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Research paper

Review on OFDM based Image Transmission System

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Abstract

Growing interest in the wireless communication technologies has been focusing on meeting the demands of consumers with respect to quality of communication in image transmission. Thus, most of the researches were giving prior interest towards providing better channel capacity, maximized transmission rate and low interference. An orthogonal frequency division multiplexing (OFDM) can offer higher bandwidth and interference-free signal transmission. Thus, the transmitted image over OFDM can have optimal image quality at the receiver end. The current researches indicated that the OFDM concept could provide satisfactory communication performance for next-generation wireless communication standards. This paper intends to discuss the investigational research on the OFDM technology for image transmission exist with respect to different approaches like Simulink, FPGA technology, etc. and the significance of current research contributions. Finally, the future line of research is illustrated to overcome the research gaps.

Keywords: *OFDM; Performance; Image Transmission; Wireless Communication.*

1. Introduction

The demand for the reliable as well as highly rated data transmission over a wireless communication network is increasing exponentially. The ever-increasing demand for networking speed, channel capacity, and high-quality data transmission has given birth to the concept of OFDM [1]. An OFDM system has the ability to work on different wireless multimedia standards like image transmission, video transmission, etc. The significance of the OFDM is that it yields the higher degree of immunity towards the impulsive noise and multipath fading [2]. Also, the OFDM offers the high spectral efficiency and effective modulation and demodulation through inverse fast Fourier transform (IFFT) and FFT respectively. The function of the OFDM is to divide the frequency selective channel as different parallel non-frequency channels and performs the signal modulation for different frequencies. The OFDM helps to enhance the channel transmission performance, and it has a wide range of applications in the image as well as video communication system [3].

OFDM is also known for its potential capability to offer reliable internet connectivity system with the aid of narrowband sub-channels that are closely spaced with each other. Because of this, OFDM can resist an adverse effect of Inter-Symbol Interference (ISI) that occurs due to overlapping of consecutive signals with each other. Hence, there is always a threat of ISI for maximized data of data transmission by OFDM [4, 5]. This problem is, somewhat, addressed by extracting data streams with a lower rate from that of the higher rate. Another frequently used solution towards ISI problem is Cyclic Prefix that is inserted in order to develop a guard interval for resisting ISI [6]. But Cyclic Prefix is also known for its adverse effect towards the throughput, i.e., Spectral Efficiency. Another solution towards issues of overlapping signals explored is to make longer guard interval compared to delay spread. This principle will resist the signal overlapping to a large extent. The legacy benefit of OFDM is also carried out in OFDM, i.e., implementation of the Fast Fourier Transform (FFT) [7] [8] [9]. This is a significant operation as it assists in transforming the signal between frequency as well as temporal domain. Using this principle, it is now feasible to decompose any complex waveforms into various smaller components of sinusoidal waveforms. Usage of Discrete Fourier Transform can be widely seen in the processing signals generated from real-world applications [10]. The best part of using Discrete Fourier Transform is its applicability over combined signals of OFDM without any form of dependencies demodulators and filter banks pertaining to each sub-carrier. The efficient utilization of channel capacity is also ensured by OFDM as all the sub-channels are spaced accordingly with respect to frequency and time-domain waveforms. Hence, a high data rate with low interference can be guaranteed using OFDM. The data distribution across the number of carriers in OFDM will have some more significant advantages. The interference and multipath effects can cause nulls on a given frequency that can affect the less number of carriers, and the remaining carriers will be received properly.

Further, the OFDM can be implemented by using Field Programmable Gate Arrays (FPGA) and WiMAX standards [1-10]. This paper aims to discuss the conceptual aspects of the OFDM technology in data/image communication with the current state of the art in the research domain. The paper is categorized with different subsections like concepts of OFDM (in Section II with the model diagram. Further, the concept of data or image transmission over OFDM system, advantages as well as disadvantages of OFDM were described in Section III. Later, existing research trend for OFDM, for image transmission issue in OFDM and Optimization Problem in OFDM were expressed in Section IV. Then the survey of OFDM, for image transmission issue in OFDM and Optimization Problem in OFDM through FPGA and WiMAX techniques is discussed in Section V. The research gap is expressed in Section VI and finally the conclusion and future scope in Section VII.

