Annals of R.S.C.B., ISSN:1583-6258, Vol. 25, Issue 4, 2021, Pages. 11294 - 11304
Received 05 March 2021; Accepted 01 April 2021.

An Opportunistic Channel Accessing Strategy over Cognitive Radio Network using Game Theory Logic

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Abstract

Game Theory assisted Cognitive Radio Network (CRN) are under major concentration now-a-days to deal with spectrum allocation and energy utilization problems. In present situations, lots of channel accessing methodologies are available to handle successful communication between sending and receiving units but the distribution of channels for Secondary Users (SUs) are doubtful. Due to lack of priority and energy allocation level, Secondary Users are facing several issues regarding communication from one end to other end. In general the licensed Primary Users (PUs) have sufficient bandwidth and associated energy levels for communication; in case of any energy or bandwidth related deficiencies, the Secondary Users need to tolerate the communication level to provide sufficient resources to the licensed PUs to complete their communication at acceptable levels.

This paper introduces a new methodology called Game Theory enabled Opportunistic Channel Accessing Strategy (GTOCAS) over Cognitive Radio Network platform to provide a sufficient support to both Primary and Secondary Users to achieve the communication in balanced and successful fashion. The game theoretic model analyzes the available bandwidth of active nodes while both communications enabled and idle nodes are present in the network environment. The scenario of communication mentioned relates both licensed Primary Users as well as Secondary Users. The Primary User communication model is standard according to the traditional laws but the Secondary User communication model is altered with respect to the opportunistic channel allocation strategy by means of identifying the inactive nodes in the network environment. Such nodes are used as alternatives instead of utilizing the energy levels and bandwidth from Secondary Users, in case of insufficiency for Primary Users. This kind of alternate routing model gives proper efficiency to manage both Primary Users and the Secondary Users in the reliable state and manage the communication strategies far better compared to the classical routing strategies. The proposed approach of this paper ’GTOCAS’ assures improvements in efficiency, throughput, energy utilization, delay management and network lifetime improvements. All specified improvements are shown with relevant results in this paper.

Keywords— Game Theory, Opportunistic Channel Accessing, GTOCAS, Cognitive Radio Network, CRN, Energy Efficiency

I. INTRODUCTION

The telecom technology and the associated industries are rising quickly and is serving mobile phones anywhere, everywhere and anywhere. Globally, the percentage of, internet users will grow around 45% to 59% by 2022 [4].

The following figure, Fig.1 also shows the increasing patterns of various innovations between 2018 and 2025. Presently the communication industry is facing the issue of intensity

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shortage for modern digital technologies and Smartphone users. The opportunistic channel access in the Cognitive Radio-Network promotes the proper use of the spectrum and eliminates spectrum scarcity problems [5][6].

A broad literature focused on optimal control based game theoretic approach has been addressed but there are still numerous unresolved complexities. The first is the propagation context during the implementation of the algorithm and the second is the sharing of comprehensive environmental information between SUs. A significant quantity of energy and several other network metrics such as bandwidth, time to access and exchange this information on the environment is lost and this is not possible in reality as well. Cognitive Radio based network environment is a powerful communication medium, in which it provides an efficient way of transmission and reception strategies to provide a reliable communication between transmitter and receiver entities [1]. The Cognitive Radio environment provides a fastest and reliable wireless communication services with respect to dynamic channel allocation paradigm, in which the licensed Primary User has a highest priority and the Secondary User has a normal privilege to access the communication channel [2][3].

A noteworthy distinction from conventional wireless networks between a Cognitive-Radio-Network is that users must be mindful of the complex environment and change their operational parameters depending on the evolutionary processes and other network users. Traditional methods for resource management and sharing typically assume, however, that all network users operate in a static environment unconditionally and are thus not important to a Cognitive-Radio-Network.

Users are smart and able to observe, learn and act in such a CR modeled Network to automate their performance. If they adhere to a variety of institutions and follow various objectives, for example to contend for such an open, unlicensed frequency, full cooperation behaviors. Typically, clients can only collaborate with the others if they will gain more from cooperation. Furthermore, because of the unstable and transmitted existence of data transmission, consumer versatility and complex topology including network variance, the ambient broadcasting landscape continues to be evolving.

