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Adaptive Energy Efficient Transmission Scheme for OFDM Systems

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Abstract: ***In orthogonal recurrence division multiplexing (OFDM) frameworks, for given aggregate transmit power, insertion of the non data bearing cyclic prefix (CP) will decrease the compelling vitality for every data bit. For the most part, the vitality misfortune is corresponding to the degree of CP length to the image span. On the off chance that the CP is too long, the vitality misfortune will be extensively high. In this venture, vitality proficient transmission plan for OFDM frameworks has been proposed which is produced in light of lessening of the CP vitality and gauge the length of the channel utilizing cumulate highlights. The legitimacy of the proposed technique is checked utilizing PC reenactment. Reproduction results demonstrate that the proposed system can set aside to around 1.8dB of the aggregate vitality, while keeping practically the same bit-lapse rate (BER) execution in a few applications.***

Key words: ***OFDM; cyclic prefix; LTE; Energy Efficiency (EE)***

I. INTRODUCTION

In the most recent decade, orthogonal recurrence division multiplexing (OFDM) has been effectively connected to a wide mixture of computerized correspondences for its high ghostly productivity. As of late, OFDM is received by long haul advancement (LTE) in the third era organization extend (3GPP) as the fundamental air interface system [11]-[13]. LTE underpins an adaptable data transmission from 1.25 MHz to 20 MHz with subcarrier dispersing of 15kHz. Taking into account the data transmission, the quick Fourier change (FFT) size is transformed from 128 to 2048. LTE utilizes OFDM for downlink information transmission and discrete Fourier change spread OFDM (DFT-s-OFDM) for uplink transmission. In remote correspondences, multipath blurring channel presents between image impedance (ISI) and between bearer obstruction (ICI) to OFDM signal which corrupts the framework execution genuinely. Subsequently, in down to earth OFDM frameworks, a cyclic prefix (CP), which is a duplicate of the last piece of the image, is embedded before the image. At the point when the CP is longer than the channel length, the ICI and ISI can be disposed off completely. The CP additionally changes over direct convolution of sign and channel into roundabout convolution which makes it feasible for one-tap adjustment in the recurrence area at beneficiary. Be that as it may, for given aggregate transmit power, insertion of the non-data bearing CP will lessen the compelling vitality every data bit. For the most part, the vitality misfortune is corresponding to the proportion of CP length to the image span. In the event that the CP is too long, the vitality misfortune will be significant high. For instance, agreeing, there are three sorts of CP in LTE as demonstrated in Fig. 1. From Fig.1, if Extended CP or Long CP is utilized, just around four fifths of the aggregate vitality is utilized for the transmission of data bits which diminishes the powerful vitality of frameworks to a great extent. Along these lines, how to spare the vitality of CP is the worry of this paper. As of late, vitality proficiency (EE) is getting to be progressively vital for future remote correspondences because of restricted battery assets in cell phones. Enhancing the EE can likewise lessen the nursery gas emanation which is seen as a standout amongst the most genuine dangers to the worldwide environment ever confronted in mankind's history. There have been numerous works mulling over EE, ghastly proficiency spectral efficiency (SE), or the mix of the two in the structure of remote interchanges. To enhance EE of framework or attain to a tradeoff in the middle of EE and SE, numerous techniques have been proposed. On the other hand, these strategies can't be utilized to tackle the issue of vitality sparing in this paper. This is on the grounds that that diminishing the vitality of CP will present between transporter obstruction to every subcarrier and the framework execution corrupts drearily with the increment of the spared vitality. A large portion of the works in the writings is given to the examination of CP. Notwithstanding, these papers concentrate just on the configuration of ideal CP length. In this paper, through hypothetical investigation and processing reenactments, we find that decreasing the CP vitality to some degree won't debase the framework execution generally. Taking into account above perception, vitality effective transmission plan to enhance the EE for the OFDM frameworks is proposed.

II. OFDM SYSTEM

An OFDM system consists of N subcarriers. In each symbol, the input data stream is first grouped into a vector $X=\{X(0),...,X(N-1)\}$ with $X(K)$ belonging to a QAM or PSK constellation and then modulated onto the N orthogonal subcarriers. After performing an

