# Improving the QoS for the 3rdG and beyond systems

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**Abstract:** Many generations have been developed and still a big challenge for the researcher to meet the Quality of service (QoS) in different applications. As the demand to meet the QoS of high-quality multimedia application is increasing, the development of the future generation (4G) wireless and mobile communication systems must be based on powerful technologies.

To meet the 4G robustness while we trying to increase the Bandwidth (BW). The use of Orthogonal Frequency Division Multiplexing (OFDM) permits an efficient use of the BW by allowing overlapping between the orthogonal subcarriers. It decreases the cost of the equalisation techniques by enabling it in the frequency domain, and combats the effect of multipath channels by dividing the whole channel into a lot of flat subchannels. The use of Multi-Input Multi-Output (MIMO) provides a spatial diversity in the fading environments. So it can be based on the combination of the OFDM, and MIMO systems.

This paper we will illustrate the main features for the above two systems, and mentioned the main problem that faces the researchers and the proper techniques that are used to solve these problems.

## 1. Introduction.

OFDM is a popular method for high data rate transmission over the wireless channels. It is chosen over a single carrier solution due to lower complexity of equalisers for high delay spread channels or high data rates, and it’s ability to deal with large delay spreads with a reasonable implementation complexity. For Single carrier systems with equalisers, the performance degrades abruptly if the delay spread exceeds the value for which the equaliser is designed and because of error propagation, the raw bit error probability increases thus quickly that introducing lower rate coding or a lower constellation size does not significantly improve the delay spread robustness. For OFDM, there are no such nonlinear effects as error propagation, and coding and lower constellation sizes can be employed to provide fallback rates that are significantly more robust against delay spread. This enhances the coverage area and avoids the situation that users in bad spots cannot get any connection at all. Due to the mentioned capability, it is considered as a hot topic and the potential candidate for the fourth-generation (4G) mobile wireless systems [1].

The attraction of OFDM is mainly due to how the system handles the multipath interference at the receiver. Multipath generates two effects: frequency selective fading and Inter Symbol Interference (ISI). Adding a guard period to the symbol to be transmitted ensures robustness against multipath delay spread. This step can be achieved by having a long symbol period, which minimises ISI. The level of robustness can be further increased by the addition of a guard period between successive symbols. The most popular and effective method of doing this, is the addition of a cyclic prefix. A cyclic prefix is a copy of the last part of the OFDM symbol, which is preceded the transmitted symbol [2-4].

OFDM breaks the broadband signal down into multiple narrowband carriers, that’s mean it converts a frequency-selective channel into a parallel collection of frequency flat subchannels. The narrowband carriers have the minimum frequency separation required, that will not affect the orthogonality after using the Inverse Fast Fourier Transform (IFFT). Due to the overlapping between the narrowband carriers, we get an efficient use of the available bandwidth [5, 6]. To realise the overlapping multicarrier technique, we need to have the orthogonality between the different modulated carriers. In a normal Frequency Division Multiplexing (FDM) system, many carriers are spaced a part in such a way that the signals can be received using classical filters and demodulators, with guard intervals are imposed between the different carriers and in the frequency domain which results in a lowering of spectrum efficiency. The use of OFDM permits the carriers arranging so that the sidebands of the individual carriers overlap and the signal still received without either adjacent inter carrier interference or inter symbol interference [1].

There are some obstacles in using OFDM in transmission system in contrast to its advantages. A major obstacle is that the OFDM signal exhibits a very high Peak to Average Power Ratio (PAPR). The other limitation of OFDM in many applications is that it is very sensitive to frequency errors caused by frequency differences between the local oscillators in the transmitter and the receiver. Carrier frequency offset causes a number of impairments including attenuation and rotation of each of the subcarriers and Inter Carrier Interference (ICI) between subcarriers. In the mobile radio environment, the relative movement between transmitter and receiver causes Doppler frequency shifts; in addition, the carriers can never be perfectly synchronised. These random frequency errors in OFDM system distort orthogonality between subcarriers and thus ICI occurs [7-9].

Multiple Input Multiple Output (MIMO) systems have evolved quickly to become one of the most popular topics among wireless communications researchers and reach a spot in today's 'hottest wireless technology' list that may have a chance to resolve the bottlenecks of the traffic capacity in the forthcoming high speed broadband wireless internet access networks The most striking property of MIMO systems is the ability to turn multipath propagation, usually a pitfall of wireless transmission, into an advantage for increasing the user's data rate. Current transmission schemes over MIMO typically fall into two categories: Data rate maximisation or diversity maximisation schemes. The first kind focuses on improving the average capacity behaviour. The objective is just to perform spatial multiplexing as we send as many independent signals as we have antennas [10].

