Middle-East Journal of Scientific Research 23 (7): 1498-1505, 2015
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2015.23.07.22350

Quality of Service Aware Dynamic Channel Allocation for Multichannel Multi Radio Wirelessmesh Network

[1]*N. Ananthi* and [2]*S. Sudha*

[1]Department of Information Technology, Easwari Engineering College, Chennai, India
[2]Department of Electronics and Communication Engineering, Easwari Engineering College, Chennai, India

Abstract: Multichannel multi radio wireless mesh networking is an emerging technology that can support numerous multimedia applications. Efficient channel assignment is essential in Multichannel multi radio wireless mesh network deployments to support QoS requirements, i.e., delay bandwidth, throughput and packet loss ratio to enable such QoS-demanding multimedia applications. This paper proposes QoS aware Dynamic Channel Allocation (QSDCA) algorithmwith the objective of providing an optimized performance over meshnetwork. The algorithm considers the available bandwidth at each node, waiting time of the end user and the service time of the servicing node to avoid co channel interference. The performance of the proposed algorithm has been evaluated using the metrics such asthroughput, channel access probability and delay. The result shows that the network performance has been improved when compared to the existing channel allocation schemes.

Key words: Multichannel multi radio wireless mesh network · Multimedia applications · Channel assignment · QoS

INTRODUCTION

Wireless mesh networks have become an essential part of the future internet, whose nodes are linked to each other via multiple hops. It offers the broadband and mobile wireless connectivity in a flexible and cost effective way. A sensitive service such as multimedia has become an integral ingredient of broadband wireless mesh networks (WMN), which require end-to-end quality of service (QoS) support [1]. Nowadays, the multi-channel multi-radio networking is used as a promising solution to boost the capacity of the network. The problem of optimized performance of multi-channel multi-radio WMNs in the presence of QoS requirements is viewed as an interesting open problem. In this problem, the performance of the network is measured in terms of the acceptance data rate of traffic demands as if the QoS requirement demand is not guaranteed by the network, the user is not admitted to enter to the network.

Channel assignment has been seen as a key issue in multi-channel multi-radio WMNs. It has the capability to manage the network resources dynamically since the bandwidth estimation on each link is determined by the interference on it, which depends on its allocated channel. In the presence of co channel interference with QoS constraints, the main issue is to dynamically allocate the channels in order to provide an optimized network performance in terms of acceptance rate of traffic demands [2].

In this paper, Qos aware dynamic channel allocation (QSDCA) algorithm is proposed. The QSDCA assigns the channels dynamically to each receiver based on the QoS constraints such as bandwidth, waiting time of the end user and service time of the servicing node. An optimized network performance can be yielded by the QSDCA algorithm by guarantying the QOS at the same time [3].

The rest of the paper is organized as follows: Section 2 describes the recent related work of the channel assignment in wireless mesh network. Section 3 describes the system model and problem formulation. The proposed QSDCA algorithm is explained in the Section 4. The simulation results are discussed in the Section 5. Finally, Section 6 renders the conclusion [4].

Related Work: An efficient channel allocation solution was proposed in [2] for overall network throughput optimization. A mathematical formulation has been done for the joint problem of random network coding, broadcast

Corresponding Author: N. Ananthi, Department of Information Technology, Easwari Engineering College, Chennai, India.

link scheduling and channel assignment by considering the interference constraints, opportunistic overhearing, number of orthogonal allocation, the coding constraints, fairness among unicast and number of radios per node. A suboptimal, auction-based solution has been developed based on the formulation. The performance evaluation result shows that the algorithm can exploit the multiple radios and channels effectively [5].

A channel assignment scheme called MesTiC has been presented in [3] to minimize the interference in multi-radio mesh network to improve the aggregate network capacity and also to maintain the network connectivity. The algorithm incorporates the mesh traffic pattern together with the issues in the connectivity. The experimental results of the MesTiC show that it improves the network performance by minimizing the network interference in multi radio mesh networks [6].