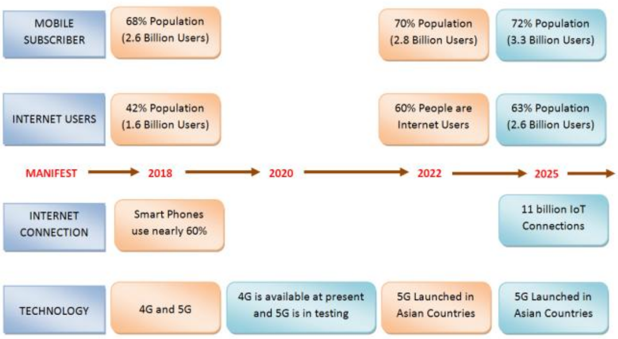

Fig. 1: Technology Development Manifest Chart with respect to Asian Countries

Even a minor shift in the transmission medium can in conventional wireless channels cause a central server to reallocate the frequency bands that lead to a lot of overhead communication. Naturally, to address abovementioned hurdles, gaming theory is becoming a useful aspect for the research, modeling, analysis and functional, self-implementing, massively parallel frequency band sharing systems. Amplitude modulation that analyses the strong alliances of many decision-makers is game theory. Its function is similar to that same publication, by Von Neumann et al., of the book

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Theories of Games-and Economic-Behavior in 1944, which included a method to find common approaches for two person zero sum games, and laid the cornerstone of the theory of games. At the end of the 1940, competitive gaming theory emerged, analyzing viable resolutions for categories of individuals, provided they could work together to strengthen their outcomes in a game. In the mid-1950s, Nash released a new principle called Nash balance to describe players' mutually coherent strategies. This definition is more general than that of VonNeumann et al., as it applies to non-zero summary games and represents a radical shift forward advancement of non cooperative gaming theory.

As during 1950, most significant issues of game theoretic logics such as core concepts, comprehensive games, and repetitive games as well as the proposed numerical value were created. In the 1960s, enhancement of comprehensive knowledge of Nash equilibrium principles including Bayesian Game Theory model were suggested. In the 1970, Smith introduced development of cognitive psychology to genetics, i.e. the influence of new theory of games, at which time the conceptions of proportional balance through patently obvious scheme were proposed by Aumann. Starting in the 1960, theoreticians began investigating the new game theory branch, shape optimization theory, which focuses on the resolution principles for a private knowledge game. A Game theoretic model has now become widely regarded as a significant method of assessing collaboration as well as rivalry involving entities in many areas, like social science, genetics, technology, sociology, international diplomacy, systems engineering, etc.

In a Cognitive Radio environment, the robust and dynamic decision making process enables the user to intelligently select the channels for communication between transmission and reception entities. The operating metrics of the Cognitive-Radio-Network belongs to the spectrum density and the channel occupancy level. The game theory logics are applied to the CRN to improve the channel selection process efficiently with spectrum sensing nature and the game theory principles allow the cognitive network to operate dynamically without any interference.

In a game theoretical context it is essential to research cognitive radio networks. First, by modeling spectrum resources allocation between Primary Users and Secondary Users as like a game logic, the conduct and actions of network users can be analyzed in a formalized game structure that completely utilizes the technical improvements in probability theory. Secondly, game theoretic logic offers us some optimal conditions for the problem of dynamic spectrum. In particular, spectrum efficiency is typically a multi-target iterative method that is quite difficult to evaluate and overcome. Game theory offers us well-defined balance parameters to assess game effectiveness in different type of game configurations. Thirdly, non cooperative play analysis, including some of the key branches of game theoretic logic, facilitates us to use only local knowledge to draw efficient, centralized frameworks for flexible spectrum access. This is hugely valuable if centralization is not appropriate or modular self organized methods are needed