This system can be viewed as an extension of the "smart antennas", a popular technology of improving wireless transmission that was invented in the 70s. The underlying mathematical nature of MIMO can give performance which goes well beyond that of the conventional smart antennas [10].

The *spatial diversity* is a powerful effect of smart antennas. In the presence of multipath, the receive power level is random function of the user location and, at time, experiences *fading*. When using antenna arrays, the probability of losing the signal altogether vanishes exponentially with the number of decorrelated antenna elements. In fact MIMO links offer advantages which go far beyond that of the smart antennas because the multiple antennas at both the transmitter and receiver create a *matrix* channel. The key advantage lies in the possibility of transmitting over several spatial modes of the matrix channel within the same time-frequency slot at no additional power expenditure. After processing the signal and lunched through the channel they naturally mixed together as they use the same frequency spectrum. At the receiver side, after having identified the mixing channel matrix through training symbols, the individual bit streams are separated and estimated [10].

## 2. OFDM Difficulties.

A big challenge faces the researchers while trying to meet the 4G robustness is to increase the Bandwidth (BW) to deal with the high-quality multimedia applications. This turned the researcher's interest to the use of OFDM instead of the using of Single carrier modulation. This permits an efficient use of the BW by allowing overlapping between the orthogonal subcarriers generated by the use of the IFFT. Also, it decreases the cost of the equalisation techniques by enabling it in the frequency domain, and combats the effect of multipath channels by dividing the whole channel into a lot of flat subchannels. A major obstacle is that the OFDM signal exhibits a very high PAPR. Therefore, RF power amplifiers should be operated in a very large linear region. Otherwise, the signal peaks get into non-linear region of the power amplifier causing signal distortion. This signal distortion introduces intermodulations among the subcarriers and out of band radiation. Thus, the power amplifiers should be operated with large power back-offs. On the other hand, this leads to very inefficient amplification and expensive transmitters. Thus, it is highly desirable to reduce the PAPR. Various techniques are proposed to reduce PAPR in OFDM signals, but that reduction is not obvious because PAPR and SNR are closely linked. There are three different techniques are used to overcome this problem: signal distortion techniques, coding techniques, and the scrambling techniques. The signal distortion techniques, which reduces the peak amplitudes by a nonlinearity distortion OFDM signal at/or around the peaks. Example of distortion techniques are clipping, peak windowing, and peak cancellation. Clipping and peak windowing is the simplest way to reduce the PAPR is to clip the signal, such that the peak amplitude becomes limited to some desired maximum level. Although clipping is definitely the simplest solution, there are a few problems associated with it. First, degrades the Bit Error Rate (BER) by distorting the OFDM signal amplitude. Second, increase the level of out-of-band radiation. To remedy the out-of-band radiation, a different approach is to multiply large signal peaks with a certain nonrectangular window. The second category is coding techniques that use a special forward-error correcting code set that exclude OFDM symbol with a large PAPR. The third technique is based on scrambling each OFDM symbol with different scrambling sequences and selecting that sequence that gives the smallest PAPR. Recently, two promising techniques for improving the statistics of the PAP of an OFDM signal have been proposed: the selective mapping (SLM) and partial transmit sequence (PTS) approaches. In SLM, at the transmitter, one favourable signal is selected from a set of different signals which all represent the same information [1, 7].

## 3. Why MIMO Systems

In any communication channel the multipath fading problem is exist. While trying to mitigate this problem, the use of a special version from the smart antennas was appear. The most striking property of MIMO systems is the ability to turn multipath propagation, usually a pitfall of wireless transmission, into an advantage for increasing the user's data rate [10].

MIMO systems may be implemented in a number of different ways to obtain either a diversity gain to combat signal fading or to obtain a capacity gain. Generally, there are three categories of MIMO techniques. The first aims to improve the power efficiency by maximising spatial diversity. Such techniques include delay diversity, space-time block codes (STBC), and space-time trellis codes (STTC). The second class uses a layered approach to increase capacity. One popular example of such a system is Vertical Bell labs Layered Space-Time (V-BLAST) suggested by Foschini *et al.* [5] where full spatial diversity is usually not achieved. Finally the third type exploits the knowledge of channel at the transmitter. It decompose the channel coefficient matrix using singular value decomposing (SVD) and use these decomposed unitary matrices as pre- and post-filters at the transmitter and the receiver to achieve near capacity [5].

## 4. Conventional OFDM System Simulation and Analysis.

Due to the simplicity of implementation, the conventional OFDM systems are proposed and adapted in several wireless standards such as digital audio broadcasting (DAB), digital video broadcasting (DVB), local area networks (LAN), and others.

In this paper the efficiency of the conventional OFDM systems is tested by sending a binary data by the OFDM system through a channel with different parameters, such as attenuation, multipath fading, and noise level then received it to calculate the bite error rate.

