iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 2 Issue: VII Month of publication: July 2014

DOI:

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

A Survey On Cognitive Radio

Manisha[1], Anju[2], Naveen[3]

M.Tech, M.D.U Rohtak[1]
M.C.A, M.D.U Rohtak[2]
M.C.A ,Mphil[3]

Abstract: Cognitive radio (CR) has emerged as a promising technology to exploit the unused portions of spectrum in an opportunistic manner. The fixed spectrum allocation of governmental agencies results in unused portions of spectrum, which are called "spectrum holes" or "white spaces". CR technology overcomes this issue, allowing devices to sense the spectrum for unused portions and use the most suitable ones, according to some pre-defined criteria. This paper survey on cognitive architecture, fundamentals of CRN and also explains the routing.
Keywords: Cognitive radio, Channel Assignment, Spectrum Assignment, Spectrum Selection, Spectrum Allocation.

IJRASET: ISSN: 2321-9653

I. INTRODUCTION

Over the last few years, economical and technological driving forces have emerged and are expected to shape the design of future wireless networks. Everyday usage of wireless networks has increased significantly in the last decade and life without wireless devices (such as mobile phones, PDAs, smartphones, laptops etc.) seems impossible. The need for mobility and wireless connectivity has driven the widespread deployment of many wireless networks either in local areas (WiFi) or in metropolitan areas (WiMAX, 3.5G, etc.). The radio spectrum is a natural resource regulated by governmental or international agencies and is assigned to license holders on a long term basis using a fixed spectrum assignment policy [1]. This has an impact on the spectrum usage because recent measurements [1], have shown that for large portions of spectrum, the utilization is quite low, leading to a waste of valuable frequency resources. To exploit the unused portions of spectrum, the concept of Cognitive Radio (CR) technology has been proposed. CR is based on Software Defined Radio (SDR) that was proposed in order to liberate the radio networks from the previous dependencies on hardware characteristics such as frequency bands, channel coding, and bandwidth.

CR networks, however, impose unique challenges due to the high fluctuation in the available spectrum, as well as the diverse quality of service (QoS) requirements of various applications. In order to address these challenges, each CR user in the CR network must:

- Determine which portions of the spectrum are available
- Select the best available channel
- Coordinate access to this channel with other users
- Vacate the channel when a licensed user is detected [2]

These capabilities can be realized through spectrum management functions that address four main challenges: spectrum sensing, spectrum decision, spectrum sharing, and spectrum mobility.

II. COGNITIVE RADIO

Most of today's radio systems are not aware of their radio spectrum environment as they are designed to operate in a predefined frequency band using a specific spectrum access system. As elaborated in the introduction, investigations of spectrum utilisation indicate that spectrum is not efficiently utilised most of the time. Overall spectrum utilisation can be improved significantly by allowing secondary unlicensed users to dynamically access spectrum holes temporally unoccupied by the primary user in the geographical region of interest as shown in Figure 1 [3].

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

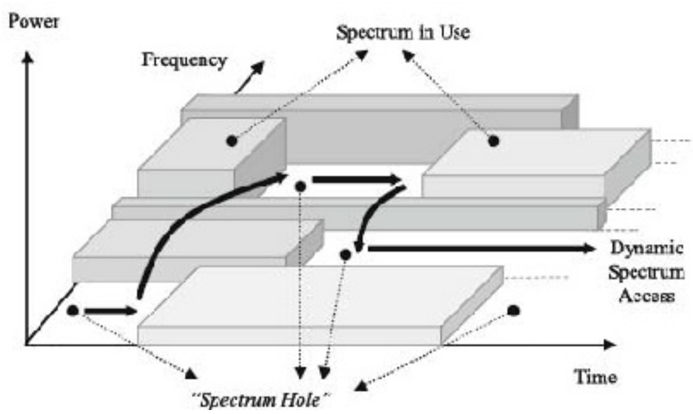


Figure 1: Spectrum hole [4]

A spectrum hole [5] (or also called white space) is a band of frequencies assigned to a primary user, but at a particular time and specific geographic location, the band is not being utilised by that user. Spectrum hole concept can be further generalised as transmission opportunity in radio spectrum space. Radio spectrum space is a theoretical hyperspace occupied by radio signals which has dimensions of location, angle of arrival, frequency, time, energy and possibly others [6].