2. OFDM

The technology OFDM is a widely used in the recent wireless communications systems as it offers higher spectrum efficiency as well as robustness during the multi-path propagation. The OFDM is an advanced modulation technique, i.e., multi-carrier modulation. The OFDM also resolves the issues related to the intersymbol interference (ISI) by performing image multiplexing on the orthogonal property. Furthermore, OFDM is spectrally sufficient mechanism than the conventional signal carrier modulation technique. The OFDM exhibits the high PAPR of the transmitted signal [1-3]. To minimize PAPR, various methods have been presented in the recent past. These methods of PAPR minimization can be divided into signal distortion and scrambling methods.

The signal distortion methods reduce high peaks directly by distorting the signal which is meant for amplification. The method of clipping the signal prior to the amplification process is a simple to limit PAPR. But, the interferences (in band and out band) due to these methods can lead to system performance degradation. A method of Signal scrambling methods helps to minimize the PAPR by using scrambling codes like selective mapping, block coding, and partially transmit sequences [4], [6], [7]. These techniques are categorized as schemes with side and without side information. The schemes with side information may lead to the redundancy causing degradation of throughput. Also, the higher redundancy also impacts total transmission rate. Hence, the higher redundancy for every packet image needs to be estimated with respect to packet data significance. An OFDM system is represented with Figure.1, which exhibit complex symbol blocks formed through symbol modulation one of the R subcarriers which are orthogonal with frequency. The complex form of the transmitted signal through OFDM can be considered as:

$$x(t) = \frac{1}{R}\sum_{r=0}^{R-1} S_n \times e^{j2\Pi f_n t} \tag{1}$$

In the above equation, the data symbol is represented as Sn, a number of subcarriers as N and frequency at nth subcarrier can be indicated as fn. In transmission unit, the input image is supplied to the encoder and then forwarded to the serial to parallel converter to get parallel symbols and then to the mapper. Then, OFDM modulation is performed by inverse FFT to get time components from the frequency component. Further, the image is converted from digital to analog then given for modulator. Similarly, the reverse processes of transmitter unit are performed in the receiver unit to recover the image in receiver end.

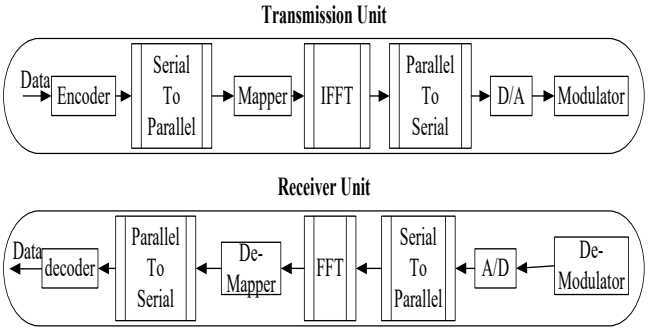

Fig. 1: Model of OFDM System.

3. Transmission of image over OFDM

The image transmitted over the OFDM signal is expanded between the carriers of the signal where every carrier will participate as the part of the payload. Thus, minimizes the data rate considered by every carrier. The significance of the lower data rate is that the interferences generated by the reflection will be less critical. This can be achieved through the addition of guard interval or guard band time to the system. Hence, it will assure the sampling of data in the stable state only and also no new delayed signals will arrive which can alter the signal time and signal phase [11].