A survey on the latest growth in multichannel wireless mesh networks by focusing the channel allocation algorithm and wireless interference models has been presented in [4]. The studies of the different interference models illustrates that different interference models affect the design of channel assignment. The two strategies of channel allocation algorithms are summarized and concludes both the strategies have advantages and disadvantages and also states that the channel assignment algorithms strongly depends on the interference network model and the assumption of network traffic [7].

A receiver based channel allocation strategy is presented in [5] for wireless cognitive mesh network. The strategy is formulated as a mixed integer linear program and proposes a heuristic solution. The strategy outperforms in terms of the number of mesh clients served and the fact that there is no need to have a common control channel for coordinating the communication process.

An innovative interference model is presented in [6] for wireless mesh network. Using this model, a channel assignment algorithm is formed for multi radio wireless mesh network based on graph theory. The performance of the formulated channel assignment algorithm shows a better improvement over the existing channel assignment algorithms.

In [7], the authors achieves interference free communication by determining the minimum number of non- overlapping frequency channels. A topology control algorithm is used to construct a connectivity graph to minimize the number of channels required by enhancing the channel reuse. The maximum throughput is achieved by using multi-path routing. An effective heuristic method is developed for interference-free channel assignment by determining the minimum number of channels required.

In [8], the authors proposed three intelligent computation algorithms to search minimum interference multicast trees in wireless mesh network for optimizing the network resources and end to end delay constraints. The performance results show that it better performs in terms of both the tree cost and total channel conflict.

In [9], the author proposed an economic framework by studying the joint channel allocation and routing in wireless mesh networks including the opportunities to reuse the channels for improving the network performance. A routing metric node shadow price is used to allocate the channels among different nodes. The channel allocation schemes simulation results shows that it maximize the network profit with the integrated channel reuse algorithm.

A dynamic and distributed channel assignmentprotocol is proposed in [10] for wireless mesh networks. The protocol is capable of detecting the failure nodes and mobility and also channel monitoring module records the quality of bi directional links. A Quality of Service based Multi-Radio Ad-hoc On Demand Distance Vector routing protocol has been devised additionally to provide end to end paths without delay. The simulation results shows that it reduces routing overhead and less network delay respectively.

System Model and Problem Formulation: A multi-channel multi- radio wireless mesh network is considered, where all the nodes in the networks are mobile. The network is modeled as a unidirectional graph G = (V, E), where V is the set of vertices representing the wireless router nodes in the network. An edge $e = (v, w)$ if and only the routers denoted by v and w are situated within each other transmission range.Let assume that there are K number of channels available, that each node i has r_i radio interfaces, where $1<r_i= K$.

There is N number of nodes belonging to the network. The assignment of channels to radios, source node and the receiver node can communicate if and only if they share a common channel and are within communication range of each other. If these conditions are satisfied, we say that a link exists between source node and destination node. The neighboring nodes operating on the same channel can cause co-channel interference when they transmit the data simultaneously. The efficient channel allocation algorithm considering the co-channel interference has been formulated.

destination	sequence Number	advertisement hop_count	route list			
			next_hop 1	last_hop 1	hop_count 1	timeout 1
			next_hop 2	last_hop 2	hop_count 2	timeout 2

Fig. 1: AOMDV routing table structure

Quality of Service (Qos) Aware Dynamic Channel Allocation (QSDCA): The aim of the QSDCA is to provide a QoS to the sensitive services in wireless mesh network by maintaining higher network throughput and lower delay while allocating channel to the receiver node by avoiding the congestion [10].

Link Establishment: The Multiple paths from the source to destination are determined by using AOMDV protocol [11], which is the extension of AODV protocol. The entries of the routes for each destination contain a list of the next-hops and the corresponding hop counts. The sequence number for all the next hops will be same, which helps to keep the track of a route.An advertised hop count is maintained by a node for each destination to define the maximum hop count for all paths, which is used for sending route advertisement to the destination. Once a route advertisement with a higher sequence number is received by the destination, all routes with the old sequence number are removed. The two additional fields, hop count and last hop, are stored in the route entry helps to address the problems of loop freedom and path disjointness respectively. AOMDV also provides the intermediate nodes with alternate paths, which helps in reducing route discovery frequency [12]. The routing table structure of AOMDV is shown in the Figure 1.