A radio build on cognitive radio concept have the ability to sense and understand its local radio spectrum environment, to identify spectrum holes in radio spectrum space, to make autonomous decisions about how it accesses spectrum and to adapt its transmissions accordingly. Such cognitive radio using dynamic spectrum access has the potential to significantly improve spectrum efficiency utilisation resulting in easier and flexible spectrum access for current or future wireless services.

Cognitive radio as a new concept was firstly introduced by Joseph Mitola and Gerald Maguire in [7] where cognitive radio is presented as an extension of software defined radio enhancing flexibility of personal wireless services with radio domain model based reasoning using new language called the radio knowledge representation language (RKKL).

III. FUNDAMENTALS IN CRNS

In this section, the fundamentals of CRNs, such as basic components, opportunistic spectrum access, and several inherent reliability issues in CRNs, are reviewed in detail [8]. A. Basic Components in Cognitive Radio. The main motivation behind CR is to increase the limited spectrum utilization by allowing SUs to opportunistic access the frequency band actually owned by PUs. CR, built on a software radio platform, is a context-aware intelligent radio potentially capable of autonomous reconfiguration by learning from and adopting to the radio environment [7][5]. CR is a link level technology requiring: reliable sensing information for spectrum utilization, dynamic spectrum access, and possible programmable radio to support, etc. So SUs could adjust their transmission to fill in the spectral void, as shown in Figure 2.

Authors in [4] presented two main characteristics of CR: cognitive capability and configurability. The ability to capture or sense the information from its radio environment is referred to as cognitive capability of CR; reconfigurability of CR is the capability of dynamically adjust operating parameters for the transmitter or/and the receiver without any modifications on the hardware component. Therefore, the cognitive capability provides spectrum awareness whereas reconfigurability enables the radio to be dynamically programmed according to the radio environment.

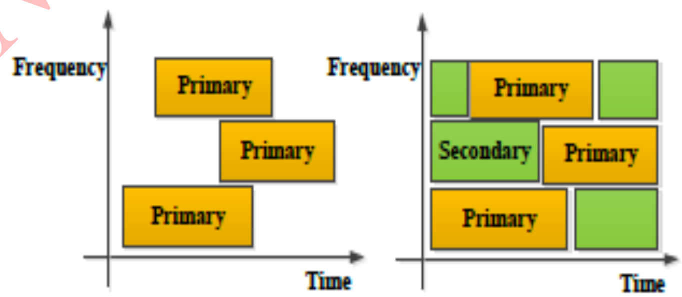


Figure 2: One of the simplest instance of cognition: a cognitive user senses the time/frequency white spaces and opportunistically transmits over these detected spaces.

CR represents a much broader paradigm where many aspects of communication systems can be improved via cognition and networking. When multiple CR devices are interconnected, CRNs are formed along with the existing networks. CRNs open up exciting opportunities to enable and support a variety of emerging applications, ranging from smart grid, public safety and broadband cellular, to medical applications [9], etc. Figure 3 shows one opportunistic link window in CRNs. There are two types of (CRN) are being deployed [10] in practice: centralized and distributed. The centralized network is an infrastructure-based network, where the SUs are managed by secondary base

IJRASET: ISSN: 2321-9653

ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

stations which are in turn connected by a wired backbone. In a distributed architecture, SUs communicate with each other in an ad hoc manner. Two SUs who are within communication range can exchange information directly, while the SUs who are not within direct communication range can exchange information over multiple hops. Spectrum sensing operation in distributed architecture is usually performed collaboratively.

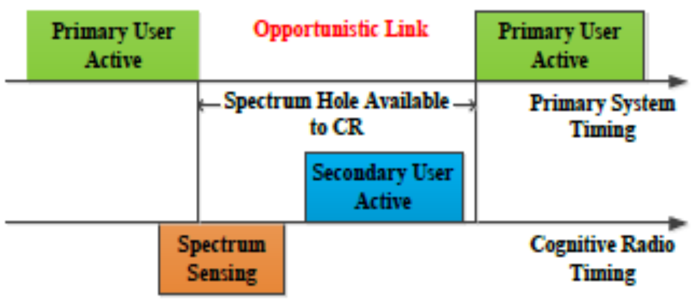


Figure3: Opportunistic link in cognitive radio networks

Collaborative sensing techniques [11] highlight the fact that is the SUs share their relative sensing information, then the overall primary user detection for the cognitive network can be improved. However, these protocols do not consider malicious users in the network.

