International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163
Volume 1 Issue 10 (November 2014) www.ijirae.com

OVERVIEW AND LITERATURE SURVEY ON ROUTING PROTOCOLS FOR COGNITIVE RADIO NETWORKS

Apurva Varade
Sinhgad Academy of Engineering,
Pune, India

Shriram Kulkarni
Sinhgad Academy of Engineering,
Pune, India

Abstract: Cognitive radio (CR) technology is introduced to solve the problem of spectrum underutilization in wireless networks by opportunistically exploiting portions of the spectrum temporarily vacated by licensed primary users. Cognitive radio networks (CRNs) comprises of cognitive, spectrum easy moving devices which are efficient of changing their configurations depending upon the spectral environment which they use. This capacity opens up the likeliness of designing flexible and dynamic spectrum access strategies. In this paper, we present a survey of recent routing protocols in Cognitive Radio Networks (CRNs). We start by listing routing challenges as well as propose the classification of routing protocols followed by a comprehensive survey of different routing techniques. The main purpose of the survey is to provide exhaustive and critical study on the current routing schemes in order to bring out new open issues as well as being utilized to either improve the existing routing techniques or to develop new routing solutions.

Keywords: Cognitive radio network, Routing protocols, Routing challenges, Routing Categories

I. INTRODUCTION

Cognitive Radio Networks (CRNs) can operate in the licensed frequency band to improve its utilization with the coexistence of the Primary Users (PRs) or licensed users. PRs have the main rights over the licensed band in which they are operating. Radio frequency (RF) is an important resource that people uses all around the world for many services i.e. safety, communication, employment, and entertainment [2].The dedicated frequency band is allocated to the paid user that uses this frequency for specific service. Thus, the RF band allocated can be vastly underutilized. Recent studies show that only 5% of the spectrum from 30 MHz to 30 GHz is used in the US [3]. The Federal Communications Commission (FCC) of United States of America found that the spectrum usage is a more significant problem than the actual physical availability of RF spectrum [4]. The spectrum availability problem arises due to the currently deployed static spectrum allocation policy that limits the usage of the licensed RF band only to the licensed user or primary user. These findings need more efficient methods for utilization of the RF resources and the Cognitive Radio (CR) technology is envisioned as a new mechanism for flexible usage of the RF spectrum. This technology enables the secondary users or unlicensed users to operate in the licensed band with the coexistence of the licensed users or primary users. Secondary users have the ability to identify and utilize the available channels in the RF spectrum. The ability of a secondary user to change its frequency of operation is commonly referred as dynamic spectrum access (DSA).Thus, we can say that cognitive network is a network that can observe current network conditions and act on those conditions. The network can learn from these actions and use them to make future decisions [5]. Ryan W. Thomas and Daniel H, define the CRNs in the context of machine learning as “cognitive network improves its performance through experience gained over a period of time without complete information about the environment in which it operates” [6]. Therefore, a secondary user can change its transmitter parameters based on its learning from the environment, depending on these changes the secondary user can efficiently utilize the frequency band and avoid from the interference on the primary user.

The main feature of CR technology that how it operates in the licensed band with the coexistence of the PR users is that it identifies the spectrum holes in the RF spectrum called white spaces. These white spaces are the wastage in the RF spectrum and would be secondary user for its communication.

CRNs are an emerging research study domain, and there are many open issues that are remained to be solved. Most of the research on CRNs till date are focused on the lower layer (PHY and MAC) issues [7][8][9][10], as a result, the study of CRNs routing protocol on network layer is unexplored. Applying CR technology in the wireless network improve the system capability and spectrum utilization efficiency. Nevertheless, due to unique network characteristics, it comes out with several indicative challenges which need to be considered for routing design as follows:

• **Network topology change:** The topological changes in CRNs occur primarily due to fluctuations of PU activity and node mobility. Whenever PU activity is identified, the SU must immediately vacate the channel that overlaps the PU’s transmission frequency in order not to cause a harmful interference to PUs.

