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Cross-Layer Energy-Efficient Multimedia Transmission using Hybrid Fuzzy GWO in MIMO-OFDM

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Abstract*: *Wireless communication multimedia applications are increasing day by day in traffic, security, agriculture and health care service sectors. Multimedia communication itself involves a complex process that consumes more power at transmitter and receiver. Our research evolves start to end layer design margin to reduce power consumption and increase multimedia data quality. In this we propose the MIMO-OFDM system with a hybrid fuzzy GWO technique to minimize consumed power. Cross-layer margins are optimized by Grey Wolf Optimizer with a fuzzy algorithm that analysed compression and communication techniques for wireless communication. This cross-layer design provides power reduction and energy-efficient multimedia data transmission in the MIMO-OFDM system. We use a fuzzy approach for the fast processing speed of GWO.

Index Terms: Cross-layer, Multimedia, Energy, Fuzzy, GWO and MIMO-OFDM.

I. INTRODUCTION

Multimedia transmission requirement has increased from the last decade using the wireless network for health, security and entertainment sector. Ericsson Mobility Report states that the number of users in wireless networks has grown tremendously over the last few years, networks have become increasingly spectral and energy efficient because of low power circuit designing and technologies like MIMO-OFDM, Beamforming, heterogeneous cell structure even with 40% higher energy consumption. Wireless communication channel works with OSI model for data transmission. OSI layer model has a sufficient margin which can be overcome by choosing a cross-layer (Application+ MAC + Physical) design for better spectrum and energy utilization. WLAN is low-cost management to transmit multimedia data for applications as video conferencing, remote teaching and surveillance. These applications need loss tolerance, high bandwidth and delay-sensitive for its quality [1]. Real-time multimedia can be transferred with some amount of packet loss, the application layer cooperates with the lower layers. OFDM Low Complexity Transceiver, very good Multi-Path combating capability applicable in LTE downlink, Wi-Max, Wi-fi. Our research moved towards power consumption reduction in the manner without decreasing the quality of multimedia data. Cross-layer optimization provides an efficient and effective quality of service which is required for multimedia communications. We applied a cross-layer design for energy efficiency optimization that gives the transmitter to receiver end fine line solution of multimedia data transmission wirelessly with fuzzy logic. A novel algorithm is proposed using Gray wolf optimization technique with fuzzy.

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II. RELATED WORK

A. Joint Phy-Mac-App Optimization: -

A cross-layer wireless network is implemented for application, MAC and physical layer. In this, we gave less importance to the Network and Transport layer. This design allocates resources to Physical, MAC and Application layers in the joint strategy adopted as SA, SP, and SM for application, Physical and MAC layer. Application layer has a strategy as S_{Ai} from I Ɛ (1,2,3….N_a),
Physical layer has a strategy as Spi from I Ɛ (1,2,3……..Np) and
MAC layer has a strategy as Spi from strategies as
I Ɛ (1,2,3……..Nm)
There are a number of strategies can be driven and the number of solutions can be given as
S_i ={Phy_1, Phy_2, Phy_3, ……….. Phy_{Np}, MAC_1, MAC_2,……. MAC_{Nm}, App_1, App_2…… App_{Na}}
And total of are = N_p* N_a* N_m.

It becomes very challenging to select one strategy for quality, processing time and power requirement of channel. Function of channel gives random values of parameters, which can be used in the form of worst or average values. Adaptation of cross layer strategy of PHY_i, MAC_i, APP_i for video transmission parameters are SNR, packet size, scheduling, routing, number of users. Cross layer approach application layer rate, enhancement layer rate, packet size of MAC layer and modulation technique at physical layer optimizes minimum power usage for energy efficient system of video data in different channel condition [2]. The scalable video encoder function is to compress a raw video in to multiple sub streams. These sub streams contain base sub-streams which provide coarse visual quality and independently decodable. Other sliced sub streams are enhanced sub streams which are used for better visual quality and decoded with only base sub streams. So scalable video encoder provides highest quality with all sub streams [3].

$$S_{opt} = \arg\max Q(S(x)) \qquad (1)$$

Where s(x)= { R_{bl}, $R_{el.}$, P_{kt} , M}

R_{bl} - rate of the base layer in application layer

R_{el} - rate selection in enhancement layer

P_{kt} - packet size (MAC-layer)

X- Channel condition (probability of error with signal to noise ratio) for physical layer

modulation technique M has chosen to maximize quality of multimedia.

