A Unique Channel Distribution and Mapping for Plan Engine Using Cognitive Radio Technology in 5G

REKHA M[1], DR. M. BHUVANESWARI[2]
[1]Department of Electronics and Communication Engineering
Dhanalakshmi Srinivasan Engineering College (Autonomous)
Perambalur, INDIA

[2]Department of Electronics and Communication
Engineering, University College of Engineering,
BIT Campus, Anna University, Chennai
Tiruchirappalli, INDIA

Abstract: —The spectrum distribution in some auctioned wireless facilities mainly rests upon the need and the tradition of approved primary users (PUs) of a confident band of frequencies. These frequencies are employed by the PUs as per their requirements and necessities. Once the distributed spectrum is not being employed in the complete effective way, the unemployed band is preserved by the PUs as white space without trusting much in the idea of spectrum shortage. There are techniques that numerous researchers have developed and used, such the cognitive radio system, which makes use of a radio controlled by software and adjustable antennas tuned to different frequencies at varying moments. The secondary users (SU) who would be waiting in line to use the unoccupied spectrum, also known as the white space, have needs that are realized by cognitive radio (CR) equipment. The CR techniques enhanced with various frequency distribution engines and techniques in various geographic locations while adhering to FCC and ITU supervisory requirements.The current CR technology embraces the intelligence in time schedule and knows the differences of both static and dynamic spectrum allocation by scheduling the SUs while the PUs are not using the spectrum and forcing them to leave the band fast when the PUs pitch in. This work identifies a number of the research gaps reported in the earlier literature. Over a 90-day period in India, the properties of the PUs and SUs were investigated while being applied in a few particular spectrum areas. Different time zones ,the needs of the SUs, the necessity of the applications, static and dynamic spectrum usage, the development of the spectrum policy engine allied with cooperative and adaptive spectrum access, techniques utilizing artificial intelligence , and the development of the utility element of the entire spectrum have all been taken into account(AI).As a result, without being limited but established policies, the PU and SU channel mapping can be improved. For cognitive radio, we identify the transmitter and receiver parameters and apply them to a proposed channel adaption method. We also utilize a real time survey and a spectrum analyzer to examine the white spaces provided by the VHF,GSM-900 and GSM -100 spectrum bands. Using the Swotting algorithm, the detected variables and white spaces are mapped. Where such regulations can be activated in a policy server, a sample policy has been presented for the ISM
band 2.4 GHz. The 5G CORE spectrum allocation feature is advised to be implemented over the policy engine.

Key-words: cognitive radio; wireless communications; 5G CORE; spectrum allocation; 5G communications

1. Introduction

A 5G wireless architecture aims to serve a variety of service modes, various delays, and stable needs. Several issues relating to real-time radio resource management are brought on by 5G broadband wireless communication. For instance, implementations of wireless infrastructure for latency and dependability are necessary for ultra-reliable communication. By making improved modifications to the current deterministic control and radio resource management models, it is possible to simulate an autonomous wireless connection with synchronous service given in real time. Cognitive spectrum sharing management needs proper coordination between spectrum management capability and software-defined radio properties, i.e., physical layer-supported modes of operation. Distributed artificial intelligence (DAI) is an approach that aims to overcome the limitations of classical artificial intelligence (AI) while addressing complex problems that need the distribution of intelligence across several entities. The three primary research areas of DAI are distributed problem solving, parallel AI, and multi-agent systems. AI and 5G mobile technology have the potential to considerably boost profit, originality, and dependability in many economic and societal sectors because they have the ability to produce previously imagined goods and services. Despite the fact that mainstream applications have not yet emerged, the integration of AI with 5G will have a huge impact on expanding sectors like agriculture, healthcare, and education. Even while many mobile operators are still making back their investments in legacy network technologies, interest in 5G networks is rapidly increasing. Due to increased spectral efficiency, 5G networks are able to transmit more data each second and per hertz of the spectrum than earlier generations of cellular networks. This is essential since spectrum has a finite quantity and is costly. In order to increase spectral efficiency, more simultaneous customers may be serviced at a reduced cost.

As a result of advances in new technologies, the advent of artificial intelligence, and faster data rates, mechanization and machine-enabled choice will alter practically every aspect of daily life. This upcoming technological revolution is unquestionably being driven by 5G and AI. But since they do not necessitate a technology advance, the vast majority of AI-based 5G use cases are not actually 5G use cases. Less latency will make apps come out that have reaction times of under a millisecond. Enhancing current use cases and creating new ones that aren't supported by current technology will undoubtedly be necessary for growing economies as they embark on the AI and 5G path. The faster data rates of 5G open up a plethora of new opportunities when combined with artificial intelligence (AI).