© 2014, IJIRAE- All Rights Reserved

• **Different spectrum characteristics:** In a practical CRNs, spectrum channels at each SU may have contrasting channel properties, such as bandwidth, delay, loss rate, propagation characteristic, etc., and also being available for an unequal period. As a result, different channels may support different transmission ranges.

• **Effect of spectrum handoff:** Large numbers of spectrum handoff (the process for an SU to change its frequency of operation) caused by multi-channels transmission or route recovery process may lead to the increased end-to-end delay and high energy consumption.

• **Interference impact:** According to the principle of the CRNs, desirable routes should be selected with a minimum interference to the PU networks and the interference effect must keep below the acceptable threshold level.

• **Route recovery mechanism:** For general wireless networks, link failures may result from node mobility, node fault or link deterioration. Though, route breakages in CRNs can be also caused by PU activity.

• **Common control channel:** SUs usually coordinate with each other by utilizing a common medium for spectrum related information exchange, known as a common control channel (CCC). A CCC [11] in CRNs facilitates the neighbour discovery and helps in channel access negotiation as well as routing information updates.

• **Energy consumption:** In some CRNs, such as CR mobile ad hoc networks [12] or CR sensor networks [13], SUs generally are smaller in size, and have a restriction on energy capacity. However, SUs must be capable of sensing the spectrum in a broader frequency band, so an adequate power control is required.

The rest of this paper is organized as follows. In Section II, we discuss the CRN architecture. In section III, we discuss classification of routing protocols, routing differences and challenges. A comprehensive survey of routing techniques in CRNs is presented in Section IV. Finally, Section V concludes the work.
.

II. ARCHITECTURE FOR CRN

A clear description of the CRNs architecture is important for the better understanding of their working and designing novel protocol for communications. Fig 1 describes the architecture of the CRNs.

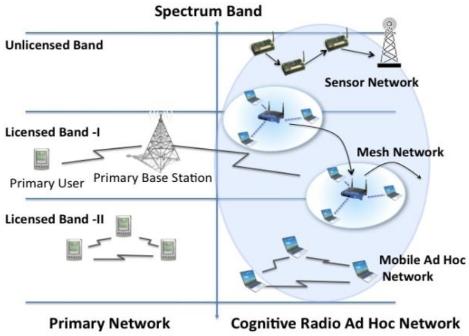

Fig 1.CRN architecture

The CRNs can be classified into two main categories as follows:
1. Infrastructural CRN
2. Infrastructure less CRN

Infrastructural CRN: The CRN in which the communication is done with the help of a fixed infrastructure component called CRN base station.

Infrastructure less CRN: The CRN in which the communication is done without the support of fixed infrastructure or base station. It is similar to ad hoc multi-hop network. The elements of the primary and the cognitive network are defined as follows:

© 2014, IJIRAE- All Rights Reserved

Primary Network: A network that owns a separate RF spectrum band for its services (e.g. cellular and TV broadcast networks).The components of the primary network are as follows:

Primary User: Primary user or licensed user has main rights to operate in its RF spectrum band. The primary user cannot bear any interference on its RF band due to any secondary user.

Primary Base Station: It is a fixed infrastructure component that controls the access of its licensed users. This component does not have any ability to share RF spectrum band with CR users.

Cognitive Network: Cognitive network does not have any RF spectrum band for their communication. That's why these networks are called unlicensed networks.

The components of cognitive networks are as follows:

Cognitive User: Cognitive user does not have its own frequency band; therefore these us called secondary users or unlicensed users. These users share only the licensed band in an opportunistic manner. Secondary user requires extra functionality such as spectrum sensing to operate in licensed band.

Cognitive Base Station: Cognitive base station is a fixed infrastructure component similar to primary base station with cognitive capacities. The secondary users access other networks through it. It provides single hope connection to secondary users.

