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Performance Evaluation of Routing Protocols in Cognitive Radio Network

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ABSTRACT

Cognitive Radio (CR) is an adjusting of quick, ready intelligence radio and network technology that can automatically discover ready narrow ways in a radio band and change sending parameters making able to more making connections to run taking place together and also get well radio operating behaviour. CR uses a number of technologies including adjusting radio and software formed radio (SDR) where old and wise hardware parts including mixers, modulators and makes greater have been put in place of quick, ready intelligence software. Wi-Fi based wireless terminal structure block that can be used to design cognitive radio network (CRN). In this paper the design procedure of cognitive radio network using IEEE 802.11 wireless standards is given. Also new reactive routing protocol namely Improved Ad-hoc On-demand Multipath Distance Vector (IMAOMDV) which is extension of Adhoc On-demand Multipath Distance Vector (AOMDV) is designed. The performance of Wi-Fi based CRN is evaluated by its performance parameters like average throughput, average end to end delay and packet delivery ratio. Finally designed routing protocol's performance is compared with various reactive and proactive routing protocols.

Keywords: Cognitive radio network, routing protocols, primary detection, spectrum sensing, dynamic spectrum access

INTRODUCTION

Cognitive radio has become a promising technology to increase spectrum use through spectrum sharing between licensed users (first (or most important) users) and unlicensed users (secondary users). Performance and analysis is of very important importance to get more knowledge of this newly visible technology. Basically there are two types of cognitive radio namely full cognitive radio and spectrum-sensing cognitive radio. Full cognitive radio takes into account all constraints that a wireless node or network can be attentive of. Spectrum-sensing cognitive radio is used to sense channels in the radio frequency spectrum. There is a hopeful expectation of cognitive radio technology in requisites of dynamic spectrum selectivity, high speed not to be faulted communications, and low employment expenditure. In the meantime, the essential features of the new communication technology oblige new challenges in the plan of efficient spectrum supervision and sharing schemes. Researchers are expected to come up with new solutions to superior spectrum efficiency [1-2].

The general model of cognitive radio network is given in figure 1. The important elements of CRN are sensing, analysis, reasoning and adaptation. The function of sensing element is real time wideband monitoring and sensing f empty radio channels. Analysis plays an important role in radio environment system. Analysis analyses the rapid characterization of radio environment. Next reasoning determines the best response strategy in radio communication system. At last adaption provides transition to new operating parameters. Each element is depending on other in radio environment. The stereotype topics depend on the set of cooperative CRs, detecting range, and improving the resource sharing. The stereotype end-to-end wait depends on stable and reliable SBs, low rates of interference and interruption, and a short negotiation time [3]. In CRNs secondary user might depend on energy gathering or resourceful data transmission on primary user channels [4].

For security purpose use of security algorithms may be used in CRN. RSA encryption and decryption method may be used to advance its speed for dealing with the extended data [5]. It left over most working cryptosystem even today. The implication of high protection and quicker applications smooth the way for RSA crypto accelerators, hardware applications of the RSA algorithm [6-7]. The toughest test in cognitive radio is to project efficient spectrum sensing procedure so that non utilized spectrum can be proficiently used by numerous wireless technologies. This is because spectrum is scarce supply. Data sharing between cognitive radios can be attained efficiently. Consider any wireless network which is full of customers in which huge demand of spectrum but at the same time all customers cannot utilize the full spectrum. The some of the spectrum remain unused. To utilize this unused spectrum CRN plays an important role.