Some of them include the following: networks and services for mobile communications improvements. Service providers for mobile communications confront further difficulties. The establishment of 5G networks is substantially more challenging than in earlier generations due to the modifications needed for radio, edge, transport, core, and cloud infrastructure to handle the complexity of 5G networks and the billions of Internet of Things (IoT) devices they can serve. All of these upgrades ought to be handled by AI in the best possible way.

Therefore, abandoning the current well-before approaches is necessary due to the dynamic spectrum access used by CR instruments. A policy-based approach for CR platforms and a new policy thinking model have been utilized to create regulations for the CR system. The fundamental idea behind CR [1] reconfigures how radio equipment apply their policies; as a result, the adaptable and flexible character of radio systems results in the best possible utilization of the spectrum. As a result, stockholders profit from the techniques and frequently change them.

The creation of a strategy spectrum arrangement is essential for 5G networks, hence we constructed:

(i) An expert channel assignment system that chooses from a vast array of parameters the variables that should be chosen for successful spectrum allocation.

(ii) A fresh method of variable mapping that converts the required channel specifications to open spectrum gaps.

(iii) A resource management program with POMDP support that offers secondary users service based on pre-mapped channels.

Following is how the paper's remaining portions are arranged. Section 2 covers work on 5G networks, methods for channel allocation and selection, and policy-based systems. Presented in Section 3 is the policy engine structure. In sections 4 and 5, we demonstrate the parameter mapping and POMDP-enabled reward mechanisms, and in section 6, we present the results and testing results. We shall present our results in Section 7 as well.

2. Related Work

2.1 Spectrum Allocation and Algorithms Review

The cognitive radio (CR) networks use the hidden Markov model (HMM) to analyze collaborative spectrum allocation for efficient spectrum access (OSA). The main channel is assumed to run in TDMA mode, thus slot-by-slot spectrum sensing was done[4].Reduced latency was the only goal of the initial strategy. As a result, it was theoretically possible to implement a narrowband (NB) sensing system using traffic loads in wideband (WB). The second approach, that was based on Q-learning, attempted to lessen sensing latency while still accommodating other user requirements. The first strategy reduced the sensing latency of random selection by 59%, whereas the second method used Q-learning to increase satisfaction by 95.7% [5].

2.2 Study on Learning-Based Distribution

The algorithms made use of linkages in space, time, and frequency. Spectrum sensing ability could be significantly improved by ML algorithms if the input training data set is carefully chosen. Investigated were the advantages and disadvantages of employing input data sets that included ED evaluations and energy values in real-world settings[6].The results also showed that the neural network had a high rate of success and quick convergence in learning the best user selection method in an unknown changing situation[7].

For a variety of occupancy rates, choices were taken and the consequences of waste and interference were assessed. Also carried out were comparison studies between the simulated Markov decision process (POMDP) and the Markov decision process (MDP)[8].Since the nodes have all of the essential files contained in the repository and the system is driven by AI, they can autonomously decide which channel to utilize and how to switch between different channels. Better results were obtained by increasing the simulation's utilization of both the spectrum[9].

3. Administration of Policy in Cognitive Radio

The principles of the policies that must be created for channel allocation and channel mapping are examined and understood in this section. With network and information system administration, there is a financial justification for automatic policy control of resources. In the process of managing policies, you can create corporate objectives that the network can read and enforce[10].To obtain opportunistic spectrum access, the following abilities are required:

- Establishing a primary channel link and sensing over a wide frequency band
- Outlining possible opportunities
- Organizing the use of organizational priorities through cross-departmental communication
- 4. Establishing and applying policies that limit disruption

3.1 Engine for Policy

A computer or system has to be able to receive and implement machine-readable rules in order to regulate the behavior of network resources. As seen in Figure 1, the computer/process is known as the policy engine.The policy engine is in charge of responding to events that call for modifying a resource's configuration. The output of the policy engine is frequently configuration instructions or approvals that are tailored to certain network devices. The policy engine in Figure 1 links domain-specific objectives with the functionalities of the devices they are linked to. [11].With a transmission plan it has created based on the behavior data it has gathered from the channel's key users and its current condition, the SR sends a channel demand to the RBR [12,13].