II. SYSTEM MODEL

In this paper, a novel Cognitive Radio Network operation are handled by means of game theory logic with advanced channel optimization strategies, in which the routing scheme follows opportunistic model to elect the channel and transmit the data packets accordingly. The proposed approach is called as Game Theory enabled Opportunistic Channel Accessing Strategy, in which it dynamically elects the channel with respect to game strategies based on CRN metrics. In this summary, we assume X number of Secondary Users and Y number of Licensed Channels' for opportunistic channel accessing nature. Rx is the transmission data-rate, in which it will be defined such as $1 <= x <= Y$ and $1 <= Y <= X$. It is assumed that each medium maintains a similar network throughput to every Secondary Users [15]. There is another presumption that the Primary User uses approved channels in a slotted way and their

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acts do not depend on streams and targets. In this job, the following conclusions can be drawn:

1) The Channel Sensing information and the availability ratios are not defined yet but all are static.

2) Secondary Users count is unknown.

3) There is no information sharing facility between Secondary Users

The following figure, Fig-2 shows the proposed Opportunistic model of dynamic channel selection with respect to both time constrain and the frequency metrics. In which the figure illustrates the channel and spectrum usage scenario with active spectrum range and the spectrum holes while communication. This scenario is shown properly in graphical manner with respect to time, energy and the frequency metrics The remaining sections of this paper describe regarding Related Study over section 2, further section of Section 3 illustrates the proposed system methodologies in detail with proper algorithm flow and the Section 4 illustrates the Result and Discussion portion of the paper and the final section, Section 5 illustrates the concept of Conclusion and Future Scope of the proposed paper. These all will be explained in detail over the further section summaries.

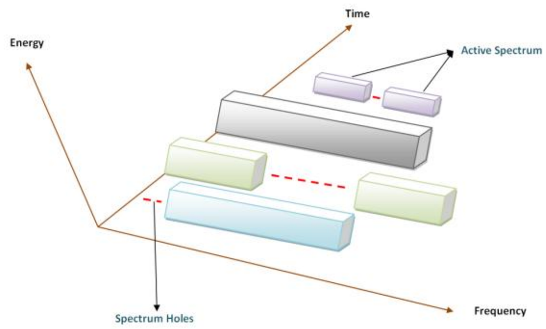

Fig. 2: Opportunistic Channel Allocation Model

III. RELATED WORK

Bing-Ning et al., 2020 [7] proposed a paper related to Cognitive-Radio-Network resource allocation principles with respect to multiple users based on Stackelberg game theory. In this paper [7], the authors illustrated such as: for multi-user cognitive radio networks, a resource allocations at a sensor based interference price are considered where the predominant base station governs Secondary Users communication by regulating interference capacity. The Secondary User activates wireless communication on the basis of a sensing decision, and then the PBS calculates the interfering cost depends on the interference power of each Secondary User. Stackelberg is designed to jointly generate the maximum PBS revenue and to optimize the distribution of resources to maximize the propagation benefit for Secondary Users. Two realistic Cognitive Radio control structures are examined: sensor dependent adjusting the frequency and deceitful access to spectrum. For each case, under two pricing systems, consistent interruption costing and non uniform impact pricing, the resources compensation policy are investigated and in particular, the Stackelberg equilibriums of the proposed games are characterized and the distributed sensing dependent interference pricing algorithm is proposed for the non uniform interfere costing situation, in accordance with different channel status information. Methods were compared to show the usefulness of the implemented game methodology across various costing schemes [7].

Liqun-Fu et al., 2020 [8] proposed a paper related to Cognitive-Radio-Network based energy efficiency management with respect to resource sharing features and battery

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management schemes. In this paper [8], the authors illustrated such as the problem of energy minimization is examined with a cognitive capacity collection network, wherein Secondary User communicate through Device-to-Device transmissions with Cognitive Radio routers without Cognitive-Radio capabilities and Cognitive-Radio device that connects with Base stations.

Unlike conventional Device-to-Device networks that share a cellular transmission resource on another cell, that Device to Device connections are considered to share a neighboring cells edge router wireless frequency band. An inter cell hand shaken mechanism is suggested in important to maintain that transmissions through SUs don't really influence cellular user transmissions in neighboring cells. As a mixed integer, the resource minimization problem is formulated for Secondary Users. It is divided into two nesting sub problems in order to overcome these problems: a sub-problem for transmitting power optimization and a Cognitive-Radio router.