Channel Selection: The channel assignment scheme selects and allocates a channel to the R radio of each node. In this paper, a priority is assigned to each channelfor the nodes in the network based on following factors.

- The aggregate traffic$\boldsymbol{T}$ at a node at the channel c_i is determined based on the offered load of the mesh network and it is given by the authors in [13].
- The number of packet dropped$\boldsymbol{PD}$ of a node at the channel c_i is calculated by the difference of the number of packet transmitted to the number of packets read for forwarding.
- Thethroughput$\boldsymbol{Th}$ of a node using the aggregate arrival rate at node for channel c_i, which consists the originating traffic at the node and it also consider the average view of the neighbors and the formula for determining the throughput of a node is briefly explained in [14].
- The averaging queuing delay$\boldsymbol{D}$ at a node [15] for the channel $c_i$and it is calculated using the following equation

$$D_i = \alpha D_{j-1} + (1-\alpha)D_j \quad (1)$$

$$\alpha = \frac{queue_{size} - queue_{length}}{queue_{size}} \quad (2)$$

where $queue_{size}$ is the current size of queue at node i, $queue_{length}$ is the length of the queue at node i and j is the current period.

A weight for each channel of a node i is assigned based on the above mentioned factor of the node i

$$\begin{cases} w_1 = \frac{Th_1 - T_1 - PD_1}{D_1} \\ w_2 = \frac{Th_2 - T_2 - PD_2}{D_2} \\ \dots\dots\dots\dots \\ \dots\dots\dots \\ w_k = \frac{Th_k - T_k - PD_k}{D_k} \end{cases} \quad (3)$$

A priority P_i will be assigned for the channel selection of a node is based on the equation given below.

$$Priority(P) = \max(w_1, w_2, \dots\dots, w_k) \quad (4)$$

Channel Allocation: The multipath from the source to destination was estimated at the higher layer and sends the data to the lower layers for further actions[15]. Initially the available bandwidth at each node is calculated using the following formula

$$Bandwidth_{node\ i} = Bandwidth_{channel} \times \left(\frac{t_{channel\ idle}}{t_{total}}\right) \times 0.08 \quad (5)$$

where $Bandwidth_{channel}$ is the bandwidth of the wireless channel, $t_{channel\ idle}$ is the ideal time of the channel, t_{tatal} is the test total time and 0.08 is the weighting factor.

The Receiver node requestedbandwidth, which is less than or equal to the bandwidth of the next hop nodethen the channel will be allocated between a link. Otherwise the service time of the servicing node and the waiting time of the receiver node will becalculated as follows.

The mean service time E [S_i] of a node i is calculated using the following equation

Algorithm
Input: Connectivity graph G= (V,E), K distinct channels, radio interfaces ri

Output: Assignment of channels to radio interfaces at each node that preserves the connectivity specified by C
Priority table
1. Assign a priority to all the channels for the nodes in the network based on the priority calculation

$Priority(P) = \max(w_1, w_2, \ldots \ldots, w_k)$

Channel Assignment
1. Initially perform routing and establish the multiple paths between the source and the destination
2. For N number of user requesting the service from the network
3. Call Allocate_channel (i)
4. End for
5. Allocate_channel (user i)
6. For node i requesting the service do
7. Check the channel inference from the node i to node j based on the following conditions
8. Check If ($Requested\ bandwidth_{nodei} \leq current\ bandwidth_{nodej}$)
9. Then assign channel between the nodeiandnodej
10. Else check for the service time of $node_j$
11. if ($Service\ time_{nodej} \leq Wait\ time_{nodei}$) then
12. Channel is assigned between the nodeiandnodej
13. End if
14. End if
15. Else
16. Next intermediate node is selected and based on the priority the channel is selected and perform steps 8 to 16

