International Journal of Innovative Research in Engineering & Management (IJIREM)
ISSN: 2350-0557, Volume-9, Issue-2, April 2022
https://doi.org/10.55524/ijirem.2022.9.2.8
Article ID IJIR-1190, Pages 59-63
www.ijirem.org

Spectral Efficient Resource Allocation using Bio-Inspired Algorithm for NOMA Networks

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ABSTRACT- Today's wireless networks allocate radio resources to users based on the Orthogonal Multiple Access (OMA) principle. However, as the number of users increases, OMA based approaches may not meet the stringent emerging requirements including very high spectral efficiency, very low latency, and massive device connectivity. Non-Orthogonal multiple access (NOMA) principle emerges as a solution to improve the spectral efficiency while allowing some degree of multiple access interference at receivers. NOMA is fundamentally different than orthogonal multiple access schemes which provide orthogonal access to the users either in time, frequency, code or space. In NOMA, each user operates in the same band and at the same time where they are distinguished by their power levels. NOMA uses superposition coding at the transmitter such that the successive interference cancellation (SIC) receiver can separate the users both in the uplink and in the downlink channels.

This paper analyzes the spectral efficiency of Filter Bank Multiple Carrier (FBMC) and Universal Filter Multiple Carrier(UFMC) Modulation Schemes with NOMA while considering Orthogonal Quadrature Amplitude Modulation (OQAM) as the modulation scheme and NOMA as the multiple access scheme.

KEYWORDS- Fbmc, Oma, Noma, Ufmc, Oqam, Sic.

I. INTRODUCTION

The vision of wireless communications supporting information exchange between people or devices is the communications frontier of the next century. This vision will allow people to operate a virtual office anywhere in the world using a small handheld device - with seamless telephone, modem, fax, and computer communications. Wireless networks will also be used to connect together palmtop, laptop, and desktop computers anywhere within an office building or campus, as well as from the corner cafe. In the home these networks will enable a new class of intelligent home electronics that can interact with each other and with the Internet in addition to providing connectivity between computers, phones, and security/monitoring systems. Wireless video will be used to create remote classrooms, remote training facilities, and remote hospitals anywhere in the world.

There is a general consensus in the industry that recent data-traffic growth trends will continue into the future. In recent years, many forecasters have projected mobile data traffic will grow 24-fold between 2010 and 2015, which corresponds to a compound annual growth rate of almost 1.9 Ref [1]. On NTT's DOCOMO network in Japan, mobile data traffic almost doubled during 2010 and a 12-fold traffic increase is expected between 2011 and 2015 Ref [2]. In 2011 alone, the volume of mobile data traffic grew 2.3-fold with a nearly 3-fold increase in the average smartphone usage rate Ref [3].

II. LITERATURE REVIEW

This summarizes the related work of the proposed work. The current work is going on at future generation (5G) level. The future generation networks will be facing major challenges in the provision of high spectral efficiency, throughput, and efficient utilization of bandwidth. Efficient Modulation Schemes have been proposed for the 5G Networks that are aimed to provide high spectral efficiency, throughput and will support massive device connectivity. Universal Filter Multi Carrier (UFMC) and Filter Bank Multi Carrier (FBMC) are the popular modulation schemes proposed for 5G

The goal is to maximize the sum throughput of the whole system including the cellular users and the D2D users. To make the problem tractable, instead of maximizing the sum throughput directly, the authors formulate the problem in terms of maximizing the summation of all SINR, subject to the constraints consisting of the minimum throughput requirements of both the cellular users and the D2D users. MINLP is notoriously hard to solve in general; the authors propose a heuristic greedy algorithm such that the interference is minimized in each step.

III. OBJECTIVES

The objective of this research is to analyze the spectral efficiency of Filter Bank Multiple Carrier(FBMC) and Universal Filter Multiple Carrier(UFMC) Modulation Schemes with NOMA while considering Orthogonal Quadrature Amplitude Modulation (OQAM) as the modulation scheme and NOMA as the multiple access scheme. The performance of the proposed scheme can be verified through simulations carried out on MATLAB software.

