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A Survey on Spectrum-Map Based on Normal Opportunistic Routing Methods for Cognitive Radio Ad Hoc Networks

Hesham Mohammed Ali Abdullah
Research Scholar,PG & Research Department of Computer Application,Hindusthan College of Arts &Science,Coimbatore
Email: heshammohammedali@gmial.com

Dr.A.V.Senthil Kumar
Director,PG & Research Department of Computer Applications,Hindusthan College of Arts & Science,Coimbatore.
Email: avsenthilkumar@yahoo.com

ABSTRACT

Cognitive Radio (CR) technology has significant impacts on upper layer performance in Ad Hoc Networks (AHNs). In recent times, several number of investigation are conducted in CR are mostly focusing on the opportunistic spectrum admission and physical layer transmission throughput. However, CR technology determination also have considerable impacts in mobile Ad Hoc networks (AHNs), which enables wireless devices to dynamically create networks without essentially use of a fixed infrastructure . Nowadays, establishing a cognitive network is such a difficult task. The most important issues is routing in CRAHNs. In this paper, it majorly focuses on the survey of routing and opportunistic routing schema in CRAHN. The most significant scheme behind this concept is to make use of a suitable routing protocol designed for establishing Cognitive Radio Network (CRN). Due to licensing, the accessibility of radio frequency for wireless communication gets reduced day by day. Thus, there is a necessitate to have some other way to use these frequencies in an efficient manner. Routing is efficient method to solve these issues, but the use of geographical concept is also a challenging task in CRN. Since, there is a lack in detailed understanding of these extremely dynamic opportunistic links and a consistent end-to-end transportation mechanism over the network. Here, it focuses on the study of possible routing approaches with the purpose of be able to be employed in CRAHNs. There is a comparison on performance evaluation of various potential routing approaches in terms of table significant reduction and what solution can be found from the routing protocol are also discussed. The routing protocol attains reliable communications for CRAHNs, without usually getting feedback information from nodes in a CRAHN to considerably accumulate the communication overhead.

KEYWORDS: **Cognitive Radio (CR), CR routing Protocol (CRP), CR Ad Hoc Network (CRAHN), Dynamic Spectrum Access (DSA), Spread Spectrum, opportunistic routing, classical routing schema and Spectrum Sharing.**

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1. INTRODUCTION

Cognitive Radio (CR) technology aspires to improve the spectrum deployment and alleviate the congestion in the 2.4GHz ISM band. Recent investigation done in this area has essentially focused on spectrum sensing and sharing issues in infrastructure-based networks. It relies on the existence of a centralized entity designed for collecting the spectrum information. Then, it chooses best possible spectrum and allocating them to CR users during transmission. Furthermore, such CR technology is generally single hop, through every CR straightforwardly communicating through the central entity to reach destination nodes in CRN. Hence, the application of CR technology in accessed via distributed scenarios. There is several open research issues are faced during this process which is specified in [1]. This paper work studies the process of CR routing Protocol for ad hoc networks (CRP). It specifically deals with the problems of end-to-end CR performance over multiple hops and the difficulty of protecting the PU transmissions to satisfy QOS. CR has two important characteristics:

1) Cognitive Capability: It is capability of radio knowledge toward sense the radio environment. It confines the temporal and spatial variations in CRN and circumvents interference to PU.

2) Reconfigurability: Once radio environment obtained reconfigurability assist CR to move in dynamic manner.

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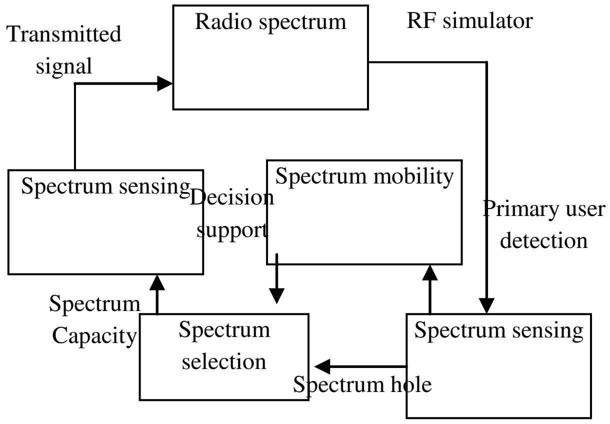

Figure 1: Cognitive radio network life cycle

As shown in Figure1 the steps of the cognitive cycle consist of four spectrums management functions: spectrum sensing, spectrum decision, spectrum sharing, and spectrum mobility:

1) Spectrum sensing: A Cognitive Radio (CR) user is able to be allocated to simply an unused piece of the spectrum. Consequently, a CR user must monitor the accessible spectrum bands, and subsequently notice spectrum holes. Spectrum sensing is a fundamental functionality in CR networks, and consequently it is strongly connected to other spectrum management functions as well as layering protocols to provide information on spectrum accessibility.