Inverse Discrete Fourier Transform (IDFT) on N-parallel subcarriers, then the corresponding time domain vector $x=\{x(0),\ldots\ldots\ldots\ldots,x(N-1)\}$ can be obtained. Before transmitting, the last G samples of x are copied and appended in front of x to form the cyclic prefix. The CP length is assumed to be larger than the delay spread of the channel to eliminate any interference between adjacent symbols. Assuming the channel remains unchanged during one OFDM symbol transmission, the received baseband equivalent discrete-time signal is given by

$$y(n) = \sum_{l=0}^{L-1} h(l)x(n-1) + v(n) \qquad (1)$$

where L is the total number of paths and $v(n)$ is the noise in the time domain. $h(l)$ denotes the l-th path gain which is usually modeled as a zero-mean complex Gaussian random variable with variance $E\{|h(l)|^2\} = \sigma_l^2$. The different path gains $h(l)$'s are assumed to be independent of each other, i.e. $E\{h(l)h^*(n)\}=0$ for $l\neq n$. After an N-point DFT, the received signal in the frequency domain can be written as

$$Y(k)=H(k)X(k)+V(k) \qquad (2)$$

where $V(k)$ is a white complex Gaussian noise with zero mean and variance . $H(k)$ is the channel frequency response (CFR) given by

$$H(k) = \sum_{l=0}^{L-1} h(l)e^{-j\frac{2\pi kl}{N}} \qquad (3)$$

In this paper, the Signal-to-Noise Ratio (SNR) is defined as

$$\text{SNR}=\frac{E_s}{\sigma_n^2} \qquad (4)$$

Where Es is the energy of data symbol.

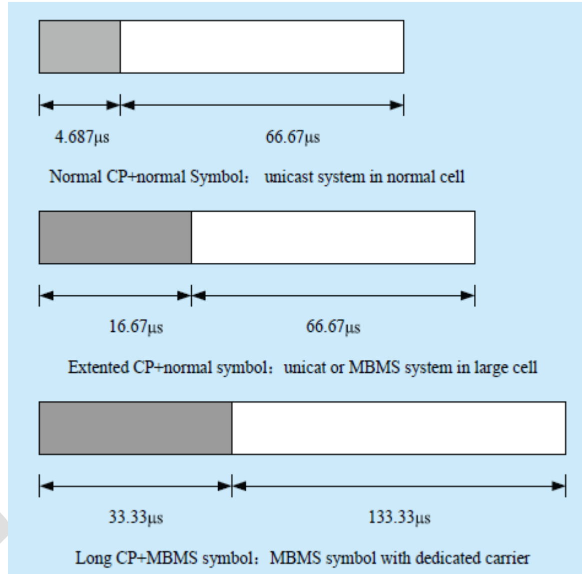

Figure1: ***CP in LTE***

III.PROPOSED ALGORITHM

Before transmitting, CP is multiplied with a real number α, i.e.,

$$\alpha X_{CP} = [\alpha X_{CP}(0), \alpha X_{CP}(1), \ldots\ldots, \alpha X_{CP}(G-1)]$$

$$0 < \alpha \leq 1 \qquad (5)$$

Where $\{\alpha X_{CP}(k): k = 0,1, \ldots\ldots\ldots G-1\}$ denotes the samples in CP [1].When$\alpha < 1$, the power required for the conventional OFDM symbol can be calculated by the following formula

Power_W_{Xcp} = sum (abs(W_{Xcp})).^2) (6)

Power_W_{Xcp}_dB = 10*log10(Power_W_{Xcp}) (7)

W_{Xcp} = OFDM symbol

The power required for the Proposed technique can be given by

Power_$W_{\alpha Xcp}$ = sum(abs($W_{\alpha Xcp}$))^2) (8)

Power_$W_{\alpha Xcp}$_dB = 10*log10(Power_$W_{\alpha Xcp}$) (9)

$W_{\alpha Xcp}$ = OFDM symbol to which CP is multiplied with the real number α.The saved energy can be calculated by subtracting (7) from (6)

Saved Energy=Power_W_{Xcp}_dB-Power $W_{\alpha Xcp}$_dB
(10)

In order to reduce the power requirement for OFDM systems still more the Blind Channel Length Estimation Algorithm Using Cumulant Values has been adopted.
To understand the above algorithm, one needs to understand the effect of multipath channel on cumulant values and some of its assumptions and properties [6]

The samples of the transmitted signal are assumed to be independent to each other. That is

$$E[X(n)X(n+1)] = 0 \qquad \forall \quad i \qquad (11)$$

First property: (Additivity): Consider $x(k)$ and $y(k)$ are two independent random processes. If $z(k) = x(k) + y(k)$ then the n^{th} order cumulant value of $z(k)$ is equal to the sum of those $x(k)$ and $y(k)$. That is

$$C_{z(n,m)} = C_{x(n,m)} + C_{y(n,m)} \qquad (12)$$

Second property2: (Scaling): Consider $x = ay$. Then the n^{th} order cumulant value of x is equal to $|a|^n$ times the cumulant value of y

