Secure Radio Resource Management In Cloud Computing Based Cognitive Radio Network

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Abstract: Cognitive Radio Network has emerged as a solution to the growing spectrum scarcity and inefficiency problems. However, Cognitive Radio Networks face performance and security bottlenecks due to lack of memory and vast computational capabilities. This problem could be solved if we make use of Cloud as a central entity for storing spectrum availability information and processing of the spectrum availability data and correctly map the location of the unlicensed user to that of the available spectrum bands. We will be considering only those spectrum bands for communication where the primary users are absent. If the licensed user is detected, we shall empty that band and move to another idle spectrum band that matches our requirements. Admittance will be based on FCFS basis and at the same time the Quality of Service requirements (in terms of data rate) of the unlicensed users will satisfied.

Index Terms: Cloud Computing, Cognitive Radio Network, Dynamic Spectrum Access, Hierarchical Access Structure, Spectrum Assignment Policy.

I. INTRODUCTION

The fixed spectrum assignment policies rule today's wireless network. This means that the spectrum is regulated by governmental agencies and is assigned to license holders or services on a long term basis for large geographical regions. This leads to sporadic usage of the spectrum and concentration of signal strength in certain portions while significant amount of spectrum is left unused. According to Federal Communications Commission (FCC) [1], there exist temporal and geographical variations in the utilization of the assigned spectrum. The utilization ranges from 15% to 85%. The problems with the spectrum assignment policy started recently with the growth of usage of wireless networks and mobile services. These problems have resulted in need for Dynamic Spectrum Access to exploit the spectrum opportunistically.[2] For Dynamic Spectrum Access we can make use of Cognitive Radio Networks. However, the limited memory and computational capacity of Cognitive Radio devices result in decreased performance making their realization on global basis impractical.[3] To solve this problem, we propose the use of Cloud Services. The details of what is exactly cognitive Radio Network, what is Cloud Computing and how we can use it to implement the Dynamic Spectrum Access are given below.

I. COGNITIVE RADIO NETWORKS

The formal definition of Cognitive Radio is[4]: *A "Cognitive Radio" is a radio that can change its transmitter parameters based on interaction with the environment in which it operates.* Cognitive radio is a software radio that can be used to detect the presence of licensed users in their spectrum bands using sensors. Further, these sensors can give us information of white spaces [4] which are nothing but the spectrum bands that are temporarily not being used. Using this information we can develop algorithms to allocate these unused spectrum bands to users requesting for service. The cognitive radios being software radios are programmable making them easy to be reconfigured without making many changes to their hardware. This aspect of the cognitive radios gives us freedom to choose or develop different methods to implement them depending on the surrounding environment and helps us reconfigure them to receive and transmit on different frequencies. Dynamic Spectrum access is an important application of Cognitive Radio. We will discuss the Hierarchical Access Model falling under Dynamic Spectrum Access Model [5] as this is the scenario we will consider for our proposals.

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II. SPECTRUM OVERLAY SCENARIO

Under Hierarchical Access Model, we have two scenarios [5]: Spectrum Underlay and Spectrum Overlay. In Spectrum Underlay scenario, the unlicensed users requesting for service can utilize the licensed spectrum bands even during the presence of licensed users as long as they do not create more noise than predefined by the licensed users. In Spectrum Overlay scenario, the unlicensed users occupy only those spectrum bands where no licensed users are present and the former have to shift to another idle (unused) spectrum band if the presence of licensed users is detected in the band they are using.

III. HMM

We will take the input i.e. the data reported by sensors for time period 0 to t in the form of sequences of 0 and 1 where 0 indicates the channel is available for the instance, while 1 indicates that the channel is unavailable for that instance. Later we generate next sequence using Hidden Markov Model and train the sequence using Baum Welch Learner Algorithm [6] so that there is minimum difference between the predicted sequence and the sequence that is actually generated by the sensors. The sequence length considered here is of 13-bit length. We have used a metric called Channel Availability Metric (CAM)[6] in order to determine the availability of a channel over some fixed period of time. CAM is calculated on the predicted sequence. The formula for CAM is as follows:

$$CAM= \beta_i+1/(|HS_i^1|/|HS_i|)$$

Where for channel i,

β_i is the average distance between any two consequent 1s
$|HS_i^1|$ is the total number of 1s in the entire sequence
$|HS_i|$ is the sequence length.

The channel with greater CAM has greater probability of availability for time period t+1 to 2t.

