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PAPR and ISI Reduction in Cognitive Radio Network based 5G Network using Massive MIMO SC - FDMA ES.

P Deepanramkumar, N Jaisankar

Abstract: ***Extended use of spectrum increased the number of users; this was the major cause to introduce Cognitive Radio Networks (CRN) which is designed to access the available spectrum effectively. Advanced telecommunication technology that is fifth-generation (5G) is inbuilt in CRNs. Fusion Center (FC) in CRN plays an important role in decision making for allocating available spectrum. A novel FC rotation (FCR) method is applied over FC to mitigate the occurrence of interference. Massive-Multiple Input Multiple Output (MaMi) system is used to enhance network performances to accommodate the huge participation of users by means of having a large number of antennas. Existing research works in CRN based 5G network fails to decrease intersymbol interference (ISI) and Peak-to-Average Power Ratio (PAPR). A novel Massive MIMO SC – FDMA ES is proposed in this paper to mitigate high PAPR values to enhance network performance. Our proposed work in CRN is experimentally designed using Network Simulator 3 from which the performances are evaluated. The extensive simulation result shows betterment in terms of channel capacity, reduction of PAPR, bit error rate and spectral efficiency.***

Keywords**: *CRN, 5G, Fusion center, Intersymbol interference.***

I. INTRODUCTION

The driving force behind the fifth-generation (5G) systems will be Cognitive radio technology (CRNs) as it gives the best solution for the issue of spectrum shortage through dynamic spectrum usage. In CRN, different strategies used in dynamic Spectrum Access [1]. Security and dynamic use of spectrum are major problems in CRN assisted 5G. Each cognitive radio is fed with functions such as spectrum management, spectrum sensing, and spectrum adaptation to identify white space in the spectrum. The tremendous rise of mobile data traffic has made the wireless network to advance towards 5G. Millimeter-wave access technology used in 5G to exploit the spectrum above 6GHz [2].

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* Correspondence Author
P. Deepanramkumar, School of Computer Science and Engineering, Vellore Institute of Technology(VIT), Vellore, Tamilnadu, India. Email: deepanramkumar.p@gmail.com
N. Jaisankar*, School of Computer Science and Engineering, Vellore Institute of Technology(VIT), Vellore, Tamilnadu, India. Email: njaisankar@vit.ac.in

A higher level of efficiency can be achieved by MIMO antenna technology in 5G that enables ultra-wide bandwidth. To evaluate the spectrum utilization; the energy-efficient scheme is proposed [3]. In CRN assisted 5G, spectral and energy efficiency play an important role [4]. To sustain spectral and energy efficiency; a cooperative medium access scheme is used. The open research challenges in 5G cognitive radio are security, connectivity, dynamical spectrum allocation, complex computations, resource management, reliable reconfiguration and privacy [5].

In CRN assisted 5G; to increase spectrum efficiency and utilization, a dynamic decision-based spectrum sharing model is modeled [6]. Analytical Hierarchy Process (AHP) is involved in this work that includes, Bit Rate (BR), Received Signal Strength Indicator (RSSI), movement direction, and user history for allocating spectrum. Interference is the major cause to downgrade performances of network. To mitigate interference in CRN; Interference Subspace Distance Minimization (ISDM) scheme is developed [7]. To define the rank constraint scheme an antenna technology called MIMO is used. MIMO is extended to Massive MIMO (MaMi) technology that is comprised of hundreds of antennas [8]. To analyze the better utilization of MIMO; channel parameters are measured.

The purpose of the use of Massive MIMO in 5G technology is to reduce overhead. And over high frequency, the total pattern of the antenna for long-distance communication is governed [9]. To enhance network performance and to attain rich user experience; Massive MIMO in 5G plays a vital role. It is designed to maintain performance over numerous user participation [10]. In Massive MIMO, the antennas are modeled with low power consumption due to the consumption of low circuit power that is ensured in antenna design. Therefore Massive MIMO in 5G is assured with increased spectral efficiency over 5G cellular networks with the potential of minimizing the demands on the spectrum. In many countries, the use of 5G in cellular networks is awaited. To accommodate a large number of users and to reduce the spectrum scarcity issues; 5G advancements are utilized in CRN [11]. Flawed Channel State Information is reduced by the use of a large number of antennas in MIMO in cognitive radios [12]. To maintain security, the two-level authentication scheme is introduced in a cognitive radio network [13]. This guards the network against different attacks by malicious users. So security is an important factor in the cognitive radio network.

A. Major contributions

The major contributions can be summarized as follows,

- The main objective of this proposed work is to decrease ISI and PAPR in CRN assisted 5G to enhance spectral efficiency and other associated parameters. A combination of 5G with CRN is comprised of entities such as primary users, secondary users, malicious users, spectrum agents, fusion center, base station, and certificate authority.
- To reduce overhead among spectrum agents; a Fusion Centre Rotation (FCR) method is proposed. As per timestamp and angle variations; coverage space of the fusion center is compressed.
- To increase energy efficiency; a secondary user's spectrum sensing capability is reduced by the introduction of an entity called spectrum agent (SA). Spectrum agent is embedded with cognitive radio instead of secondary users.
- Massive MIMO SC - FDMA Efficient Signaling is introduced to reduce PAPR by choosing signals with less number of subcarriers using the firefly algorithm to achieve high spectral efficiency.
- Based on the union of AND rule, K-out-of-N rule, and OR rule; Spectrum decision making is achieved in the fusion center.
- To overwhelm malicious users in CRN, a novel fusion center time-based Elliptic curve cryptography method is proposed to deliver authenticated keys among secondary users to perform secure data transmission after the allocation of spectrum.