Delay in (S(x)) ≤ D_{max}

Power (S(x)) ≤ P_{max}

Here we will use optimal power for QoS, delay due to channel condition. Required power is function of data rate of application, physical and MAC layer as R_{bl}, R_{el} and P_{kt}. Energy consumption increases data throughput which will improve energy efficiency.

$$\eta_{EE} = \arg\min p \ of \ S_{opt} \qquad (2)$$

We are using joint selection of application, MAC and Physical parameters with different modulation techniques, video quality score or mean opinion score of international consultative committee on radio communication (CCIR) recommendation. Video quality of outputs a score from 0 to 5 video quality level defined on the basis of human eye perception and subjectivity aspects of colour distortion including blurring, global noise, block.

Table 1

Layer optimization	Quality score for video data
No selection	1.4
MAC optimization	1.9
Application	3.8
Joint App-MAC	4.6

Wireless video data streaming user experience optimization solution proposed in three steps for first parameter extraction from application, data link and physical layer, second step parameters are integrated an finally Optimized values assigned to layers. This mechanism reduces amount of information which is extracted from each layer. In this solution quality of video data optimizes from start to end as video source rate, time slot, location and modulation scheme are used as parameter for single objective function. As above discussion different strategies for different layers to enhance efficiency of scalable video transmission. Here a multipath model designed and used to evaluate video distortion characteristics in terms of packet loss and throughput with respect to channel condition as signal to noise ratio and the selection of FEC, retransmission policy for optimal result of quality to minimize power consumption. Optimal Power can be derived with two strategies to deploy video data in good channel condition or bad. In first strategy transmitter sends data when channel is sensing the condition is good or medium bad condition. We will fix maximum power required in data transmission as P_{max} in practical condition of zone. In bad condition to improve data quality channel needs more power, even more power multimedia quality of reception not guarantee. Here a trade-off between power saving and QoS of multimedia.

MIMO-OFDM channel gives spectral as well as energy efficient system in this traditional average power allocation (APA) algorithm [7,8] states that transmission power allocation in every subchannel is equally distributed. Energy consumption and throughput both depends on transmission power. X. Ge et al proposed an energy efficient algorithm for MIMO-OFDM system as energy efficiency optimization algorithm (EEOPA)which shows that requirement of high-quality multimedia transmission needs more power. EEOPA uses singular value decomposition method to form group of sub channel for distribution of power which should always be less than average power [12]. X. Chen et al proposed a near optimal power allocation scheme works on scalable video coding (SVC) for transmitting videos over MIMO systems for increase in QoS. They draw optimal solution from sub problems formulated by corresponding theoretical reason. They combine transmission errors from the physical layer and video coding parameters from application layer for near optimal power allocation method [13].

III . SYSTEM MODEL

Cross layer system design for 4G network consider multi in multi out (MIMO) technique with orthogonal frequency division multiplexing (OFDM) with Grey Wolfe optimization technique. GWO developed from the grey wolves' natural abilities of solving their real life and general problems. GWO apply hunting process and leadership position formation. The GWO algorithm mimics, leadership and hunting mechanism of grey wolves perform in natural way. Four types of grey wolves considered as alpha, beta, delta and omega for leadership position to perform. Optimization implements three main steps of hunting as searching, encircling and attacking of prey technique of grey wolves. Optimization process splits into four different sets as alpha, beta, delta and omega for simulating leadership task of grey wolves. If a wolf is not in group of alpha (α), beta (β), or omega (ω), it is signified as a subordinate in delta (δ). A novel algorithm proposed as hybrid fuzzy GWO [15,16] to improve the energy efficiency and also reduce the power consumption of the entire transmission. OFDM multiplexing implemented using Inverse Fast Fourier Transform (IFFT) block to replace bank of modulators required for conventional multi carrier System. IFFT modulates the input symbol to the sub carriers, each data symbol modulates one sub carrier. Each has a pulse period which is the product of sampling period to the system times the number of carriers in the system. These frequencies are mutually orthogonal to each other for orthogonal frequency division multiplexing. OFDM system can be expressed for two function f_x and f_y are orthogonal for time interval of (t_1, t_2), if it satisfy