2) Spectrum decision: Formerly the accessible spectrums are recognized, it is important with the purpose of the CR users choose the largest part suitable band according to their QoS requirements. It is significant to distinguish the spectrum band in terms of together radio situation and the numerical behaviors of the PUs. In order to devise a decision algorithm with the intention of integrate self-motivated spectrum characteristics; necessitate attaining a priori information concerning the PU action. In addition, in CRAHNs, spectrum decision involves together responsibility spectrum range and route configuration.

3) Spectrum sharing: Because there might be numerous CR users difficult to admission the spectrum, their transmissions must be coordinated to stop collisions in go beyond portions of the spectrum. SS give the ability to distribute the spectrum store opportunistically through numerous CR users which comprise resource allocation to circumvent interference basis to the main network Additionally, this function require a CR Medium Access Control (MAC) protocol, which make easy the sensing control in the direction of deal out the sensing task amongst the coordinating nodes as well as spectrum admission to establish the timing designed for transmission.

4) Spectrum mobility: If a PU is distinguishing in the precise fraction of the spectrum in use, CR users must leave the spectrum right away and maintain their communications in a further empty piece of the spectrum. For this, moreover a novel spectrum should be selected might be avoiding completely. Thus, spectrum mobility requires a spectrum handoff system to distinguish the link malfunction and to switch the existing communication to a new route through minimum value deprivation.

The mechanism of the Cognitive Radio Ad hoc Network (CRAHN) structural design, as illustrated in Figure 2, is able to classify into two parts the primary network and the CR network. The primary network is considered as the existing network, where the primary users (PUs) contain a permit to function in a confident spectrum band. If primary networks contain a communications support, the operations of the Pus are prohibited all the way through primary base stations. Appropriate to their precedence in spectrum access, the PUs be supposed to not be precious through unlicensed users. The CR network does not contain a license to function in a preferred band. Therefore, additional functionality is essential designed for CR users in the direction of split the licensed spectrum band. In addition, CR users are movable and be able to converse by means of each other in a multi-hop manner on together licensed and unlicensed spectrum bands. Typically, CR networks are implicit to purpose as stand-alone networks, which do not contain straight message channel through the main networks. Thus, every accomplishment in CR networks depends on their restricted interpretation.

To develop under-utilized portions of the spectrum, known as white spaces .It motivates the necessitate for a new creation of smart, programmable radios with the purpose of be able to interference sensing, channel state knowledge, and dynamic access of spectrum. In the most common design considered nowadays, Cognitive Radios (CRs) for sensing spectrum with licensed frequency bands. As the FCC [2] support the spectrum handling of databases toward standardize the make use of licensed frequency bands. Cognitive Radio (CR) which equips short-range communication and sensing capability is being widely considered for efficient spectrum utilization. Dynamic Spectrum Access (DSA) permits many CRs to the use of transmission opportunity after identifying the spectrum hole from deployment of Primary System(s) (PS) [3]. Once required DSA is realized, then packets are transmitted from source to destination, which results in a demand designed for multi-hop networking of a CRAHN consists of CRs and PSs through cooperative relay technology [4].

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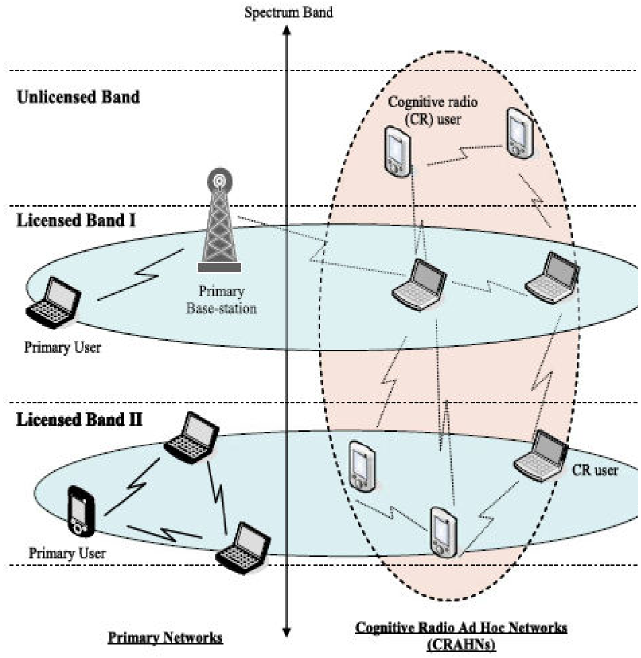