II. PREVIOUS WORKS

In general, CRN involves with Dynamic Spectrum Access and Opportunistic Spectrum Access (OSA). OSA was introduced for improving the performance of Primary Users. OSA involves with Myopic algorithm and online learning algorithm. Further, the major part of energy detectors in CRN is provided. Energy Detectors are used for detecting the presence of idle Primary signals in the network [1]. The next generation of 5G cellular network is combined with CRN for improving efficiency. For detecting the available white space in the channel, an entity called Spectrum Agent (SA) is used [15]. So, the secondary user (SU) requests SA for detecting the white space in the channel and then the Spectrum Agent senses the channel for that specific SU and replies back with the sensed result. SA first detects the available Primary User spectrum, then the sensed data is forwarded to Fusion Center. Based on the result of the Fusion Center, the spectrum is distributed for that particular Secondary User which demands spectrum. So it requires the implementation of a higher number of SA and if the participating users increase it becomes complex to manage.

To reduce this complexity and for managing the number of users; MIMO-OFDM antenna technology involved in CRN [14]. In this, the authors have concentrated on estimating the Successful Reconstruction Rate, Mean Square Error, and spectrum sensing. To detect whether the primary signals are present or absent in a channel, a Cyclostationary detection process is applied. The signals are reconstructed if the intended signal is obtained from Cognitive Radio User. Alamouti's Space-time Block Coded (ASTBC) MIMO-OFDM system is concentrated in [17]. Deterministic, random and correlated Rayleigh fading channels derive a mathematical model which is majorly for channel capacity. Initially, MIMO-OFDM systems were introduced in 4G for evaluating its performance. This also does not consider noise as a major constraint.

Further MIMO-OFDM-IM was proposed in [16] which elaborates the resolution between spectral efficiency and error performance. It involves simple Minimum Mean Square Error (MMSE), Maximum Likelihood (ML), near-ML, Ordered Successive Interference Cancellation. But this method failed to reduce Peak-to-Average Power Ratio (PAPR) that is the main constraint existing in OFDM. The previous Massive MIMO model uses traditional Zero-Equalizer for reducing bit error rate but neglects the noise [18]. But noise is becoming the major constraint that is involved in a signal.

Finally in [19], distributed key management algorithms such as certificate-based and identity-based schemes are proposed. In the identity-based scheme, all the SUs sends their channel key. A channel certificate is constructed using a Certificate-based scheme by which the SUs shares information. These key management schemes take a longer process. Since this takes up time, there is also the possibility of the occurrence of a higher level of overhead. Hence these schemes need to stabilize the interference and energy utilization.

III. PROBLEM STATEMENT

From the previous works in CRN assisted 5G, it is observed that the spectrum sensing capacity of SU's is reduced. However, they failed to mitigate the interference among secondary users (SU's) which decreases the spectral efficiency. Spectral efficiency should be increased in order to achieve higher data rates. The main problem in the existing MIMO – OFDM based system is that high PAPR observed in the OFDM symbol. System performance degrades due to high PAPR. When a high number of subcarriers participates in the signal; PAPR value will increase. The decision-making mechanism should be incorporated in the fusion center before allocating the spectrum to secondary users. Complex key management techniques have been proposed in previous works for secure data transmission among secondary users after the spectrum allocated to SU's. But they consume high energy and having complex computations. Our novel framework in CRN assisted 5G solves the above-stated problems.

