Analysis of Phase Noise and Frequency Offset using wavelets under different Channels for WPM Based Adhoc Networks

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Abstract— **An adhoc network consists of the nodes which communicate with each another within the network in dynamic manner. Multicarrier modulation employed for Adhoc network gives efficient communication between the nodes. Even in multicarrier modulation technique parameters like phase noise and frequency offset affects the communication links between the nodes. Wavelet Packet Modulation (WPM) is an efficient technique to achieve multicarrier modulation. In this paper analysis of link parameters phase noise and frequency offset is done using wavelets under different channels for efficient WPM system. Many wavelets are available but the use of efficient wavelet in WPM system provides stabilize connectivity in the link between nodes. Performance of wavelets is more or less similar at lower values of SNR but significant difference occurs as SNR increases. Simulation results show the difference in the performance of different wavelets for analysis of phase noise and frequency offset under different channel conditions. To maintain robust and reliable link between nodes, higher values of SNR are considered for analysis of wavelets under different channel conditions.**

Keywords- WPM, Phase noise, Frequency offset, Adhoc Network, SNR.

I. INTRODUCTION

For high speed reliable data transmission between nodes in an adhoc network multicarrier modulation is employed. Although in all the wireless communication systems multicarrier modulation makes the communication fast and reliable but multicarrier modulation can be made more efficient by close analysis of its parameters. Amongst the various parameters involved in multicarrier modulation system phase noise and frequency offset are the major parameters which are the main role players to make the multicarrier modulation technique more efficient [1]. At lower values of SNR the multicarrier parameters performs satisfactorily for all the wavelets. As the SNR increases there is a drastic change observed in the performance of phase noise and frequency offset parameters. So, performance analysis of phase noise and frequency offset is required at higher SNR values so as to make the system reliable and robust [2]. Also due attention is to be given to the noise present in the channel and the modulation technique used for the transfer of data. Phase noise is nothing but the small random fluctuations in the signal which generally occurs during transmission between transreceiver. It may results due to the different noise present in the channel. The phase noise of signal increases with the increase in the carrier frequency of the signal. But the phase noise can be reduced if the signal frequency is divided properly.

Frequency offset which is closely associated with the phase is also one the major parameter which affects the performance of multicarrier modulation system. In multicarrier system the orthogonality of subcarriers is maintained only if the frequencies of transmitter and receiver are synchronized. Any offset in the frequency of signal will result in loss of orthogonality. Frequency offset is the slight shift in the frequency of the signal which is due to inter carrier interference and it is the main reason for phase shift and attenuation of signal.

Fourier transforms had been used since decade as multicarrier modulation system [3]. Fourier transforms are reasonable for multicarrier systems as compared to advanced transform. Today with the need of high performance systems for Adhoc networks WPM is the promising technique for high performance network. The major advantage of WPM system is the flexibility which makes it suitable for next generation of wireless communication systems. With this advantage wireless communication systems are designed for enhanced performance in channel conditions as compared with today's average performance of wireless communication systems [4-5]. Also for instantaneous propagation conditions in adhoc network new generation systems like WPM is used to synchronize with the condition. According to the current adhoc wireless channel response, flexible and reconfigurable systems capable of optimizing performance need to be verified.

In this paper detailed analysis of frequency offset and phase noise effects of WPM system are proposed with the use of QPSK. Section II gives the literature related to phase noise and frequency offset. Section III gives idea related to the block schematic of the WPM system. It also gives the explanation related to different wavelets to be used within WPM system. Section IV discusses the simulation parameters used for analysis of the wavelets under different channel conditions. Section V gives the conclusion for efficient WPM system for Adhoc network by giving proper guideline of using wavelet for system and the channel condition in which it is suitable.

II. LITERATURE REVIEW

Phase noise and frequency offset analysis of the signals had been carried by many authors for various types of signals. Phase noise causes due to small random fluctuations or uncertainty in the phase of a signal. Analysis of phase noise is required since it limits the dynamic range in the performance of system. The theory of phase noise mainly focus in frequency can be quantified as jitter in the time domain.