Figure 2. The CRAHN architecture

To dynamically use of the pre-assigned range of spectrum bands, CR should collect and progression information regarding co-existing users inside the spectrum of interests, which necessitate advanced sensing and signal-processing ability [5]. Motivated through widespread spectrum sensing [6], sensing information of together the CR's transmitter (CR-Tx) and the CR's receiver (CR-Rx) is dangerous. This motivates the creation of the spectrum map more potential routing paths. The spectrum map demonstrates the existing spectrum through geographic region, all the way through sensing and a variety of presumption techniques be able to be functional on the way to create such a spectrum map [7]. Thus, dynamic and the opportunistic routing schema provide a valuable spectrum sensing toward preserve growing information in a consistent manner and in a resource-efficient manner. As the periodically used heterogeneous environment of the CR Ad Hoc Network (CRAHN) [8] posses another important issues during routing process that is reliable cooperative communication.

Conventional routing algorithms designed for wireless ad hoc networks to optimize an end-to-end delay, fewer network latency, quantity of hops, achieves high throughput etc. In recent work several number of Conventional routing algorithms have been in literature with the intention of utilize network-wide transmit not including any localization information , acquisitively forward packets relying on destination location toward enhance the selection of path. Conversely, these Conventional routing algorithms is not suitable for CRAHN, since there is no sustain designed for concurrently decide the spectrum band. To solve these problems, numerous works have been proposed for CR networks [9-10].

Conversely, still lack of problems occurs in routing algorithm designed for CRAHNs through practical network size, examination of information transportation through opportunistic communication links suitable toward wireless fading and operations. In addition, depending on feedback message overheads beginning nodes is able to considerably decrease the spectrum effectiveness, and assumption to implement networking functions such as routing. In this paper mostly study on the focus of CRAHNs based routing schema and their major issues of routing schema is also studied. The remaining part of the survey paper is summarized as follows: In Section II illustrate the study is based on spectrum sensing and routing schema in CRN. So in this paper illustrate the study of existing routing schema in cognitive radio network throughout consideration of routing metrics approximating delay, throughput designed for spectrum aware routing, In Section III showing the discussion of inference from existing work, In Section IV discuss the simulation study, In section V discuss the findings of existing routing protocol is also discussed, and in Section VI concluded the paper and scope of future work is also discussed.

2. LITERATURE SURVEY OF SPECTRUM-MAP BASED OPPORTUNISTIC ROUTING METHODS

In adhoc networks, routing is the procedure of choosing optimal paths to reduce the network traffic and process of sending a packet or data from source to destination node. The routing system frequently directs forwarding packets from source to destination is performed based on the maintaining of routing table to reach destination path correctly. Thus, maintenance of routing table is stored in router's memory, is extremely imperative designed for well-organized routing. In literature many of traditional routing algorithms make use of only single network path at a time. Multipath routing procedure permits the make use of various alternative paths at a time. CRN routing process the spectrum as well as node self-control modifies in the routing procedure, direct mobility and the nodes determination modify here. CRN routing is varied from traditional routing schemas, since CRN routing methods is grouping of conventional routing schemas and spectrum sensing is performed based on time and location. Spectrum sensing management accessibility is moreover affected through the Primary User (PU) behavior via the following constraints:

1. Spectrum accessibility: Routing section is required to be sensitive of spectrum accessibility which is attained through examining spectral location.

2. Primary User Activity responsiveness: CRN topology is pretentious through PU activities as well as through route QOS parameters namely network delay, bandwidth, throughput, energy effectiveness which must be measured through spectrum accessibility.

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3. Route protection: PU activities might results in regular changing of nodes which results degradation the network performance. Thus efficient signaling methods are necessary designed for suitable routing in CRN.

4. Require Common Control Channel (CCC): In conventional routing protocols, precise functionalities such as neighbor detection, route detection and route concern are completed during neighborhood or global broadcast communication. In CRN, due to be deficient in CCC broadcasting develop into a most important difficulty.

5. Intermittent Connectivity: In CRN, appropriate to spectrum accessibility and PU activities available nodes might alteration regularly. Thus, Intermittent Connectivity in CRN is majorly relies on spectrum accessibility. It is solved by the use of time and space based location through respect to channels. Conversely among these conventional routing protocols considerate of these extremely dynamic opportunistic routings and a consistent end-to-end transportation over the network turn into posses numerous issues for CRAHNs. Some of the methods have been proposed in literature to solve the opportunistic routing problems and issues in CRAHNs which is mentioned above .The survey of existing opportunistic routing is described as follows.