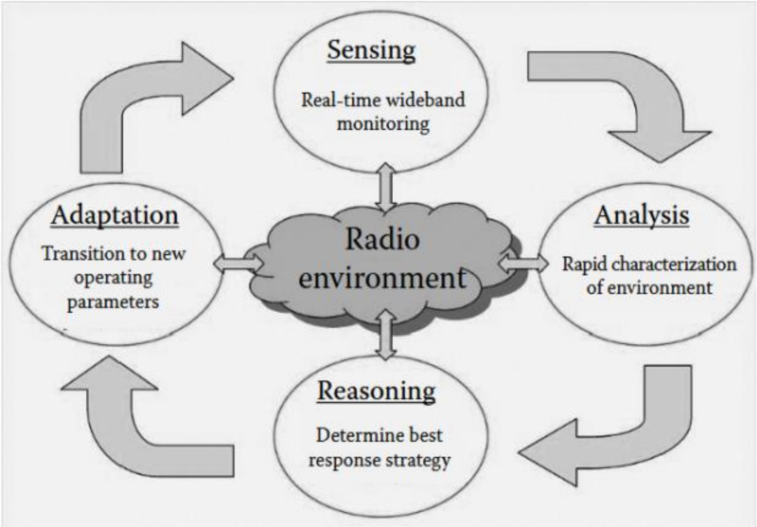


Fig. 1 General model of CR Network [1]

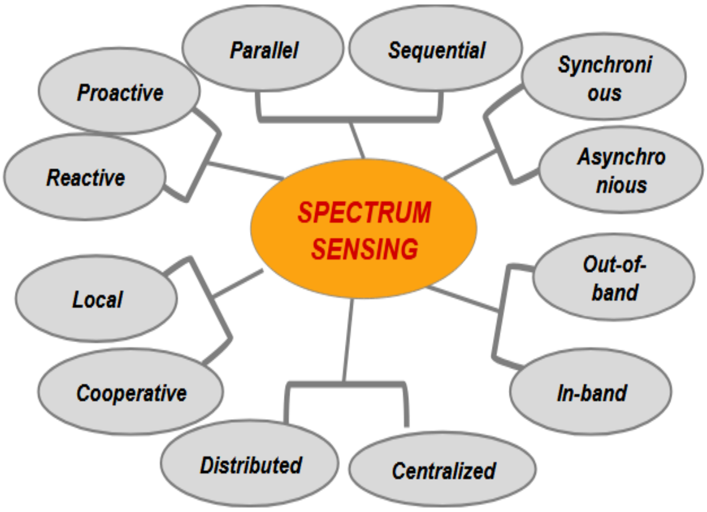


Fig. 2 Types of Spectrum sensing [2]

There are different types of sensing in wireless communication system. If there are N number of channels and simultaneously all channels get sense, then it is called as parallel sensing which require N number of sensing devices. Sensing of channel one by one it is called as sequential sensing. There is another way in sensing spectrum. A cognitive radio is a wireless communication system that logically uses any accessible side information about the activity, channel conditions and messages of other nodes with which it shares the spectrum. A sending the way approved design gives details of how routers exchange with each other, making distribution news given that enables them to select sends between any net-work points on a knowledge processing machine network. Design for the way algorithms work out the special good quality of way. It controls the data packet transmission and creates the connection in multi hop wireless network [8]. In wide-ranging routing protocols for ad hoc networks can becategorized into two groups: proactive and reactive Proactive routing protocols find tracks in advance for all source and destination couples and occasionally interchange topology information amongst nodes so as to preserve the routes. On the other hand, reactive protocols find the track on request only when there is data to transmit to a destination node [9]. Routing algorithm follows the precise option of path to distribute the data and to select a lane between any two nodes accessible in the network. Each node knows the network topology in advance and also maintains its personal routing table. Routers gather information about network topology by distributing information between nearby neighbours [10]. In proactive routing protocol each node keeps network topology information. Routing information is disseminated in the complete network. Information is requiring by lane then it run path finding algorithm. Reactive routing protocol when routes are required they are shaped hence such type of network do not switch routing information between the network [11]. Reactive protocols are on demand routing protocols. As the name suggests, the routes to target nodes are recognized only when the nodes must send data to target whose route is strange. This implies that the source node initiates the searching of routing routs only when needed. When a node wants to transmit data to a target node, it starts a route finding process inside the network [12].