Authors K. Nikitopoulos and A. Polydoros [6] in their work had mentioned the various schemes that may reduced the phase noise and frequency offset impairments in the transreceiver for OFDM system. But still better can be achieved if the same can be applied in WPM system. The problem of orthogonality can be better resolved with the WPM system as compared to OFDM system.

Authors D.D. Lin et al. [7] in their paper mentioned regarding the efficient channel usage for perfect synchronization of the transreceiver pairs for OFDM system. Work once again concentrated on the phase noise and frequency offset parameters, which are the main front end radio impairments taken into account for smooth and efficient functioning of the transreceiver.

Authors Q.H. Spencer et al. [8] in their research work have used the zero forcing method in channels so as to prove the efficient multiple input and multiple output (MIMO) operation. More or less authors had given thought on phase noise and frequency offset for proper operation of multiplexing in multiuser channel. Further it was observed that the front end impairments of radio channel are required for efficient system.

Authors M. K. Lakshman and H. Nikookar [9] in their work had mentioned regarding the flexibility and adaptability of wavelets as compared to OFDM for next generation high speed communications system. According to authors, wavelets are having the ability to characterize the signals accurately. Looking towards large number of available wavelets it seems to be difficult to identify the exact wavelet for efficient communication.

Zakaria Mohammad et al. [10] in their work had proved the wavelet packet transform based multicarrier modulation as an efficient modulation technique. Here authors had used the Zero Forcing (ZF) and Minimum Mean Square Error (MMSE) equalizers as compared to OFDM. Authors has used AWGN channel for calculating the Power Average Peak Ratio (PAPR) for their systems.

Until now for WPM system, very less literature is available for estimation of phase noise and frequency offset under different channel conditions. In this paper an attempt has made to find the suitable channel condition for finding the perfect match of wavelets for efficient WPM system. From the plots obtained using standard wavelets an attempt has been made to prove the better responsive transreceiver with the proper wavelets under different channel conditions.

III. FUNCTIONAL BLOCK DIAGRAM

The generalized block diagram of the wavelet packet modulation system is shown in Figure 1. In discrete domain the transmitted signal of WPM consists of successive symbols modulated in nature. These symbols are due to combination of all waveforms which are themselves amplitude modulated. If we combine all such waveforms then the transmitted signal of WPM in discrete domain. It can be expressed in discrete field as:

$$x[n] = \sum_{k} \sum_{m=0}^{M-1} a_{k,m} . \Phi m[n - kM] \text{------} \quad (1)$$

Where, x[n] is the transmitted signal, Φm[n] represents each symbol constructed by combining M waveforms, m is a constellation encoded kth data symbol modulating the mth waveform. Denoting T the sampling period, the interval [0, L_{T-1}] is period where Φm[n] is non-null for any m ε {0...M − 1}. In any general channel, if such waveforms Φm[n] are to be mutually orthogonal then it should satisfy (Φm[n], Φm+1[n]) = δ [m – (m+1)]. If the above given condition is satisfied then the lowest probability of erroneous symbol can be achieved at the receiver side of the transreceiver.

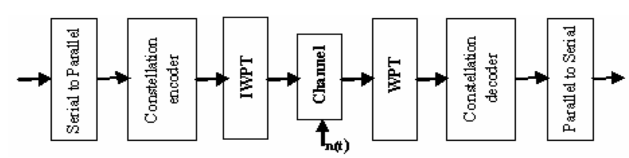

Figure 1. Block Diagram of WPM System

The wavelet systems are generated from a scaling function or wavelet by simple scaling and translation and all wavelet systems should satisfy the multiresolution conditions. Many practical signals and signal generating processes forms the basis of scaling function. Filter bank which is a tree structured algorithm, used in WPM calculates the lower resolution coefficients from the high resolution coefficients, gives the discrete wavelet transform. Such wavelet expansion gives more accurate local description and separation of the signal characteristics. If it is assumed that the WPM transmitter and receiver are perfectly synchronized and the channel is ideal, the detected data at the receiver output can be represented mathematically as,

$$r_k = e^{j(\theta k + 2\pi k \in /N)} \sum_{l=0}^{L-1} h_l s_{k-1} + b_k \quad \text{----------- (2)}$$