SAMER [11] attempt to discover a high-throughput path through opportunistically make use of high-throughput links at the same time as satisfaction of path's long-term strength. In the way to satisfy the channel accessibility, the proposed SAMER attempt to discover path between PU and SU activity. Each SU approximation the fraction of time throughout which a channel be able to be used and it is not used by other SU and PU. Because neighboring nodes estimation of PU and SU will varies depends on channel accessibility designed for a link is known through the smaller of the two values. For each and every one channel, SAMER approximate the estimated throughput as the multiplication of channel accessibility, link bandwidth, and packet loss rate. The link metric is then determined as the summation of all throughput values for presented channels. SAMER methods achieves higher throughput among each and every one links along a path, but end to end delay restriction not attained i.e., a bottleneck metric.

CRP [12] proposed a new opportunistic routing schema based on the two different levels of classes with the purpose of suggest diverse stage of security to PUs. Class I intend to reduce the end-to-end delay at the same time as still providing suitable safeguard to PUs. Alternatively, Class II permits a stage of performance degradation and prioritizes PU protection through choosing as relays SUs with the purpose of PU receivers. So CRP major focus on security of users based on the Class I level only. In CRP opportunistic routing schema when an SU accept a route request, it decides a rebroadcast interruption through determining a cost function relying simply on local information. The cost function considers the SU's approximation of channel accessibility, difference of intensities of PU behavior, etc. An SU with a higher channel accessibility and lower cost determination rebroadcast the route request previously, without performing any neighborhood calculation.

Joint on-demand routing and spectrum sensing based routing schemas is proposed in [13] for CRN during a multi-hop transmission. In this work the routing is performed based on the delay metric. They delay metric is also used to select path to minimize switching, queuing and back-off delay for selected route during a multi-hop transmission. Multi-hop Single-transceiver CR routing Protocol (MSCRP) [14], equivalent to the traditional AODV. In this MSCRP method the RREQ request is forwarded to each and every one the probable channels to reach the destination. Spectrum Sensing based path selection is performed based on the determination of time designed for spectrum switching, channel conflict, and data communication. The MSCRP, decrease intra- CR interfering and spectrum sensing switching cost throughout routing and link scheduling.

SEARCH [15] routing protocol is designed for path selection and channel selection in CRAHNs without consideration of PU activity. It is developed based on the principle of geographic forwarding principle. In CRN, route is created on network layer must not concern PU communication and thus should be responsive of spectrum accessibility. The regularity changing PU activity and mobility of CR user formulate the difficulty of maintaining most select routes in CRAHNs becomes challenging, this problem is solved by using SEARCH with two concepts.

Activity awareness: In CR network, route should be build without consideration of PU activity. When PU activity influence region, it primary employ greedy geographic routing schema to reach destination through recognize PU activity region. The path information of diverse channels is merging at destination in sequence of optimization steps to choose on best end-to-end route in a computationally well-organized manner. Secondly performs, CR user mobility results into recurrent path disconnections. Thus designed for every one node, all the way through interrupted beacons, revise its one-hop neighbors regarding it present location SEARCH guarantee performance as well as less interfering in CRN. Spectrum-aware and Energy-efficient Routing (SER) [16] protocol is designed for Routing in CRAHNs. It consists of three major steps such as route detection, data transmission, and route protection. During data transmission, broad cast communication is performed based on DSR protocol. CR user sends a packet from source to destination via begin a route discovery. To choose the energy-efficient path, they

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select minimal residual energy mEres consumption node through lower hop count as metric and threshold energy, Eth. This determination makes sure the route with the intention of has the minimal nodal residual battery energy.

Spectrum-Aware Routing Protocol (SARP) [17] protocol is designed for dynamic opportunistic routing in CRN, it consist of two major parts such as Multi-Interface Selection Function (MISF) and Multi-Path Selection Function (MPSF). MISF is second-hand to allocate a suitable interface toward a route to proficiently assign the channels. MPSF is second-hand to choose a suitable path toward route packets together the spectrum and space to increase the performance. It uses the delay of the RREQ packets and highest throughput as the metric to select the path in CRN. So the destination nodes are supposed to choose the path through the largest throughput.

A path-centric spectrum assignment structure (CogNet) is introduced in [18] with the intention of build a multi-layered graph of the network on each node .In this CogNet, edge weights symbolize the spectrum accessibility among the nodes. The distribution of the network broad edge weights to everyone node acquire an excessive overhead, so it is not applied for mobile ad hoc network. Conversely, CogNet (i) make use of theoretical assumption to PU models, (ii) are not guaranteed designed for perfect detection of route to the PU receivers. Lien et al. [19] proposed a new dynamic Opportunistic Routing in AdHoc networks (OPRAH) to assurance of Quality-Of-Service (QOS) in cyber-physical systems through proposition of CR resource management. OPRAH is also uses an air interface to discover a more optimal path designed for each packet in a dynamic AdHoc networks. Thus OPRAH has the following advantages: capability to interoperate through wired protocols, to guarantee with the intention of the ad hoc network is able to communicate through the legacy wired communications, it works in a small mobility environment.