It is not genuine for CR users to sense whole spectrum in exercise due to hardware limits [13]. WLANs that are established on the IEEE 802.11 can now be providing with CR proficiency. These CR-based WLAN can abuse the licensed spectrum for transmission of real-time traffic [14]. The spectrum waste ratio can hypothetically not ever be blocked minor than the sensing time ratio in a slot [15]. Energy efficiency plays an important role in any wireless communication system. The energy efficiency of the CRN can be calculated as follows [16].

$$\eta = \text{Average number of bits transmitted / Average energy consumed} \quad (1)$$

The total interference power received at the SU performing the sensing is expressed as [17]

$$I = \sum_{i=1}^{N_{AI}} I_i \quad (2)$$

Alternatively, with the underlay approach, the secondary user and primary user can simultaneously access the spectrum as long as the secondary user transmit power does not cause harmful interference to the primary user [18].

SIMULATION PARAMETERS

Following are the simulation parameters of table 1 which are we used for design Wi-Fi based cognitive radio network. Wireless local area network channels using IEEE 802.11 protocols are sold mostly under the trademark Wi-Fi.

The 802.11 workgroup has documented use in five distinct frequency ranges: 2.4 GHz, 3.6 GHz, and 4.9 GHz, 5 GHz, and 5.9 GHz bands. With the use of IEEE 802.11n, there is the possibility of using signal bandwidths of either 20 MHz or 40 MHz When 40 MHz bandwidth is used to gain the higher data throughput, this obviously reduces the number of channels that can be used. IEEE 802.11n 2.4 GHz Wi-Fi 40 MHz channels, frequencies & channel numbers. In this research we use propagation model as two ray ground propagation model. Queue is drop tail because when more number of packets will be in queue so at that time if queue limit ends last packet will be dropped. Number of packets in queue are 40 and total number of nodes in this simulation are 40. The routing protocols play an important role in wireless network. So to provide suitable route to the nodes here we used reactive and proactive routing protocols such as AODV, AOMDV, DSDV and IMAOMDV. The packet size decides the value of throughput. So digital multimedia data flows by an average value of 800 Bytes, hence we choose packet size as 800 Bytes. The total area of the cognitive area network is 600m X 600m.

Table -1 Simulation Parameters

Parameter	Quantity	Parameter	Quantity
Frequency	2.4 GHz	Antenna	Omni Directional Antenna
Bandwidth	20 MHz	Max packet in queue	40
Channel	Wireless Channel	Number of nodes	40
Mac	802.11	Routing Protocols	AODV, AOMDV, DSDV, IMAOMDV
Propagation	Two Ray Ground	Packet size	800 Bytes
Network	Cognitive Radio Network	Area	600m X 600m
Queue	Drop Tail		

METHODOLOGY

The design of Wi-Fi based cognitive radio network is challenging task. As explained in introduction part the radio environment elements play an important role in CRN. The design step of CRN includes, use of MAC 802.11 wireless standard protocol as a wireless network which are having number of primary users and secondary users. The radio channels are created and connected in between transmitters and receivers. The bandwidth is specified for each and every radio channel so that the capacity of the radio channel gets defined. The sensing element continuously sense the empty channels by sensing algorithm and if it finds empty radio channel then it provides to needy users, so that unused channels gets utilized properly. Here the thing which is important is that don’t disturb primary users because they are the main and actual users of that wireless channels. Various antennas are designed to operate in the cognitive radio network.

IMAOMDV is a distributed rules of conduct designed to be highly able to change and get better so it can operate in a energetic/changing network. As a significance of this multiple routes are often present for a given destination, but none of them are necessarily the shortest route The IMAOMDV routing rules of conduct is based on the LMR rules of conduct. It usages like route reversal and route reparation procedure as in LMR and also the development of a DAGs, which is like to the query/reply procedure used in LMR. So, it also has the same welfares as LMR. The benefit of IMAOMDV is that it has condensed the far-reaching controller messages to a set of adjacent nodes, where the topology modification has happened. Additional benefit of IMAOMDV is that it also ropes multicasting; however, this is not combined into its basic operation. IMAOMDV can be used in combination with Lightweight Adaptive Multicast Algorithm (LAM) to deliver multicasting. IMAOMDV as their names propose is a routing algorithm. It is mainly used in MANETs to improve scalability. IMAOMDV is layered over Internet MANET Encapsulation rules of conduct. This is to ensure reliability in the delivery of control messages and announcements about link status. The key objective of IPAOMDV is to boundary switch message broadcast in the extremely energetic mobile computing atmosphere. Each node has to obviously recruit an inquiry when it needs to send data to a specific destination. IPAOMDV fundamentally achieves three tasks: Formation of a route from a transmitter to a receiver, upkeep of the route and removal of the route when the route is no lengthier valid.

