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A Review of Load Balancing Schemes for Cognitive Radio Networks

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Abstract- Wireless networks, one of the most growing fields in research area suffers from a lot of problems. Wireless networks deals with connecting devices in a wireless fashion. These networks are usually deployed and managed with the help of radio communication. Wireless networks offers a lot of advantages over traditional wired networks such as flexibility, durability, less costly than wired networks, ease of installation etc. but at the same time it suffers from various problems like overloading of traffic, compatibility with all the devices etc. Our work concentrates on the problem of over loaded traffic on the wireless networks which is composed of nodes. These nodes handle the traffic and are usually responsible for the proper functioning of the whole network. Sometime even if once single node goes down or gets over loaded, then the performance of the whole network is degraded. After deployment of the wireless network there is a constant need to monitor the network so that this condition does not arise as it will degrade the performance of the network. Our work focus on the automatic monitoring of the networks so that the load will always stay balanced among various nodes. This will help in increasing the overall performance of the network. This scenario will be simulated in ns2, a networking simulator. We will also use cognitive radio networks for this purpose since they are better known as intelligent networks which means they can automatically detect available channels in a wireless spectrum and change transmission parameters enabling more communications to run concurrently and also improve radio operating behavior.

I. Introduction

Spectrum is a very limited product and due to the spectrum insufficiency facing by the wireless based service providers lead to high overcrowding stages. The main reason that leads to useless utilization of the radio spectrum is the licensing system itself[1]. If the allocated radio spectrum is not used by primary users (PU) then it also cannot be utilized by Secondary Users (SU). As a result, wireless systems are intended to work only on a devoted band of spectrum for fixed and rigid allocations. It cannot change the band as changing the surroundings. As illustration if one channel of spectrum band is greatly used, the wireless system cannot alter to work on any other more lightly used band.

Cognitive Radio (CR) is the category of wireless system in which either an entire network or a single node varies its communication or response parameter to correspond effectively[2]. It avoids obstruction with PU and SU. It is considered to be an intelligent communication system which is sensitive of surrounding atmosphere and uses the techniques to gain knowledge from the surroundings and adjust its internal conditions to arithmetic changes in the arriving RF by creating consequent variation in definite working factors [3].

CR is a structure that senses its equipped electromagnetic surroundings atmosphere and can separately and dynamically change its radio in service factors to update system action such as minimizing obstruction, take advantage of throughput, easiness interoperability. Cognitive ability indicates to the capability of radio technology to sense the data or capture the data from its radio surroundings. The potential cannot be recognized by checking the control in a few frequency band of concern but other refined methods like action decision and autonomous learning are needed to capture spatial variations and the temporal in the radio surroundings and reduce intervention to supplementary users. The SU can take an idle segment of the spectrum. Thus the SU should capture their information, check the existing spectrum bands and after that identify the spectrum holes.

A CR is intended to be alert and responsive to alters in its neighboring that makes spectrum sensing an imperative necessity for the understanding of secondary networks. Spectrum sensing method allows SUs to use the vacant spectrum segment adaptively to the radio atmosphere. The authorized access of spectrum is usually defined by owner of spectrum; transmit power, frequency, space and the license duration. In general, a license is allocated to one licensee and the use of band by this owner must have the requirement e.g. highest power of transmit, base station location. In present spectrum licensing system, the license cannot vary the application or giving the access to another licensee. This restriction causes in low consumption of the frequency spectrum. Spectrum hole is defined as a group of frequencies given to a licensee, except that user is not using the band at exact time and exact geographic location.

Present wireless networks are distinguished by a fixed spectrum allotment strategy where the government organization allots wireless range to license owners on long-standing bases for huge geographical areas. In recent times due to the increment in spectrum requirements, the strategy has suffered with spectrum shortage at definite spectrum bands. On the opposite, a huge part of the allocated spectrum is still used once in a while, leading to underutilization of a considerable quantity of the spectrum. The restricted vacant spectrum and ineffective spectrum consumption make it essential to build up a new communication model to take advantage of the existing wireless spectrum opportunistically. To deal with these serious problems, FCC in recent permitted the use of unlicensed devices in licensed bands. As a result the DSA methods are projected to resolve these current spectrum inadequacy troubles. CR networking is the chief enabling technology for DSA methods which allows clever spectrum alert devices to opportunistically utilize the licensed spectrum bands for transmissions.

Thus Cognitive Radio Network has been projected as an answer to both spectrum inadequacy and spectrum shortage troubles. In this literature we will study about numerous problem based on the irregular natural history of the presented spectrum which makes it more hard to sustain seamless communication in CR cellular network. In this paper we review the existing literature on Cognitive Radio Networks and present a detailed description of some key proposals in the area of load balancing.