IV. PROPOSED CRN ASSISTED 5G ARCHITECTURE.

A. System architecture

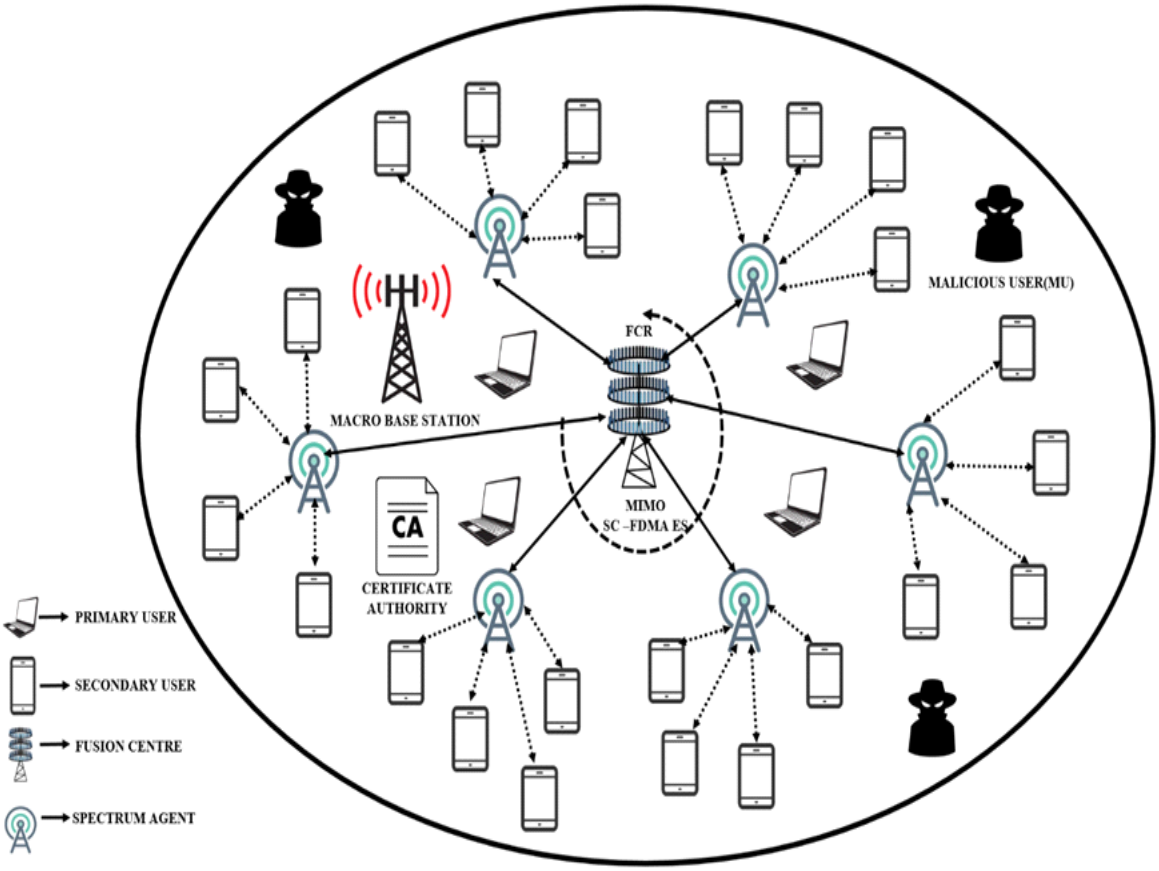

Fig 1 System Model

This paperwork concentrated on the building of a Cognitive Radio Network that is supported by 5G based communication. Our proposed work in CRN is designed to improve the utilization of spectrum along with secure data transmission. The complete framework consists of Primary Base Station (PBS), Spectrum Agents (SA's), Certificate Authority (CA), Fusion Center (FC), Primary Users (PUs), Secondary Users (SUs), and Malicious Users (MUs). The proposed architecture is illustrated in fig 1. In our work, FC performs an important part in receiving multiple signals and transmitting multiple output signals. A novel Fusion Center Rotation (FCR) method is designed for reducing the overhead among the SA's. This FCR method covers only a particular area until the timestamp 'ti_x' reaches the threshold value. If the FC covers an area of 'ar_1' at a time 'ti_1', then it receives signals only from the SA's that are present in that coverage area 'ar_1'. Hence this method reduces overhead among SA's. Each SU sends the request to its SA to sense the channel whether the intended white space is present or absent in the primary user signal. Then the SA senses the PBS spectrum and forwards its local decision to the FC when the FC's rotation reaches its coverage.

To assure that the specific SU and SA is a normal user, all the legitimate SUs and SAs are certified by CA. Spectrum sensed SAs send the local decision to FC including with the certificate and so if a malicious user is involved in sensing, it is detected by FC and its request is discarded. The Massive MIMO in 5G is a key technology that improves spectral efficiency. We use MaMi SC - FDMA for the purpose of improving spectral efficiency. To overcome PAPR we introduce a novel MaMi SC - FDMA Effective Signaling (MaMi SC -FDMA ES) for the purpose of reducing PAPR in the signals. We select the signals that are available with a smaller number of subcarriers and then we compute SINR value for each signal. Then we compute the attractiveness of the signal and select a signal with lower attractiveness. SINR is taken for considering the amount of noise present in the signal.

After completion of this process, the legitimate SUs are allocated with the spectrum for secure data transmission, we use the Fusion center time- based Elliptic Curve Cryptography (FC - ECC) method. This method FC - ECC is involved in which the spectrum allocated SUs are commonly provided with the same key by the CA. The SU's on sharing the key starts secure data transmission. Finally, our research work is a completely novel framework for the forthcoming next generation to use high-speed data transmission with a secure environment.

B. Fusion Center rotation

Fusion center rotation is regularly executed in order to minimize overhead among spectrum agents while reporting sensing reports. The fusion center is defined with only one working area at a duration i.e (-π≤θ≤π). A reporting field is defined and reports from SA's are aggregated. The pattern of circulation of FC is determined from the following,

$$OD(R) = \frac{360°}{4} = 90° \quad (1)$$

Totally 4 directions are proposed in this system based on $OD(R)$. Based on four rotated areas, four equal timestamps are allocated for collecting sensed reports of spectrum agents and spectrum is distributed to secondary users via SA. Totally four rotations are executed such as Rot_{t1}, Rot_{t2}, Rot_{t3}, Rot_{t4}. The rotations are indicated as,

$$Rot_{t1} = 0° - 90° \quad (2)$$

$$Rot_{t2} = 90° - 180° \quad (3)$$

$$Rot_{t3} = 180° - 270° \quad (4)$$

$$Rot_{t4} = 270° - 360° \quad (5)$$

The timestamps for respective directions are shown as ti_1, ti_2, ti_3, ti_4 respect to coverage areas ar_1, ar_2, ar_3, ar_4.

The static spectrum agents existed in a specific coverage area based on FC rotations exploits the allocated time stamp to report, it carries out the sensing process until it's timestamp is arrived. Upon satisfying the Euclidean distance condition only, the FC will collect the sensing reports of Spectrum agents. The formulation is given as

$$\sqrt{(a - a_s)^2 + (b - b_s)^2} \leq s \quad (6)$$

Here the fusion center position is represented by the point (a, b), i.e. it's broadcasting area; Whereas the spectrum agent's positioning point is defined as (a_s, b_s) and the radius of the spectrum agent is defined as s. Each spectrum agent on satisfying this condition will be enabled to report at a specific timestamp. This criterion is ensured for verifying that the specific spectrum agent is present in the broadcasting area of a fusion center. To send the sensing reports in FCR, the active area is ar_1 at timestamp ti_1 is illustrated in fig 2. Based on this, the periodic rotation is carried out.

FCR is proposed to decrease interference that takes place between spectrum agents. At the same time, when entire spectrum agents send sensing report, interference will occur, fusion center rotation is followed in order to mitigate such interference. To make sure that the reported spectrum agent is legitimate or not, each SA's certificates are authenticated upon receiving requests from $su_1, su_2, su_3, \ldots, su_N$ present in a_1 at FC. By certificate validation, malicious users are filtered out. Further unused spectrum is allocated for the authentic users.

