A Review of Load Balancing Spectrum Decision for Cognitive Radio Network

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***Abstract* - The scarcity of spectrum is increasing day by day due to the spectrum scarcity faced by the wireless based service providers led to high congestion levels. The main reason that leads to inefficient utilization of the radio spectrum is the spectrum licensing system itself. Due to this static and rigid allocation, wireless systems have to work only on a dedicated band of spectrum and cannot change the transmission band as changing the environment. To address these critical problems, the FCC recently approved the use of unlicensed devices in licensed bands. Consequently, dynamic spectrum access techniques based on Load balancing are proposed to solve these current spectrum inefficiency problems. In Cognitive Radio Network (CRN) during the transmission period of a secondary connection, multiple and frequent requirement from the primary users result in multiple channel requests and the need of determining a set of target channels for spectrum utilization. In this work a suitable load balancing scheme has been proposed whose aim is to help cognitive user to find suitable channel in case of overload so as to enable the resumption of unfinished transmission as quickly as possible. The simulation results of the proposed scheme show that the model works well in reducing channel overload thereby reducing delay time in Cognitive Radio Networks.**

I. INTRODUCTION

Load balancing is a computer networking method for distributing workloads across multiple computers or a computer cluster, network links, central processing units, disk drives, or other resources. Successful load balancing optimizes resource use, maximizes throughput, minimizes response time, and avoids overload. Using multiple components with load balancing instead of a single component may increase reliability through redundancy. Load balancing is usually provided by dedicated software or hardware, such as a multilayer switch or a Domain Name System server Process.

Cognitive radio networks are smart radio networks that can be adjusted automatically during the network running time. These networks have the capability of dynamically changing the behavior based on the network conditions. These networks usually receive the commands from the operators and based in the received commands they change their configuration parameter. The parameter(s) considered in this work are operating frequency. The load will be balanced among various service providers which will be using cognitive networks. The collaboration of smart network with the capabilities of game theory decision making a new load balancing scheme will be proposed.

Intelligence based load balancing technique has recently become a useful tool for modeling and studying interactions between cognitive radios envisioned to operate in future communications systems. Such terminals will have the capability to adapt to the context they operate in, through possibly power and rate control as well as channel selection. Software agents embedded in these terminals will potentially be selfish, meaning they will only try to maximize the throughput/connectivity of the terminal they function for, as opposed to maximizing the welfare (total capacity) of the system they operate in.

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.

II. LITERATURE REVIEW

Sharma et al. [1] 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.

Awada et al. [2] 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.Kim et al. [3] described online bandwidth management algorithms for multimedia cellular networks which try to minimize the maximum available bandwidth among cells in an adaptive manner.

Kim et al. [4] addressed the problem in a non-uniformly distributed traffic demand. Ie a hot cell can borrow a channel from cold cell, but due to this repetitive process the cold cell becomes hot cell after some time. Author has introduced the concept of warm cell to tackle this problem. Xu et al. [5] provided self-optimizing load balancing policies to improve adaptation and robustness of networks. Kolios et al. [6] proposed an efficient load balancing technique for tolerant data services using the mobile relay nodes in cellular networks. Yanmaz et al. [7] proposed a dynamic load balancing scheme iCAR which is used in ad hoc relay stations (ARS's) in the cellular network which helps in balancing the traffic load efficiently and share channels between cells via primary and secondary relaying.

Du et al. [8] gave a detailed overview of geographical load balancing. Performance of the system for non-uniformly distributed call traffic is improved by using smart base station, which dynamically changes cellular coverage size and shapes according to geographic traffic distribution.

Wang et al. [9] presented an analytical framework to design system parameters for load-balancing multiuser spectrum decision schemes in cognitive radio networks. They proposed a spectrum decision analytical model based on the preemptive resume priority M/G/1 queueing theory to evaluate the effects of multiple interruptions from the primary user during each link connection, the sensing errors i.e. missed detection and false alarm of the secondary users and the heterogeneous channel capacity. They derived the optimal number of candidate channels and the optimal channel selection probability for the sensing-based and the probability-based spectrum decision schemes with the objective of minimizing the overall system time of the secondary users. They find that the probability-based scheme can yield a shorter overall system time compared to the sensing-based scheme when the traffic loads of the secondary users is light, whereas the sensing-based scheme performs better in the condition of heavy traffic loads.

Chronopoulos et al. [10] proposed Spectrum Load Balancing algorithm based on the non-cooperative load balancing problem in computers and is applied to a cognitive radio system. The capability of proposed approach to support QoS in the presence of other competing cognitive networks is evaluated via simulations and compared with the existing Spectrum Load Smoothing algorithm that results proposed approach is more efficient than existing Spectrum Load Smoothing approach that based on non-cooperative game theory and it provides a Nash equilibrium solution which is optimal for all users.

Wang et al. [11] assumed that the total available spectrum is divided into several bands, each consisting of a group of channels. A centralized base station, enabled by spectrum sensing, is assumed to have the knowledge of all vacant channels, which will be assigned to various CRs according to their requests. The objective of resource allocation is to maximize the sum data rate of all CRs. Since the activities of primary users may cause heavy traffic in some bands while leaving other bands idle, load balancing is first performed to equalize the traffic. The researchers proposed a multi-level subset sum algorithm as well as a simpler greedy algorithm to achieve excellent load balancing performance.

Talat et al. [12] proposed a load balancing spectrum decision scheme for CR networks with unequal bandwidth, using the concept of the delay bandwidth product to select suitable unequal width channels. A cognitive radio system scans a wide spectrum to find available channels. One of the key challenges in using these temporarily available spectrums is that bandwidths of the available spectrums are not equal. In addition, the issue of competition for a single channel by many secondary users must be resolved. Compared with other existing unequal bandwidth spectrum decision schemes, the proposed DB-based spectrum decision can improve the overall system throughput by up to 40% in our simulation results.

Yang et al. [13] 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. [14] 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. [15] 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. [16] 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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