IV. METHODOLOGY

Various Modulation Schemes have been proposed for 5G viz. Filter Bank Multicarrier (FBMC) and Universal Filter Multi Carrier (UFMC). 5G networks pose a challenge of high spectral efficiency and throughput. It must also support massive device connectivity with low latency. The proposed modulation schemes have many aspects where they are fit for 5G, but on the same time lack many other important aspects without which the implementation of 5G is nearly impossible. The Filter Bank Multicarrier (FBMC) is a development of OFDM which focus on overcoming some limitations while enabling higher throughput data rates. It is a form of multi-carrier modulation that is being investigated to be applied in wireless and cellular systems to come. FBMC relies on dividing the spectrum into multiple orthogonal sub-bands and applies a filter to each subcarrier individually. Thus, with FBMC the side-lobes are much weaker and the inter-carrier interference (ICI) is by far less critical than what is observed in OFDM

Due to the disadvantages and limitations associated with existing multicarrier communication techniques in the family of OFDM techniques, FBMC is considered as a possible alternative technique to them. The specific reasons for considering it against OFDM are listed below.

- Higher spectral or bandwidth efficiency as compared to other modulation schemes, spread spectrum and transmission techniques.
- Unlike in OFDM, no guard intervals and cyclic prefixes are needed. Higher throughput and a continuous efficient transmission can be supported. In addition, no additional processing power is needed to handle guard intervals and cyclic prefixes. In the case of FBMC, performance can be easily enhanced by integration of some of the compatible supportive signal-processing mechanisms like diversity schemes, and coding schemes.
- FBMC is capable of outperforming certain specific application areas of OFDM and related techniques. Almost perfect carrier synchronization is needed for the uplink of an OFDMA network for the signals from different nodes. In FBMC, signal separation is done through filtering. There is no such critical need for perfect synchronization or for perfect timing synchronization between users (One empty subcarrier is proposed as a guard-band between two asynchronous users.). In cognitive radios, due to the filtering capability of FBMC, this is a better choice for filling in the spectrum holes.

A. Advanced Multiple Access

NOMA is a multiplexing scheme that utilizes an additional new domain, the power domain, which is not sufficiently utilized in previous systems. Power domain utilization is enabled by the evolution in the processing power of devices. For downlink NOMA, non orthogonality is intentionally introduced via power domain user multiplexing, while user de multiplexing is obtained via the allocation of large power differences between paired users at the transmitter side and the application of successive interference cancellation (SIC) at the receiver side. The channel gain – path loss, received signal to interference plus noise ratio (SINR) – difference among multiple users is translated into multiplexing gains by superposing in the power domain the transmit signals of multiple users with large channel gain differences. As a result, both the users of high and low channel gains benefit. Indeed, although the multiplexed users are allocated less power because of power sharing, they both benefit from being scheduled more often or allocated more bandwidth. NOMA has been intensively investigated in recent years for both downlink and uplink Ref [4].

B. Genetic Algorithms

Bio-inspired genetic algorithms (GAs) Ref[5] have become a popular approach in solving resource allocation problems in wireless networks Ref [6] [7] [8] mainly because of their versatility, scalability and computational simplicity which make GA a very attractive method to solve the resource allocation problem. Resource allocation for D2D communications has been extensively studied within the literature, a proportionally fair utility maximization approach is used to allocate resources to both D2D UEs (DUEs) and cellular UEs (CUEs). The mode selection and resource allocation problems for underlay D2D communication are also investigated and solved using particle swarm optimization. Further, an efficient graph- theoretical approach is there to perform channel allocation for DUEs. GA is one of the most popular bio-inspired algorithms and is used to tackle real world NP-hard optimization problems. In general, bio-inspired algorithms imitate the natural evolution of biological organisms to provide a robust, near optimal solution for various problems. GA is inherently an evolutionary process that involves chromosome encoding, population initialization, fitness function depiction, crossover and selection mechanisms. A detailed analysis of GAs can be found in Ref [5].

Related Work

Filter Bank Multi Carrier(FBMC) modulation was studied from Ref [9] The block diagrams of FBMC Transmitter and receiver were taken from that reference. Universal Filter Multi Carrier (UFMC) modulation scheme was studied form Ref. The Spectral Efficiency, Capacity and throughput were studied. Non-Orthogonal Multiple Access (NOMA) in Ref. Genetic Algorithm was studied from Ref.Various approaches are described to solve the optimization problems. The mixed-integer nonlinear programming (MINLP) approach is described in Ref [10]. The goal is to maximize the sum throughput of the whole system including the cellular users and the D2D users. To make the problem tractable, instead of maximizing the sum throughput directly, the authors formulate the problem in terms of maximizing the summation of all SINR, subject to the constraints consisting of the minimum throughput requirements of both the cellular users and the D2D users. MINLP is notoriously hard to solve in general; the authors propose a heuristic greedy algorithm such that the interference is minimized in each step. Ref [11] formulate an optimization problem that can be decomposed into two sub- problems: power control and joint mode selection, and channel assignment. Similar to Ref [10], an heuristic low-complexity algorithm is developed.