III. CLASSIFICATION OF ROUTING PROTOCOLS THEIR DIFFERENCES AND CHALLENGES IN CRNS

Several routing protocols have been proposed for CRNs to deal with the inherent issues of the networks, which include opportunistically spectrum access, dynamic spectrum availability, and interference protection towards PU activity, multi-channel transmission and high energy consumption. The classification of the routing protocols is shown in Fig 2.These routing protocols may be categorized as:

• **PU activity aware routing:** The protocol is designed with a purpose to establish a transmission path which avoids regions of PU activity. The reason behind the design is to make routes less vulnerable to the impact of PU activity during data transmission. When a PU region is encountered, the path will enter into a detour to avoid the PU region.

• **Location-based routing:** The protocol utilizes the location information of the nodes to transmit the routing messages to the desired regions that make the most progress towards the destination rather than the entire network in order to reduce the control overhead. To obtain the entire geographical topology of the network, each node will flood its location and ID to all nodes in the networks (after the end of this process, only a topology change will be announced). In addition, the position of each node can be also determined by using GPS (Global Positioning System).

• **Cluster-based routing:** The protocol divides the network nodes into a number of clusters. The clustering algorithms can be categorized into two categories, i.e. clusters with or without cluster head. For the former category, the cluster head is elected for each cluster to help in the data transmission management and to maintain cluster membership information. The main aim of cluster-based routing is to increase network scalability, optimize the bandwidth usage, and balance the distribution of resources.

• **Multipath routing:** The protocol allows the establishment of multiple alternative paths between source-destination pairs in order to transmit multiple data streams simultaneously or be used for backup purpose. It is typically proposed to provide load balancing, increase the reliability of data transmission and maximize the utilization of network resources.

• **Reinforcement learning based routing:** The protocol applies a reinforcement learning [14] to form a route for data delivery. The reinforcement learning gives a framework of learning a control policy (a mapping of observations into actions) based on experiences and rewards. The goal of applying the reinforcement learning for data routing in CRNs is to effectively address the challenges of uncertainty on spectrum availability.

• **Mobility aware routing:** The protocol is designed with an aim to support the mobile CRNs in which the nodes (SUs or PUs) are movable, i.e. the nodes are free to move at any time, towards any direction and at any speed, resulting in frequent link breakages. To deal with these demanding networks, the protocol may establish the dependable path containing a maximum number of less mobile nodes, or provide an efficient route recovery mechanism in order to recover the failed link caused by node mobility.

© 2014, IJIRAE- All Rights Reserved

Traditional infrastructure networks and mobile ad hoc networks have been studied since last decennary and many routing protocols, e.g. proactive, reactive, hierarchical and multicast are available for such networks [15].It is important to investigate the novel routing protocols for CRNs, as routing is a challenging task in such networks, particularly in multihop CRNs due to the diversity in channel availability and data rates. Multi-interface enabled CR user can avail multiple available channels simultaneously, therefore, increasing overall network performance and reducing the interference on the primary users. Due to this necessary feature of CRNs traditional routing metrics such as hope count, congestion, etc. are not sufficient for routing decision in CRNs [15].
The primary differences and challenges between routing of CRNs and routing of conventional wireless networks can be summarized as follows:

1. Link Availability:
DSA senses the RF band and fetches the available opportunities. Thus, these networks use the licensed band in an opportunistic manner for communication. These communication opportunities are available when primary users have fewer usage of their frequency band or they are not using it at all; hence availability of channel is time and geographic based. Due to this random availability of channel the CRNs topology is random and even all communicating nodes are static[16].

2. Deafness Problem:
Due to the diversity in channel or link availability, links may be available only for a fraction of the time in CRNs. This random availability may cause the deafness problem, which is switching among available channel set to maintain the route or avoid the interference on primary users. This causes extra delay in CRNs communications [17].

3. Unidirectional Links:
In CRNs, unidirectional links are more likely to be present. In CRNs links are only available for a fraction of a time instead of minutes or hours. This cause's unidirectional links as there is no guarantee that the channel used for sending station will be available till the receiving station uses the same channel for transmission.