where k denotes the sample of the symbol and $\{h_l\}_{l=0}^{L-1}, \{s_k\}_{k=0}^{N-1}, \{\theta_k\}_{k=0}^{N-1}$ and $\{b_k\}_{k=0}^{N-1}$ denotes respectively the channel response of the known transmitted signal. If the phase noise and a circular zero mean Gaussian white noise with power $\sigma_b^2 . \in = \square fT$ is the normalized carrier frequency offset (CFO). The above equation (2) can be written in the matrix form as:

$$r_k = e^{j(\theta k + 2\pi k \in /N)} \sum_{l=0}^{L-1} S_k h + b_k \quad \text{--------- (3)}$$

Where,

$S_k = [s_k .....s_{k-L+1}]$ is the transmitted signal vector and $h = [h_0 .....h_{L-1}]^T$ is the channel response vector.

The above condition is not satisfied for the transient signals where the phase noise, frequency offset and channel conditions affects the received signal as compared to transmitted signal. Hence, WPM system are to be used in which there are family of overlapped transforms, the beginning of a new symbol being transmitted before the previous one(s) ends. The waveforms being M shift are orthogonal and the inter-symbol orthogonality is maintained inspite of the overlapping consecutive symbols. This allows taking advantage of increased frequency domain localization provided by longer waveforms while avoiding system capacity loss that normally results from time domain spreading.

IV. Simulation Results

For analysis of phase noise and frequency offset coding is done in MATLAB. By using the simulation parameters as indicated in table 1., dynamic network is designed so as to give the real time information sense of adhoc network. QPSK is used as the modulation scheme for transmitting the signal between transmitter and receiver. Simulations are done for different wavelets like daubencies (dB), Haar, Symlet (sym) and Coiflet (coif) under different channel conditions like AWGN, Rayleigh and Rician.

Table 1. Simulation Parameters

Parameters	Values
Modulation	QPSK
Carriers	128
Code length	1000
Number of Bands	4
Channels	AWGN, Rayleigh, Rician
Wavelets	Haar, Daubenchies, Symlet, Coiflet

