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A Channel Assignment in Wireless Mesh Networks based on Collaborative Learning Automata

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Abstract—Wireless mesh networks are appeared as a new technology for providing cost-effective broadband internet access to users. When used the Existing method LACA, it used only one router for sharing the information to many user. Because of this heavy data traffic occurred during used LACA. In a multichannel environment, it is a challenging task to handle heavy data traffic. In this paper, to reduce this issue, we propose a new collaborative-learning automata-base channel assignment. In the proposed scheme, Learning Automata (LA) is deployed at the nearest mesh routers. It is used to collaborate with each other for data transmission and information sharing while learning from the environment. The performance of the proposed scheme is calculated by various metrics such as throughput, data delivery ratio, switching delay, effective transmission, and effective channel utilization.

Keywords— Mesh network, Channel Assignment (CA), Learning Automata (LA).

I. INTRODUCTION

Wireless mesh network is one of the type of communications network. It is made up of radio nodes and organized in a mesh topology. It is a multihop, peer to peer wireless network. Mesh nodes are connected with unnecessary interconnections. This is used to cooperate with one another to route packets inside of the network. Mesh nodes are small radio transmitters. As a wireless router, it will function in the same way. Nodes are used the common Wi-Fi standards known as 802.11a, b and g to communicate in wireless manner with other nodes. Wireless mesh network consists of mesh clients, mesh routers and mesh gateways. The wireless mesh network is a form of wireless adhoc network. And it offers redundant communications paths throughout the network. Whenever the links are failed, the network automatically routes the messages through alternate paths. WMNs are self-configuring and self-healing networks. Mesh client is like a laptop, which is considered as the source node. Mesh router is used to form the network backbone, which is used to communicate from clients to gateway. Mesh Gateway is connected with internet.

Channel Assignment (CA) is assigning channels to the radio interfaces in a multichannel WMN environment. It is used to minimize interference. Channel assignment used to avoid a network partition and it reduces the link failure, which increases the network stability. WMNs have some features such as low cost of deployment, self forming and self healing. MCs are connected in WMNs to ensure the reliable and uninterrupted services and when one of the routes fails, MRs is used to find the alternate routes for data transmission.

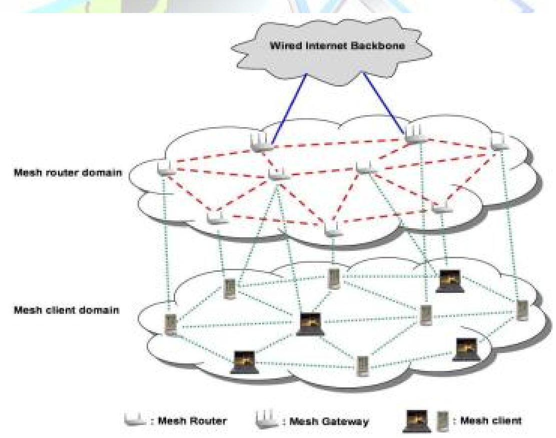

Fig. 1 Network model of mesh network architecture

In addition, the network should have capability of continuity till the end of process of channel assignment.

The following contributions are presented in this paper to provide the network stability;

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1) A proposed collaborative learning automata based channel assignment algorithm is designed, in which to transmits the data and share the information, the proposed learning automata is deployed at the nearest mesh routers to collaborate the information with each other.
2) A channel utilization factor (CUF) is used to design a channel selection when a conflict occurs.

