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Security and QoS Aware Dynamic Clustering (SQADC) Routing protocol for CRN: A REVIEW

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Abstract - *The Cognitive Radio Network (CRN) is nothing but the future communication technology. The use of CRN is increasing worldwide which resulted into the problems like suffering from of inefficient spectrum allocation and QoS challenges. Efficient spectrum distribution technique becomes new problem for research in use of CRN. A most important challenge for the new technology is how worthy assignment can be made of the spectrum available to uncertified users. Along with spectrum efficiency, security is also major issue in CRN. There are many recent efficient routing protocols presented for spectrum efficiency for QoS improvement, but very few methods presented for CRN security. Therefore, in this project we are presenting novel routing protocol to perform security aware and QoS aware routing functionality for CRNs.*

First, we are designing the dynamic clustering-based routing protocol to optimize the spectrum sensing and allocation performance i.e. QoS enhancement. The proposed clustering method is based on ACO based optimization technique and dynamic re-clustering solution. This solves the problem of frequent and unnecessary re-clustering of state-of-art clustering solutions. Second, we introduce the light weight malicious nodes attack detection mechanism based on trust-based evaluation of each target node by utilizing the channel allocation information. The anticipated protocol is called as Security and QoS Aware Dynamic Clustering (SQADC) Routing protocol.

1. INTRODUCTION

Applications of wireless networking technologies has found incredible progress. Upcoming methods, protocols, gadgets and the applications would be constantly presented to the users, making openings for upcoming conducts of interrelating and enlarged productivity in the specialized sphere. The count of wireless gadgets is rising exponentially. According to the report stated at the end of 2011 by International Telecommunication Union (ITU), around 6 billion smart phone subscriptions (apart from all other wireless gadgets such as Wi-Fi devices).Around 85.7% of the world's populations have own smart phone subscriptions, were stated at 2012 according to the Computing the Information Society 2012, and Fig. 1 shows the Information and Communication Technology (ICT) development from 2001 to 2011 with respect to wireless networks and gadgets [1][2].

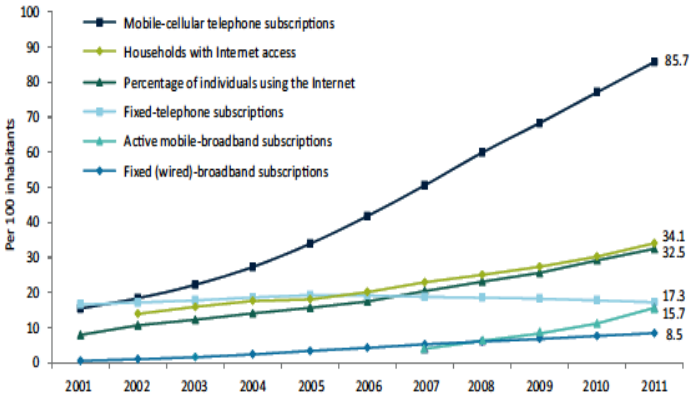

Fig - 1: The global ICT progress between 2001 and 2011 through computing the Information Society 2012, ITU.

The radio frequency spectrum is a scare natural resource. Some of the frequency bands of RF spectrum are un-utilized while some are partially or heavily utilized. Cognitive radio is a technology which allows the other users to derive unused spectrum from main or certified users or share the spectrum with Primary users. The traditional idea of the Cognitive radio concept is to let uncertified users (also called non-primary users) occupy certified bands when the primary users are not using them [7]. The unused certified bands in frequency domain and time domain are termed as white spaces; the secondary users use these white spaces without interfering to the primary users. Whenever a primary user acts, secondary users should stop the usage of those particular white spaces instantly. An example of white spaces and a secondary user using these white spaces is shown in Fig. 2. The secondary users in Fig. 2 hop from white spaces to white spaces to get access. In the last 10 years, there's been a huge attention in Cognitive radio technology. This has encouraged many standardization groups, named IEEE 802.22, IEEE 802.11af, IEEE 802.16h, IEEE 802.19.

