Optimization of Wireless Mesh Networks using Integer Linear Programming

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***Abstract*—Cognitive radio presents a new advance to wireless spectrum utilization and management. In particular, the potential benefits in terms of Quality of service (QoS) make available to users and the effectiveness of resource utilization are quantified in a system consisting of a gathering of one or more service provider wireless networks. To accomplish this, we formulate the crisis mathematically using Integer Linear Programming. It is revealed that the cognitive radio facility to provide an benefit over the standard network, either by improving QoS through increasing the possibility of accepting connection requests, or by dropping the resources needed to perform the QoS requirements of users. This improvement is gained without impacting the service of primary clients. Integer Linear Programming(ILP) technique is used to utilizing only the left over wasted bandwidth of the primary service providers. These practical networks are able to support large volume of users.**

keywords—cognitive radio(CR),integer linear programming(ILP), quality of service(QOS),wireless mesh networks(WMN)

I. INTRODUCTION

Increasing demands for broadband wireless services with prevailing coverage have made wireless mesh networks (WMNs) an attractive technology. Many WMNs have been deployed, delivering service to campuses, cities, and wide rural areas. As most WMN nodes do not require a wired connection to the Internet, nodes can be installed quickly and reasonably, with fewer restrictions on their placement. They instead rely on wireless communication to interconnect individual access points, forwarding traffic over multiple hops to its destination. A wireless mesh network is a Communications network made up of radio nodes organized in a mesh topology.

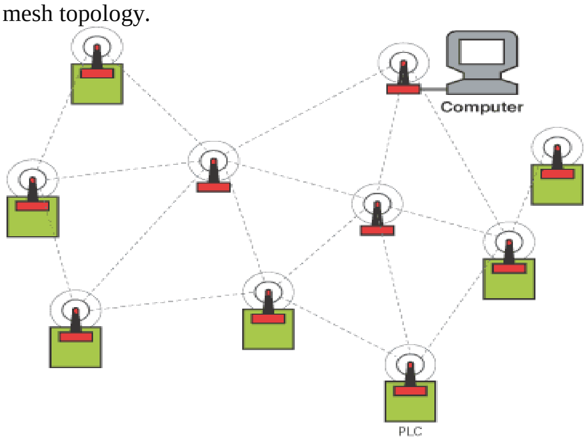

Fig. 1Wireless Mesh Network

Nodes are programmed with software that tells them how to interact within the larger network. Information travels across the network from point A to point B by hopping wirelessly from one mesh node to the next. The nodes automatically choose the quickest and safest path in a process known as dynamic routing.

II. Cognitive Radio

The idea of cognitive radio was first presented officially by Joseph Mitola III in a seminar at KTH, The Royal Institute of Technology in Stockholm, in 1998, published later in an article by Mitola and Gerald Q. Maguire, Jr in 1999.

Cognitive Radio (CR) is an emerging technology that promises to dramatically increase the utilization of the available radio resources, as well as to dramatically change the way in which a user interfaces with a communication device. Following the key features of a CR are "the awareness of the radio environment in terms of spectrum usage, power spectral density of transmitted/received signals, wireless protocol) and intelligence." A CR can be thought as a software defined radio (SDR) with possibly reconfigurable antennas that provide flexibility and re-configurability plus a machine learning device (MLD) that provides the needed intelligence to adapt the SDR to the given environment through a set of trade-offs between some optimality criteria and some user, system or environment constraints (Figure. 2).

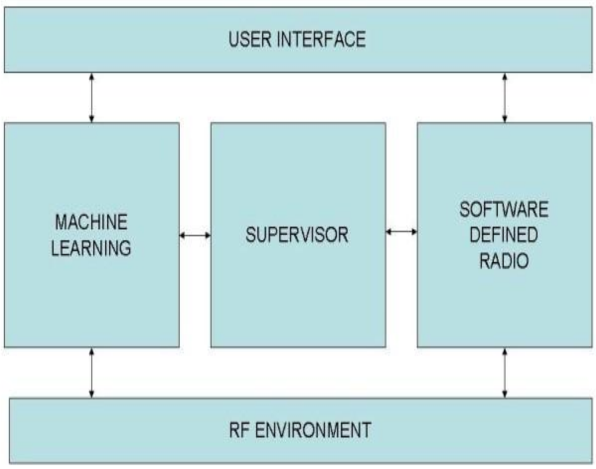

Fig.2 Block Diagram of cognitive Radio

A. Cognitive cycle: In general the cognitive cycle is a continuous process comprising of the following steps Sensing, Understanding Deciding and Adapting.

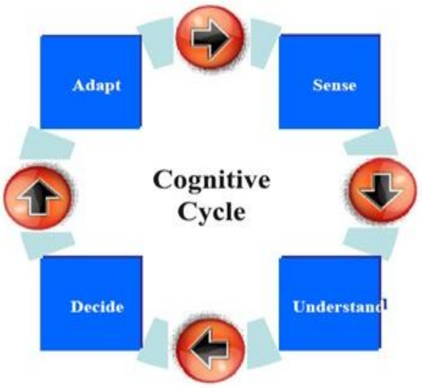

Fig.3 cognitive cycle

B. The major tasks of the cognitive radio

1. Radio-scene analysis,
2. Channel identification, and
3. Dynamic spectrum management and transmit-power control.

1. Radio-scene analysis

Performed in the receiver comprises the estimation of interference temperature of the surrounding radio environment of the receiver, detection of spectrum holes, and

Predictive modelling of the environment.