IV. COGNITIVE RADIO FUNCTIONS

A typical duty cycle of CR, as illustrated in Figure 4, includes detecting spectrum white space, selecting the best frequency bands, coordinating spectrum access with other users and vacating the frequency when a primary user appears. Such a cognitive cycle is supported by the following functions [12]:

• spectrum sensing and analysis;

• spectrum management and handoff;

• spectrum allocation and sharing.

Through spectrum sensing and analysis, CR can detect the spectrum white space, i.e., a portion of frequency band that is not being used by the primary users, and utilize the spectrum. On the other hand, when primary users start using the licensed spectrum again, CR can detect their activity through sensing, so that no harmful interference is generated due to secondary users' transmission. After recognizing the spectrum white space by sensing, spectrum management and handoff function of CR enables secondary users to choose the best frequency band and hop among multiple bands according to the time varying channel characteristics to meet various Quality of Service (QoS) requirements [4]. For instance, when a primary user reclaims his/her frequency band, the secondary user that is using the licensed band can direct his/her transmission to other available frequencies, according to the channel capacity determined by the noise and interference levels, path loss, channel error rate, holding time, and etc.

In dynamic spectrum access, a secondary user may share the spectrum resources with primary users, other secondary users, or both. Hence, a good spectrum allocation and sharing mechanism is critical to achieve high spectrum efficiency. Since primary users own the spectrum rights, when secondary users co-exist in a licensed band with primary users, the interference level due to secondary spectrum usage should be limited by a certain threshold. When multiple secondary users share a frequency band, their access should be coordinated to alleviate collisions and interference[12]

V. ROUTING IN A CR NETWORK

In traditional wireless networks, all network nodes will be provided with a certain fixed spectrum band for use. For instance, WLAN uses 2.4 and 5 GHz bands, and GSM uses 900 and 1800 MHz bands. In DSA networks, however, there may be no such pre-allocated spectrum that can be used by every node

at any time, and the frequency spectrum that can be used for communication may vary from node to node. This new feature of DSA network imposes even greater challenges on wireless networking, especially on routing. If two neighboring nodes do not have a common channel, or they have common channels but do not tune to the same frequency, then multi-hop communication will be infeasible. Thus, new routing algorithms are needed to accommodate the spectrum dynamics and ensure satisfying network performance such as high network capacity and throughput, short latency and low packet loss[12].

Due to the heterogeneity of spectrum availability among nodes, routing problem cannot be well solved without considering the spectrum allocation. In [13], the inter-dependence between route selection and spectrum management is studied, where the network layer selects the packet route as well as decides

IJRASET: ISSN: 2321-9653

ISSN: 2321-9653

a time schedule of a conflict-free channel usage. In [12], the topology formation and routing in DSA networks is discussed. DSA network nodes first identify spectrum opportunities by detection, and then the detected spectrum opportunities are associated to the radio interfaces of each node. A layered graph model is proposed to help assign the spectrum opportunities to the radio interfaces. A MAC-layer configuration algorithm is proposed [14], which enables nodes to dynamically discover the global network topology and node location, and identify common channels for communication. New routing metrics are introduced [14], such as the number of channel switches along a path, frequency of channel switches on a link, and switching delay [14]. Spectrum-aware on-demand routing protocol is proposed which select routes according to the switching delay between channels and the backoff delay within a channel. A probabilistic path selection approach is proposed for a multi-channel CR network. The source node first computes the route that has the highest probability to satisfying a required demand, and then verifies whether the capacity of the potential path indeed meets the demand. If not, extra channels are judiciously added to the links of the route until the augmented route satisfies the demand at a confidence level. Considering the channel switching constraints due to primary users' activity, [15] proposes analytical models for channel assignment in a general multi-hop CR network, studies the impact of the constraints on network performance, and investigates the connectivity and transport capacity of the network.