The block diagram of cognitive radio network designed system is given in figure 3 and 4. Figure 3 represents the transmitter and receiver section of Cognitive radio aware transport protocol in which the primary function of the system is to design cognitive radio channels and bandwidth allocation to them. Node detection is an important step in this system because in cognitive radio system the primary or secondary user can be in domain or cluster. Distributed scheduler performs the operation of providing schedules to the network. Spectrum sensing is depending on the demand of data transmission from transmitter user. For better transmission and reception of the packets in cognitive radio routing protocols plays an important role. Here we used four different routing algorithms i.e. AODV, AOMDV, DSDV and IMAOMDV.

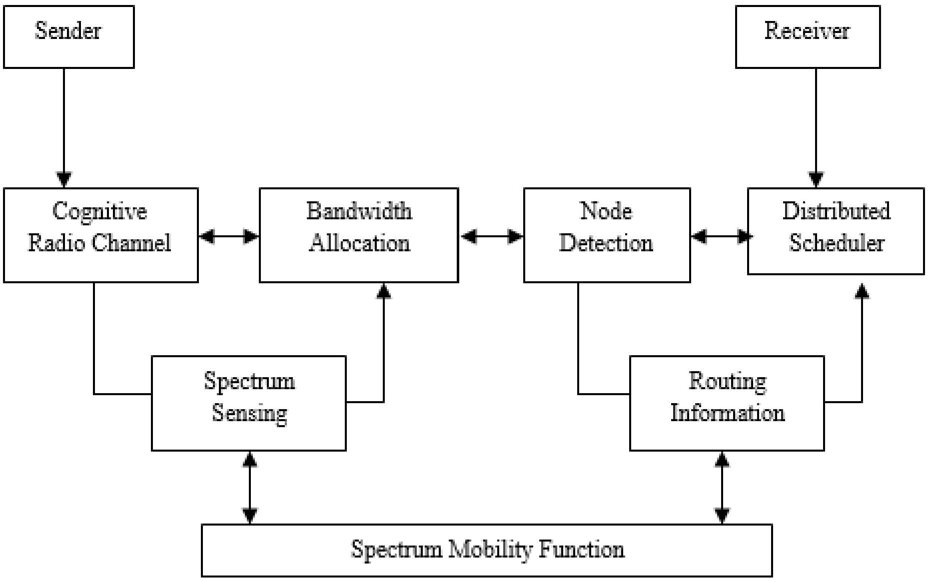


Fig. 3 Block diagram of design of Cognitive radio aware transport protocol

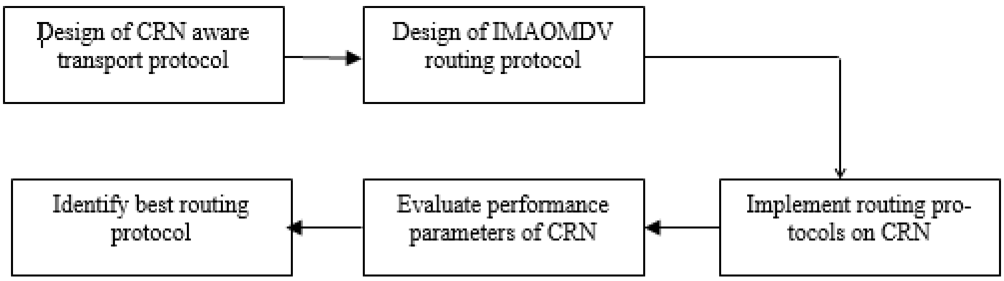


Fig. 4 Block diagram of designed CRN system

After design of cognitive radio network transport protocol with proper primary and secondary users it is important to design new routing protocol i.e. improved AOMDV. Remaining routing protocols such as AODV, AOMDV and DSDV are already inbuilt in the system. Next step is to implement various routing protocols on design cognitive radio network. Now evaluate performance parameters of the cognitive radio network such as average throughput, average end to end delay and packet delivery ratio for each and every routing protocol. Check the effect of encryption and decryption process on data transmission and reception within the network. Last step is to identify best routing protocol in used routing protocols.