The block diagram for the conventional OFDM system is shown in Figure 1.

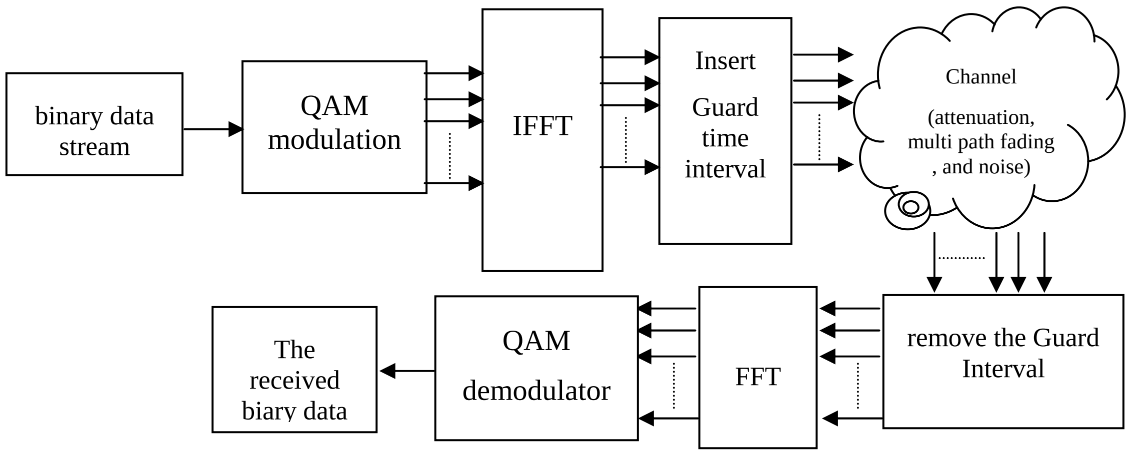


Figure 1: The conventional OFDM system's block diagram

The input binary data was generated randomly dependent on the number of subcarriers and on the modulation level. The results of simulating the above system are summarised below in table 1:

| Parameters / channel | No. of subcarriers | No. of FFT points | Modulation level | QAM cycles | Guard time period | Clipping factor | Noise value | Attenuation factor | Delay factor | Attenuation factor 2 | Delay factor2 | The ratio of Bit error |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OFF | 64 | 128 | 4 | 15 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ON | 64 | 128 | 4 | 15 | 6 | 0.01 | 0.15 | 0.001 | 1 | 0.002 | 3 | 48% |
| | 64 | 128 | 4 | 15 | 6 | 0.3 | 0.15 | 0.2 | 3 | 0.2 | 4 | 24% |
| | 64 | 128 | 4 | 15 | 6 | 0.35 | 0.15 | 0.3 | 4 | 0.25 | 2 | 20% |
| | 64 | 128 | 4 | 15 | 6 | 1 | 0 | 0.3 | 6 | 0.25 | 10 | 0.9% |

Table1: Simulation results.

As shown in Figure 1, different factors are affecting the bit error ratio. In our work, the efficiency will be improved by imposing another system which is get a benefit from the channel to make to system is more rigid. From the above table, the result which gives the ratio of the bit error equal 0.9 % is very much consistent with results obtained in [11], which considers the same conditions for the wireless communication channel.

## 6. Conclusions and Future Works.

OFDM has long been studied by researcher and implemented to combat transmission channel impairments. OFDM is computationally efficient by using FFT and its inverse technique to implement the modulation and demodulation functions. The use of OFDM system allows an efficient use of the spectrum by allowing overlapping between the orthogonal subcarriers. Due to this advantage the OFDM system used in the high data transmission rate applications.

The advantages of OFDM especially in the multipath propagation, interference, and fading environment, make the technology a promising alternative in digital communications, including mobile multimedia.

To combat the ISI a guard time must be used. The no signal guard time guarantee that there is no any interference between any symbols in the original transmitted signal with symbols in the delayed versions while the interval is greater than the spread delay of the channel. An increasing in the no signal guard interval leads to the Inter Carrier Interference (ICI) problem. To overcome this problem a cyclic prefix must be used. That's happened by allocated the symbol by the last part of it, so we precede the symbol by a periodic part from the symbol.

The future proposed algorithm divides the input data symbol into blocks. The techniques, which deal with principles of dividing the data and separating them during the transmission, should be utilised to combat the effect of the PAPR. MIMO system gives an increasing in the capacity of the system and combats the multipath fading, so it's more reliable system and worth to study its features, so the enhancement of the conventional OFDM system architecture by implementing the use of Multiple Input Multiple Output (MIMO) system to transmit the output data.

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