During the first type of problem it is proven convex and can therefore be resolved efficiently. For the following sub-problem, it suggests a theoretical two tier methodology [8] to the theoretical solution of the game. Computational results demonstrate that the proposed implementations can increase performance significantly. Using Cognitive-Radio routers/neighbor network services, average energy usage for SUs could be saved by about 30–37 percentage.

ZhouSu et al., 2020 [9] proposed a paper related to Q Learning based frequency allocation for wireless service data distribution. In this paper [9], the authors illustrated such as Wireless Communications and mobile technologies are becoming the valuable reference for Smartphone subscribers to access the Internet for their download of contents through expanding wireless networking technology.

However, sending information to many Smartphone owners creates unnecessary interruption as well as data transmission loading. In addition, demands for rich content across mobile networks have been growing, leading to severe traffic loads in the networks. To boost mobile users' experience quality, this paper first proposes a Q-learning-based mobile network spectrum access system to provide mobile users with the right spectrum and optimize the network throughput. Secondly, in line with the optimum spectrum decision, edge node, device-to-device pair and mobile consumer content distribution scheme.

Then this approach [9] structured the data distribution process as a non cooperative Markov decision process between virtual machines, Device-to-Device groups and Smartphone consumers to boost digital distribution performance. Then, the algorithm for digital distribution technique derives with respect to Stackelberg balance. Those players can get the full benefit again from game on the basis of the optimum strategy. Hopefully soon, this approach conducting analytical and technical to evaluate the project's results. Resulting emulations [9] show that the proposed technology will jointly optimize mobile network throughput and increase the quality of mobile users over traditional systems.

Shiwei-Lai et al., 2020 [10] proposed a paper related to Smart and Secured Wireless Communication Model for Multiple Primary Transmittal Networks. In this paper [10], the authors illustrated such as an intelligent safe communication system for various systemic transmitting power cognitive networks, where SU send confidential data to a supplementary nodes that is endangered by a supplementary offender. The supplementary channels restrict the transmission capacity between numerous scales to preserve the quality of service to the frequency bands.

In the conventional Q learning framework, the offender can operate in an eavesdropper, spoofing, jamming, or silent mode. And from the other end, the machine can pick the transmitting power level from many to suppress the smart intruder, which can be seen as the status of the Q learning system. We then formulate firstly this safe comprehension issue as a

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constant secured data game between the key links and the attacker using Nash equilibrium and then use the Q learning technique to pick the transmitted level of electricity. Performance parameters are finally shown to check that the proposed experiments in this article [10] will successfully suppress the smart attacker.

IV. PROPOSED METHODOLOGY

In this paper, a new optimization assisted Opportunistic Routing Algorithm is designed for managing the operations over Cognitive-Radio-Network, in which it is called as Game Theory enabled Opportunistic Channel Accessing Strategy (GTOCAS). This approach provides a constant support to both Primary Users and the Secondary Users. The spectrum allocation and channel accessing is common for Primary User and the Secondary User, in which it is achieved by means of providing the sufficient bandwidth and energy to the Secondary Users by means of sustaining the Game Theory logic associated with the proposed approach.

The proposed approach is designed based on the logic of dynamic decision making and channel utilization logic. So, that the nodes presented into the Cognitive-Radio-Network environment find out the idle nodes presented into the network environment while initiate the communication model as well as the transmitter and receiver entities belonging to the licensed channel faces any bandwidth or energy related issues, instead of electing the Secondary User as a recovery node the identified idle nodes are elected as a supplementary nodes to provide the required bandwidth and associated energy levels to accomplish the successful communication between entities.