The image distribution across the number of carriers in OFDM will have some more significant advantages. The interference and multipath effects can cause nulls on a given frequency that can affect the less number of carriers, and the remaining carriers will be appropriately received. Through the implementation of error coding mechanisms, the addition of more data to the transmitted signal can enable reconstruction of the corrupted image within the receiver. This reconstruction takes place as the error correction code is forwarded in different parts of signals. Commonly, the OFDM is used in a wireless system where the high data rate is required [12]. Following are some of the advantages of OFDM [13],

a) Resistivity towards selective fading:

The main significance of the OFDM is that it exhibits the high resistive capability towards selective fading of frequency than the single carrier systems because it partitions the complete channel into various narrowband signals which are affected separately as sub-channels of flat fading.

b) Resistance towards narrow band effect

Through proper channel coding and interleaving recovery of the lost symbols is possible. Also, all the data will not be lost.

Resistance towards spectrum: Through close spaced overlapping of subcarriers, the OFDM offers to make use available spectrum efficiently.

c) Resistance of OFDM against interference

The existence of interference on a channel can be of limited bandwidth and is not affect all the sub-channels due to which the data may not be lost.

d) Rigidness against inter-symbol interference

The OFDM exhibit the properties which show higher rigidity against the inter-symbol as well as inter-frame interference. This rigidity results due to the low data rate of every sub-channel.

e) Channel equalization:

The existing CDMA systems have complexity issues in channel equalization which need to be applied over the channel. The significant point of OFDM is that the use of multiple sub-channels can bring the simple channel equalization.

With all the significant advantages the OFDM also exhibit some limitations and are expressed as below [13, 14].

- The spectrum of OFDM exhibits the high PAPR value, and it impacts on the transmission system with the need of radio frequency power amplifier with high PAPR.
- The OFDM exhibits higher carrier frequency offset because of different local oscillators and discrete Fourier transform leakage which needs correction of complex frequency offset at OFDM receiver.
- The spectrum of OFDM travels through different paths which needs guard band to restrict the ISI errors occurred due to timing offsets.
- OFDM is vulnerable to inter symbol interference and inter-carrier interference but which needs time and frequency offset correction algorithms.

4. Existing research trends

Research on OFDM based wireless communication is currently the most widely discussed topic. In this paper, visualized the research trend from 2010 until 2016 from IEEE Xplore in the forms of graphs as shown below.

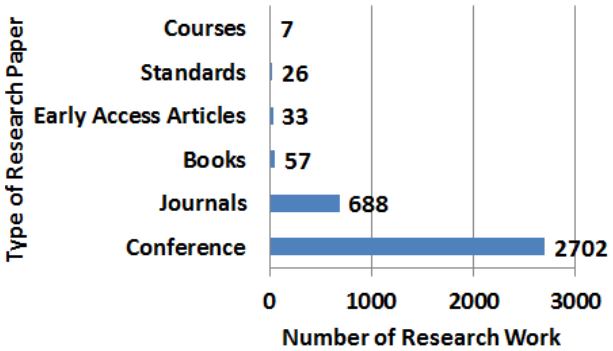

Fig. 2: Research Trend for OFDM.

It is observed that 688 Journals are being published towards cumulative problems of OFDM, where the major problems image transmission problem and optimization problem. We further explore the statistics of progress in research work towards such issues in order to visualize the problems that have to receive good attention as well as the most ignored issues in OFDM.

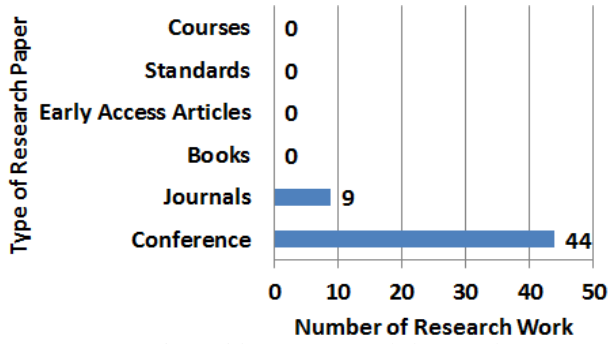

Fig. 3: Research Trend for Image Transmission Issue in OFDM.