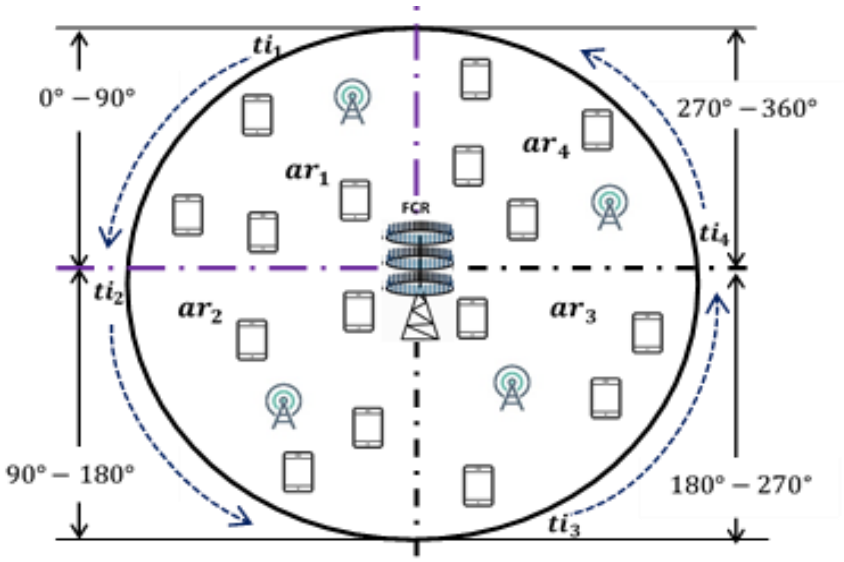

Fig 2 Fusion center rotation

C. MaMi SC - FDMA Efficient Signaling

The major problem in Massive MIMO-OFDM is high PAPR values observed in the OFDM symbol due to the IDFT summation of multiple parallel subcarriers. Also, it decreases energy efficiency for signal generation. But most of the mobile devices have limited power capacity. High PAPR values tend to subject subcarriers out of phase with each other, so spectral efficiency will be affected. This makes Massive MIMO-OFDM not suitable for uplink transmission. MaMi SC-FDMA ES is proposed in this work in order to overcome the above-stated problems.

Between subcarrier and symbol, mapping is processed as one to one in Massive MIMO – OFDM. Over various subcarriers, a symbol is communicated in parts in SC-FDMA.

MaMi SC-FDMA ES is deployed in the fusion center to allocate spectrum to secondary users via spectrum agents is illustrated in fig 3. $F \times F$ number of transit and receiving antennas is fed into FC. K no of SISO users are served by FC, i.e., $(K \ll F)$. Based on the requirement of the network, the value F varies. In contrast to OFDM, SC-FDMA acts as a single carrier transmission scheme with a small symbol duration. In order to accomplish this, a M point DFT block is added before the subcarrier mapping block in OFDM. The parallel sequence of symbols is converted from time to frequency domain using DFT block. The square of the number of active subcarriers is equivalent to the PAPR of the system. In SC- FDMA, the number of active subcarriers is reduced to mitigate high PAPR values.

Through F_c Discrete Fourier Transform (DFT); SC – FDMA is performed for S_c subcarriers. F_g denotes Cyclic Prefix (CP) length and Ts_s represents the sampling interval. SC – FDMA symbol duration before subcarrier demapping is expressed as,

$$T_c = F_c T s_s \tag{7}$$

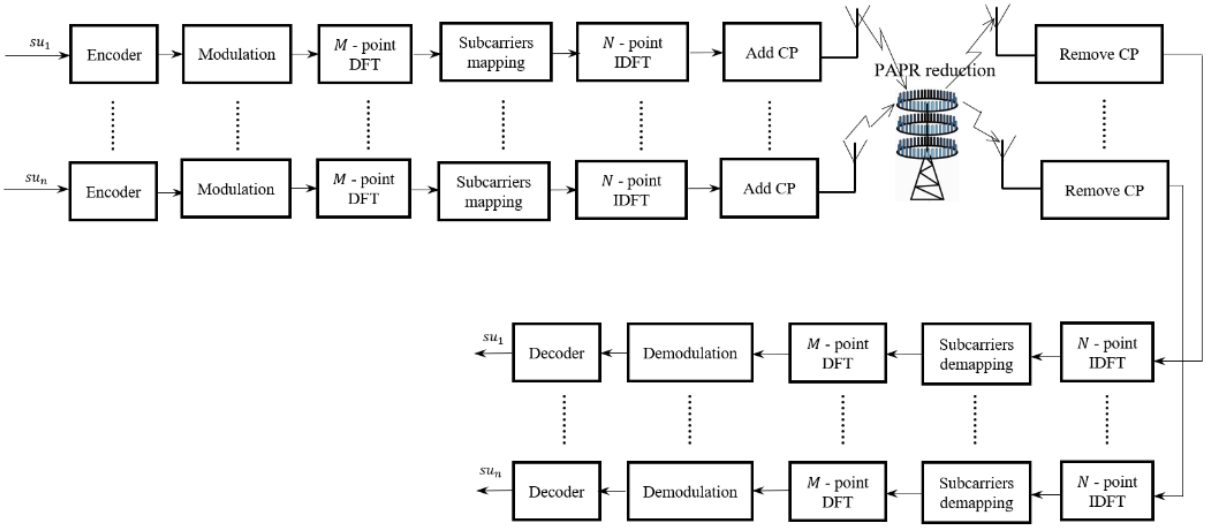

Fig 3 Massive MIMO SC - FDMA ES

The formula of the PAPR is expressed as follows,

$$PAPR = 10\log_{10} \frac{P_{peak}}{P_{average}} \tag{8}$$

For efficient signalling, signals with less number of subcarriers are selected using Signal to Interference Noise Ratio (SINR) value. SINR is given as,

$$SINR = \frac{Po_r Ch_G}{Po_r Ch_G + Np_s} \tag{9}$$

Here Po_r denotes received power, Np_s denotes noise power and Ch_G represents channel gain. These parameters used to evaluate the SINR of the signal. After estimating SINR, by using the firefly algorithm; the attractiveness of a signal is predicted. The attractiveness I is as follows,

$$I = I_0 e^{-\gamma r^2} \tag{10}$$

γ is the light intensity and r is the distance. As per distance, the light intensity value varies. For transmitting the final reports to SA's, the best signal is selected using the attractiveness in the firefly algorithm. This procedure reduces the PAPR. By reducing PAPR, our proposed work reduces the bit error rate and enhances spectral efficiency. Hereby the Massive MIMO SC - FDMA Efficient signaling is enabled to minimize PAPR and in turn, it increases the network performances and user experience in a 5G network environment.