Based on this methodology the communication processes going on without any failures or interference between transmitter and receiver unit. We've covered non cooperative frequency cooperation, spectrum exchange using equilibrium level principles, and interactive power allocation games in the above discussion of game theory logics has been applied to wireless networks networking. In general, the players in each of these games are believed to be playing a certain concert game at all times, suggesting that the game as well as the players' approaches remain unaffected by the network's present incarnation

However, in a cognitive radio network, where bandwidth preferences and also the underlying radio climate change over time, this is not the case. The hypothesis of dynamical games is a closer option for researching the collaboration as well as competitive behaviors of cognitive radio users in a complex environment. The optimized game logic of each player is obtained by means of the following epochs;

$$V_X \Leftarrow \frac{\Delta Max(x)}{\Delta x(A1)} + \frac{\Delta Max(x)}{\Delta x(A2)} + ... + \frac{\Delta Max(x)}{\Delta x(An)} \quad ..(1)$$

$$Q_{S(A1),S(A2),...,S(An)} \leftarrow \Sigma \lambda S.Max(x) \quad ..(2)$$

Where A1,A2,...,An defines the nodes initiation profile, $\lambda S{:}Max(x)$ denotes the data transmission probability initiated from idle state nodes x, when players/nodes starts from terminal λ and QS(A1),S(A2),. . . ,S(An) indicates the linear programming model logic of node positions in the Cognitive Radio environment. The following algorithm illustrates the logical flow of the proposed approach with proper specifications.

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TABLE I: Algorithm: Game Theory enabled Opportunistic Channel Accessing Strategy

Input	Number of Nodes, Tx Power, Rx Power and Environment Size
Outp ut	Allocated Channel Size, Node Strength, Energy Level of Nodes, Success Ratio and Failure Ratio.
1	Initialize the traffic associations with CBR traffic estimator.
2	Define parameters used to initiate routing configurations
3	Specify the Packet size and the data interval rate
4	Identify the node positions and the number of Primary Users and the number of Secondary Users
5	Estimate the idle node positions in the simulation environment
6	Accumulate the data packets with the associated spectrum levels of the participant nodes and the simulation area
7	Calculate the distance specifications between neighbor nodes and the transceivers
8	Define the path between the transceivers as well as the neighbor node specifications are dependent on licensed and unlicensed channels
9	Identify the primary users' sufficiency for completing the transmission between entities
10	Analyze the insufficient bandwidth and energy ratios of the Primary user
11	Identify the nearby idle node to provide the recovery options to make the licensed node to properly communicate between entities without any SUs dependency
12	Analyze the channel metrics and spectrum ratio used for communication and maintain that into the trace file for future references
13	Return the Success ratio count and the Failure ratio count of the entire transmission

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V. PROPOSED METHODOLOGY

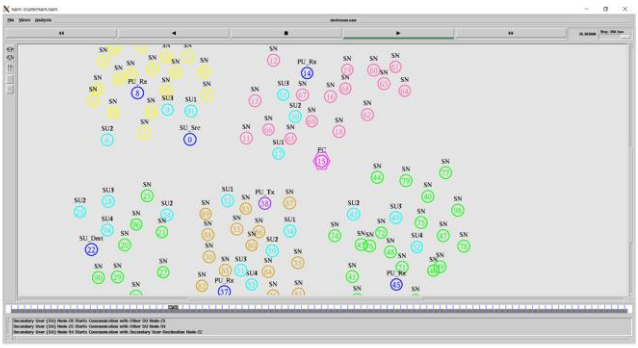
The proposed implementation is done by using the powerful network simulation tool called Network Simulator, in which the nodes are configured by using the routing protocol called Dynamic Source Routing, which will be more flexible to make the dynamic routing definitions as well as the robust path metrics are preserved with the help of such routing protocol.

In which the proposed algorithm called Game Theory enabled Opportunistic Channel Accessing Strategy is associated with the Dynamic Source Routing protocol to accomplish successful data transmission between transceivers. By implementing this proposed approach, the CRN can assure the following metrics such as improved packet delivery ratio, improved network throughput level and the reduced end-to-end delay as well as these metrics is clearly proved with following graphical results in clear manner. The following table, Table-1 illustrates the input parameters of the simulation.