Fig. 2: Channel Allocation Algorithms

$$E[S_i] = \frac{\mu + \alpha_i \beta}{\alpha_i \beta \mu} \tag{6}$$

where β is the back off rate and μ is the transmission rateand α_i is the node i probability, which successfully accesses the medium during transmission process, since α_i is a statistical view of the medium being idle state when node i has a frame to send. The α_i is calculated using the following formula.

$$\alpha_i = \frac{\mu(1 - \cup_{k\epsilon\omega_i} P_s[k]}{\mu + \beta \cup_{k\epsilon\omega_i} P_s[k]} = \frac{1 - \cup_{k\epsilon\omega_i} P_s[k]}{1 + \frac{\beta}{\mu} \cup_{k\epsilon\omega_i} P_s[k]} \tag{7}$$

where $\cup_{k\epsilon\omega i} P_s[k]$ is the busy probability of the medium around each $node_i$ in the multi hop environment.

The Binary Exponential Back off (BEB) [16] is used to calculate the waiting time for a receiver node. In the range [0, CW-1], a random Back off Time (BT) will be chosen by using the uniform random distribution, where CW is the current contention window size.

$$BT = (Rand()\ mod\ CW) * slot\ time \tag{8}$$

Check the waiting time of the receiver node, which is greater than or equal tothe service time of the intermediate node then the receiver node can wait and get the service from the same channel, otherwise the intermediate node is selected and with the highest priority channel is selected for that node and the condition process of channel allocation will be proceeds. These processes exist until the receiver node gets the proper channel allocation

After the channel allocation the nodes will be updated its bandwidth according to the following formula

$$Current\ bandwidth_{nodei} = Previous\ bandwidth_{nodei} - Allocated\ bandwidth \tag{9}$$

Each node estimates its allocated bandwidth by simply adding the size of sent packets and sensed packets over a fixed period of time [17]. The packet size is determined by estimating the medium occupancy time. This process considers data sent in the carrier sensing area. The difference of the previous bandwidth and the allocated bandwidth yields current bandwidth of the

Table 1: Simulation Setup

Simulation Parameters	Assigned value
Routing protocol	AOMDV
Medium Access Control (MAC)	IEEE 802.11s
Number of Channels	20
coverage area	100X100
Transmission Range	550 meters
Number of nodes	250

node. The process of the allocated bandwidth has been completed then it will be added to the previous bandwidth and yields the current bandwidth.

The proposed QSDCA considers the priority of nodes, service time of servicing node and waiting time of the requestor node to select the channel that ensures high throughput, minimum end to end delay.The QSDCA algorithm has been shown in the Figure 2. The QSDCA provides an optimized network performance by satisfying demands of the end user (requestor) with assuredQoS.

Simulation and Results: The NS2 simulation has been used to test the performance of the proposed QSDCA algorithm and the simulation setup is shown in the Table 1. The performance are measured in terms of channel access probability, Throughput and end-to – end delay and the results are compared with the existing Network coding based channel allocation (NCbDCA).

Performance Metrics

Channel Access Probability: Channel Access probability is defined as the n number of users can access the channel at the same time.

End –to –End Delay: End – to – End Delay is the time taken by the packet to reach the destination from the source. It includes the packet waiting time in queue, propagation and processing delay

$$Delay = Queuing\ Delay + Processing\ Delay + Propagation \quad (10)$$

Throughput: Throughput is the average rate of at which a network sends or receives data. It measures the channel capacity of a communication link and connections to the internet and it usually measured in terms of bits per second.

$$Throughput = \frac{Number\ of\ frames\ transmitted}{Time\ interval}(bps) \quad (11)$$

DISCUSSION

The channel access probability decreases with the increase of number of users, since more number of users causes more co- channel interference. Figure 3 shows the channel access probability for N number of users. The proposed QSDCA achieves 0.48 channel access probability for 8users, while NCbDCA achieves o.2 channel access probability.

The End – to - End delay increases with the increase of number of nodes in the network. Figure 4 shows the end to end delay for N number of nodes. The proposed QSDCA incurred 125ms for 50 nodes, while the NCbDCA incurred 168ms.