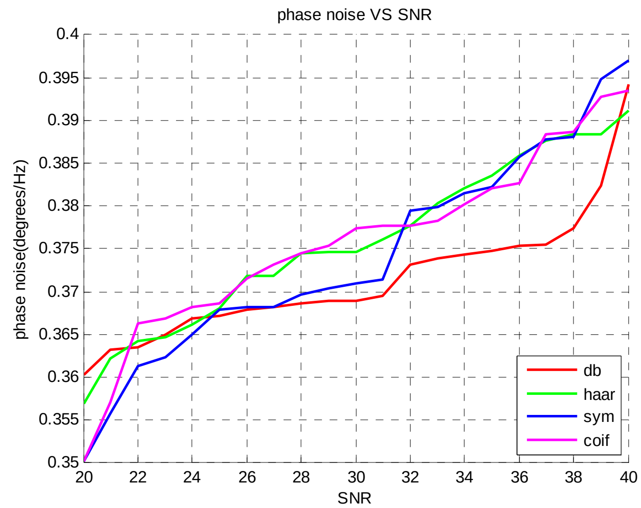

Figure 2. Performance of Phase noise using QPSK in AWGN Channel

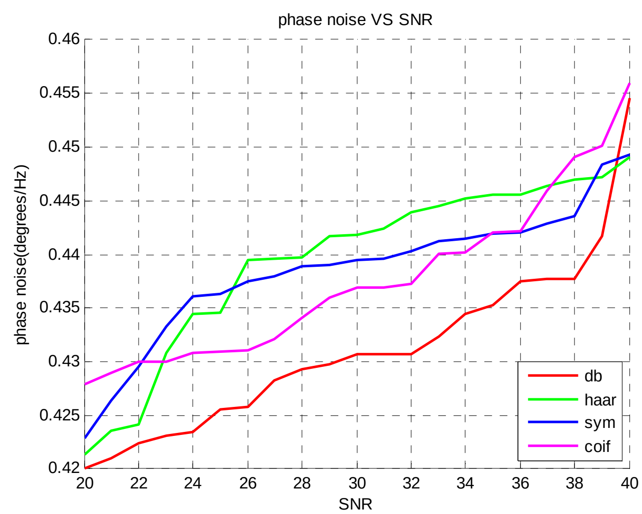

Figure 3. Performance of Phase noise using QPSK in Rayleigh Channel

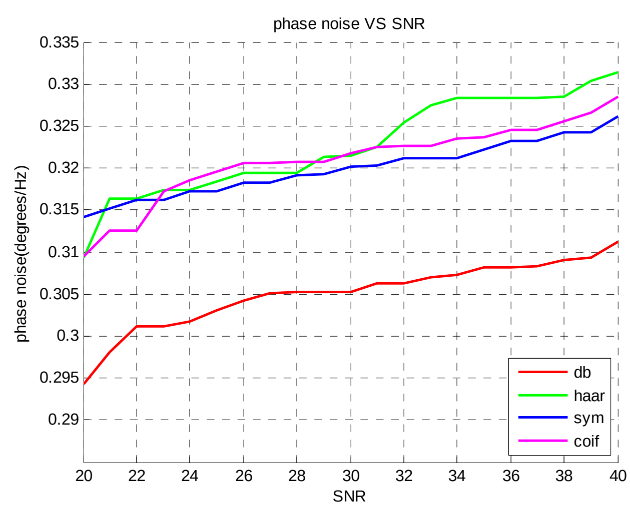

Figure 4. Performance of Phase noise using QPSK in Rician Channel

Figure 2, figure 3 and figure 4 gives the performance analysis of phase noise using QPSK in AWGN, Rayleigh and Rician Channels respectively for different wavelets in WPM based Adhoc network. In all the above figures it is observed that the average performance of db wavelet is found satisfactorily as compared to haar, symlet and coiflet wavelets. All the wavelets used are considered under different channel conditions where it has been noticed that rician channel is suitable for wpm based Adhoc network as compared to AWGN and Rayleigh channels.

Table 2. Comparative values of Phase noise using QPSK for Daubencies (dB) wavelet in different Channels

SNR	Phase Noise (Degrees/Hz)		
	AWGN	Rayleigh	Rician
20	0.360	0.420	0.294
22	0.363	0.422	0.301
24	0.366	0.423	0.302
26	0.367	0.425	0.304
28	0.368	0.429	0.305
30	0.368	0.430	0.305
32	0.373	0.430	0.306
34	0.374	0.434	0.307
36	0.375	0.437	0.308
38	0.377	0.437	0.309
40	0.394	0.454	0.311

Above table 2. represents the different values of phase noise using QPSK modulation for Daubencies wavelet in AWGN, Rayleigh and Rician Channels. Eventhough all the channel gives similar performance at different higher values of SNR but under Rician channel condition the value of phase noise is found lower as compared to AWGN channel and Rayleigh channel.