$$\int_{t=t_1}^{t=t_2} f_x(t) f_y(t)\, dt = 0$$

That the area under the product of the two functions in the region is zero.OFDM system parameters sub carrier bandwidth, coherence bandwidth is chosen as coherence bandwidth of the channel is greater than sub carrier bandwidth for flat fading environment. OFDM output symbol duration is summation of useful period and cyclic prefixed guard interval duration.

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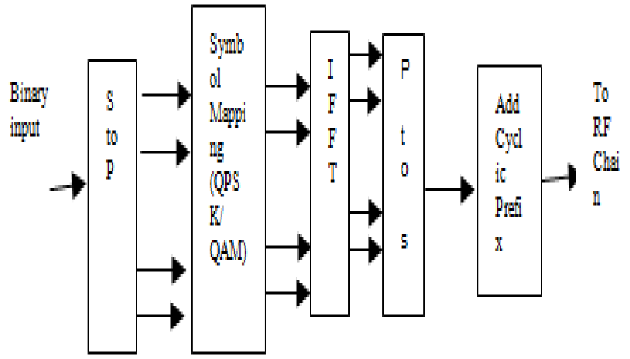

This hybrid fuzzy GWO algorithm compared with other methodology as genetic algorithm (GA), GWO and Particle swarm optimization (PSO). Our proposed strategy complexity at receiver is minimum compare to other optimization techniques.

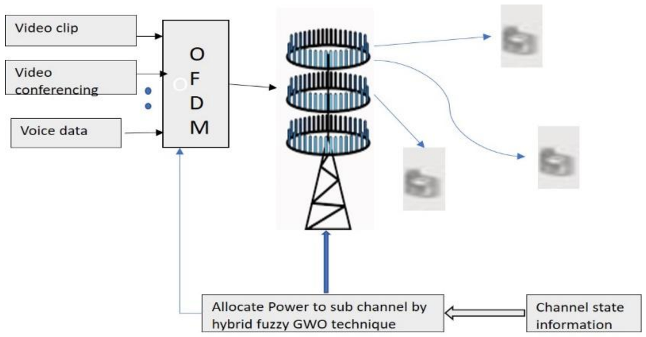

Figure 2. MIMO-OFDM System using Hybrid fuzzy GWO technique.

IV. SIMULATION

MatlabR18a version with suitable data of 4G standards with input data as a stored video clip which is transferred in wireless medium by optimized strategy of cross layer by choosing number of frames per second, FEC codes for channel using CSI feedback and modulation technique with MIMO-OFDM using singular valued decomposition (SVD) and optimized energy efficiency with constant quality score. Set maximum average power limit P_{max} and the instantaneous channel condition tolerable delay D_{max}(maximum). We applied fuzzy based GWO for minimum power transmission at every layer without affecting the quality of multimedia signal [14]. In this algorithm we picked up best suitable modulation technique according to data and channel condition. Input data [18]. A video streaming that can tolerate 1ms delay is used for delay constraint, quality index is noted according to probability of error with Signal to noise ratio. Parameters used for simulation are

Table 2

Parameter	Value
Frame length	300
Bandwidth	1MHZ
Pathloss exponent	3
Noise Power	0.01
Amplifier efficiency	0.2
Circuit power	10 W
Maximum delay	1 msec

IV SIMULATION RESULT

OFDM technique server provides several benefits in transmitting system, since it improves spectral efficiency by reducing subcarrier spacing and give multiple choices in modulation techniques.