2. Channel identification

Performed in the receiver is needed for coherent detection of the message signal as well as for improving the spectrum utilization.

3. Dynamic spectrum management and transmit-power control

It makes decision on the transmission parameters based on the information provided by radio-scene analysis and channel identification.

Cryptographic Capabilities

Military radios usually require Cryptographic security functions. For High Assurance systems, this involves dedicated hardware. There are commercially available, software programmable cryptographic processors for these requirements.

Artificial Intelligence Technology

Genetic algorithms may be used to explore the action space in a controlled manner. In a well-understood environment, a knowledge-based system can make excellent decisions. Neural engineering techniques may be used to explore the possible relationships between precepts and good actions

Cognitive Radio applications are discussed.

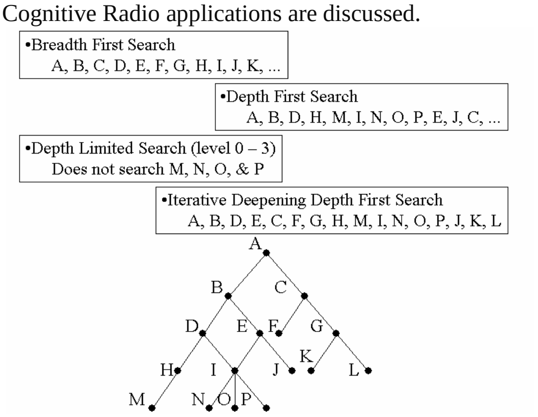

Fig.4 Searching Algorithm

Various state search algorithms yield different performance, time or space complexity, as a function of environment.

III. Integer Linear programming (ILP)

CR implemented by using Integer Linear programming (ILP). A firm has n projects that it would like to undertake but because of budget limitations not all can be selected. In particular project j is expected to produce a revenue of cj but requires an investment of aij in the time period i for i =1,...m. The capital available in time period i is bi. The problem of maximizing revenue subject to the budget constraints can be formulated as follows: let Yj = 0 or 1 correspond to not proceeding or respectively proceeding with project j then we have to

max $\sum_{j=1}^{n} C_j Y_j$

subject to $\sum_{j=1}^{n} a_{ij} Y_j \le b_i$; i = 1, ... ,m

$0 \le Y_j \le 1$ Y_j integer j = 1, ... ,n

IV. Experimental Results and Discussion

A. Acceptance Probability

P_A (K, CL) is the probability of accepting arriving classic flows belonging to network k and can be expressed as follows:

$$P_A(k, CL) = \frac{\sum_{l \in L} 1_{\{h(l)=k\}} 1_{\{CR(l)=0\}} \text{Success}(l)}{\max\left(1, \sum_{l \in L} 1_{\{h(l)=k\}} 1_{\{CR(l)=0\}}\right)},$$

where I_A is the indicator function of the condition A, i.e., it is equal to 1 if the condition A is true and 0 otherwise. P_A (K, CR) is the probability of accepting cognitive flows of network k. It is given by

$$P_A(k, CR) = \frac{\sum_{l \in L} 1_{\{h(l)=k\}} 1_{\{CR(l)=1\}} \text{Success}(l)}{\max\left(1, \sum_{l \in L} 1_{\{h(l)=k\}} 1_{\{CR(l)=1\}}\right)}.$$

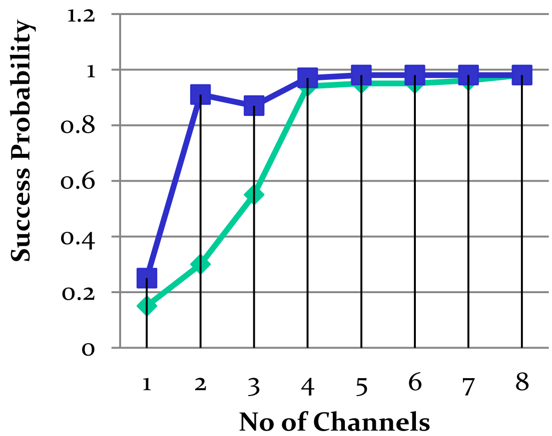

Fig. 5 probability of Accepted Connections

The total acceptance probability P_A(k) for arriving flows to network k (both classic and CR-enabled connections) is given by

$$P_A(k) = \frac{\sum_{l \in L} 1_{\{h(l)=k\}} \text{Success}(l)}{\max\left(1, \sum_{l \in L} 1_{\{h(l)=k\}}\right)}.$$

Each flow requires the full capacity of one channel over each hop, the probability of accepted connections is equivalent to the network (end-to-end) throughput. we show how our formulation can be easily extended to include the general case where connections with different rates use different channel capacities.

Table I
Acceptance Probability

	Percentage of channels utilization				
Methodology	**Channel 1**	**Channel 2**	**Channel 3**	**Channel 4**	**Channel 5**
Classic Scenario	15	30	55	90	93
Cognitive	25	90	85	93	98

V.CONCLUSION

ILP improves the QoS that can be provided to the network flows through utilizing channel reusability. ILP provides service to more users even in less resource environment. By using CR success probability, spatial reuse will be increased. Average number of hops/accepted connections are updated moderately. In this paper, we introduce the cognitive radio network (CRN) to extend networking efficiency from cognitive radios' spectral efficiency. CRN can be considered as infrastructure, ad hoc, and mesh structure in terms of network topology. We also identified possible "uni-directional" links among these network structures, while such uni-directional links are resulted from the special nature of CRN operation. We hope this effort to pave the way for future CRN systematic research.

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