II LITERATURE REVIEW

Lee and Akyildiz [1] introduced new network structural design to moderate varied spectrum availability. The authors also developed a combined mobility managing framework to maintain different mobility actions in CRNs which consist of user mobility supervision, inter cell resource allocation and spectrum mobility supervision. This scheme find out a mark cell and band for SUs adaptively reliant on time changing spectrum chances leading to rise in cell ability. In the user mobility supervision method a mobile user choose a suitable handover method so as to decrease a switch over time at the cell edge by taking into consideration spatially various spectrum accessibility. Inter cell resource distribution helps to recover the performance of both mobility management systems by capably sharing spectrum assets with manifold cells. The authors also proposed a spectrum alert mobility managing method for CR cellular networks.

Chang et al. [2] considered a Primary Radio Network that consists of a primary system base station and several primary system mobile stations. Therefore the implementers construct a CRN that consist of a Primary Radio Network with multiple CR-Mobile stations. The authors also proposed a spectrum organization strategy structure which was based on the Vickrey auction so that CR-Mobile stations can fight for utilization of the Primary Radio Network spectrum bands available for opportunistic communication of CR Mobile Stations. Primary Radio Network users are approved inducements at a discounting factor to permit spectrum bands and are being rewarded for probable operating intervention from CR-Mobile Stations, whereas the intervention is controlled under an acceptance level without losing happiness for the Primary System-Mobile Stations.

Adam et al. [3] proposed a modified cognitive radio spectrum sharing algorithm based on the Hungarian algorithm. The allocation problem divided into two parts i.e. the first part of problem occurs when all channels satisfy the minimum quality of service for all secondary users and the second problem is when one or more of the channels fails to meet the necessities. The Hungarian algorithm is applied for first problem to provide an optimal spectrum sharing solution between the secondary users while guaranteeing the different quality of service requested by each one. The researchers proposed algorithm for the second problem to find the optimal spectrum allocation for the set of channels which meet the quality of service requirements of cognitive users.

Zhu et al. [4] presented Markov chain study for spectrum access in licensed bands for CR. The authors derived compelled termination probability, traffic throughput and blocking probability. The authors also proposed a channel reservation method for CR spectrum handover. The method permits the tradeoff between forced killing and blocking according to QOS necessities. The results shows that their method can greatly decrease enforced killing probability at a small enhance in blocking probability.

Akyildiz et al. [5] described coming generation DSA cognitive radio wireless networks. The implementers discussed about the fixed spectrum assignment strategy. Though, a huge part of the allocated spectrum is used once in a while and geographical variations in the utilization of allocated spectrum ranges from 14% to 84% with a high variation in time. The restricted available spectrum and the inadequacy in the spectrum usage demand a new communication model to utilize the available wireless spectrum. This new networking model is termed as Next Generation (xG) Networks. The authors explained new functionalities and present research dares of the xG networks. More particularly the authors provided a short summary of the CR technology and the xG network construction. The authors investigated control of these procedures on the performance of the upper layer routing and transport protocols. The open research problems in these fields are also highlighted. The authors also discussed the cross layer devise challenges in xG networks.

Damljanovic [6] observes spectrum mobility necessities and the answers appropriate for use in CRNs. The necessities for mobility organization tasks in CRNs are described together with mobility organization protocol design projected to fulfill for seamless processes across diverse frequency bands and different radio entree technologies requirements. To assure mobility management necessities in CRNs, cross layer optimization and collaboration within a CR protocol stack is needed.

Wang et al. [7] explored the problem whose objective is to improve the channel efficiency related to detection time selection. The authors formulated the problem as an optimization problem. So they projected a numerical optimization algorithm to obtain the numerical answer to the difficulty. The results show that the maximum channel effectiveness can be achieved by the optimization of the recognition time. In CR systems SUs have to identify the channel from time to time during their data communication to make a decision whether the channel is free in order to keep away from undesirable interventions to PUs. The period of the finding process in a rotation will affect the channel effectiveness of the SU.

Zhang [8] proposed four metrics to distinguish short-term and long-term load balancing performance, link maintenance probability, the number of spectrum handover, switching delay and non-completion probability. The telegraphic values are relaxed to follow a general distribution function, which will facilitate a wide applicability and hypothetical importance of the derived formulae. The authors investigated both opportunistic and bargained spectrum access policies. The authors presented numerical examples to demonstrate the performance trade-off and the communication between the PUs and the SUs. The authors also discussed effect of key values on load balancing.

Wang et al. [9] presented a methodical structure to devise system values for load-balancing multiuser spectrum decision methods in CRNs. The authors proposed a spectrum decision analytical approach which is based on the preemptive restart priority M/G/1 queuing theory to calculate the special effects of multiple disruptions from the PUs during each link association, the sensing mistakes such as false alarm and missed detection of the SUs and the varied channel capacity. The authors derived the best possible number of candidate channels and the most favorable channel selection possibility for the sensing-based and the probability based decision method with the purpose of reducing the overall system time of the SUs. The authors find that the probability-based method can defer a shorter overall system time compared to the sensing based scheme when the traffic loads of the SU is low, whereas the sensing based method presents improved in the situation of large traffic loads.