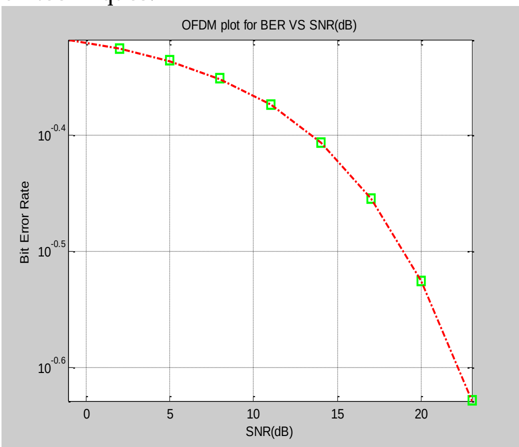

Figure 3. OFDM performance with SNR of BER.

Orthogonal frequency division multiplexing gives efficient spectrum utilization in multipath communication. Performance of OFDM in terms of bit error rate with signal to noise ratio is shown in figure 3.

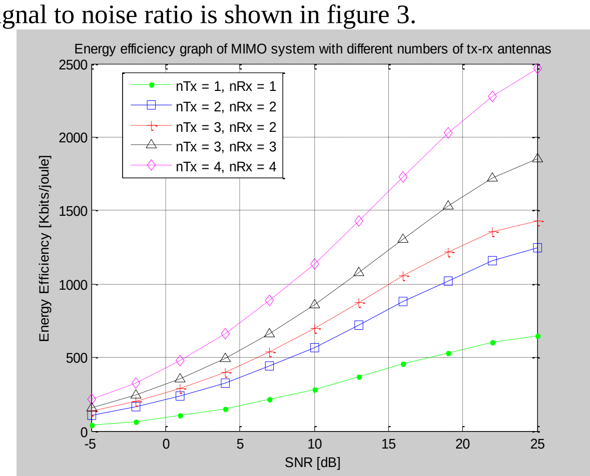

Figure 4. MIMO system energy efficiency graph with signal to noise ratio.

Figure 4 shows the capability of MIMO system that indicate that as we increase number of antennas at transmitter and receiver it increases efficiency in both the term of spectral and energy. In this system we distributed power to sub channel using SVD method by selecting minimum number of antennas at transmitter and receiver. MIMO using with orthogonal frequency division multiplexing (OFDM) give utilisation of spectral band with energy efficiency.

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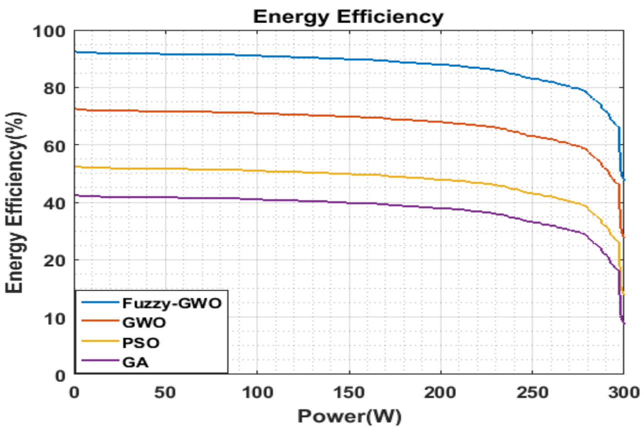

Fig. 5 Comparison graph of optimization algorithm between energy efficiencyand power [14].

Figure 5 shows energy efficiency in percentage and transmission power with constant circuit power in watt, we get constant energy efficiency as power increases and after 250 W to 300W it goes down. Our proposed method Hybrid fuzzy GWO method gives maximum energy efficiency as 92 %, GWO as 74%, PSO as 54% and GA gives as 43% with same power parameter.

V. CONCLUSION

Cross layer design and MIMO-OFDM study shows that it increases spectral and energy efficiency. Our proposed algorithm hybrid fuzzy Grey Wolfe Optimization minimizes power consumption and delay in process. System model working on MIMO-OFDM channel reduces complexity of circuit. It also reduces power and give high energy efficiency to multimedia data transmission for surveillance of home and office, health monitoring and traffic control.

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