RESULTS

The performance of CRN is evaluated on the basis of various qualities of service parameters like throughput, end to end delay and packet delivery ratio. While doing simulations one fact we kept in kind that adhoc network provides different results at every time because of its temporary changing topology behavior. The aggregation of this gives the results in terms of average of all time simulations. Here throughput or network throughput is the rate of successful message delivery over a communication channel. However, the actual data move (from one place to another) speed may be limited by other factors such as the Internet connection speed and other network traffic. Therefore, it is good to remember that the maximum throughput of a device or network may be much higher than the actual throughput in everyday use. Generally, throughput is measured in Bps, Kbps, Mbps.

$$\text{Throughput} = \text{Total number of packets received} / \text{Simulation time} \quad (3)$$

End-to-end delay denotes to the time taken by a packet to be transmitted across a network from transmitter to receiver. End-to-end delay is measured in sec.

$$\text{End-to-end delay} = \text{Packet received time} - \text{Packet transmitted time} \quad (4)$$

Packet delivery ratio is the total percentage of packets successfully received at the receiver. PDR can be calculated as follows.

$$\text{Packet delivery ratio} = (\text{Total No. of packets received} / \text{Total no. of packets sent}) * 100 \quad (5)$$

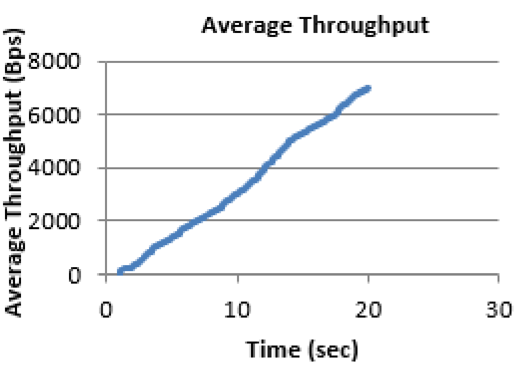
Cognitive radio network senses the empty channel and then it provides to the needy user without any interference of other users. After calculating performance parameters of the cognitive area network, here we can check the status of the system. Figure 5 shows the average throughput, PDR and EED of AODV routing protocol. Figure 6 shows the average throughput, PDR and EED of AOMDV routing protocol.

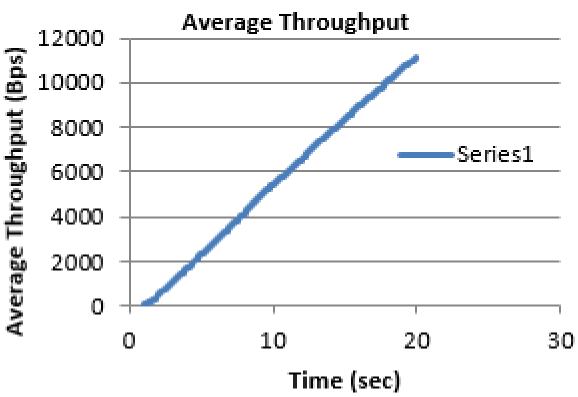
The average throughput is the total number of bytes received successfully at the receiver in given simulation time. The packet delivery ratio is how much percentage of packets successfully received at the receiver and average end to end delay means total time taken by the packet to reach from source to destination.

Figure 7 shows the average throughput, PDR and EED of DSDV routing protocol and figure 8 shows the average throughput, PDR and EED of IMAOMDV routing protocol.