II. RELATED WORK

Cheng *et al.* [4] proposed a traffic independent channel assignment scheme based on discrete particle swarm optimization. The aim of this scheme is minimizing co-channel interference and to find optimal solution even channel has the traffic load and used to preserving original topology. This scheme has robust and efficient to the channel assignment problem in WSN. The author addressed the problem of radio utilization during the channel assignment process is discussed too. F. Li, Y. Fang, F. Hu, and X. Liu [7] proposed two aware multicast routing metrics named as FLMM and FLMM^R. This proposed scheme provides better multicast performance when network is under high load. And it is used to improve the bandwidth usage and network throughput. The author addressed the problem channel overlapping. S. Kim, D. Kim, and Y. Suh [9] proposed scheme is cooperative channel assignment protocol. This scheme increases the channel capacity. Reduce the delay and channel diverse route. It needs further extending CoCA protocol to improve the network capacity by increasing the network connectivity as many as possible. M. Marina and S. Das [11] proposed cluster based multipath topology control and channel assignment scheme. This is used to minimizing flow distributions and it ensures the network connectivity. The problem is, it enhances the network capacity so channels are overlapped in the channel assignment. N. Kumar, M. Kumar, and R. B. Patel [14] proposed scheme a new aware routing metric LCM. This scheme improves the channel capacity and throughput. The problem is addressed by author; interference will be occurring during the channel assignment because of the inherent contention problem, heavy traffic load is there. So algorithm is getting bad fairness. K. Ramachandran, E. Belding, K. Almeroth, and M. Buddhikot [15] proposed interference technique. This scheme is a dynamic mesh networks. It improves the performance by using BFS-CA algorithm. Author is addressed one problem is not suitable for static mesh networks because of increased interference. J. Tang, G. Xue, and W. Zhang [16] proposed polynomial time optimal algorithm. This algorithm is used to capture the influence of the interference and used for solve the Bandwidth-Aware Routing problem (BAR) on a given network topology induced by topology control. The problem of this scheme is not suitable for distributed algorithms. J. Torkestani and M. Meybodi [27] proposed scheme is multicast approach and multicast algorithm is used. This approach used to solve the multicast routig problem. It provides good packet delivery ratio and end to end delay. The problem is the route life time is degraded as the mobility speed increases. A. Raniwala, K. Gopalan, and T. Chiueh [13] proposed channel allocation approach. It used shortest path routing and randomized multipath routing. Here overall throughput is good and bandwidth problems are solved by this approach. This author mentioned one problem is for one single radio channel it is not suitable. N. Kumar, S. Misra, and M. S. Obaidat [31] proposed learning automata approach and collaborative learning automata based routing algorithm. It has better performance and increase the packet delivery ratio. The problem of this scheme is no cache consistency and no maintenance for dissemination.

III. PROBLEM FORMATION

Learning Automata is an adaptive decision-making unit, which is an operating on unknown random environments. The Learning Automation consist a finite set of actions and each action has a certain probability and it is from getting rewarded by the environment. The target is to learn to choose the optimal action through repeated interaction on the system. If the learning algorithm is chosen properly [24]-[32], then the iterative process of interacting on the environment used to made to result in selection of the optimal action.

The probability finding equation is as follows:

$$\begin{aligned} p_j(n+1) &= (1-q)p_j(n),\ j=,\ Y=0 \\ &= qp_j(n),\ j=i,\ Y=0 \\ &= p_j(n), Y=1 \end{aligned} \quad (1)$$

Where, q is the parameter.

From [1] this paper, Let take the set of available channels as $C = \{C1, C2, \ldots, Cn\}$. The channel utilization factor is defined as;

$$CUF = \frac{\sigma^{successful}}{(\alpha_i \times \beta_i)} \times \eta_i \quad (2)$$

Where, the number of successful transmissions across the channel is $\sigma^{successful}$; the upstream and downstream traffic across the MR is denoted by α_i and β_i ; and the transmission rate of the channel is η_i. For a given interval, each channel may be underutilized, saturated or over utilized due to the incoming and outgoing traffic from a gateway. By using the CUF, the following three cases of the states of channel C^{states}_i are defined,

$$C^{states}_i = \begin{cases} CUF > thr, overutilized \\ CUF = thr, saturated \\ CUF < thr, underutilized \end{cases} \quad (3)$$

Then, the probability of over utilized, saturated, or underutilized cases is calculated using a binomial distribution as

$$Pr=\binom{n}{g}(1-CUF)^{g}(CUF)^{n-g} \quad (4)$$

where n is the total number of channels, and g is the number of channels that are overutilized, saturated, or underutilized at any instant of time.