VI. PROTOCOLS IN COGNITIVE RADIO NETWORK

6.1 An Efficient Location Server for an Ad Hoc Network

In [16] three current location service, Grid Location Service (GLS) , Simple Location Service (SLS) , and Reactive Location Service (RLS) are introduced. Grid Location service: In GLS, a node chooses a set of node in the network (i.e. ,location servers) to maintain the node's current location. Nodes that require the location of a node query the node's location servers [17]. Simple Location Service: In SLS, a node periodically transmits its location table to its neighbors. Thus, a node in the network learns the location of all other nodes in the network. Here each location packet (LP) updates location tables, contains the location of several nodes, the speed of each of nodes, and the time the LP was transmitted. The rate a mobile node transmits LPs adapts according to location change [17]:

$$\left(\frac{\mathrm{Trange}}{\propto}\right)\cdot\left(\frac{1}{\mathrm{v}}\right)=\frac{\mathrm{Trange}}{\propto \mathrm{v}}$$

Where Trange is the transmission range of the node, ∝ vis the average velocity of the node, and ∝ is a constant optimized through simulation is a scaling factor.

Reactive Location Service: RLS is a reactive location service that queries location information on an as needed basis.

6.2 An improved Map-based Location Service for Vehicular Ad Hoc Networks

In [18] a distributed hierarchical location service called Density aware Map-Based Location Service (DMBLS) for Vehicular adhoc Networks. DMBLS makes use of the street digital maps and the traffic density information to define a three level hierarchy of locations servers. The location service uses a density aware server selection policy which selects servers at high density regions of a city. DMBLS, for vehicular urban environments, based on the traffic density. In this, they have assume that each vehicle knows its own geographic position and the use of the Global Positioning System (GPS).

Updating Location Information: Due to the high mobility, the vehicles positions keep changing very fast and therefore, the location server should be informed to update the information it stores. the location information are valid for a period T equal to the time required for the vehicle to reach the next waypoint plus a threshold time Tc and it can be predicted by the following formula: $\mathrm{T} = \mathrm{Dint}/\mathrm{Savg} + \mathrm{Tc}$

Where Dint is the distance between the current intersection and the next intersection and Savg corresponds to the average speed of the vehicle. Tc represents the time spent by the vehicle near the intersection before it moves away with a distance R equal to the transmission range [17].

6.3 Search Protocol - Spectrum Aware Routing Protocol

The SEARCH protocol uses the geographic forwarding. This protocol jointly considers the path and the channel selection to avoid the regions of the Primary User activity during the route formation. Minimization of hop count to reach the destination is done by using the optimal path found by geographic forwarding [19]. The idea of the geographic forwarding is used in this protocol. It is able to deal with reasonable levels of PU activity changing rate. Also, a mechanism for disseminating the

IJRASET: ISSN: 2321-9653

INTERNATIONAL JOURNAL FOR RESEARCH IN APPLIED SCIENCE AND ENGINEERING TECHNOLOGY (IJRASET)

destination location both at the source and at each intermediate node is required.

The protocol assumes the primary users" activities in an ON/OFF process. The functions followed by the protocol are (1) Route setup phase (2) Joint Channel – Path optimization phase and (3) Route Enhancement, in order to improve the route during its operation. SEARCH mainly works on following two concepts

6.3.1 PU activity awareness

In CR network, route must be constructed to avoid region affected by active PU. When PU activity affect region, SEARCH provides hybrid solution, it first uses greedy geographic routing on each channel to reach destination by identifying and circumventing PU activity region [17]. The path information from different channels is combined at destination in series of optimization steps to decide on optimal end-to-end route in a computationally efficient way.

6.3.2 CR user mobility

Cognitive user mobility results into frequent route disconnections. Thus for each node, through periodic beacons, updates its one-hop neighbors about it current location SEARCH ensures performance as well as less interference in cognitive radio network.

VII. CONCLUSION

Cognitive radio is a promising technology for future wireless networks. It aims to exploit the underutilized spectrum bands and solve the problem of overutilization of the free bands, enabling users access any unused portion of the spectrum rather than limiting their access to specific free frequencies, like the existing wireless networks. The basic feature of CR technology is that CR devices are able to sense the operating environment and adapt to real-time changes. This means that CR devices are able to find at any given time the available non-utilized spectrum bands and access them, while not interfering with licensed transmissions. This article surveys the research in CRNs. First, the fundamentals of CRNs including the basic components (i.e., characteristics and network architectures).