IV. DATABASE

From the scenario put forth so far, few things that are clear are: We are going to need sensors for every network to continuously send information about the idle spectrum bands and these sensors are expected to keep on updating this information so that the unlicensed users are presented with greater opportunities and are informed when to migrate to other bands in case the licensed users appear in their bands. All this also implies that we are going to need vast storage and lot many calculations to locate the idle bands. However it is necessary that only those idle spectrum bands be assigned to the unlicensed users which lie in the same geographic location. To make this possible we need to make entries of the idle bands in the form of their frequencies, geographic location and data rate. We have also considered how to determine whether how long a particular spectrum band can be; used so as not to interfere with the licensed users. This is done by our CAM which acts as our Time-To-Live factor. A smaller CAM value makes a channel less desirable. The maximum data rates we will consider according to 802.11b and 802.11g are 11Mbps operating in 2.4 GHz and 54Mbps in 5GHz. Cellular downlink peak rates will be 300Mbps and uplink peak rates will be 75Mbps for 3GPP LTE wireless communication. 3G wireless systems offer data rate less than 1Mbps. Maximum upload data rate for satellite communication is 10Mbps. 3G cellular system and satellite bands are excluded here since they cannot fulfill demanded data rates of unlicensed users. In the next section we have explained why we propose using Cloud services for storage and computation.

V. CLOUD COMPUTING

According to the National Institute of Standards and Technology the definition of Cloud Computing is: *“Cloud Computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (for example, networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.”* Cloud Computing is an economic solution to tasks that require large amount of storage and fast and complex computational capacity.[7] Characteristics of cloud computing are:

1. **Elasticity and Scalability:** Cloud computing gives ability to expand and reduce resources according to specific service requirement.
2. **Pay-per-use:** We can pay only for the duration of our use.
3. **On-demand:** We can invoke cloud services only when we need them. There is no need for dedicated resources.
4. **Resiliency:** The resiliency of cloud service offering completely isolate the failure of server and storage resources from cloud users.
5. **Multi-tenancy:** Within the same infrastructure public cloud service providers can host cloud services for multiple users.

Benefits of cloud computing[7]:

1. **Scalability –** With increase in workload, the need for hardware and software increases which can be easily provided by Cloud computing without delay. Hence an organization can easily add or subtract cloud services and need not pay for anything more than what they use.
2. **Easy Implementation –** There is no need to purchase any hardware, software licenses or implementation services, an organization can easily hit the ground running by simply demanding cloud services in record time.
3. **Skilled Practitioners -** All sort of available technologies are provided and customized according to the requirements of clients by cloud providers without much delay no matter how popular that service is.
4. **Frees up internal resources –** As much of the work is assigned to third party providers, we are allowed to utilize our internal resources for other important tasks.
5. **Quality of service –** Cloud providers offer 24/7 services and immediate response to emergency situations to their clients.

Cloud will be our central entity that stores the channel data from sensors in database and processes the unlicensed user requests and responds accurately to these requests. In order to map the geo-location of unlicensed users and the idle spectrum bands, we will need a Searching algorithm that calculates the distance between the locations of idle bands and unlicensed users using the information fed by sensors in the database and decides which bands are suitable for allocation to that particular user. It simply requires calculation of distance between the center co-ordinates of idle spectrum band and co-ordinates of the geographical location of unlicensed user.

Cloud services used for our project:

1. Google App Engine –It is used for developing and hosting web application.
2. Google Web Toolkit-It is toolkit for building and optimizing complex browser based applications.
3. GWT SDK-It contains java API libraries, compiler and development server.
4. Plugin for Eclipse-The plugin for Eclipse provides IDE support for GWT and App Engine web projects.
5. App Engine Datastore-It is schemaless NoSQL datastore providing robust, scalable storage for our web application.

VI. USER REQUEST AND MAPPING

We have so far assumed that licensed users give up their spectrum bands for free use whenever they are not using. The unlicensed users communicate their requests to the Cloud server in terms of data rate requirements, source and destination of the call to be made. The unlicensed users are served on FCFS basis. Resource allocation (allocation of empty spectrum band) has to be such that the unlicensed user gets the required data rate for maximum possible time. Our search algorithm does this mapping by first finding channels having desired data rate. Then this is compared with CAM of these channels and allocate the channel with greatest CAM to the user. This is shown in the block diagram in Fig 1.