Chronopoulos et al. [10] proposed spectrum load balancing procedure based on the non-cooperative load balancing trouble in computers and is applied to a CR system. The proposed approach support QOS in the occurrence of other opposing cognitive networks. The approach is estimated via simulations and compared with the offered spectrum load smoothing algorithm. The results shows that the new approach is more efficient than existing spectrum load smoothing approach that based on non-cooperative game theory and it gives Nash equilibrium answer which is most favorable for all users.
Talat et al. [11] proposed a load balancing spectrum decision method for CR networks with asymmetrical bandwidth. The authors used the concept of the delay bandwidth product to select appropriate unequal width channels. A cognitive radio system examines a wide spectrum to discover vacant channels. One of the key dares in using these temporarily vacant spectrums is that bandwidths of the existing spectrums are not equal. In addition, the problem of competition for a single channel by many secondary users must be resolved. The proposed DB-based spectrum decision can advance the overall system throughput by up to 50% compared with other offered imbalanced bandwidth spectrum decision methods.
Awada et al. [12] described the problem of overloaded cells where each overloaded cell will offload and an under loaded cell will accept the offloaded load. Author treats this problem as game where each player will try to maximize its output. The players (ie the cells) work in time. First the under loaded cells signals to the overloaded cell the amount of traffic they are willing to accept. When all the values are received by the overloaded cell, it then decides the amount of load to offload. The payoff of each player is the number of satisfied users in the cell. More the number of satisfied users, more capacity usage and hence more income resulting from data rate charging.

Sharma et al. [13] described various techniques for load balancing in networks. Some load balancing techniques are based on dynamically changing the size of the cellular coverage area using smart base station antennas, according to the geographical traffic distribution. These schemes can be categorized as Geographic load balance schemes. A comparative study of various load balancing techniques has been reviewed by the author. A popular scheme is load balancing by using artificial intelligence. This scheme increases the usage capacity of the network even when the cells act in non-cooperative way.

Yang et al. [14] analyzed and modeled the per node delay and the path delay in multi hop Cognitive Radio Network. They proposed a framework of local coordination based routing and spectrum assignment, which consists of one protocol for routing path and one scheme for neighborhood region. They also proposed a on-demand Routing and Spectrum Assignment Protocol to exchange the local spectrum information and interact with multi-frequency scheduling in each node. A local coordination scheme is presented to support flow redirection at an intersecting node and distribute heavy multi-frequency workload to its neighborhood. They proved the correctness and effectiveness of the protocol by thorough simulations and find that
Yucek et al. [15] survey spectrum sensing methodologies for cognitive radio. They studied various aspects of spectrum sensing problem from a cognitive radio perspective and multi-dimensional spectrum sensing concept is introduced. They reviewed challenges associated with spectrum sensing and enabling spectrum sensing methods. External sensing algorithms and other alternative sensing methods are discussed. Furthermore, statistical modeling of network traffic and utilization of these models for prediction of primary user behavior is studied.
Youssef et al. [16] survey the state-of-the art routing metrics for cognitive radio networks. They started by listing the challenges that have to be addressed in designing a good routing metric for cognitive radio

networks. Then they provide taxonomy of the different metrics and a survey of the way used in different routing protocols. They also presented a case study to compare different classes of metrics. After that they discussed how to combine individual routing metrics to obtain a global one.

Wang et al. [17] presented an analytical framework to evaluate the latency performance of connection-based spectrum handoffs in cognitive radio networks. During the transmission period of a secondary connection, multiple interruptions from the primary users result in multiple spectrum handoffs and the need of predetermining a set of target channels for spectrum handoffs. To quantify the effects of channel obsolete issue on the target channel predetermination, they considered the three key design features: general service time distribution of the primary and secondary connections, different operating channels in multiple handoffs and queuing delay due to channel contention from multiple secondary connections. They also proposed the preemptive resume priority (PRP) M/G/1 queuing network model to characterize the spectrum usage behaviors with all the three design features.

III. CONCLUSION

From the extensive survey, we have concluded that CRN is well known concept for preventing the wastage of spectrum by allocating fixed and rigid spectrum through load balancing. Literature reviews have shown that the static spectrum assignment leads to disorganized use of spectrum. Since most segment of the spectrum remain under-utilized or idle most of the time. To overcome this inefficient use of spectrum the CR concept comes into play. The important aspect of dynamic spectrum distribution by the load balancing scheme is a dependable mechanism for providing fair and well organized spectrum allotment or scheduling answers between both users.

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