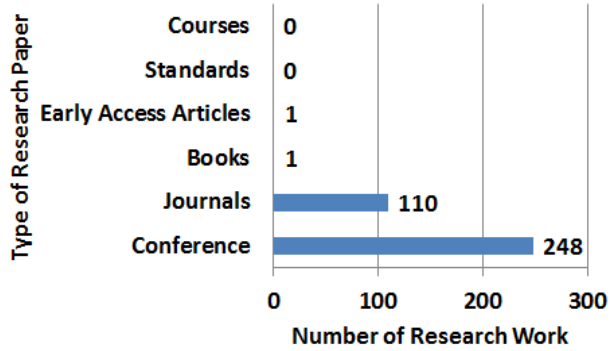

Fig. 4: Research Trend for Optimization Problem in OFDM.

Fig.2-Fig.4 shows that image transmission problem (9 journals) has received the lowest attention. It is observed that there has been enough work being carried out towards optimization problem too (110 Journals). By this, it can be concluded image transmission problems are much dependent on the specific theory and algorithms that cannot be generic in the form, and hence existing algorithms find less applicability in solving such problems. Therefore, it is required to understand the effectiveness of existing research contribution in solving such problems. The next section discusses an existing solution.

5. Existing research work

This section discusses the work being carried out towards enriching the performance of OFDM in recent times. As this is one of the most adopted wireless technologies in recent times, hence their applicability is found more in a diverse area. We will discuss briefly the essential research approaches to various problems associated with OFDM.

a) Image Transmission Mechanism

A closer look into the trends of research work being carried out in OFDM has a higher inclination towards addressing the problems pertaining to multimedia transmission. It is because OFDM is the baseline for maximum next-generation wireless standards, e.g., 3G / 4G networks. However, the work is not only limited to transmission but also pertains to perform a significant level of processing to the signal bearing multimedia contents. The research review on image transmission over the wireless channel has been found in Chandra et al. [15]. Here, various aspects related to the compatibility of the image for transmission over the wireless channel were discussed. Also, some image compression methods were reviewed and analyzed and suggested the requirement of formatting and de-formatting operation in image transmission and receiving respectively. An interesting work towards the transmission of image over the OFDM system is discussed in Fatima [16] by using trigonometric transforms. Author has improved the performance parameters like PAPR, PSNR by using the trigonometric transform techniques like Discrete Sine transform and Discrete Cosine Transform. In Wang et al. [17], a secure OFDM based image transmission system is presented by using two layer image encryption. Here, the performance analysis is measured by considering bit error rate (BER) and PSNR and found effective results. The similar direction of research is found in the work of Wang and Qui [18], were Chebyshev Chaos method was used to achieve secure image transmission which improves the performance of BER. In order to bring further security in the image transmission over OFDM system and have improved quality of the image, a chaotic baker map is implemented by Soliman et al. [19] and achieves the efficient performance with low PAPR value of OFDM signal. The extended work of Chandra [15], have presented the image transmission over Rayleigh channel [200] of OFDM and performed the performance analysis with respect to SNR. Research on the transmission of JPEG2000 image over OFDM based cognitive radio network is presented in Javadi et al. [21]. Here, the method improves the quality of the image received at secondary user end by offering the effective access to the available spectrum. An experimental approach is chosen for performing real-time streaming using Field Programmable Gate Array (FPGA). The work of Sabelkin and Gagnon [22] have expressed the combined channel transform image transmission mechanism over the wireless channel. The work evolves with lossless image transmission in low fading effect and achieves fast analysis. The implementation of OFDM through FPGA is expressed in Mohamed et al. [23] and found the significant value of SNR. In Kareem et al. [24], a simulating model of WiMAX baseband (IEEE 802.16d) is presented which incorporates the MATLAB and Xilinx system generator and does the synthesis of OFDM system. The similar direction of work has been observed in Harikrishna et al. [25] in which implementation FPGA based FFT algorithm implementation for mobile WiMAX (IEEE 802.16e) was discussed. The radix 22 FFT algorithm is presented to perform the communication of the OFDM system. From the performance analysis of the system has been found that the system achieves higher design speed which satisfies the need for high-level computation.