D. Spectrum Decision Making

Spectrum decision making (SDM) is performed in FC to learn whether the intended signal is present or not. SDM is executed in fusion center by the combination of K-out-of-N rule, AND rule and OR rule based on union operation. The probabilities of false alarm(FA) and detection of K-out-of-N rule, AND rule and OR rule are defined as follows,

i. *K*-out-of-*N* rule :

If K-out-of-N inputs are true of a logical operation, the corresponding output is true. If K out of N SA's inform signal presence, then the FC will declare that the Primary user signal is present. The detection and FA probabilities of K-out-of-N rule is shown as :

$$PK_{det} = \sum_{k=K}^{n} \binom{n}{k} PK_{det}{}^{k}(1 - PK_{det})^{n-k}, \quad (11)$$

$$PK_{fa} = \sum_{k=K}^{n} \binom{n}{k} PK_{fa}{}^{k}(1 - PK_{fa})^{n-k}, \quad (12)$$

ii. AND rule:

In AND rule, if all inputs are true then the output is true. If all the SA's inform signal presence, then the FC will declare that the Primary user signal is present. The detection and FA probabilities of AND rule is shown as :

$$PA_{det} = PA_{det}{}^{n} \quad (13)$$

$$PA_{fa} = PA_{fa}{}^{n} \quad (14)$$

iii. OR rule:

In OR rule, if at least one of the inputs is true, then the output is true. If at least one of the SA's inform signal presence, then the FC will declare that the Primary user signal is present. The detection and FA probabilities of OR rule is shown as :

$$PO_{det} = \sum_{k=1}^{n} \binom{n}{k} PO_{det}{}^{k}(1 - PO_{det})^{n-k}, \quad (15)$$

$$PO_{fa} = \sum_{k=1}^{n} \binom{n}{k} PO_{fa}{}^{k}(1 - PO_{fa})^{n-k}, \quad (16)$$

The reports based on the *K*-out-of-*N* rule, AND rule and OR rule are evaluated in FC. The Combined results are given as,

$$SDM = \{(PK_{det} \cup PA_{det} \cup PO_{det}), (PK_{fa} \cup PA_{fa} \cup PO_{fa})\} \quad (17)$$

The FC allocates spectrum to SU's via SA's, if the SDM result is true. Otherwise, FC evaluates the next channel.

E. Fusion center time - based Elliptic Curve Cryptography (FC - ECC)

SU's key distribution is discussed in this section. A novel Fusion center time- based Elliptic Curve Cryptography (FC - ECC) is proposed in this work to deliver session keys to SU's after FC allocates spectrum. At time $t_{i1} = 0$, when the FC rotates to the coverage area ar_1, the FC – ECC session keys are delivered to SU's that are spectrum allocated. An elliptic curve is defined by an equation,

$$y^2 = x^3 + ax + b \quad (18)$$

A prime number pr, curve point Cp_p , and an elliptic curve is required to generate a key pair in ECC. The pr and Cp_p is randomly chosen. To maintain security level, for each timestamp Cp_p is varied. The random number is selected between Ra_m and $0 - pr$. The public key Pu_{ky} is computed as follows,

$$Pu_{ky} = Ra_m \times Cp_p \quad (19)$$

The Certificate Authority distributes the public key Pu_{ky} to the spectrum allocated SU's. Pv_{ky} denotes private key which is defined by Ra_m . The Curve point is vital to maintain security since the timestamp is varied for each session. The secondary users on receiving this session key i.e., Pu_{ky} applicable only for a time T_1. The Session key i.e., Pu_{ky} is valid only for a time T_1. Then, within the allocated spectrum, the secondary user encrypts and sends the data to other users using the session public key. After receiving Pu_{ky1} at T_1, the su_1 executes,

$$su_1 = Enc\{Pu_{ky1}(Da_t)\}, T_1 \quad (20)$$

The SU's need to finish the transmission between them within the session time, else they need to wait for their next rotation. During idle time, the SA's will perform sensing until the FC rotates to their broadcasting area.

The decryption performed by another end-user as follows,

$$su_2 = Dec\{Pv_{ky2}(Da_t)\} \quad (21)$$

The Curve point in the ECC is very hard for malicious users to predict. Finally, the security is achieved by using a novel Fusion center time- based Elliptic Curve Cryptography (FC - ECC) in this work after the SU's are allocated with spectrum.

V. SIMULATION RESULTS AND DISCUSSION

A. Network Configuration

NS3 is used in this work to simulate the proposed CRN assisted 5G architecture and the results are discussed with respect to previous works. In this work, our implementation in NS3 is installed over the Ubuntu Operating System. Results obtained in this simulation include the following, cognitive-module, network-module, spectrum-module, lte-module, mobility-module, cosine-antenna-module and other modules for attaining better efficaciousness.

Table 1 Simulation Configuration.

Parameters		Values
Network Environment	No of Spectrum Agents	6
	No of Primary Users	3
	No of Secondary Users	24
	No of Fusion centers	3
	No of PBS	2
	SU Speed	150 m /s
Simulation area		600×600 m
No of MaMi antenna		64×64
Order of Orientation		6
Key length		521 bit
The maximum distance between the fusion center and secondary users		250m
Inter packet interval		100ms
Bandwidth		25 Mbps
Data rate		100 Gb/s
Simulation time		20 s

Table 1 depicts the configurations that are utilized to evaluate the proposed CRN assisted 5G architecture to enhance spectrum efficiency. This work includes NetAnim's view for better visualizations in NS3. In NS3 the entire work is coded using C++ language and the algorithms are complied using Python language, further the results are obtained from Gnuplot by which the achievements of proposed work with novel methodologies are analyzed.