4. Heterogeneous Wireless Networks:
CRNs are usually come into existence by multiple and heterogeneous wireless networks. Therefore, intersystem handover is critical and required for routing. Along with this channels or links are available for an extremely short duration; therefore successful networking lies in cooperative relaying among such heterogeneous wireless networks [18]

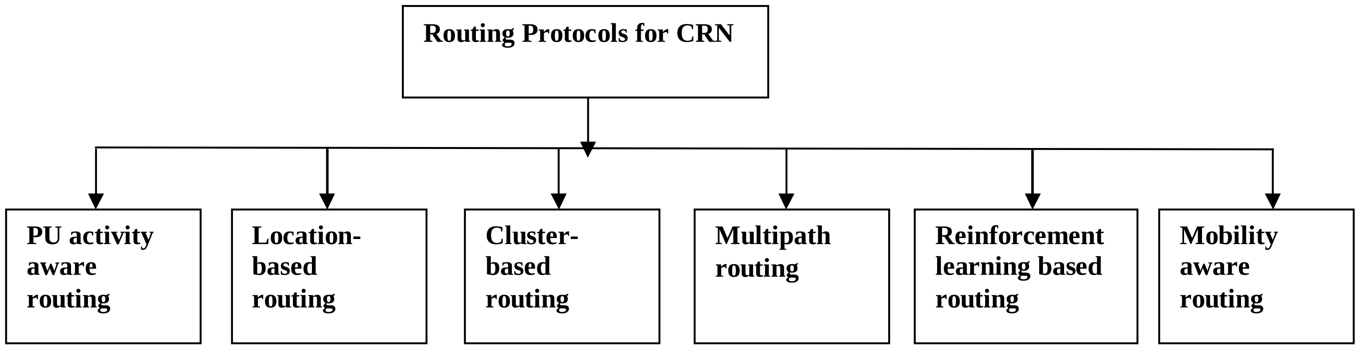

Fig 2.Routing Protocols for CRNs

IV. STUDY OF DIFFERENT ROUTING PROTOCOLS
A. MSCRP-Multi-hop Single-transceiver CR routing protocol

Huisheng Ma, Lili Zheng, Xiao Ma, Yongjian luo presented Spectrum Aware Routing for Multi-Hop Cognitive Radio Networks with a Single Transceiver (MSCRN) where they propose a spectrum aware on-demand routing which doesn't base on the control channel, and a channel assignment algorithm aimed at improving link utilization is derived from delay-analysis[17]. MSCRP uses on-demand routing for multi-hop, single transceiver networks similar to that of AODV. When there is no flow across a node, or there are flows only on the channel the node selects to stay, we say that this node is in a *single channel state*, and we call this node a *single channel node*. When the flows distribute on different channels, the node is in the *switching state*, and we call this node a *switching node*. To avoid the deafness problem, two consecutive nodes in a flow cannot be in switching state simultaneously, one of them has to stay on one channel. When a node has packets to send, it initiates a route discovery by broadcasting a Route Request (RREQ) packet. It then sends back a Route Reply (RREP) to the source,

© 2014, IJIRAE- All Rights Reserved

encapsulating the assigned channel. In MSCRP, LEAVE/JOIN messages are used to inform switching nodes' working channels to their neighbours.

B. SORP-SPECTRUM AWARE ON-DEMAND ROUTING

Geng Cheng, Wei Liu, Yunzhao Li, Wenqing Cheng presented Spectrum aware on-demand routing in Cognitive radio networks where they propose an approach to reactively initiate route computing and frequency band selection[19].
SORP implements a joint approach of on-demand routing and frequency band selection, satisfying the fact of SOP diversity, also considers the effect from other existing multifrequency flows and propose a novel scheduling scheme for intersecting nodes and defines a metric that evaluates the effectiveness of candidate route, taking into account the spectrum switching delay and backoff delay, while previous work only took part of them into consideration.