Cedric [20] dealt solves the mobility management problem via constantly changing the packet header. In the direction of decrease the message communication overheads of channel sensing, apply compressive sensing. CS is used to build a spectrum map representative the radio resource accessibility with Cyber-Physical Systems (CPS) coverage. This type of Spectrum Map Resource Management (SMRM) simply make use of a little piece of machines to achieve channel sensing , however allow disseminated cluster-based spectrum sharing in an well-organized manner. So SMRM controls offered resources to assurance the QOS designed for communications of CPS.

MAC-independent Opportunistic Routing protocol (MORE) [21] is for CRAHNs. In this dynamic MORE schema randomly combines several number of packets earlier than forwarding them. This will ensure the route efficiency during data transmission. It doesn't desires no extra scheduler toward coordinate routers and be able to run straightforwardly on top of 802.11. Experimental work is conducted to 20-nodes, it demonstrate that the MORE's unicast achieves 22% higher throughput than ExOR. For multicast, MORE's achieves 35-200% higher throughput than ExOR with the number of destinations.

Khalifé et al. [22] proposed an opportunistic forwarding in CR networks relying on proportional timescale of the key bands' idle time through CR communication period. Propose methodical models with the intention of distinguish the performance of various routing protocols in lossy wireless networks through Rayleigh fading channels. Examine the effectiveness of a small number of representative deterministic and opportunistic routing schemas below together light-loaded and saturated traffic situation. This proposed schema considerably outperforms its deterministic counterpart in standard successful development completed in single-hop transmissions to attain optimal network performance.

3. INFERENCE FROM EXISTING OPPORTUNISTIC ROUTING METHODS

1. DORP: In joint on-demand routing and spectrum assignment DORP protocol is proposed. In this DORP method the path selection based joint on-demand routing is proposed for routing in CRN. The DORP protocol presents the improved flexibility and obtains paths through lesser cumulative delay. Although it comprise lesser end to end delay from source to destination and achieves high throughput with less communication overhead in the CRNs.

2. SEARCH: Distributed opportunistic routing protocol designed for CRAHNs. This SEARCH equally optimizes the link pathway and channel assessment; therefore with the purpose of the end-to-end delay is reduced. SERACH achieves higher throughput, less communication overhead and less end-to-end delay in the CRAHNs.

3. SER: Spectrum-aware and Energy-efficient Routing (SER) protocol is designed for Routing in CRAHNs. It consists of three major steps such as route detection, data transmission, and route protection. During data transmission, broad cast communication is performed based on DSR protocol. SER protocol maintains and balances the traffic load of various CR users based on their residual battery energy. So it achieves lower end to end delay, high throughput and standard overhead.

4. SARP: Spectrum-Aware Routing Protocol for Cognitive Ad-hoc network consists of Multi-Interface Selection Function (MISF) and Multi-Path Selection Function (MPSF) as a metric to select suitable interface. It uses the delay of the RREQ packets and highest

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throughput as the metric to select optimal path in CRN. This achieves high throughput, extremely low overhead and delay.

5. MSCRP: Multi-hop Single-transceiver CR routing Protocol (MSCRP), equivalent to the traditional AODV. In this MSCRP method the RREQ request is forwarded to each and every one the probable channels to reach the destination. Spectrum Sensing based path selection is performed based on the determination of time designed for spectrum switching, channel conflict, and data communication.

6. SAMER: SAMER attempt to discover a high-throughput path through opportunistically make use of high-throughput links at the same time as satisfaction of path's long-term strength. In the way to satisfy the channel accessibility, the proposed SAMER attempt to discover path between PU and SU activity. SAMER methods achieves higher throughput among each and every one links along a path, but end to end delay restriction not attained i.e., a bottleneck metric.

7. CogNet builds a multi-layered graph structure of the network for each node. In this CogNet, edge weights symbolize the spectrum accessibility among the nodes. The distribution of the network broad edge weights to everyone node acquire an excessive overhead, so it is not applied for mobile ad hoc network.

8. OPRAH: Novel opportunistic routing permit assistance through intermediate nodes in a probabilistic way on the way to discover supportive assortment proficiently and practically through considerable throughput gain.