B. Comparative Analysis

The network parameters such as channel capacity, spectral efficiency, energy efficiency, bit error rate and amount of PAPR are examined in this proposed work and compared with previous research works. By examining the results achieved, our proposed work performs better than the previous works.

C. Channel capacity

The maximum rate of information that can be transferred over a communication channel is defined as channel capacity(Cc). To formulate channel capacity, the Shannon Hartley theorem was proposed based on signal-to-noise ratio and bandwidth that is present in a specific channel. The channel capacity based on Shannon Hartley theorem is given as

$$Cc = B\log_2(1 + S/N) \tag{22}$$

When the signal-to-noise ratio rate at signals increases, the channel capacity increases. Comparing with previous studies, our proposed MaMi SC - FDMA ES exhibit an increase in channel capacity is illustrated in fig 4. If SNR is high, then the signal presence is high in that specific channel. Likewise, the channel that having high noise denotes signal with low SNR. To increase channel capacity, 64×64 antennas are used under MaMi configuration in the proposed work. Whereas the

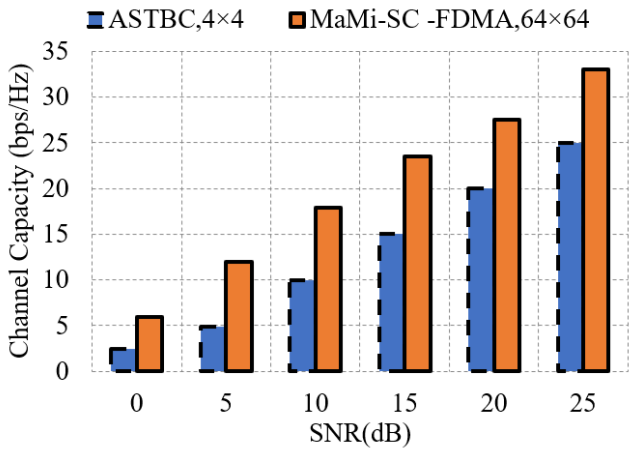

Fig 4 Channel Capacity Comparison

the previous work ASTBC used 4×4 antennas under 4G specifications. About 30% of channel capacity is enhanced in our work when compared to ASTBC. Channel capacity is not increased only due to the MaMi, the major reason for this increase is interference avoidance among SU's. Interference reduction is performed in this work by using a novel FCR method.

D. Bit error rate

Due to the presence of interference, distortion, fading, and noise, the bit error rate increases.
The bit error rate is given as,

$$BR = \frac{Num_E}{Tox_{T_o}} \tag{22}$$

Here Num_E denotes the number of erroneous bits and Tox_{T_o} represents the total number of bits. The bit error rate value decreases when the value of SNR increases. Since higher the value of SNR achieves higher channel capacity that implies ensured communication between end-users.

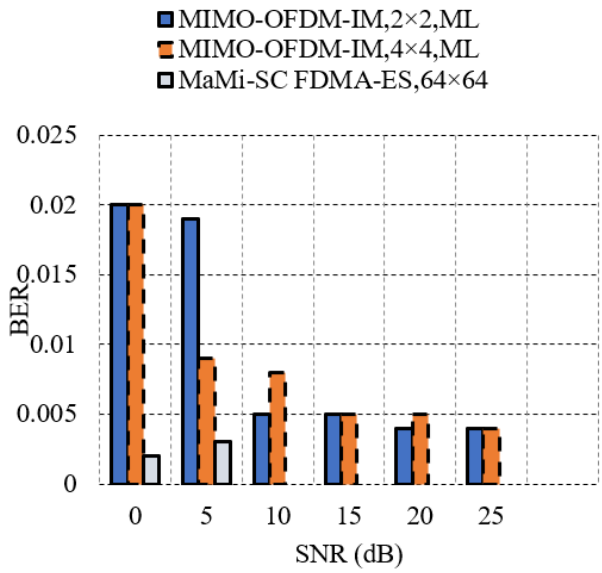

Fig 5 Comparison on the bit error rate

Fig 5 demonstrates the comparison on the bit error rate in which the proposed MaMi SC - FDMA ES exhibits a decline in bit error rate and subsequently reaches zero when the signal to noise ratio reaches above 10. Previous work MIMO-OFDM-IM was not able to perform bit error rate reduction. The user experience enhanced by a reduction in bit error rate.

E. Spectral and energy efficiency

The measured information rate that is transmitted to end-user over a given bandwidth is defined as spectral efficiency. A reduction in bit error rate enhances spectral efficiency. The bandwidth efficiency is measured which is also known as spectral efficiency. When spectral efficiency enhanced, energy efficiency also increases. The energy efficiency is given as,

$$E_{eff} = \frac{\sum_{k=1}^{N} R_k}{P_t} \tag{23}$$

The average E_{eff} energy efficiency for N SU's is shown in the above equation.

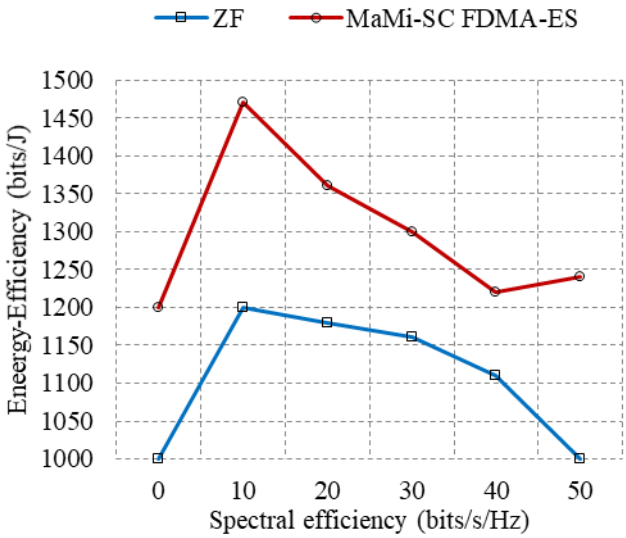

Fig 6 Comparison of Spectral efficiency against Energy efficiency

Fig 6 illustrates the results based upon the comparison of Spectral efficiency against Energy efficiency. Our proposed work enhances spectral and energy efficiency when compared to the zero forcing method. The main problem in the ZF method is that it does not consider noise as a major constraint. Spectral efficiency increased to 15% approximately when compared to the zero forcing method.