Table -2 Comparison of Performance Parameters

Performance Parameter	AODV	AOMDV	DSDV	IMAOMDV
Average throughput (Bps)	3525.80	5767.60	2787.23	6983.11
PDR (%)	92.72	94.81	87.86	98.11
Average end to end delay (Sec)	0.001031	0.001023	0.001096	0.001004





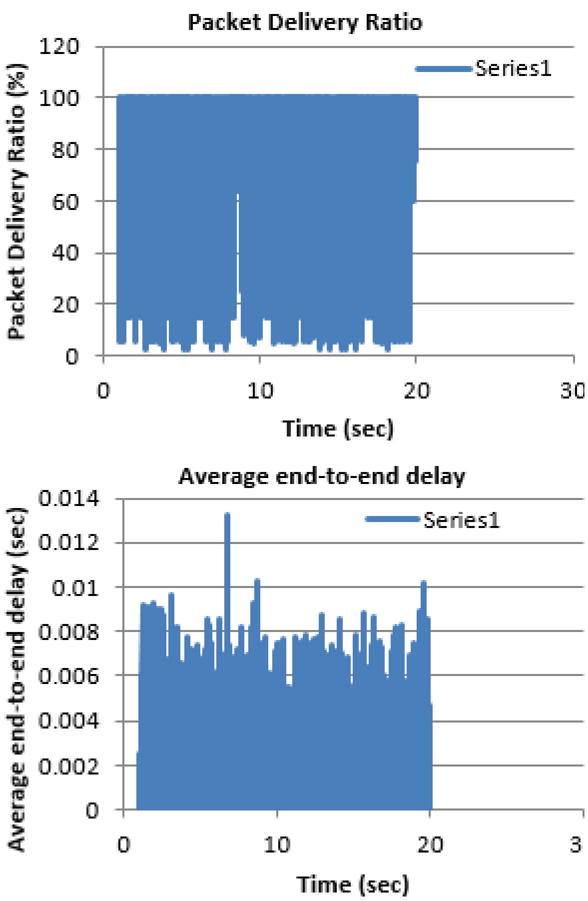


Fig. 5 Average throughput, PDR and EED of AODV routing protocol

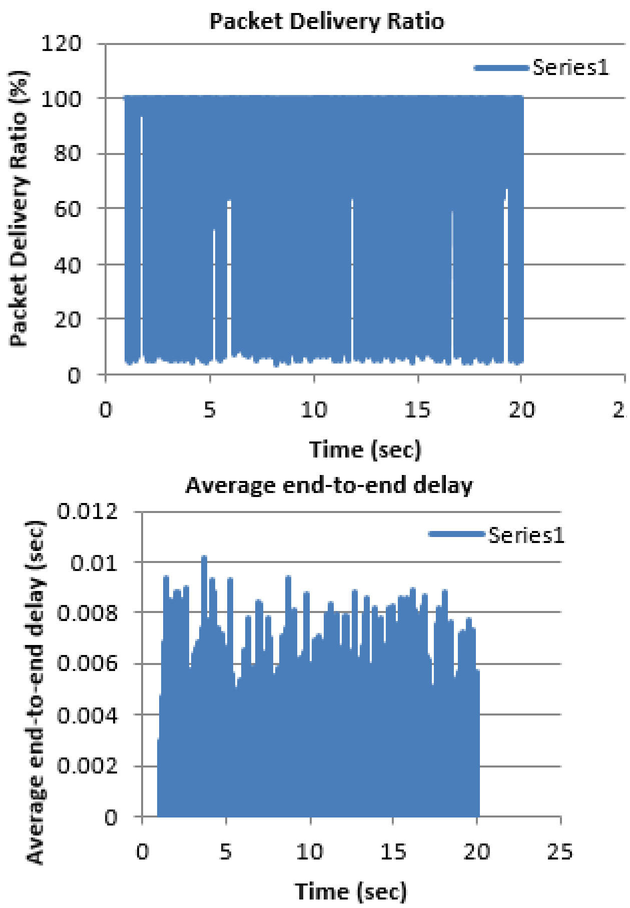
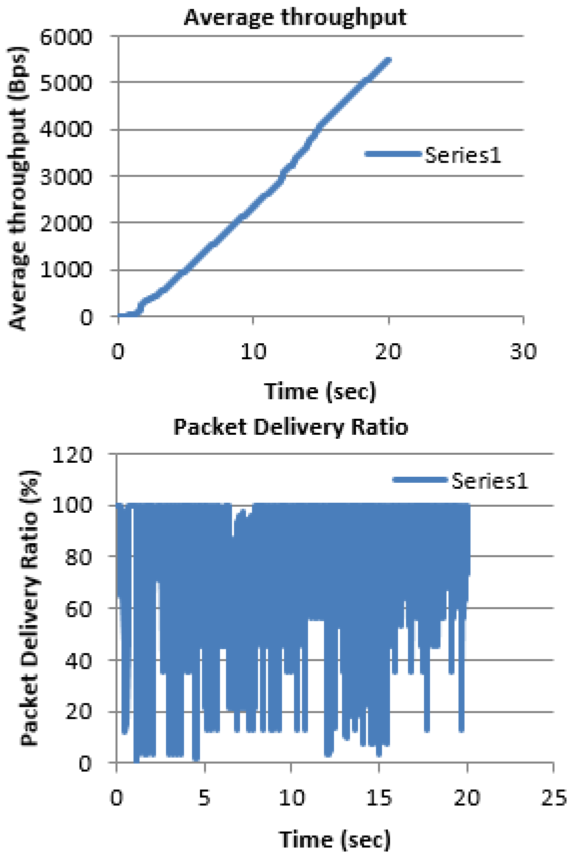
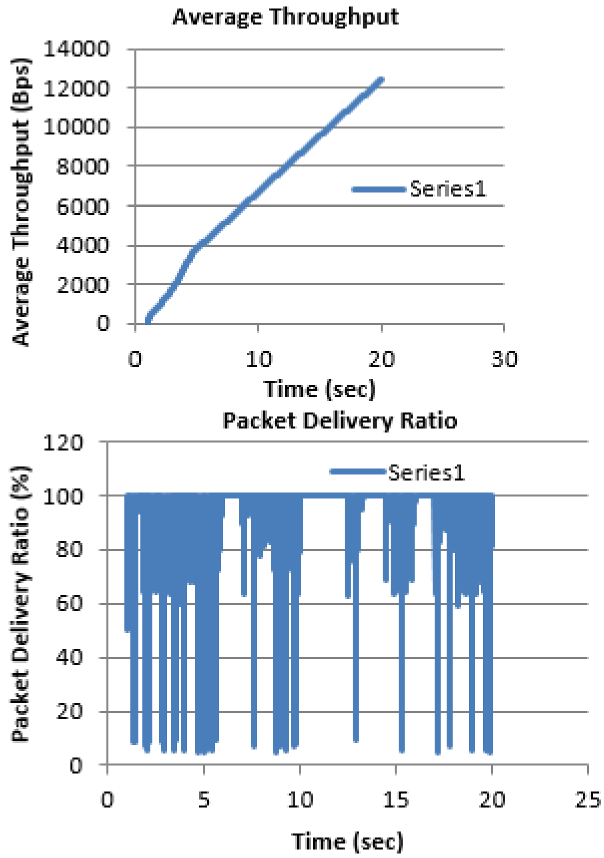