6. Research gap

The prior section has discussed the existing research work towards the frequently explored problems in OFDM. This section discusses the prominent research gap after reviewing the existing techniques. We find that certain issues are left unaddressed are as follows

- More focus on data quality and less focus on resource utilization in existing OFDM based image transmission scheme.
- Existing image transmission scheme is not applicable for upcoming next-generation standards and hence needs further investigation.
- Existing techniques don't address the problem of radio frequency imbalances that potentially degrade the quality of image delivery performance in OFDM based networks.

- Very rare investigational research on FPGA based image transmission.

From the statistics shown in Section IV, it was initially found that there is less number of studies towards addressing the problem of image transmission in OFDM. However, upon a closer look, it is found that image transmission is the most ignored area of the research in OFDM. Therefore, the first prominent research gap from the existing literature is the lack of any efficient modeling of Image Transmission that has considered using Resource Optimization over OFDM. The wide usage of image transmission over various applications in a wireless network will lead to consumption of various resources directly or indirectly. Hence, it is required that the resource allocation mechanism over OFDM should be appropriately investigated in order to realize various problems related to channel capacity, power, sub-channels, etc. There is few benchmarked work existing today to solve such ongoing issues. The QoS parameters, e.g., energy, bandwidth, memory, etc. are always limited to any wireless network. Although, there are studies related to such QoS limitations in OFDM only a few of them has related such problems associated with resource efficient image transmission. Still, a trade-off exists in OFDM about how to bridge the gap between throughput and increasing resource consumption for a limited set of QoS.

The second prominent research gap explored is few existences of any modeling for fault tolerant image transmission in OFDM. In order to transmit the image faster without much loss of significant information, it is necessary that the multiplexing scheme should support both times as well as the frequency for user allocations. Unfortunately, the existing architectures of image transmission scheme don't support the frequency-based allocation of a user that may result in potential loss of image information as well as degrade the delivery performance too. Because of problems as mentioned above, existing architectures of image transmission using OFDM will not be much applicable in upcoming next generation of telecommunications; those networks construct a scheduling principle on the basis of frequency.

The third prominent research gap is arising from the usage of existing techniques is radio-frequency imperfection. Although, this problem has been addressed by many researchers in the past they miss the inclusion of the OFDM technique and its possible adverse effect on fault tolerance. Because of this, there is a severe degradation of the quality of the signal on the receiver and declination of overall network performance.

The fourth research gap talks about the current researches meant for image transmission through FPGA. From the existing research survey, it is found that most of the image transmission techniques were based on software-based designs. Also, it is found that very fewer researches were considered the FPGA concept to perform the real-time implementation for image transmission over OFDM. Thus, there is further need of more focus in researches using FPGA based image transmission using OFDM.

7. Conclusion & future work

The OFDM offers a higher number of multiple channels of transmission resulting in linear maximization of the channel capacity with the incorporation of antenna numbers. The promising principle of OFDM is also known for its maximized data rate. Looking into the future OFDM is highly dependable requirement of upcoming standards as it can offer a potential capacity gain in order to accommodate a higher number of consumers in demand of maximized rate of image transmission with higher network sustainability and no higher consumption of valuable resources of communication. This paper has presented a discussion of the frequently used problems and different research techniques to solve it and also shows that it is not at par with the original research trend where certain problems, e.g., image transmission is left ignored.

Therefore, our future work direction will aim to design and develop a system for image transmission to ensure optimally enhanced signal quality. In order to perform better performance and more applicability of the proposed image transmission mechanism for the upcoming standards of telecommunication, we will focus more on implementing OFDM. In order to accomplish the problem mentioned above, the following research objectives are set, i.e., i) To design a transmission system using a conventional transceiver (OFDM) for the image. ii) To develop an image transmission system using OFDM transceiver design using Simulink Modelling, iii) To design an efficient image transmission in OFDM for a communication system using FPGA, finally iv) Perform the performance analysis of the proposed models with the existing system.

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