TABLE II: Simulation Parameters

Parameters	**Value**
Channel Type	Channel / WirelessChannel
Propagation	TwoRayGround
MAC Specification	Mac/802.11
Layer	Link Layer
Antenna Type	OmniAntenna
Tx Strength	1000bps
Rx Strength	1500bps
Idle Node Strength	1000bps
Cooperative Detection Probability	40-50%
Packet Size	1000-2000 bps
Primary User Maximum TX Power	1000-2000 bps
Secondary User Maximum TX Power	500-1000 bps
Average Delay	10-50 ns

Fig-3 illustrates the overall network formation and the total communication scenario of the proposed approach network structure as well as the simulation view is displayed on the figure with clear graphical manner.



(a)

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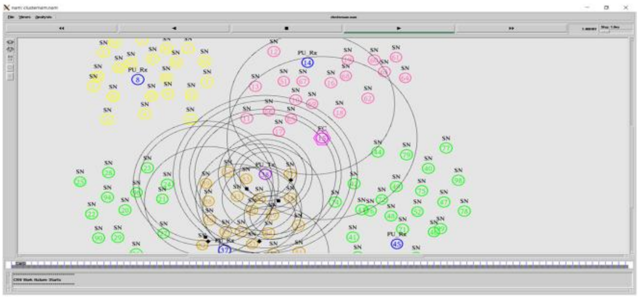

(b)

Fig. 3: Simulation Model

Fig-4 illustrates the throughput ratio of the proposed approach, in which the classical AODV model is considered for the comparative analysis of the proposed model DSR and the resulting perception clearly illustrates the proposed model of GTOCAS with Dynamic Source Routing improves the throughput range in higher manner.

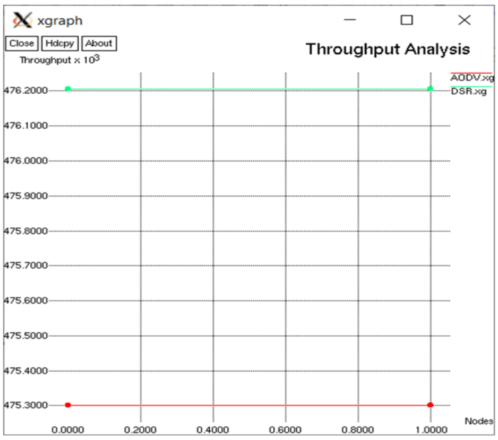

Fig. 4: Throughput Analysis

Fig-5 illustrates the packet delivery ratio estimation of the proposed approach, in which the classical AODV routing protocol is taken for comparison with the proposed GTOCAS with DSR model and the resulting scenario shows the proposed approach is far better than the classical model.

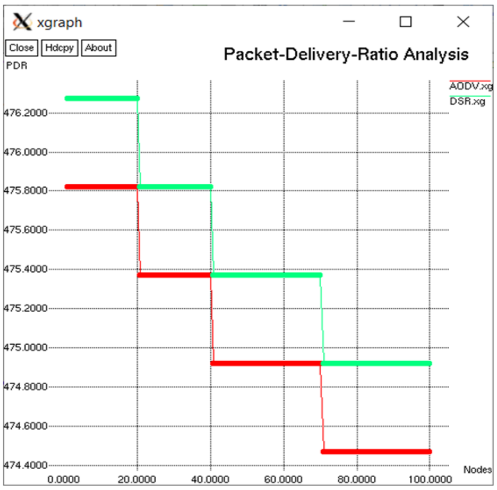

Fig. 5: Packet Delivery Ratio Analysis

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Fig-6 illustrates the overall Cognitive Radio Network end to end delay analysis process, in which the classical AODV routing protocol is compared with the proposed Dynamic Source Routing model.