Fig. 6 Average throughput, PDR and EED of AOMDV routing protocol





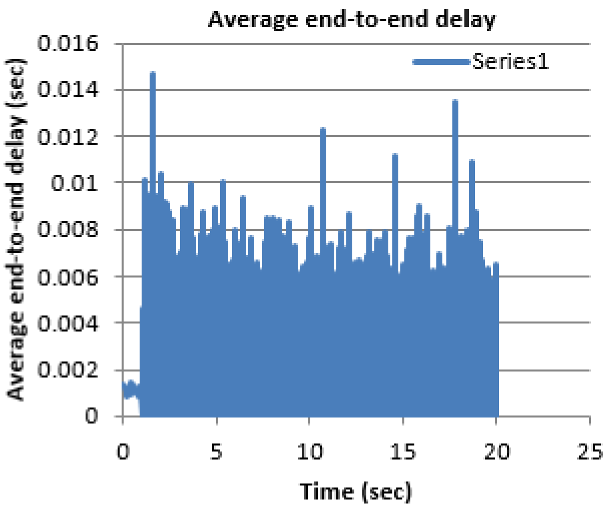


Fig. 7 Average throughput, PDR and EED of DSDV routing protocol

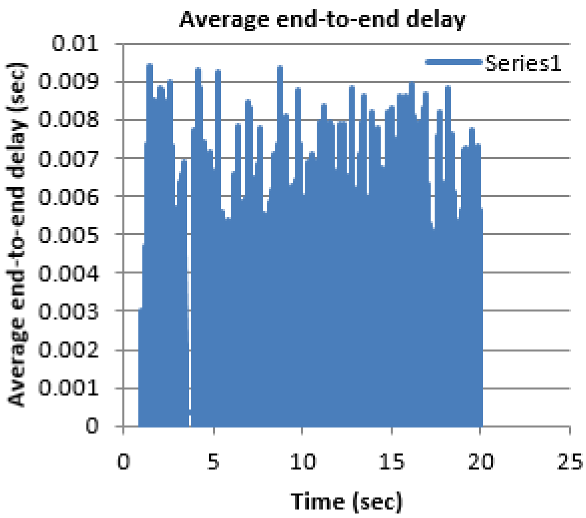


Fig. 8 Average throughput, PDR and EED of IMAOMDV routing protocol

Table 2 shows the comparison of performance parameter of the cognitive radio network system for different routing protocols. Here we can see that the average throughput of the improved AOMDV routing protocol is better than that of other three routing protocols. Similar case is happened for packet delivery ratio also. With improved average throughput the packet delivery ratio is also improved. But when you check for the average end to end delay the IMAOMDV gives lowest delay than other three routing protocols. After IMAOMDV, AOMDV routing protocol is giving better results as compare to AODV and DSDV routing protocols. Here DSDV routing protocol provides worst results because it is proactive routing protocol which continuously upgrade their routing table without any reason and so it takes more time for its functioning.

DISCUSSION

Cognitive radio networks also get well the amount covered by sending on way of doing from one point to the others next net-work point. It helps to gets changed to other form the power using up and does not give up doing a play of the network. To design cognitive radio communication system is the major challenge for the researchers. In future one can design cognitive radio communication system by using various hybrid routing protocols. For any network power consumption is the main issue. So to reduce power requirement one can use various power reduction techniques. Here many antennas can be used due to MIMO technique, so we can use various types of antennas. Various modulation techniques also can be used in future cognitive radio communication system. End to end delay is the key parameter to make fast communication. So researchers can use various techniques to reduce end to end delay. Also at the same time cognitive radio communication system can be designed for low level hot line service also. Cognitive radio communication system can be used with internet of things (IoT) that can mark IoT more inexpensive and appropriate.

CONCLUSION

Cognitive radio is miraculously helping technology ready for current increasing numbers of users in this hundreds of year's world. It builds a network of radio stations with the mix of cognitive radio hard growths for this reason gives important push up to the rate of motion and able to use of narrow ways for the new coming after first or chief radio networks. IPAOMDV ropes multiple routes. It holds multiple route potentials for a single Source as well as destination pair. Bandwidth is preserved because of the lesser route transformation. IPAOMDV also supports multicasts data transmission technique. The Wi-Fi based cognitive radio network performance is better for primary as well s secondary users. It saves bandwidth and transmitted power. The designed improved routing protocol provide better performance on cognitive radio network as compared to AODV, AOMDV and DSDV routing protocols in terms of average throughput, average end to end delay and packet delivery ratio. IMAOMDV routing protocol is reactive routing protocol so that it is better than proactive routing protocol because it makes routing table when user demands. Here we conclude that improved AOMDV routing protocol works better for this designed cognitive radio network in terms of calculated performance parameters.

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