C. Delay-Sensitive Resource Management in Multi-hop Cognitive Radio Networks

Hsien-Po Shiang and Mihaela van der Schaar presented Delay-Sensitive Resource Management in Multi-hop Cognitive Radio Networks where they discussed the main challenges of performing dynamic resource management by emphasizing the *distributed information* in a dynamic multi-agent system[22]. Specifically, the decisions on how to adapt the aforementioned resource management at sources and relays need to be performed in an informationally-decentralized manner, as the tolerable delay does not allow propagating information back and forth throughout the multi-hop infrastructure to a centralized decision maker.
The delay sensitive resource management enables required information exchange across the network nodes for dynamic resource management in multi-hop cognitive radio networks. The notion of an "information cell" is introduced to explicitly identify the network nodes and to convey timely information to a certain center node. Based on the available information exchange, we propose a multi-agent learning approach which allows the various nodes to optimize their transmission strategies autonomously, in a distributed manner, in multi-hop cognitive radio networks.

D. Probabilistic Path Selection in Opportunistic Cognitive Radio Networks

Hicham Khalife, Satyajeet Ahuja, Naceur Malouch, and Marwan Krunz presented Probabilistic Path Selection in Opportunistic Cognitive Radio Networks where in the first phase, the source node tries to compute the *most probable path* (MPP) to the destination (including the channel assignment along that path) whose bandwidth has the highest probability of satisfying a required demand *D[21]*. In the second phase, we verify whether the capacity of the MPP is indeed sufficient to meet the demand at confidence level δ. If that is not the case, we accordingly add channels to the links of the MPP such that the augmented MPP satisfies the demand D at the confidence level δ.

A novel routing metric that is based on a probabilistic definition of the available capacity over a channel. This definition depends on the probability distribution of the PR-to-CR interference at a given CR node over a given channel, which was shown in [24] to approximately follow a log normal distribution. This distribution accounts for the activity of PR users and their random deployment. Our routing metric is used to determine the most probable path (MPP) to satisfy a given bandwidth demand D.

E. STOD-RP: A Spectrum-Tree Based On-Demand Routing Protocol for Multi-Hop Cognitive Radio Networks

Guo-Mei Zhu, Ian F. Akyildiz, Geng-Sheng (G.S.) Kuo presented STOD-RP: A Spectrum-Tree Based On-Demand Routing Protocol for Multi-Hop Cognitive Radio Networks a Spectrum-Tree base On-Demand routing protocol (STOD-RP) is proposed where a spectrum-tree is built in each spectrum band [20].

The formation of the spectrum-tree addresses the cooperation between spectrum decision and route selection in an efficient way. STOD-RP is an On-Demand routing protocol (STOD-RP) which simplifies the collaboration between spectrum decision and route selection by establishing a "*spectrum-tree*" in each spectrum band. The routing algorithm combines tree-based proactive routing and on-demand route discovery. Moreover, a new route metric which considers both CR user's QoS requirements and primary user activities are proposed. In addition, our work provides a fast and efficient spectrum-adaptive route recovery method for resuming communication in multi-hop CR networks.

F. SAMER: Spectrum Aware Mesh Routing in Cognitive Radio Networks

Ioannis Pefkianakis, Starsky H.Y. Wong and Songwu Lu presented SAMER: Spectrum Aware Mesh Routing in Cognitive Radio Networks where, SAMER opportunistically routes traffic across paths with higher spectrum availability and quality via a new routing metric[23]. It balances between long-term route stability and short-term opportunistic performance. SAMER builds a runtime forwarding mesh that is updated periodically and offers a set of candidate routes to the destination.

© 2014, IJIRAE- All Rights Reserved

SAMER (spectrum aware mesh routing), a new routing solution for CORNETs that addresses both above issues. The design of SAMER seeks to utilize available spectrum blocks by routing data traffic over paths with higher spectrum availability. In SAMER, routes with highest spectrum availability are selected as candidates. Therefore, SAMER computes its long-term routing metric based on spectrum availability and is more or less a "least-used spectrum first" routing protocol. Moreover, it tries to balance between long-term route stability and short-term route performance via building a runtime forwarding route mesh. Once a route mesh that offers a few candidate routes is computed, the runtime forwarding path is determined by instantaneous spectrum availability at a local node. This can lead to short term opportunistic performance gain.