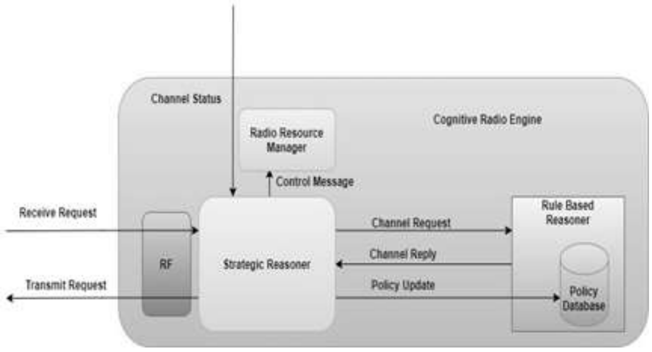

Figure 1. Engine for Policy.

3.2 Norms for Elite Channel Distribution Process

It is impossible for hardcode regulations allowing secondary users to use available spectrum holes across several radio bands that fluctuate in frequency and location.The spectrum occupancy denoted by G by primary users, is given by [14,15]:

$$\Gamma = (1/KN)\ \Sigma_{k=1}^{K}\ \Sigma_{N=1}^{N}\ \Gamma f\ (n), t\ (k) \quad (1)$$

where the total number of operating frequencies in a band is denoted by N and K denotes the number of total samples associated with each point of frequency fb [(99 kHz–3 GHz), (100 MHz–1000 MHz) (50 MHz–4400 MHz)].Figure 2 summarizes cognitive radio parameters for transmitters, receivers, and channels. Before channels are mapped, the swotting technique outlined in Algorithm 1 takes into account the parameters [16,17].

Algorithm 1 For Cognitive Radio Channel Selection and Distribution
for All Channels,
SetIdle
{
If Channel Ch is IDLE attme T_a
I f authorized
Check Primary User back-off time B_{ta}
If available IDLE for Time T b-a, Mark Channel specification Γ, and release for Secondary User
Channel Specification as in Equation (1)

$$\Gamma = (1/KN)\ \Sigma_{k=1}^{K}\ \Sigma_{N=1}^{N}\ \Gamma f\ (n), t\ (k)$$

N—Number of frequency points in the band
K—Number of time samples for each frequency point
} Repeat SetIdle for all channels;
For all Idle Channels
{
AllocateSU
Check SU Queue
If unauthorized
Transfer Channel specifications
Γ_1, $\Gamma_{2,\ldots}$ Γ_N and
Idle Time Slots—$T_{b-a}(\Gamma_1)$, $T_{b-a}(\Gamma_2)$, … $T_{b-a}(\Gamma_N)$,
to SU
Identify the QoS requests from Secondary User
For

$$R(SU1) = \sum_{n=0}^{n-1} \sum_{m=0}^{m-1} (ch_{mn}\ B_{mn}\ log2\ (Pow_{mn}/\lambda) * (PoG_{mn}\ /\mu))$$

If Γ_x satisfies the requirements R (SUy)
Allocate
Ch_x to SUy with B_x Bandwidth of channel m utilized by node y, Pow_x, the Power re- quired in dB for channel m utilized by node y, PoG_x Power Gain in dB for all fading and path loss over the channel
} Repeat AllocateSU for all Idle Channels
When PU arrives,
If the channel is occupied by SUz,
Pre-empt SUz from Channel Chz and release for PU
For SUz, call AllocateSU and identify spectrum hole for reallocation
end