F. PAPR reduction

The PAPR is the major problem in MIMO – OFDM systems which considerably degrades the network performances.

Fig 7 illustrates the comparison of proposed work with respect to the previous Bayesian approach. Network performances enhanced by minimizing the PAPR. The previous research works in MIMO – OFDM fails to mitigate PAPR, which also involves complex mathematical computations. Our proposed MaMi SC FDMA- ES shows efficaciousness in PAPR reduction. Hence PAPR reduction is performed in this work to enhance network parameters.

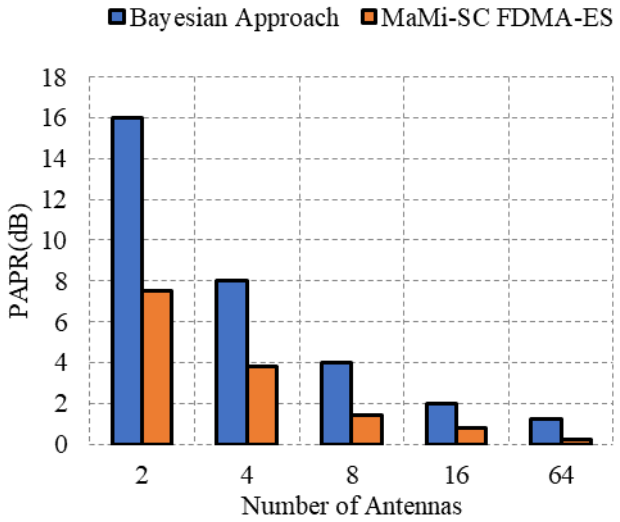

Fig 7 Comparison on PAPR

G. Security result

To improve network performances, security is concentrated on this work. Threats such as resource occupancy, collisions, interferences, data gathering, etc., degrades performances of network. To overcome such threats, the secure key is distributed to spectrum allocated SU's which present in particular FC rotated area.

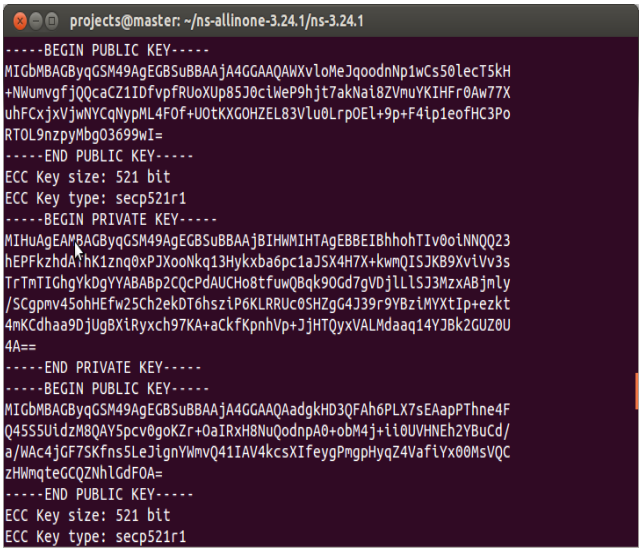

Fig 8 Obtained Ns3 security result

Fig 8 depicts the result in NS3, which prints the generated public key and private for secondary users with which they perform secure data transmission between end-users. Providence of security in this work is also has a major impact on increasing the performance metrics.

VI. CONCLUSION

In this work, Cognitive Radio Network is involved with 5G technology for improvising the network performances.

Fusion center rotation is performed to mitigate interferences among spectrum agents.

MaMi SC - FDMA is involved in fusion center to serve secondary users for the available spectrum and also to decrease PAPR values. A bio-inspired firefly algorithm is used to predict the signal with high SINR to select fewer subcarriers for transmission. Spectrum decision making is incorporated in FC based on *K*-out-of-*N* rule, AND rule and OR rule to obtain the correct result. Followed by the absolute sensing report, the spectrums are allocated to secondary users to perform their transmission. Then a fusion center time - based Elliptic Curve Cryptography is used for providing security to overwhelm malicious users. On the whole, the participation of 5G in CRN has achieved better results when compared with previous research works. In future this work can be further extended in the study of minimization of PAPR and mitigating primary user emulation attacks.