V. RESULTS AND OBSERVATIONS

Table 1: Parameters for Simulation

S. No.	Parameters	Value
1.	No. of Sub-Carriers	52
2.	Bits Per Sub-Carrier	4
3.	Sub-Carrier Spacing	15 kHz
4.	FFT Length	512
5.	Modulation	m-QAM
6.	Channel	AWGN
UFMC		
1.	Length of Filter	43
2.	Stop-Band Attenuation	40
FBMC		
1.	Spreading Factor	4

The parameters taken in above table can be used to find spectral efficiency, Spectral efficiency is defined below as

C. Spectral Efficiency

Spectral efficiency/ spectrum efficiency or bandwidth efficiency refers to the no. of bit that can be transmitted over a bandwidth. It is the information rate that can be transmitted over a given bandwidth in a specific communication on system.

$\eta FBMC = (m*S) \div (S+K-1/2)$
$\eta UFMC = (m*NFFT) \div (NFFT+L-1)$
Where $m = Symbol\ Index$
$S = SpreadingFactor$
$K = InterpolationCoefficient$
$L = LengthofFilter$

Using the above values of table, we get the below results shown in Figures 1 to 3.

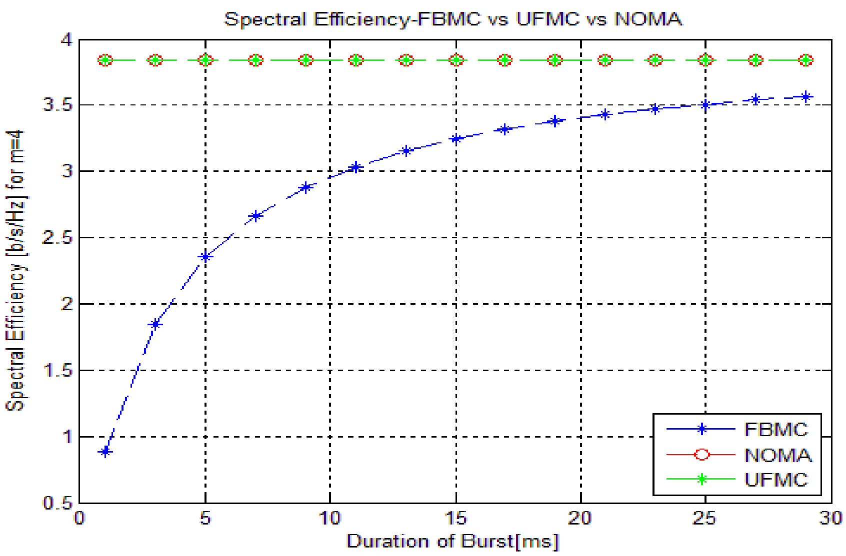

Figure 1: Plot of Spectral Efficiency FBMC vs UFMC vs NOMA

The graph denotes the spectral efficiency of UFMC vs NOMA vs FBMC. The graph is generated by varying the duration of burst from 0 to 30. It's observed that the FBMC 's spectral efficiency increases with the increase in duration of bursts. It is greater than other two if duration of bursts is larger.