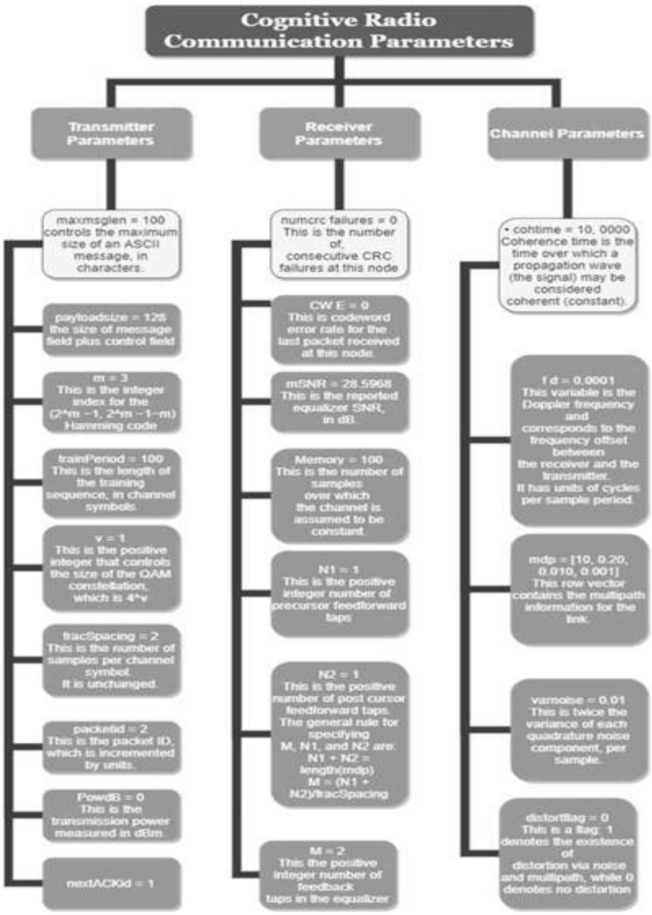

Figure 2. Parameters of Cognitive Radio

3.3 Elite Mapping—Swotting Algorithm for Parameter Mapping Repository

The swotting algorithm, which is described in Algorithm 2, is a reinforcement Q-learning algorithm that determines decision-making policies without thorough radio environment modeling. This shows that Q-learning describes and enhances the desired performance metrics rather than focusing on issues linked to network performance, such as wireless channel status and mobility, for example.It has four inputs: the state, the action, the probabilistic transition function, and the reward function, Sb, b. The state may reflect internal activities taking place within the agent, like the size of the instantaneous queue, or external activities taking place outside the agent, such the agent's use of the wireless medium. The reward function demonstrates the system's reaction to how well its activities were executed, and as a result, the system gains experience.

Algorithm 2 :*Elite Mapping—Swotting Algorithm for Parameter Mapping Repository*

Prerequisites: present state cs(t), previous state ps(x), and F(t)
Ascertain that the Swotting algorithm selected produces the maximum possible output. OP
Training: given the state of the network cs(t);
Probabilistic exploration γ ;
Choose one action at random;
New Update $UP(t) = \{b|W\left(cs\left(t\right), b\right) = 1\}$ for cs(t);
Probabilistic Exploitation is $1 - \gamma$;
Choose α records UP''(CS'(ps(x),F(t)) from actions F in accordance with CS'(ps(x),F(t)
Resolve Re(cs(t),r) in accordance with next r(x) and fill UP_R(cs(t));
if (y* exist = max_y(y|cs(y) Î UP''(CS'(cs(t)),F(t)) Ç UP'(cs(t)) then
Choose the action r(x) ;
Else if
Choose action from UP_R(cs(t));end if
do update UP(cs(t), r)
do
repeat SWQ;
_while (t = t + 1 and s = s.t + 1)

3.4 PMDP Model for Channel State and Reward

Decisions are made in a discrete-time stochastic management process using a Markov decision process (MDP), as seen in Figure 3. S(t) S, where S denotes the entire state space, is the current state. Recent states are flexible in real-time applications, and partially observable MDP (POMDP) has been used to compute the decision policy based on partially available inputs[18].

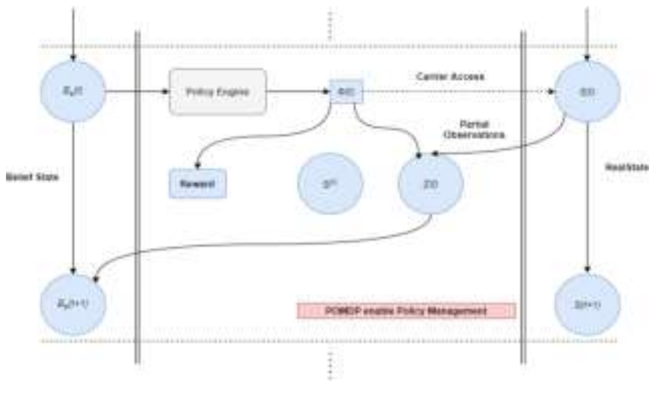

Figure 3. POMDP-enabled policy management.

Therefore, considering NOCs reduces SU collisions on the common spectrum. In order to prevent small cells from interfering with the small cell-enhanced node B (SeNBability)'s to operate as many UEs [19,20], as shown in Figure 4, the power and channel allocations are established.