The Table 1 summarizes the various protocols comparing them against different features.

Table 1: Comparative study of different Routing Protocols

Objective / Features	**MSCRP**	**SORP**	**Delay-Sensitive Resource Management in Multi-hop CRN**	**Probabilistic Path Selection in Opportunistic CRN**	**STOD-RP**	**SAMER**	**(LCB) Local Coordination Based Routing**
End-to-end throughput	Spectrum aware routing and leave/join messages	Spectrum aware on demand routing and multi-flow multi-frequency scheduling	Using multi-radios and multipath	Selecting MPP path that fulfils the application capacity demand	5 times better than hop count scheme	Path with high spectrum availability, long-term stability and short-term opportunistic utilization of spectrum	Adaptive relay is cooperating with routing protocol
Route discovery	RREQ message on all available channels rather on single channel	Broadcast RREQ messages	Control channel, Broadcasting RREQ message	OSPF, Dijkstra-like algorithm to compute the route	Broadcast Root Announcement (RANN) message	Link state packets	Broadcast RREQ messages
Routing decisions	With the collaboration of MAC, physical and network layers	With the collaboration of MAC and network layers	Does not base on cross layer	Does not base on cross layer	Does not based on cross layer	With the Collaboration of PHY and MAC layers	Joint decisions based on MAC and Network layer
Route nature	On demand	On demand	Periodical	On demand	Periodical	Periodical	On demand
Route discovery packet size	All intermediate nodes append their state information and available channel set	Each node appends SOP list	Each node appends its ID and BRT	Hop-to-hop communication	Every node updates a single field known as "cumulative metric"	Hop-to-hop calculation	Each intermediate node appends SOP list
Best path selection	Number of flows on each channel	Path delay and node delay	Minimum hop count	Based on the probabilistic definition of available capacity over channel	Based on basics of global and local decision schemes	Minimum hop count and spectrum availability	Based on the cumulative delay of the path

V. CONCLUSION

© 2014, IJIRAE- All Rights Reserved

Routing in CRNs has attracted immense attention in the recent years and has introduced unique challenges compared to traditional data routing in wireless networks. In this paper, we have presented the routing design challenges and introduced the categories of routing protocols for CRNs. Moreover, we have analysed and summarized the recent routing techniques for CRNs and address the routing related problems on CRNs. Therefore, there is need to design new metrics those exploits all the dynamic characteristics of CRNs and based on such metrics novel routing proposals should be presented.

REFERENCES

[1] Amjad Ali, Muddesar Iqbal, Adeel Baig, Xingheng Wang, "ROUTING TECHNIQUES IN COGNITIVE RADIO NETWORKS: A SURVEY" in International Journal of Wireless & Mobile Networks (IJWMN) Vol. 3, No. 3, June 2011

[2] B. Fette, Cognitive Radio Technology, Elsevier Inc.(2006).

[3] Yuan Yuan, Paramir Bahl, Ranveer Chandra, Thomas Moscibroda, Yunnan Wu. Allocating Dynamic Time-Spectrum Blocks In Cognitive Radio Networks. In ACM MobiHoc 2007.

[4] Federal Communications Commission, Spectrum Policy Task Force Report, ET Docket No. 03-222, Notice of Proposed Rule Making and Order2003.

[5] I. F. Akyildiz, W.-Y. Lee, M. C. Vuran, and S. Mohanty, NeXt generation/ dynamic spectrum access/cognitive radio wireless networks: A survey, Elsevier Computer Networks, 50(3), 2127–2159 (Sept, 2006).

[6] R. W. Thomas, L. A. DaSilva, and A. B. MacKenzie,"Cognitive networks," in Proc. of IEEE DySPAN2005, pp. 352–360, November 2005.