9. SMRM: The simulation results of SMRM demonstrate successful QOS assurance of CPS through SMRM in the practical background.

Table I summarizes the differences among the various routing methods for CRAHNs in the evaluation of (i) Node channel accessibility (ii) channel accessibility for a node (iii) Link and path metric, and (iii) solution.

TABLE 1: Qualitative comparison of various routing methods considered in this survey

Routing methods	Node channel accessibility	Channel accessibility	Link and path metric	Solution
DORP	Based on PU and SU activity.	Scheduling-based channel accessibility development towards nodes decides frequency bands.	Minimum of accessible channels since of on-demand interaction through diverse frequency bands.	Minimization of switching delay, queuing delay and back-off delay designed for the selected route.
SEARCH	Based on PU activity.	In this protocol routing and channel chosen is performed while avoiding area of PU activity simply, consequently less channel accessibility.	The path information of diverse channels is merging at destination in sequence of optimization steps to choose on best end-to-end route in a computationally well-organized manner.	Must not influence PU transmission and thus should be aware of spectrum accessibility.
SER	Based on CR activity	It consists of three major steps such as route detection, data transmission, and route protection. So need more channel availability.	Energy-efficient path selection is decided based on maximal and minimal residual energy through lesser hop count value as metric.	So it achieves lower end to end delay, high throughput and standard overhead.
SARP	Based on PU and SU activity.	Intelligent multi-interface selection function (MISF) which is used to assign an appropriate interface to a route to efficiently allocate the channels.	It is used to select an appropriate path to route packets.	Throughput increment as the predicted throughput after a new application joins minus the current throughput.
MSCRP	Based on PU activity.	MSCRP is equivalent to the traditional AODV. In this MSCRP method the RREQ request is forwarded to each and every one the probable	Spectrum Sensing based path selection is performed based on the determination of time designed for spectrum switching, channel	Correspondingly, the greatest routing paths are primary recognized and then the preferred channels allocation for selected path.

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		channels to reach the destination.	conflict, and data communication.	
SAMER	Based on PU and SU activity	Lowest channel allocation between nearest nodes.	The link metric is then determined as the summation of all throughput values for presented channels.	For each and every one channel, SAMER approximate the estimated throughput as the multiplication of channel accessibility, link bandwidth, and packet loss rate.
CogNet	Based on PU and SU activity.	graph characterize the spectrum accessibility between the nodes, consequently ensures fewer usage of channels.	Bellman Ford-like algorithm is applied to discover the optimal path.	The distribution of the network broad edge weights to everyone node acquire an excessive overhead, so it is not applied for mobile ad hoc network.
OPRAH	Based on PU and SU activity.	Connectivity is established through fading among two fixed points, so this becomes less usage of channels.	OPRAH makes use of air interface toward discover a more best path designed for each packet.	Novel opportunistic routing permit assistance through intermediate nodes in a probabilistic way on the way to discover supportive assortment proficiently and practically through considerable throughput gain.
SMRM	Based on PU and SU activity.	Achieve channel sensing, however allow disseminated cluster-based spectrum sharing in a well-organized manner.	CS is used to build a spectrum map representative the radio resource accessibility with Cyber-Physical Systems (CPS) coverage. Highly ensures the path and link availability.	So SMRM controls offered resources to assurance the QOS designed for communications of CPS.

4. SIMULATION STUDY

In this section, primary initiate simulation setup to CRAHN and then discuss the simulation results of various
Routing methods.

Simulation Setup, in this work to measure the simulation results of various routing methods we use the topology shown in Figure 3, which is same like as [23] and [24]. A square region of side 1200 m is categorized into 9 square cells of side 400 m. In the simulation setup, totally there are 9 Primary User (PU) locations. In each PU location, totally there are 10 Primary User (PU) locations; it might be designed for data transmissions. Every one PU has an interfering range of 250 m. 49 SUs are positioned in a grid design; the distance among any two neighboring SUs is 160 m. Every one SU has a greatest transmission range of 250 m on every one channel.