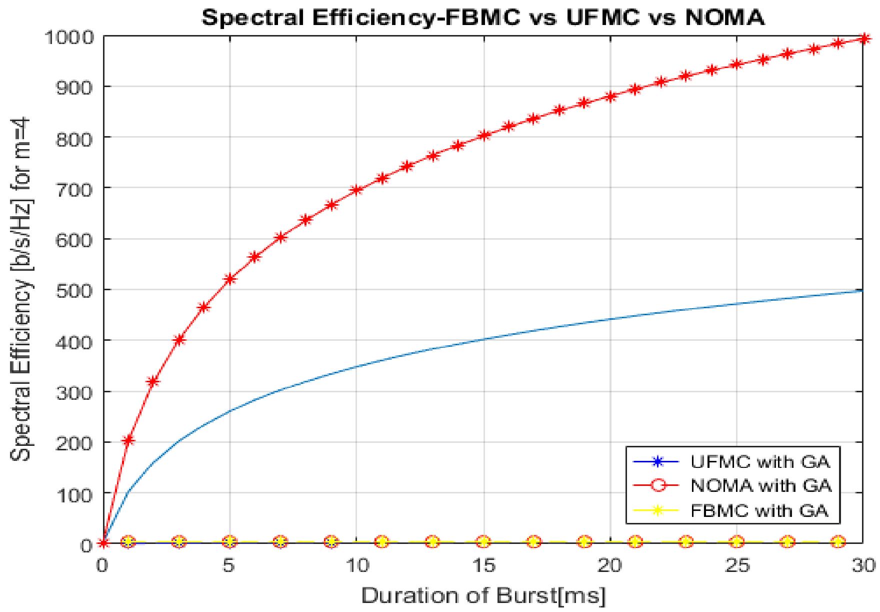

Figure 2: Plot of Spectral Efficiency FBMC vs UFMC vs NOMA with GA

The graph denotes the spectral efficiency of UFMC vs NOMA vs FBMC with GA. The graph is generated by varying the duration of burst from 0 to 30. It's observed that the spectral efficiency of NOMA is more as compared to FBMC and UFMC. It further increases with the increase in duration of bursts.

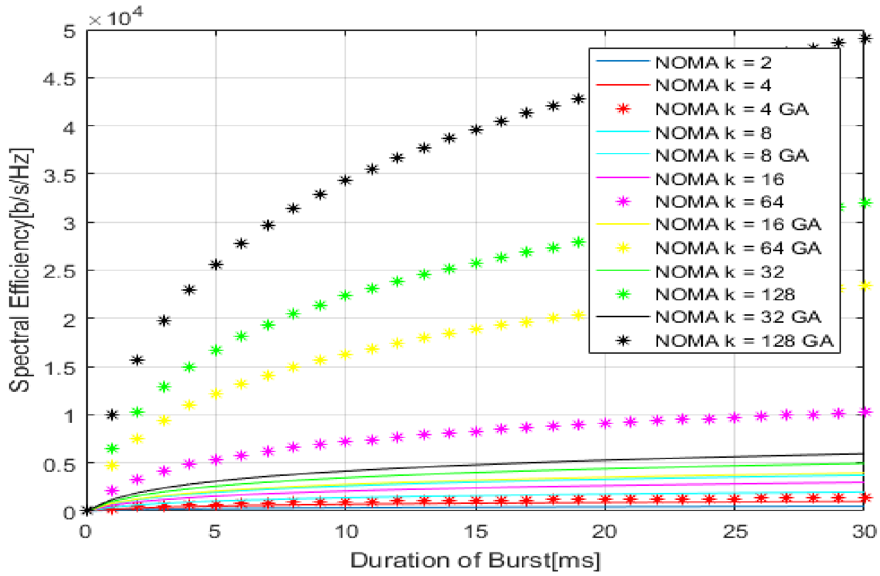

Figure 3: Plot of Spectral Efficiency for various QAM with and without GA

The graph denotes the spectral efficiency of NOMA for various QAM with and without GA. The graph is generated by varying the duration of burst from 0 to 30. It's observed that the spectral efficiency of NOMA increases with the increase in the value of k (where k = 2, 4, 8, 16, 32, 64, 128 for k-QAM). It further increases with the application of GA.

VI. CONCLUSION

In this dissertation, I compared the Spectral Efficiency of Various Modulation Schemes proposed for 5G viz. Filtered Bank Multiple Carrier (FBMC), Universal Filter Multiple Carrier (UFMC) and NOMA, where the modulation Scheme was OQAM and NOMA was a Multiple Access Scheme. The Results obtained using the MATLAB Software show that the Spectral Efficiency of NOMA is better as compared to FBMC and UFMC.
Further Bio-Inspired Genetic Algorithm (GA) was used to allocate resources and for solving the Optimization Problem. After applying GA, the results show that the Spectral Efficiency increases by many folds.

VII. FUTURE WORK

The Future Scope of this thesis is that another Bio-Inspired Algorithm Viz. Particle Swarm Optimization can be applied to allocate the resources and to solve the optimization problem and see its effect on the Spectral Efficiency of various modulation Schemes.

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