue for an optimization problem. Firefly, a robusttype of metaheuristic algorithm, is employed to solve the issue of optimization. In addition, the standard FFA is altered depending on the features typical to optimize load reduction and simple convergence issues. The proposed system is contrasted with the standardized complete ICI cancelation system depending on quantization in multiple situations. From simulation outcomes, uniform quantization schemes are observed to involve unusable calculations as we proceed to a higher modulation order and the precision of the assessment is not sufficient to totally remove ICI. Simultaneously, the assessment system for firefly algorithms can assess CFOs with high precision and can replace ICI for the same computational load as the complete ICI cancelation system.

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