REFERENCES

[1] Tragos, E. Z., Zeadally, S., Fragkiadakis, A. G., & Siris, V. A. , "Spectrum Assignment in Cognitive Radio Networks: A Comprehensive Survey" .IEEE Communications Surveys and Tutorials, 15(3), 1108-1135. (2013).

[2] Akyildiz, I. F., Lee, W. Y., Vuran, M. C., & Mohanty, S. , "A survey on spectrum management in cognitive radio networks.", Communications Magazine, IEEE, 46(4), 40-48. (2008).

[3]Tabaković, Ž. A Survey of Cognitive Radio Systems.

[4] I. F. Akyildiz, W. Y. Lee, M. C. Vuran and S. Mohanty, "NeXt Generation / Dynamic Spectrum Access / Cognitive Radio Wireless Networks: A Survey,", Computer Networks, pp. 2127-2159. (2006)

[5] S. Haykin, "Cognitive Radio: Brain-empowered Wireless Communications," IEEE Journal on Selected Areas in Commun., Vol. 23, No. 2, February 2005, pp. 201-220, (2005)

[6] A. L. Drozd, I. P. Kasperovich, C. E. Carroll and A. C. Blackburn, "Computational Electromagnetics Applied to Analyzing the Efficient Utilization of the RF Transmission Hyperspace", In Proc. Of IEEE/ACES Conf. on Wireless Comm. and Applied Computational Electromagnetics, Hawaii, USA, April 2000, pp. 1077-1085(2000),

[7] J. Mitola and G. Q. Maguire, "Cognitive radios: Making Software Radios More Personal", IEEE Pers. Commun., Vol. 6, No. 4, August 1999, pp. 13-18(1999)

[8] Wang, F. Cognitive Radio Networks and Security: A Survey.

[9] Wang, J., Ghosh, M., & Challapali, K. "Emerging cognitive radio applications: A survey". Communications Magazine, IEEE, 49(3), 74-81. (2011).

[10] Q. H. Mahmoud, C. N. Mathur, and K. P. Subbalakshmi, "Cognitive Networks: Towards Self-Aware Networks". USA: John Wiley & Sons, May 2007.

[11]K. Ben Letaief and W. Zhang, "Cooperative communications for cognitive radio networks", Proc. IEEE, vol. 97, no. 5, pp. 878 –893, May 2009.

[12] Wang, B., & Liu, K. R. "Advances in cognitive radio networks: A survey".Selected Topics in Signal Processing, IEEE Journal of, 5(1), 5-23. (2011).

IJRASET: ISSN: 2321-9653

[13] Wang, Q., & Zheng, H. , "Route and spectrum selection in dynamic spectrum networks." In IEEE Consumer Communications and Networking Conference (CNCC) (pp. 342-346). (2006, January).

[14] Krishnamurthy, S., Thoppian, M., Venkatesan, S., & Prakash, R. , "Control channel based MAC-layer configuration, routing and situation awareness for cognitive radio networks". In Military Communications Conference, 2005. MILCOM 2005. IEEE (pp. 455-460). IEEE. (2005, October).

[15] Bhandari, V., & Vaidya, N. H., " Capacity of multi-channel wireless networks with random (c, f) assignment." In Proceedings of the 8th ACM international symposium on Mobile ad hoc networking and computing (pp. 229-238). ACM. (2007, September).