The above stated two properties and assumption of cumulants are used for understanding the effect of multipath channel on transmitted cumulant values. The cumulant value of the received signal y(k) i.e., $\tilde{C}_{y(n,m)}(\tau)$ is given as

$$\tilde{C}_{y(n,m)}(\tau) = \xi(L)\tilde{C}_{s(m,n)}(\tau) \qquad (13)$$

Where $\tilde{C}_{y(n,m)}(\tau)$ is the normalized cumulant value of the transmitted sequence s(i) and

$$\xi(L) = \frac{\sum_{k=0}^{L-1} |h(k)|^n}{[\sum_{k=0}^{L-1} |h(k)|^2]^{\frac{n}{2}}} \qquad (14)$$

is a function of L. It can be easily shown that $(L) < 1$, that is the magnitude of the cumulant values of shrinkage depends on the value of L that is $\xi(L) = \xi(L')$ for L>L' and hence

$$\tilde{C}_{y(n,m)}(\tau, L) < \tilde{C}_{y(n,m)}(\tau, L') \qquad (15)$$

$for\ L > L'$ Based on the observation we proposed the following algorithm : Using N samples of the received data estimate the received cumulant $\tilde{C}_{y(n,m)}$ values

For L =1,,2,3………

If $\frac{C_{y(n,m)}(L+1)+C_{y(n,m)}(L)}{2} < \tilde{C}_{v(n,m)} < \frac{c_{y(n,m)}(L-1)+C_{y(n,m)}(L)}{2}$ choose the estimated length of the channel and then the loop is terminated

Else

Continue the loop.

Hence the Channel Length can be estimated without the requirement of any pilot pulses and any prior knowledge about the Wireless medium (Channel).Length of the CP is kept double that of the channel length which have been estimated from the Blind Channel Length Estimation Algorithm. The power required for the transmission of OFDM symbols will be still more reduced when compared with the Conventional OFDM transmission scheme.

IV. SIMULATION RESULT

In the simulation, the channel is assumed to be static over one OFDM symbol duration but independently variable on a symbol-by-symbol basis. Figure shows the BER performance as a function of SNR. In the simulation, firstly α should fixed in between 0 and 1 then CP is multiplied with α. From Figure we find that although the proposed method performs better than the conventional method, which demonstrates the validity of the proposed method.

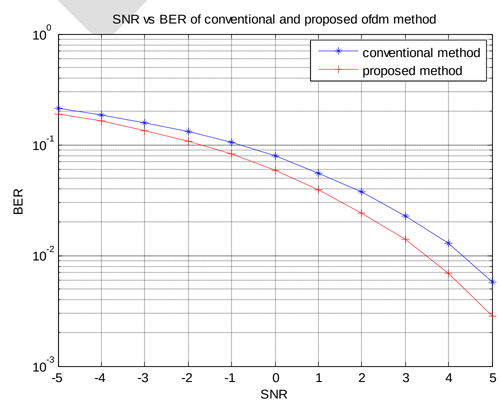

Figure2: BER performance comparison

From the fig (2) i.e., SNR(dB) vs BER the simulation results shows that the proposed method keeps almost the same bit-error-rate (BER) performance.

Table1: Power requirement analysis in OFDM System of proposed scheme

Variables to which power requirement has been calculated	Amount of power required (dB)

W_{Xcp}	31.0600
$W_{\alpha Xcp}$	29.7221
When channel length = 1 and CP length = 2	29.2541
Saved energy when CP is multiplied with α	1.3379
Saved energy when channel length = 1 and CP length = 2	1.8059

From the simulation results it is shown that, the power required for the conventional OFDM technique for 1024 bits of single OFDM symbol is 31.0600 dB when CP length is one-fourth i.e., 256 bits, the power required for the OFDM system when CP is multiplied with α is 29.7221 dB, hence approximately 1.3 dB of energy is saved just by multiplying CP with α and subtracting from conventional CP. Channel Length is calculated using the Blind Channel Length Estimation Algorithm using Cumulant values i.e., if channel length = 1 then CP is kept double that of the channel length i.e., CP length = 2, then the power required for OFDM symbol is 29.2541dB, therefore almost 1.8 dB of energy is saved by adopting this technique.

V. CONCLUSION

In this undertaking, the proposed scheme is a vitality proficient transmission plan for OFDM frameworks . Through lessening the length of CP, the proposed technique can enhance the EE of the framework while keeping practically the same BER execution. The power required for the transmission of OFDM symbols will be much more reduced when compared with the Conventional OFDM transmission scheme i.e., approximately 1.8 dB of the energy is saved.

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