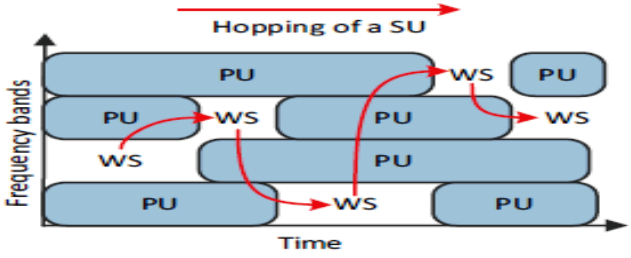

Fig - 2: An example of frequency reuse in CR.

There are number of research challenges associated with CRNs because of its dynamic nature. CRN is an upcoming generation wireless communication system that allows Secondary users to use the underutilized spectrum, known as white spaces, in certified spectrum with minimum interference to primary users. However, the dynamic situations of CRNs (e.g. Primary users activities and channel availability) making routing much more difficult as compared to old wireless systems routing. Additionally, as the CRNs most of recent past works focused on improving the QoS (Quality of service) by solving the spectrum sensing and allocation problems, security major research challenge for CRNs. In this research work, we will attempt to design the QoS and security aware routing algorithm for future network communications to solve the multiple problems such as spectrum detection, resource division and security problems. Complexity analysis and violation of the current protocols are also provided.

1.1 Mustafa Ozger et.al (2015)

In [5], the authors suggests that a spectrum-aware clustering protocol can be used for addressing the event-to-sink communication which is used for the coordination problem in mobile CRSNs. Their grouping structure has two phases. The first phase includes resolving of nodes entitled for gathering, while the other phase includes formation of clusters between those nodes which would empty spectral bands. Groups are impermanent and they are lost when event expires. Furthermore, they find mean of the re-clustering possibility, expected cluster exposure area I calculated, and maximum frequency that would lead to low energy consumption during operation of their protocol is found. The achievement of their protocol is studied in terms of data packet exchanges and its control; time steps signals are required in order to do clustering, connection of clusters; due to mobility, energy consumption for clustering ratio, and re-clustering ratio. Performance evaluation is being done based on their procedure that has better outcome in terms of energy consumption as well as the connection.

1.2 Amr A. El-Sherif et.al (2014)

In [6], the author's studies the combined design of routing as well as source distribution procedures in cognitive radio based wireless mesh systems. The mesh nodes uses cognitive connection mode to deliver the spectrum to the primary users. Before every transmission, nodes in the mesh detect the wireless intermediate to recognize available spectral resources. Based on the primary user activities as well as the traffic features, the available spectral resources would diverge between the transmission mesh challenges, a rising a task that the resource and routing distribution procedures give assurance of time to time transfer of the traffic on network. To trap the network accessibility dynamics, the structure is examined from a queue up theory perception, and the combined routing and resource allocation problem is expressed as a non-linear integer software design problem.

1.3 Petros Spachos et.al (2013)

In [7], Cognitive Networking with Opportunistic Routing (CNOR) protocol for Wireless Sensor Networks is presented. The prime objective of the projected protocol is to improvisation in the system performance when network scalability is increased. The performance of the projected protocol is assessed by simulations. Aprecise channel model is made to assess the signal strength at different areas where indoor environment is complex. Then, a separate event simulator is made functional to inspect the performance of the projected protocol in comparison with other two routing protocols. Simulation outcomes show that while comparison with other ordinary routing protocols, the projected protocol performs much better with respect to the output, packet delay and consumption of total energy.

1.4 Li Sun et.al (2013)

In [8], the authors conduct the first detailed, experiential performance as compared to three typical routing rules for cognitive Radio Networks, beneath the same realistic set of expectations. Their wide simulation study shows that the performance of routing rules in Cognitive Radio Networks which hinders amount of factors, adding to primary user activity, some of which were mainly overlooked by the majority of former works. They find that diverse protocols do well under different situations, and examine the causes of the practical performance.