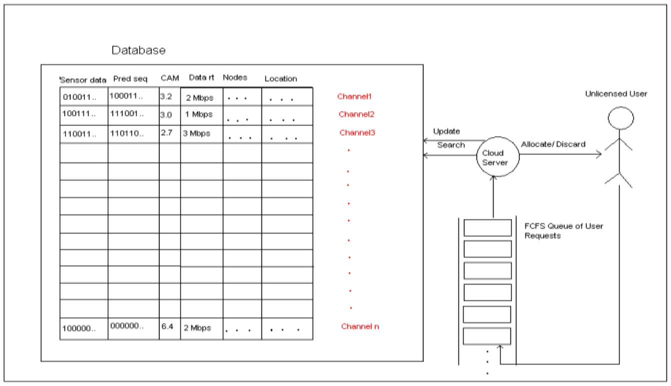

Fig 1: Block diagram

VII. SECURE RADIO RESOURCE MANAGEMENT

We are processing the user requests by considering online sensor data. Suppose a channel is allocated to some secondary user and while the unlicensed user is utilizing this particular band, the licensed user of that band is detected. In this case, the unlicensed user is forced to empty the band so that the licensed user can use it. This unlicensed user is then put to the front of FCFS queue so that he/she gets allocated another channel with minimum disturbance. In this manner, the licensed user can use his/her band without any interference from the unlicensed users.

VIII. ROUTING

We have considered overlapping channels in our simulation. Each channel has a coverage area and some communication nodes are present in each channel coverage area. These nodes will help in communication by passing data, thus they act as source and destination respectively. Also while communicating we dynamically decide which route to follow (shortest route) from source to destination.

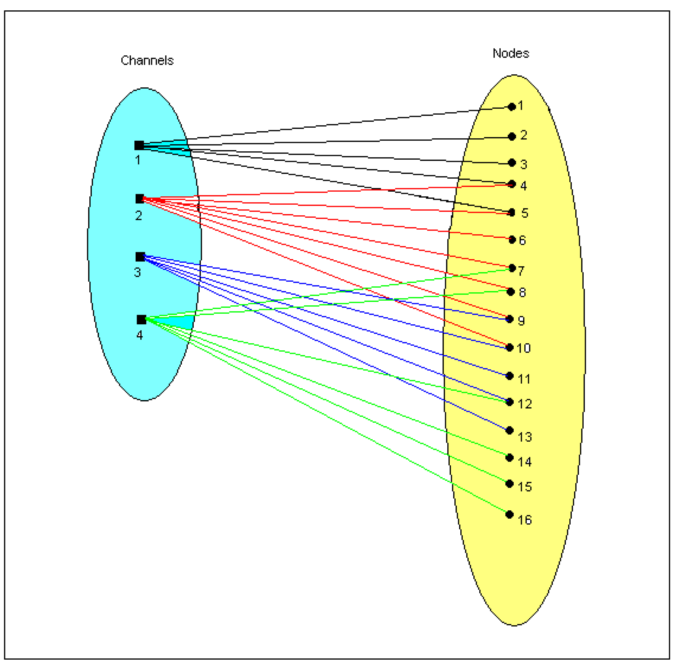

Fig 2: Bipartite Graph

We have considered a channel/communication scenario consisting 4 channels with 8 nodes in them distributed per channel (attached image of that scenario). So to go from one node to other node there are many routes(using intermediate nodes). Each route has its own length/cost to travel. The route which has minimal length is our target. In our project by clicking on "Request Route" Link we are directed to a page where a user can find route between nodes on demand. User will select two distinct nodes as source and destination. We have given weights/length (indicative of geographic distance or congestion or other such factors that determine the transmission speed associated with them) to each route from one node to every other node. So when user selects a particular source and destination node, all available/possible routes between those two particular nodes are discovered. From that discovered set of routes, we consider length for each route and then the route having minimal length is selected as our output. The output route is then showed back to user on UI (eg: node1->node3->node6).

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CONCLUSION

In this paper, we have presented opportunistic spectrum access by unlicensed user whose geo-location matches with the geo-location of the ideal licensed spectrum. Those unlicensed users who offer higher benefit are admitted. We have given the problem to maximize the profit and also satisfying the geo-location matching criteria. Malevolent unlicensed user can be tracked by geo-location matching.

FUTURE WORK

Further, we propose under future scope we can make use of dynamic decision making algorithm for channel availability where penalty should be given to nodes to chose that channel. Also we can reward the nodes if a particular channel is used without any interruption.

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