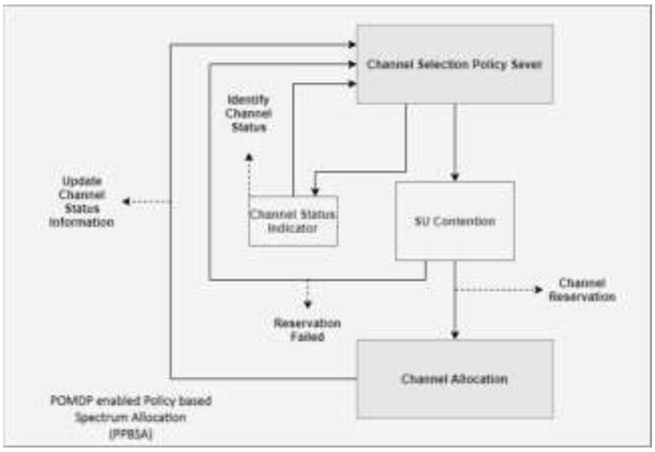

Figure 4. POMDP-enabled policy-based spectrum allocation (PPBSA).

4. Results

The sensing time is thus shown to be 1 ms as a result of this. Additionally, it has been found, as shown in Figure 5, that our projected PPBSA strategy outperforms alternative models in both crowded and sparse circumstances.

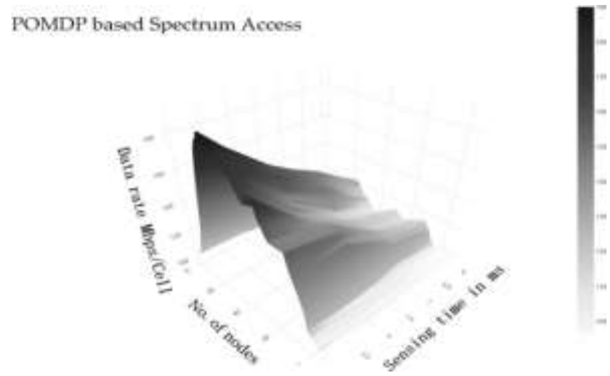

Figure 5. POMDP-based spectrum access by SU.

As shown in Figure 6, an experiment is conducted to determine the best method for handing off spectrum from the primary to the secondary user and from the secondary to the primary user.

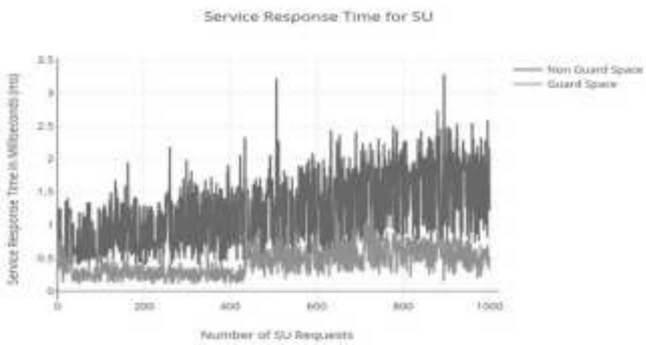

Figure 6 : Service response time

5. Conclusion

To provide service to the secondary customers who just needed one service, different real-time bands were examined, and the suggested elite channel distribution and mapping methods were evaluated. The elite-CAM is improved as a policy, and a policy engine is subjected to the policies. To rank and encourage a static environment, a policy-based spectrum distribution has been designed and put into practise. The 5G CORE specification's spectrum management capability is suggested to be configured using the policy engine. It has not been tested to see how the principal users' and users who don't suit the ranking mechanism's criteria change their behavior over time. Therefore, it is not preferred that users of cognitive radio who have previously been tested with a particular model continue for an extended period of time. It is quickly evolving.

References

[1] Ahmad, W.S.; Radzi, N.A.; Samidi, F.S.; Ismail, A.; Abdullah, F.; Jamaludin, M.Z.; Zakaria, M.N. 5G Technology: Towards Dy- namic Spectrum Sharing Using Cognitive Radio Networks. *IEEE Access* **2020**, *8*, 14460–14488.

[2] Do, D.T.; Le, A.T.; Hoang, T.A.; Lee, B.M. Cognitive radio-assisted NOMA broadcasting for 5G cellular V2X communications: Model of roadside unit selection and SWIPT. *Sensors* **2020**, *20*, 1786.

[3] Besher, K.M.; Nieto-Hipolito, J.I.; Briseno, M.V.; Mariscal, R.B. SenPUI: Solutions for sensing and primary user interference in cognitive radio implementation of a wireless sensor network. *Wirel. Commun. Mob. Comput.* **2019**, *2019*, 2405141.