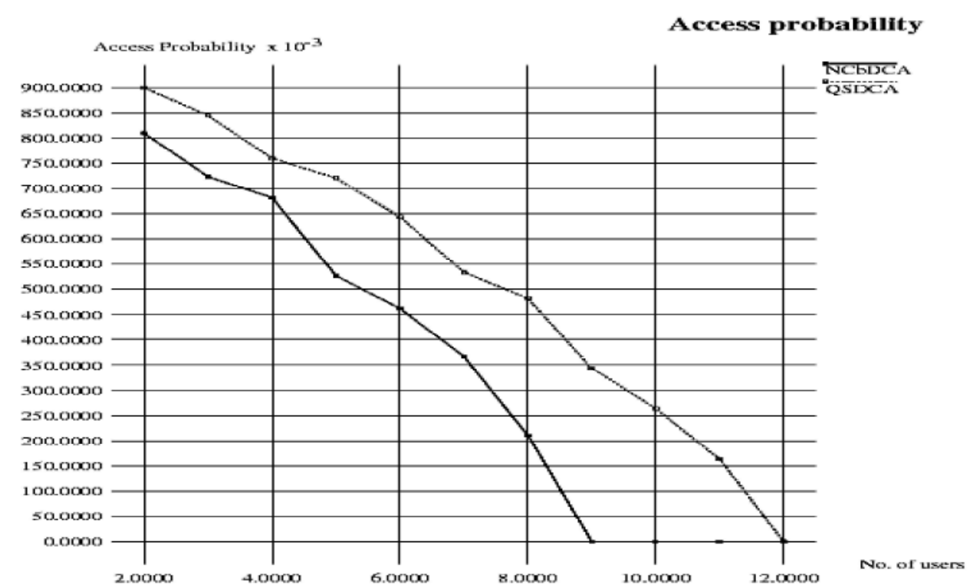

Fig. 3: Channel Access Probability for N number of users

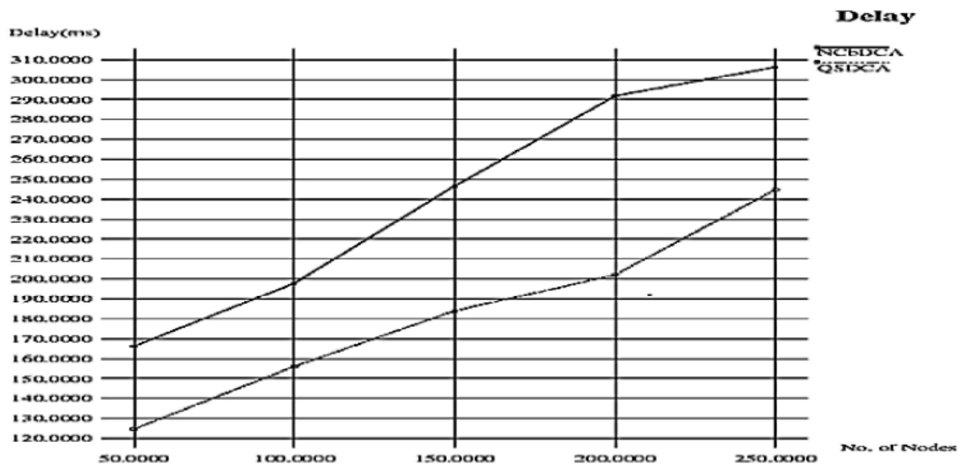

Fig. 4: End to End Delay for N number of nodes

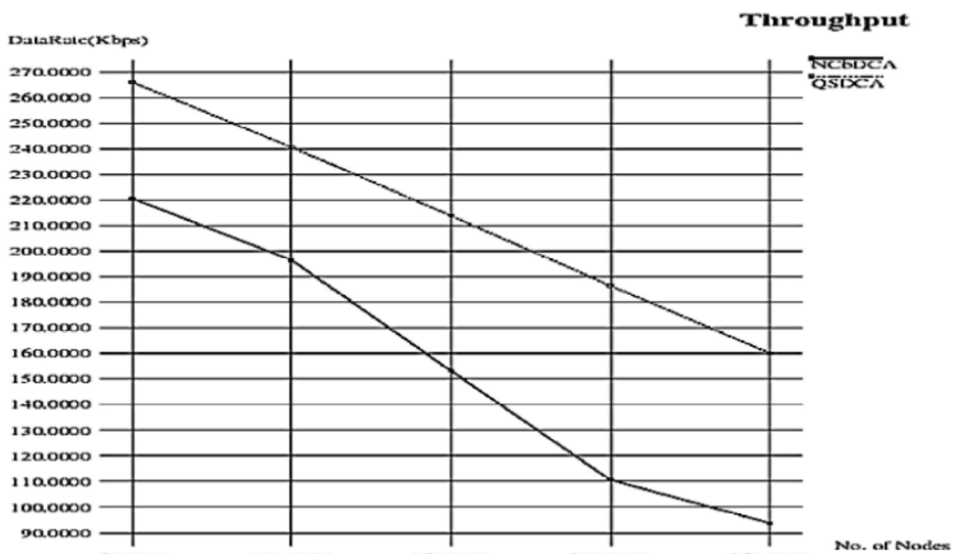

Fig. 5: Throughput for N number of nodes

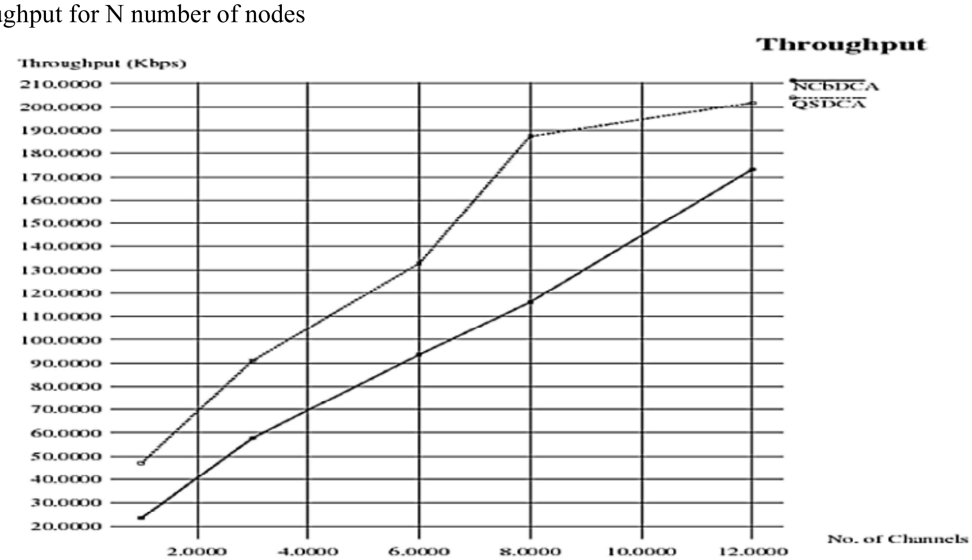

Fig. 6: Throughput for N number of Channels

Figure 5 shows the throughput for N number of nodes, where the throughput is high when compared to the existing NSbDCA. When the n number of nodes chooses the same channels it will leads co channel interference and these problems are rectified in the proposed QSDCA, where the co channel interfaces will be limited and it yields to higher throughput for N number of nodes.

The throughput increases as the number of channels increases. The Figure 6 shows the aggregate throughput for N number of channels. The proposed QSDCA achievesan aggregate throughput of 188 Kbps for 8 channels, whereas NCbDCA achieves an aggregate throughput of 117 Kbps.

CONCLUSION

The paper proposed aQoSaware Dynamic Channel Allocation (QSDCA) algorithm to provide an optimized network performance in Multichannel multi radio wireless mesh network deployments to support QoS demand multimedia applications, which is an integral ingredient of wireless mesh network. The algorithm considers available bandwidth at each node, waiting time of the receiver node and the service time of the serving node to avoid co channel interference. The proposed algorithm is compared with the existing channel allocation scheme evaluation results shows that the proposed QSDCA produces a better optimized network performance while considering the existing channel allocation schemes.