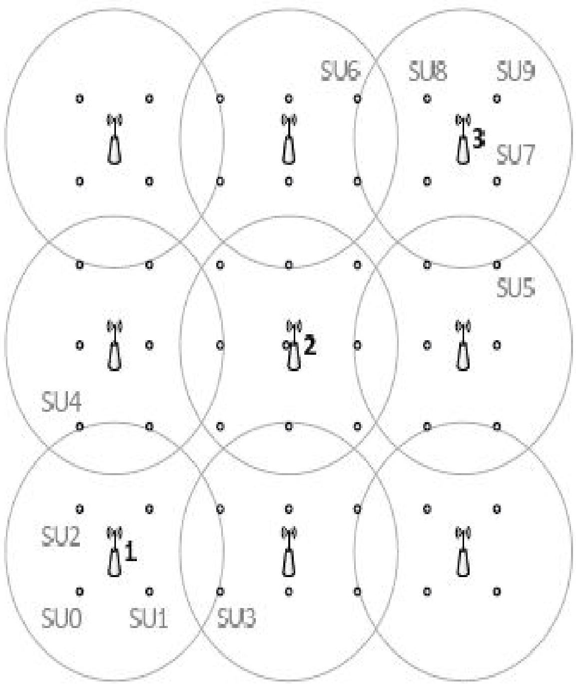
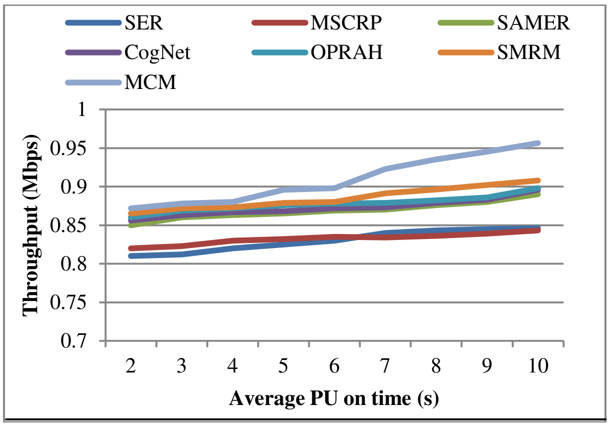


Figure 3. Simulation topology

Throughput comparison

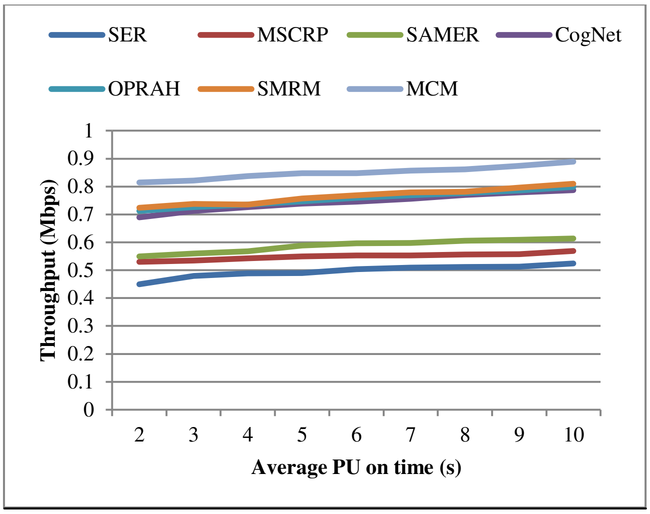
In order to measure routing methods result, first use the throughput comparison, in which make an assumption that all PUs be have equivalent ranger of average ON and OFF times. For every one grouping of average ON/OFF times, replicate the simulation 20 times, by means of every time a diverse start to create PU activities, i.e., ON/OFF intervals subsequent an exponential distribution. Throughput comparison results of various routing methods with respect to time is measured based on the following formula.

$$Throughput = \frac{packet\ received}{amout\ of\ packet\ forward} \quad (1)$$



(a) Avg. PU OFF time = 6 sec

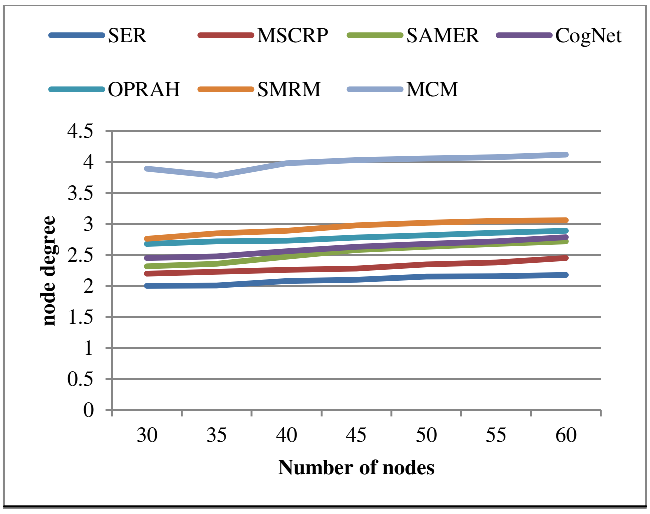
In the Figure 4(a), measure the throughput comparison results by predetermining the average PU OFF time at 6 sec and differ the normal ON time beginning 3-10 sec. Each point communicates toward the average throughput over 20 simulation runs and the error bar communicates to the standard deviations. Examine the throughput of all SER, MSCRP, SAMER, CogNet, OPRAH, SMRM and Markov Chain Modeling (MCM) routing protocols drops when the strength of PU actions increases.