Furthermore, they present a general software structure for the experimental calculation of Cognitive Radio Network routing rules/protocols on a test bed based on the USRP2 stage, and compare the performance of two protocols on a node test bed. The test bed outcomes confirm the results of our simulation study.

1.5 Jie Wang et.al (2016)

In [9], taking the a fresh projected Cognitive Capacity Harvesting system, they study the routing delinquent in multi-hop Cognitive Radio Networks and proposition a spectrum aware any path routing (SAAR) arrangement with attention of both the salient spectrum ambiguity feature of Cognitive Radio Networks and the undependable broadcast properties of wireless path. A new cognitive any path routing metric is made considering the station and connection stats to accurately evaluate the performance of any path under indeterminate spectrum accessibility. A polynomial-time directing procedure is established to find the available medium and the linked ideal progressing set and calculate the least cost of any path. Widespread simulations say that the projected protocol SAAR significantly increases packet delivery ratio and decreases the endwise lag with short communication and calculation above, making it apt for using in multi-hop Cognitive Radio Networks.

2. MOTIVATION

The traditional routing methods those are used in wireless systems such as MANET to maintain the end-to-end routes (e.g. ad hoc on-demand distance vector (AODV) routing protocol) are undesirable for Cognitive Radio Networks as such routing protocols not addressed the problems of multi-hop-routing in Cognitive Radio Networks and highly increase the network overhead by constantly flooding the routing messages. Therefore, protocols can't be functional directly in Cognitive Radio Networks. Hence routing protocols for Cognitive Radio Networks must address the challenges of CRNs by considering spectrum awareness in order to establish stable routes so that Secondary users can perform data communication for long durations without having much disruption from primary users, as well as with minimal interference to primary users. For wireless networks, the clustering-based routing protocols already proved to be efficient as compared to non-clustering routing protocols, therefore designing the optimized clustering created routing protocol is strong candidate for CRNs as well. On the other hand, as CRNs is opportunistic communication technology, it may suffer from the malicious nodes attack in network.

Therefore, this becomes another motivation to address the malicious nodes attack for CRNs along with QoS efficiency.

3. RESEARCH GAPS

In this research work, we are concurrently working on two main research problems for future communication wireless technology such as (1) adaptive and dynamic CRN opportunistic routing protocol for solving the problem of spectrum sensing and allocation efficiently, (2) detecting and preventing malicious nodes attack efficiently (e.g. selfish attack, faulty node attack or black-hole attack etc.). To solve the first problem, there are different routing algorithms reported in last 2-3 years as discussed in literature review; however, we noticed the number of research gaps listed below:

- In [2] [7] [8] [9], spectrum efficient routing method proposed, however authors failed to present the applicability of such routing protocols for network reliability analysis as well as primary user receiver protection.
- In [3] the routing protocols designed for practical Advanced metering infrastructure (AMI) networks based on Cognitive Radio Networks with limited scope. Such methods are not scalable as well as missing the protection of resources.
- As the routing protocols proposed in [2] [3] [7] [8] [9] are not reliable, scalable for large scale networks and multiple networks, the clustering is best solution to optimize the routing performance.
- In [1] attempt made to design clustering-based routing protocols for Cognitive Radio Networks to improve stability and scalability. However, such methods the extra routing overhead is imposed because of frequent clustering task in each round. This may lead to resources power consumption.
- Additionally, there is no provision to achieve the security from the malicious nodes attack in [1].

To solve the second problem, CRN based malicious node security algorithm needs to design. The security methods of wireless networks may lead to the extra overhead CRNs routing performance as well as spectrum sensing as well as allocation problems. Therefore, for this research our main problem is (1) solving the problems of dynamic spectrum allocation and attacks detection for any type of network through the original routing protocol for Cognitive Radio Network, (2) achievement of the trade-off between the network security and QoS performances.