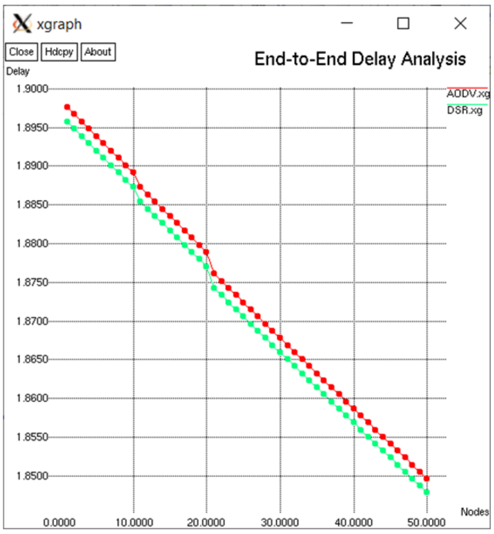

Fig. 6: End to End Delay Analysis

VI. PROPOSED METHODOLOGY

Cognitive Radio Network, the growing usage of digital data and the internet necessitates a paradigm shift toward higher frequency as well as channel accessibility. In this paper, we looked at how to use Game Theoretic logic to solve the issue of data transmission in Cognitive Radio Network because when climatic factors are uncertain. To begin, we look into a channel estimation algorithm, called Game Theory enabled Opportunistic Channel Accessing Strategy is introduced to improve the system's throughput and reach equilibrium points.

Then we look at a stochastic routing protocol called Dynamic Source Routing (DSR) in association with the proposed model called GTOCAS, in which Secondary Users take into account their previous action reward and adjust their output to equilibrium points. Prior knowledge of the Secondary Users statics and channel availability is not needed for the proposed algorithm. The suggested methodology and its performance demonstrate a higher level of operation and experience.

Finally, we compare the device throughput of various channels with respect to secondary user count as well as the logic of classical model AODV. The results show that as the quality of proposed approach GTOCAS with DSR increases. This efficient use of resources aids Secondary Users maximum throughput balancing across networks and reduces the likelihood of Secondary Users being blocked. The work can further be enhanced by means of adding some deep learning techniques to train the communication channel with respect to the success and failure probability structures, so that the communication channel selection process is far better and the resulting performance will also be improved

REFERENCES

[1] J. Mitola, Cognitive radio: an integrated agent architecture for software defined radio, Ph.D. Dissertation, KTH Royal Institute of Technology, Stockholm, Sweden, 2000

[2] S. Haykin, Cognitive radio: brain-empowered wireless communications, IEEE Journal on Selected Areas in Communications 23 (2) (2005) 201–220.

[3] I. Akyildiz, W. Lee, M. Vuran, S. Mohanty, NeXt generation/dynamic spectrum access/cognitive radio wireless networks: a survey, Computer Networks 50 (13) (2006) 2127–2159.

[4] C. V. networking Index, “Forecast and methodology, 2016-2021, white paper,” San Jose, CA, USA, 2016.

[5] R. Checi´nski, A. Kaszuba-Checi´nska, M. Kryk, J. Łopatka, K. Malon, and P. Skokowski, “Performance analysis of the Cognitive-Radio-Network with opportunistic spectrum access,” International Journal of Electronics and Telecommunications, vol. 64, no. 1, pp. 51–56, 2018.

[6] M. Gupta and K. Kumar, “Progression on spectrum sensing for Cognitive-Radio-Networks: A survey, classification, challenges and future research issues,” Journal of Network and Computer Applications, 2019.

[7] Bing Ning, Gangcan Sun, Jianjun Li, Aihua Zhang, Wanming Hao and Shouyi Yang, "Resource Allocation in Multi-User Cognitive Radio Network With Stackelberg Game", IEEE Access, 2020

[8] Shijun Lin, Haichuan Ding, Liqun Fu, Yuguang Fang and Jianghong Shi, "Energy Minimization of Multi-Cell Cognitive Capacity Harvesting Networks With Neighbor Resource Sharing", IEEE Transactions on Wireless Communications, 2020

[9] Zhou Su, Minghui Dai, Qichao Xu, Ruidong Li and Shu Fu, "Q-Learning-Based Spectrum Access for Content Delivery in Mobile Networks", IEEE Transactions on Cognitive Communications and Networking, 2020

[10] Shiwei Lai, Junjuan Xia, Dan Zou and Liseng Fan, "Intelligent Secure Communication for Cognitive Networks With Multiple Primary Transmit Power", IEEE Access, 2020.