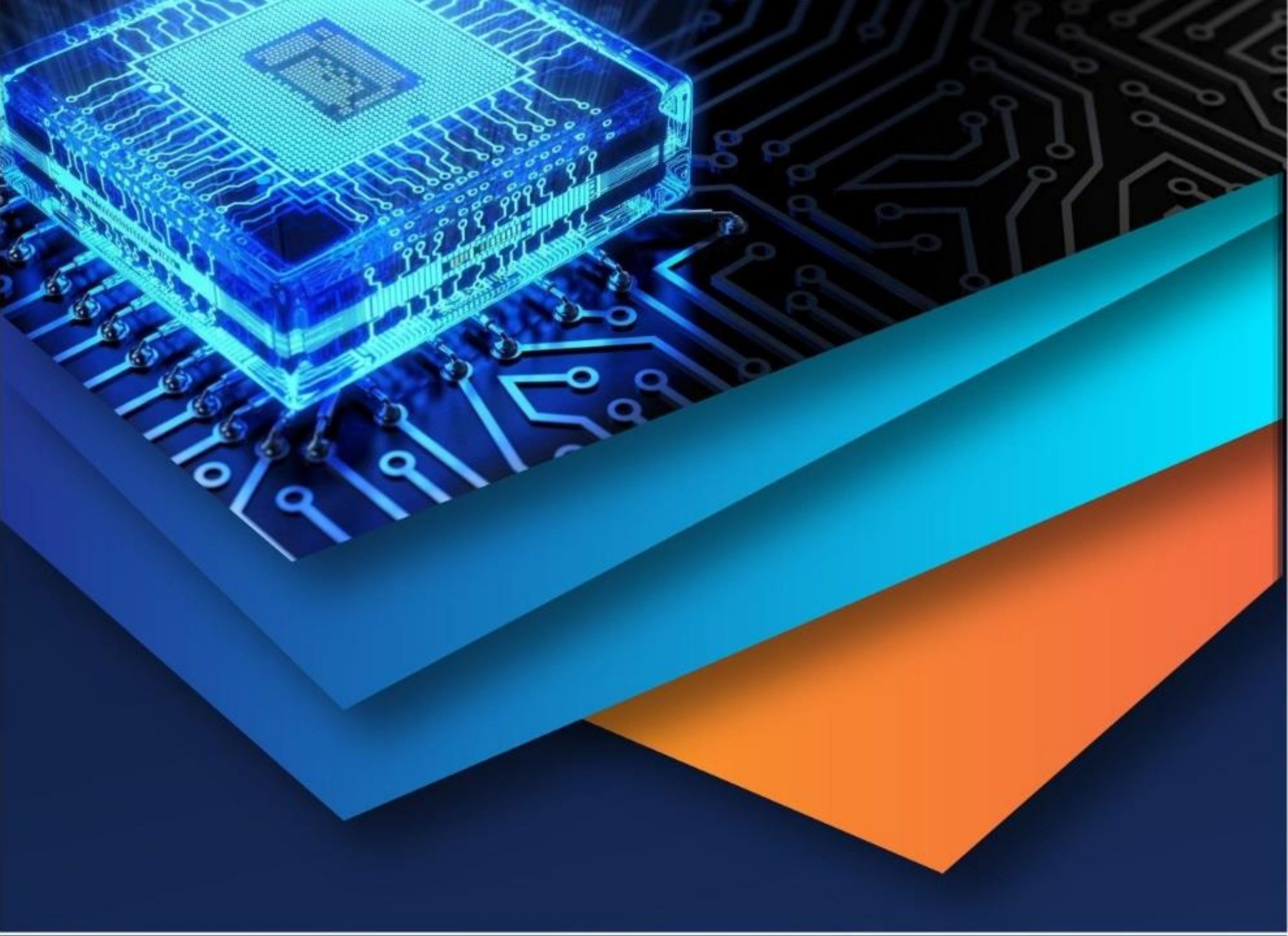
[16] Jiang, Xia, and Tracy Camp, "An efficient location server for an ad hoc network", .Colorado School Mines, Golden, CO, Tech. Rep., MCS-03-06 (2003).

[17] Nilima Walde, Sunita Barve, "A Study: On Routing Schemes in Cognitive Radio Network", (2013) Vol. 2, Issue 8, August.

[18] N.Brahmi, M. Boussedjra, J. Mouzna, A K.V. Cornelio and M.M. Manohara, "A Improved Map based location service for vehicular adhoc network" 2010 IEEE 6th International conference on wireless and mobile computing, networking and communication.

[19] Selvakanmani, S., and M. Sumathi., "A Review of routing protocols for mobile cognitive radio ad hoc networks." arXiv preprint arXiv:1207.5734. (2012)

IJRASET: ISSN: 2321-9653



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)