[4] Huang, Y.F.; Wang, J.W. Cooperative spectrum sensing in cognitive radio using Bayesian updating with multiple observations.*J. Electron. Sci. Technol.* **2019**, *17*, 252–259.

[5] Ozturk, M.; Akram, M.; Hussain, S.; Imran, M.A. Novel QoS-Aware Proactive Spectrum Access Techniques for Cognitive Radio Using Machine Learning. *IEEE Access* **2019**, *7*, 70811–70827.

[6] Wasilewska, M.; Bogucka, H. Machine learning for LTE energy detection performance improvement. *Sensors* **2019**, *19*, 4348.

[7] Shi, Z.; Xie, X.; Lu, H. Deep Reinforcement Learning Based Intelligent User Selection in Massive MIMO Underlay Cognitive Radios. *IEEE Access* **2019**, *7*, 110884–110894.

[8] Arunthavanathan, S.; Kandeepan, S.; Evans, R.J. A Markov Decision Process-Based Opportunistic Spectral Access. *IEEE Wirel. Commun. Lett.* **2016**, *5*, 544–547. https://doi.org/10.1109/LWC.2016.2600576.

[9] Jaishanthi, B.; Ganesh, E.N.; Sheela, D. Priority-based reserved spectrum allocation by multi-agent through reinforcement learn- ing in cognitive radio network. *Automatika* **2019**, *60*, 564–569. https://doi.org/10.1080/00051144.2019.1674512.

[10] Jamoos, A.; Abdou, A. Spectrum Measurements and Analysis for Cognitive Radio Applications in Palestine. In Proceedings of the 2019 6th International Conference on Electrical and Electronics Engineering (ICEEE), Istanbul,

[11] Turkey, 16–17 April 2019; pp. 180–185. https://doi.org/10.1109/ICEEE2019.2019.00042.

[12] Liu, Y.; Peng, J.; Kang, J.; Iliyasu, A.M.; Niyato, D.; El-Latif, A.A. A Secure Federated Learning Framework for 5G Networks.*IEEE Wirel. Commun.* **2020**, *27*, 24–31.

[13] Wang, W.; Lv, T.; Wang, T.; Yu, X. Primary user activity based channel allocation in cognitive radio networks. In Proceedings of the IEEE Vehicular Technology Conference, Ottawa, ON, Canada, 6–9 September 2010. https://doi.org/10.1109/VETECF.2010.5594260.

[14] Shafin, R.; Liu, L.; Chandrasekhar, V.; Chen, H.; Reed, J.; Zhang, J.C. Artificial Intelligence-Enabled Cellular Networks: A Crit- ical Path to Beyond-5G and 6G. *IEEE Wirel. Commun.* **2020**, *27*, 212–217.

[15] Zhou, H.; Elsayed, M.; Erol-Kantarci, M. RAN Resource Slicing in 5G Using Multi-Agent Correlated Q-Learning. In Proceedings of the IEEE International Symposium on Personal, Indoor and Mobile Radio Communications, PIMRC, Helsinki, Finland, 13– 16 September 2021; pp. 1179–1184. https://doi.org/10.1109/PIMRC50174.2021.9569358.

[16] Jang, S.J.; Han, C.H.; Lee, K.E.; Yoo, S.J. Reinforcement learning-based dynamic band and channel selection in cognitive radio ad-hoc networks. *J. Wirel. Commun. Netw.* **2019**, *2019*, 131. https://doi.org/10.1186/s13638-019-1433-1.

[17] Mitola, J.; Maguire, G. Cognitive radio: Making software radios more personal. *IEEE Pers. Commun.* **1999**, *6*, 13–18.

[18] Haykin, S. Cognitive radio: Brain-empowered wireless communications. *IEEE J. Sel. Areas Commun.* **2005**, *23*, 201–220.

[19] Jeya, R.; Amutha, B.; Singh, M.; Arora, C. Performance Analysis and Comparison of Different Modulation Schemes with Chan- nel Estimation Methods for MIMO-OFDM System. *Int. J. Innov. Technol. Explor. Eng.* **2019**, *8*, 2278–2307.

[20] Long, Q.; Chen, Y.; Zhang, H.; Lei, X. Software Defined 5G and 6G Networks: A Survey. *Mob. Netw. Appl.* **2019**.

[21] Minoli, D.; Occhiogrosso, B. Practical Aspects for the Integration of 5G Networks and IoT Applications in Smart Cities Environ- ments. *Wirel. Commun. Mob. Comput.* **2019**, *2019*, 5710834.