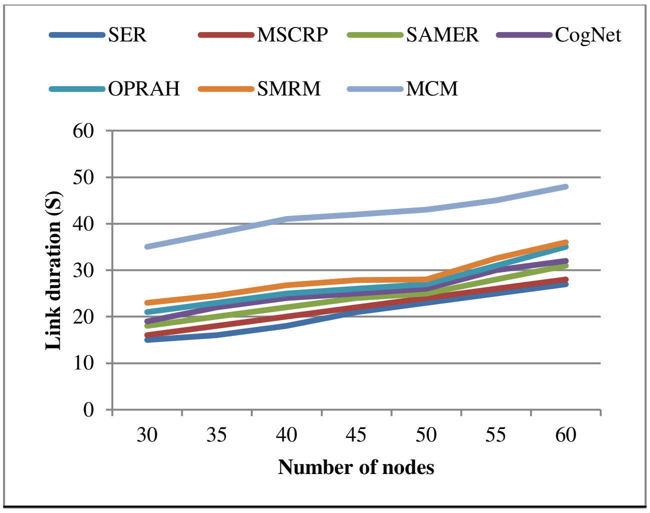
(b) Avg. PU ON time = 6 sec.

Figure 4. Baseline throughput comparison, the data points for methods

In Figure 4(b), measure the throughput comparison results by predetermining the average PU ON at sec and differ the normal OFF time beginning time from 3-10 sec. Examine the throughput of all SER, MSCRP, SAMER, CogNet, OPRAH, SMRM and Markov Chain Modeling (MCM) routing protocols . Again, MCM outperforms when compare to other routing protocols the best when the intensity of PU actions is low.



(a) Node degree



(b) Link duration

Figure 5. Baseline throughput comparison, the data points for methods

Figure 5 shows detailed performance comparison results of the various routing protocols and results are measured in terms of node degree and link duration of the topology control algorithm. Run the simulations for 100 times. From Figure 5(a) examines the resulting of various routing protocols under average node without topology control. It observed that the results of MCM with average node degree retains small in the network increases, which moreover build network scalable. In adding together to node degree, the topology control algorithm as well results in longer link duration is shown in Figure5 (b). This designate that the resulting topology is more stable and it is probable toward decrease re-routings in the network.

5. FINDINGS FROM ROUTING METHODS

The major findings from survey are discussed as follows are:

1) Consideration of link quality and interfering amongst various SUs might increase the throughput and reduce end-to-end delay .However path constancy and path duration becomes major important factors to affect the throughput and increase end-to-end delay under PU activity

2) The spectrum map demonstrate the existing spectrum through geographic area, via sensing and locating .In recent work several number of spectrum sensing schema is studied in literature which increase total throughput at the cost of reduced fairness.

3) Link and path stability are not constantly good performance indicators.

4) For link routing metrics with the intention of disregard link quality, restrictive the path length throughout the make use of an additive as an alternative of a bottleneck path metric classically improves performance.

5) First, several number of routing algorithms is proposed in literature, there is still a require to assurance the traffic QOS, such as network throughput, end to end delay and loss rate becomes unsolvable. So the possible future work will be extended to study the relationship among end-to-end delay and throughput.

6) In addition, depending on feedback communication overheads might decreases the spectrum efficiency.

6. CONCLUSION AND FUTURE WORK

In this paper, the first study the details on routing protocols for CRMHNs and has been effectively experimented by using ns-2 simulator. They are predict to solve the difficulty of spectrum scarcity through making well-organized and opportunistic employ of frequencies reserved for licensed users of the bands. This survey strongly study on cooperative spectrum-aware communication protocols with the intention of considers the spectrum management functionalities. This survey studies various routing methods such as SEARCH, DORP, SER, SARP, MSCRP, SAMER, CogNet, OPRAH, and SMRM for mobile CR networks. The main challenge of CRN is routing awareness of PU activities, chosen of routes and maintenance of route depending on QOS becomes also main challenge. Here, there are some different approaches discussed for finding solutions in routing problems. Study of these approaches provides probable solution to solve routing challenges in CRN. There are various routing measurements provided for CRAHN to calculate and examine performance of proposed routing solutions. To improving end-to-end network performance such as throughput and delay, a well-organized and consistent link prediction schema is introduced in future work. Furthermore make easy a new model for multi-hop transmissions. Furthermore, it assurance the traffic QOS, such as network throughput, end to end delay, link accessibility, link path detection, routing and accurateness.

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