REFERENCES

1. Ali Amjad, Muhammad Ejaz Ahmed, Md. JalilPiran and Doug Young Suh, 2014. Resource Optimization Scheme for Multimedia-Enabled Wireless Mesh Networks, Sensors, pp: 14.
2. Chieochan, S. and E. Hossain, 2013. Channel Assignment for Throughput Optimization in Multichannel Multiradio Wireless Mesh Networks Using Network Coding, IEEE, 12(1): 118-135.
3. Skalli H., S. Ghosh, S.K. Das and L. Lenzini, 2007. Channel Assignment Strategies for Multiradio Wireless Mesh Networks: Issues and Solutions, IEEE, 45(11): 86-95.
4. Ding Yong and Li Xiao, 2011. Channel allocation in multi-channel wireless mesh networks", Science Direct, 34(7): 803-815.
5. Almasaeid Hisham, M. and Ahmed E. Kamal, 2010. Receiver-Based Channel Allocation for Wireless Cognitive Radio Mesh Networks, International conference on New frontiers in dynamic spectrum, IEEE, ISBN: 4244-5188, 1-10.
6. Garroppo, Rosario G., Stefano Giordano, Davide Iacono, Stefano Lucetti and Luca Tavanti, 2008. Interference-Aware Channel Assignment in Wireless Mesh Networks, Springer, 5122: 73-88.
7. Chaudhry Aizaz, U., John W. Chinneck and Roshdy H.M. Hafez, 2013. On the number of channels required for interference-free wireless mesh networks, EURASIP Journal on Wireless Communications and Networking, pp: 1.
8. Cheng Hui and Shengxiang Yang, 2011. Joint QoS multicast routing and channel assignment in multiradio multichannel wireless mesh networks using Intelligent Computational Methods, 11: 1953-1964.
9. Amini Reza Mossanen and Zbigniew Dziong, 2014. An Economic Framework for Routing and Channel Allocation in Cognitive Wireless Mesh Networks, International conference on Network and Service management, IEEE, 11(2).
10. Shah, IbrarAli, Sadaqat Jan, Imran Khan, Muhammad Abbas Mehmood and Muhammad Ali Shah, 2014. Qos Based Joint Channel Assignment and Routing in Wireless Mesh Networks, World Appliance Sciences Journal, 31(10).
11. Kushwaha, U.S. and P.K. Gupta, 2014. AOMDV routing algorithm for Wireless Mesh Networks with local repair (AOMDV-LR), International conference on Communications and Signal Processing, IEEE, pp: 818-822.
12. Parameswaran, T., C. Palanisamy and P. Sathiya Devi, 2014. Self-Reconfigurable Secure Routing Method with AOMDV Protocol, International Journal of Inventions in Computer Science and Engineering (IJICSE), 1(11).
13. Raniwala, A., K. Gopalan and T. Chiueh, 2004. Centralized Channel Assignment and Routing Algorithms for Multichannel Wireless Mesh Networks, ACM Mobile Comp. and Commun. Rev., pp: 50-65.
14. Zhou Jiazhen and Kenneth Mitchell, 2009. A scalable delay based analytical framework for CSMA/CA wireless mesh networks, Computer networks, Elseiver.

15. Obaidat, M., 2011. A Novel Multipath Routing Protocol for Manets, International conference on Wireless Communications, Networking and Mobile Computing (WiCOM), IEEE, pp: 1-6.
16. Tiwari,Vaishali, DamodarTiwari and Vijay Lokhande, 2014. Modifying BEB Algorithm an Optimized MAC 802.11 Protocols for Wireless Network, International Journal of Advanced Research in Computer Science and Software Engineering, 4(1).
17. de Renesse, R., M. Ghassemian, V. Friderikos and A.H. Aghvami, 2005. Adaptive Admission Control for Ad Hoc and Sensor Networks Providing Quality of Service, King College London.