REFERENCES

1. Joanna Wallace, Kyle Richardson, Bob Gill, Stephen Makonin, "Cognitive Radio Technology: System Evolution", IEEE, International Conference on Wireless Networks and Embedded Systems, 2015.
2. S.Sasipriya, R.Vigneshram, "An overview of cognitive radio in 5G wireless communications", IEEE International Conference on Computational Intelligence and Computing Research, 2017.
3. Constandinos X. Mavromoustakis, Athina Bourdena, George Mastorakis, Evangelos Pallis, Georgios Kormentzas, "An energy-aware scheme for efficient spectrum utilization in a 5G mobile cognitive radio network architecture", Telecommunication Systems, Springer, vol. 59, no. 1, pp 63 – 75, 2015.
4. Yi Liu, Yan Zhang, Rong Yu, Shenglli Xie, "Integrated energy and spectrum harvesting for 5G wireless communications", IEEE Network, vol. 29, no. 3, pp 75 – 81, 2015.
5. Olayinka Adigun, Mahdhi Pirmoradian, Christos Politis, "Cognitive Radio for 5G Wireless Networks", Fundamentals of 5G Mobile Networks, Wiley Online Library, pp.149-163, 2015.
6. Zhaleh Sadreddini, Pavel Masek, Tugrul Cavdar, Jiri Hosek, Erkan Guler, "Dynamic decision-based spectrum sharing framework for next-generation (5G) systems", IEEE, Signal Processing and Communications Applications Conference, 2017.
7. Yibing Li, Xueying Diao, Qianhui Dong, Chunrui Tang, "Interference Alignment Based on Rank Constraint in MIMO Cognitive Radio Networks", Symmetry, MDPI journals, vol.9, no. 7, 2017.
8. Erik L. Bengtsson, Fredrik Rusek, Steffen Tufvesson, Peter C. Karisson, Ove Edfors, "A Simulation Framework for Multiple-Antenna Terminals in 5G Massive MIMO Systems", IEEE Access, vol. 5, pp 26819 – 26831, 2017.
9. H.M.El Misilmani, A.M. El-Hajj, "Massive MIMO Design for 5G Networks: An Overview on Alternative Antenna Configurations and Channel Model Challenges", International Conference on High Performance Computing and Simulation, 2017.
10. K.N.R.Surya Vara Prasad, Ekram Hossain, Vijay K. Bhargava, "Energy Efficiency in Massive MIMO-Based 5G Networks: Opportunities and Challenges", IEEE Wireless Communications, vol. 24, no. 3, pp 86 – 94, 2017.
11. Lifeng Wang, Hien Quoc Ngo, Maged Elkashlan, Trung Q. Duong, Kai-Kit Wong, "Massive MIMO in Spectrum Sharing Networks: Achievable Rate and Power Efficiency", IEEE Systems Journal, vol. 11, no. 1, pp 20 – 31, 2017.
12. Girraj Sharma, Ritu Sharma, "A review on recent advances in spectrum sensing, energy efficiency and security threats in cognitive radio network", International Conference on Microwave, Optical and Communication Engineering, pp 114 – 117, 2015.
13. Mahmoud Khasawneh, Anjali Agarwal, "A Secure and Efficient Authentication Mechanism Applied to Cognitive Radio Networks", IEEE Access, vol. 5, pp 15597 – 15608, 2017.
14. Danda B. Rawat, "Evaluating Performance of Cognitive Radio Users in MIMO-OFDM Based Wireless Networks", IEEE Wireless Communication Letters, vol. 5, no. 5, pp 476 – 479, 2016.
15. Zhenjiang Zhang, Wenyu Zhang, Sherali Zeadally, Yanan Wang, Yun Liu, "Cognitive radio spectrum sensing framework based on multi-agent architecture for 5G networks", IEEE Wireless Communications, vol. 22, no. 6, pp 34 – 39, 2015.
16. Ertugrul Basar, "On Multiple-Input Multiple-Output OFDM with Index Modulation for Next Generation Wireless Networks", IEEE Transactions on Signal Processing, vol. 64, no. 15, pp 3868 – 3878, 2016.
17. Md. Mejbaul Haque, Mohammad Shaifur Rahman, Ki-Doo Kim, "Performance Analysis of MIMO-OFDM for 4G Wireless Systems under Rayleigh Fading Channel", International Journal of Multimedia and Ubiquitous Engineering, vol. 8, no. 1, pp 29 – 40, 2013.
18. Ramanpreet Kaur, Sonia Goyal, "Bit Error Rate reduction in MIMO systems using Equalization techniques", International Journal of Engineering Science and Innovative Technology, vol. 2, no. 3, pp 36 – 40, 2013.
19. Behzad Kasiri, Jun Cai, Attahiru S. Alfa, "Lightweight key management in distributed multi-channel cognitive radio networks", Military Communications Conference, IEEE, 2013.
20. You C, Lee J, Kim J, Heo J. Efficient cooperative spectrum sensing for Wi-Fi on TV spectrum. In2011 IEEE international conference on consumer electronics (ICCE) 2011 Jan 9 (pp. 903-904). IEEE.
21. Zhang, Wei. (2019). Handbook of Cognitive Radio. 10.1007/978-981-10-1394-2.

AUTHORS PROFILE

P. Deepanramkumar is currently pursuing M.Tech (By Research) in Computer Science and Engineering from VIT University, Vellore. He received his B.Tech degree in School of Electronics Engineering from VIT University, Vellore. His current research interests include cognitive radio networks, IoT, wireless body area networks,cryptography, wireless sensor networks, mobile ad hoc networks.

Dr.N.Jaisankar is a Professor in the School of Computer Science and Engineering at Vellore Institute of Technology, Vellore, India. Also he was program head for MTech(CSE) program and division head for Computer Network division. He received his BE (Computer Science and Engineering) from Bharathiar University, M.E. (Computer Science and Engineering) from M.K.University and Ph.D. (Computer Science and Engineering) from VIT University. He has 20+ years of experience in teaching and research. He received certification for CCNA Instructor and SUN certified JAVA instructor. He has reviewed many books titled Network Security, Data Mining, TCP/IP protocol suite and Programming in JAVA. He has participated as a coach in the International Programming Contest held at IIT, Kanpur, India. He has published many papers in International and National Journals and conferences on Network Security, Computer Networks and Data Mining. His research interest includes Computer Networks, Network Security, cloud computing, Data Mining. He has served in many peer-reviewed International Journals as an editorial board member, Guest handling editor, advisory board member, and reviewer, etc. Also he has served in many international conferences as General Chair, International advisory board member, technical program committee member, publication chair, organizing committee member, reviewer etc. He has worked in Neusoft Institute, Guangdong, China. He is a life member of Indian Society for Technical Education, Computer Society of India, International Association of Computer Science and Information Technology, International Society for Research in Science and Technology and member of International Association of Engineers.