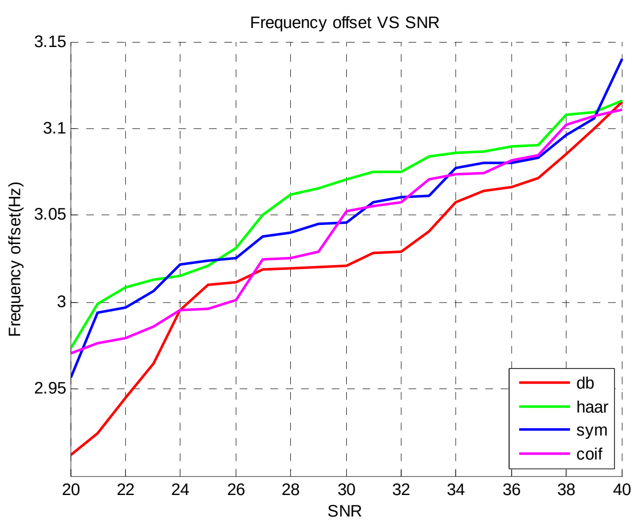

Figure 5. Performance of Frequency Offset using QPSK in AWGN Channel

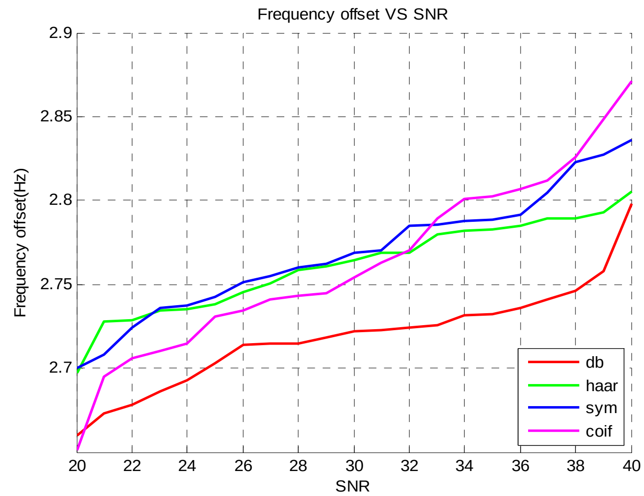

Figure 6. Performance of Frequency Offset using QPSK in Rayleigh Channel

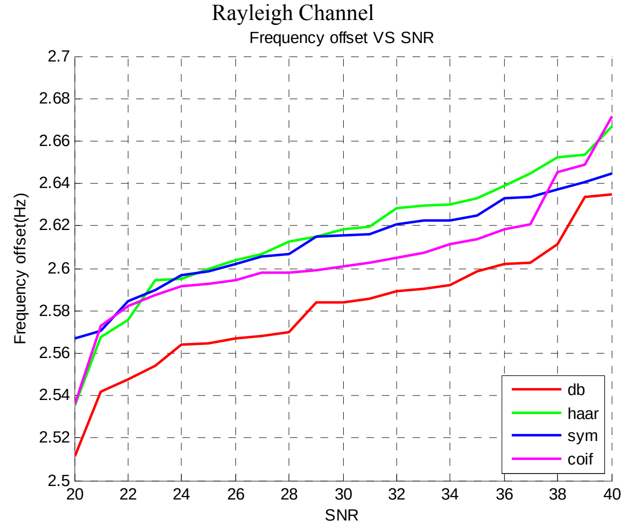

Figure 7. Performance of Frequency Offset using QPSK in Rician Channel

Similarly the performance of frequency offset is carried out using QPSK modulation for daubencies, haar, symlet and coiflet wavelet under AWGN, Rayleigh and Rician Channel as shown in figure 5, figure 6 and figure 7 respectively. Here we found that the daubencies wavelet performs best as compared to haar, symlet and coiflet wavelets in AWGN, Rayleigh and rician channels. As we compared the channels the performance of Rician channel is found more satisfactorily as compared to AWGN and Rayleigh channels.

Table 3. Comparative values of Frequency Offset using QPSK for Daubencies (dB) wavelet in different Channels

SNR	Frequency Offset (Hz)		
	AWGN	RAYLEIGH	RICIAN
20	2.912	2.660	2.512
22	2.945	2.678	2.548
24	2.996	2.693	2.564
26	3.012	2.714	2.567
28	3.019	2.715	2.570
30	3.021	2.722	2.584
32	3.029	2.724	2.589
34	3.057	2.732	2.592
36	3.066	2.736	2.602
38	3.085	2.746	2.612
40	3.116	2.798	2.635

Above table 3. gives the values of frequency offset under different channel conditions for daubencies wavelet, which is the best performer in the WPM based Adhoc network.

V. CONCLUSIONS

Analysis of phase noise and frequency offset using daubencies, haar, symlet and coiflet wavelets under AWGN, Rician and Rayleigh channels using QPSK for WPM based adhoc network is successfully done using simulation. It is clear from the simulation results that performance of daubencies wavelet is more suitable as compared to haar, symlet and coiflet wavelets. Also, the simulation is successfully done under different channel conditions like AWGN, Rician and Rayleigh. The Rician channel performance is satisfactorily as compared to AWGN channel and Rayleigh channel. Finally, it is concluded that at higher values of SNR, Daubencies wavelet performance under Rician channel is perfect for WPM system based Adhoc network which will make the multicarrier modulation more efficient.

In future more parameters like throughput and energy consumed will be analyzed so as to make multicarrier modulation more efficient for adhoc network.

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