4. AIMS AND OBJECTIVES

The main aim of this research work is to designing original routing protocol for Cognitive Radio Networks to accomplish the trade-off between QoS performance and security performance for small to large scale CRNs. Below are main objectives of this research work

- To study and examine the architecture and functionality of spectrum sensing and allocations in CRNs.
- To study the diverse spectrum detecting and allocation methods for CRNs.
- To present the review of routing protocols and procedures for CRNs reported recently in different categories.
- To discuss the impact of using the clustering-based routing mechanism in CRNs.
- To discuss and evaluate the existence of malicious nodes in CRNs.
- To design novel clustering-based routing protocol for efficient spectrum allocation and QoS improvement.
- To design light weight and scalable procedure for malicious nodes detection along with clustering method.
- To simulate and estimate the proposed routing protocol performance against the state-of-art methods.

Cognitive radios have been occurred as auspicious techniques to exploit the portions of spectrum which were unused. The fixed spectrum provision of governmental agencies results in unused portions of spectral beam, termed as "spectrum holes" or "white spaces". This problem is overcome by permitting devices to detect the spectrum for unused portions and use the most apt ones, conferring to some pre-defined conditions. Security is also major challenge in CRN, as it is vulnerable to different kinds of security attacks. Very few methods presented for detection of attacks in CRN, and those are specific or limited to particular theory and practical works. Therefore, in this thesis we attempt to present novel CRN routing protocol to accomplish the trade-off between QoS efficiency and security. The projected

procedure is based on three contributions towards this research work as discussed in table 1.

Table 1: Proposed Contributions

Number	Methodologies
Designing Attack Model and QoS Evaluation	In our first contribution, we are aiming to designing CRN routing protocols with consideration of selfish nodes attack. We are considering the existing clustering-based routing protocol.
Dynamic clustering protocol	In our second contribution, we introduce the concept of dynamic clustering for CRNs with aim of refining the tasks of frequent clustering and improving the QoS performance with and without selfish attack.
Security Aware Dynamic Clustering	Still to second contribution, we have evaluated the routing methods performance with and with selfish attack in network. In our third contribution we redesign the second contribution algorithm with trust-based attack detection algorithm.

- **Contribution 1:** In first step, we will design the clustering-based routing protocols reported in [1]. These routing protocols further modified to introduce the selfish node attack to evaluate the impact of presence and absence of selfish nodes in CRNs. The QoS performance is neatly analyze and evaluate with existing clustering solutions.

- **Contribution 2:** As the existing grouping procedures are very basic reported for CRNs, in our second contribution our main aim is to proposed novel dynamic clustering method for CRNs to improve the efficiency and scalability. This proposed clustering approach is based on (ACO) Ant Colony Optimization for cluster head selection and performing re-clustering dynamically. This prevents the unnecessary clustering tasks as it can perform only at required time by tuning the re-clustering time dynamically. This approach helps to control routing overhead and hence improve scalable and QoS performance.

- **Contribution 3:** In second contribution we solve the problem of network scalable and QoS improvement for CRNs. However, the problem of malicious nodes attacks is still unhandled. In this contribution, we will modify the contribution 2 algorithm with inclusion of dynamic trust based malicious nodes attack through the cooperative neighbours analysis. With this method, the genuine Secondary users will identify the attacker Secondary users based on their computed and exchanged channel allocation information. This contribution 3 performs the dynamic clustering with dynamically detection of selfish attacks to solve the difficulties of reliability, security, scalable and efficiency. This proposed routing method is called as Security and QoS Aware Dynamic Clustering (SQADC) Routing protocol for CRN.

5. PERFORMANCE METRICES

- Packet Delivery Ratio
- Throughput
- Detection rate
- Delay
- Energy consumption

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