[7] A. D. Domenico, E. C. Strinati and M. G. D. Benedetto, "A survey on MAC strategies for cognitive radio networks," *IEEE Communications Surveys and Tutorials*, vol. 14, no. 1, pp. 21- 44, 2012.

[8] L. Wang, J. Wang, G. Ding, F. Song and Q. Wu, "A survey of cluster-based cooperative spectrum sensing in cognitive radio networks," in *Proc. of Cross Strait Quad-Regional Radio Science and Wireless Technology Conf. (CSQRWC)*, pp.247-251, July, 2011.

[9] H. Sadeghi, P. Azmi and H. Arezumand,"Cyclo stationarity-based soft cooperative spectrum sensing for cognitive radio networks," *IET Communications*, vol. 6, no. 1, pp. 29-38, Jan. 2012.

[10] L. T. Tan and L. B. Le, "Distributed MAC protocol for cognitive radio networks: design, analysis, and optimization," *IEEE Trans. on Vehicular Technology*, vol. 60, no. 8, pp. 3990-4003, Oct. 2011.

[11] I. F. Akyildiz, W. Y. Lee and K. Chowdhury, "CRAHNs: cognitive radio ad hoc networks," *Ad Hoc Networks*, vol.7, no. 5, pp. 810-836, July, 2009.

[12] Q. Guan, F. R. Yu and S. Jiang, "Topology control and routing in cognitive radio mobile ad hoc networks," *Cognitive Radio Mobile Ad Hoc Networks*, in F. R. Yu(Ed.), Springer New York, pp. 209-225, 2011.

[13] O. Akan, O. Karli and O. Ergul, "Cognitive radio sensor networks," *IEEE Network*, vol. 23, no. 4, pp. 34-40, Aug. 2009.

[14] S. S. Keerthi and B. Ravindran, "A tutorial survey of reinforcement learning," *Sadhana*, Springer India, vol. 19, no. 6, pp. 851-889, Dec. 1994.

[15] Yang Xiao, Fei Hu "Cognitive radio networks". 2009 Taylor & Francis Group, LLC. ISBN: 978-1-4200-64209

[16] De Cout, D. S. J, et.al. A high-throughput path metric for multihop wireless routing. In Proc. Of MobiCom (Sept.2003).

[17] Ma, H. and Zheng, L. and Ma, X. and Luo," Spectrum-aware routing for multi-hop cognitive radio networks with a single transceiver", Proceedings of the Cognitive Radio Oriented Wireless Networks and Communications (CrownCom) 2008

[18] Kwang-Cheng, Chen, Ramjee Prasad, "Cognitive radio networks". 2009 John Wiley & Sons Ltd. ISBN: 978-0-470-69689-7

[19] G. Cheng, W. Liu, Y. Li and W. Cheng, "Spectrum aware on-demand routing in cognitive radio networks," in *Proc. IEEE DySPAN*, April 2007.

[20] G-M. Zhu, I. F Akyildiz, and G-S. Kuo, "STOD-RP: A spectrum tree based on-demand routing protocol for multi-hop cognitive radio networks," in *Proc. IEEE Globecom*, November-December 2008.

[21] H. Khalife, S. Ahuja, N. Malouch, and M. Krunz, "Probabilistic path selection in opportunistic cognitive radio networks," in *Proc. IEEE Globecom*, November-December 2008.

[22] H.-P. Shiang and M. van der Schaar, "Delay-sensitive resource management in multi-hop cognitive radio networks", in *Proc. IEEE DySPAN*, October 2008.

[23] I. Pefkianakis, S. H. Y. Wong, S. Lu, ―SAMER: Spectrum aware mesh routing in cognitive radio networks,‖ in *Proc. IEEE DySPAN*, October 2008.

[24] H. Salameh, M. Krunz, and O. Younis, "Throughput- oriented mac protocol for opportunistic cognitive radio networks with statistical performance guarantees," *Technical report, University of Arizona UAECE-2007-2*,2007.

© 2014, IJIRAE- All Rights Reserved