Let us consider the capacity of the channel in terms of accepting the number of requests from the MCs. We define the blocking probability Pr^B as the number of requests dropped when the capacity of the channel is full and new requests come from the MCs. Suppose λ and μ are the request arrival rate and the service rate, respectively. Then, if $\lambda > \mu$, some of the requests are dropped until the CUF falls below the defined threshold *thr*. The effective transmission rate can be transmitted keeping in view of the capacity constraints, is thus defined as

$$\eta i = \frac{\mu}{\lambda}(1 - Pr^B) \quad (5)$$

The time required to transmit a packet is composed of three delays as follows:

$$T_{time}^{C(p)} = BT^{C\,(p)} + TS^{C\,(p)} + CA^{C\,(p)} \quad (6)$$

Where, $BT^{C\ (p)}$ is the duration for which MCs are waiting to access a particular channel C for transmitting the packet p. It is calculated as $BT^{C\,(p)} = 2i+1, i = \{1, 2, 3, \ldots, max\}$, where max is the maximum number of attempts made by the MCs to access the channel. $TS^{C\ (p)}$ is the time for the successful transmission of the packets. It is the ratio of the size of the packet to the data rate at which the channel is transmitting. It is calculated as $TS^{C\ (p)} = p^{size}/\eta i$, where p^{size} is the size of the packet to be transmitted across the channel having effective transmission rate ηi. $CA^{C\ (p)}$ is the time taken to resolve a collision (if any). It is calculated as $CA^{C(p)} = (CN^C/TS^C) \times ST^C$, where CN^C is the number of collisions during a particular time interval for accessing C, TS^C is the total number of signals transmitted across C, and ST^C is the time taken to switch from one channel to another. Putting the values in (6), we can rewrite as

$$T_{time}^{C(p)} = 2^{i+1} + \frac{p^{size}}{\eta_i} + \frac{CN^C}{TS^C} \times ST^C \quad (7)$$

Then, the total time taken for all the packets Z is as follows:

$$T_{time}^{C(p)} = \sum_{p=1}^{z} 2^{i+1} + \frac{p^{size}}{\eta_i} + \frac{CN^C}{TS^C} \times ST^C \quad (8)$$

We define an objective function to maximize ηi with minimum value of Pr^B and $T^{C(Z)}_{time}$ as follows:

$$\psi^{obj} = max\left(\frac{\eta_i}{Pr^B \times T_{time}^{C(Z)}}\right) \quad (9)$$

From (9), it is clear that, as the value of effective transmission is increased, the blocking probability and the total time to transmit the packets from a source to a destination are decreased, which is the objective of the proposed scheme.

a)

Contention Matrix Construction

In the proposed scheme, we have considered different data rates for the channels to reduce the contention among these. Before performing any operation, the LA operates on respective MRs. LA checks the capacity of each channel with respect to the number of requests. Based on these values, the incoming traffic flows are grouped together in an increasing order of capacity of the channel. In addition, the contention matrix is constructed based on the incoming requests and their resource requirements in terms of bandwidth and number of channels. The contention in the channel access is defined as [1]:

$$C_{ij} = \begin{cases} 0, & if\ i = j \\ Xij, & if\ i \neq j \end{cases} \quad (10)$$

the diagonal elements in the matrix are zero, which is an indication of no interference from the same channel; therefore the other nondiagonal elements are having some interference from the neighbouring channels [1]. The values of each parameter can be calculated as follows:

$$X_{ij} = \left(\frac{\eta_i}{t^{switch}}\right) \times B^{avail} \quad (11)$$

Where, t^{switch} is the switching time from one channel to another. B^{avail} is the available bandwidth on the channel, which can be calculated as follows:

$$B^{avail} = \frac{CUF}{N^{req}} \quad (12)$$

Where, N^{req} is the number of the upstream and downstream requests across the mesh backbone router. We then rewrite (12) as follows:

$$X_{ij} = \frac{\eta_i}{t^{switch}} \times \frac{CUF}{N^{req}} \quad (13)$$

The corresponding entries are substituted in (11). In this from each element in Cij , entries along horizontal and vertical directions are added, and those rows or columns are selected for CA, which has the minimum value of sum of Xij values as follows:

$$C_{ij} = \min \sum_{i,j-1}^{n} X_{ij} \quad (14)$$

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The maintenance of a topology involves a tree construction with various queries, which are handled by the LA. Suppose C^{req}_{ij} and C^{rep}_{ij} are the average cost of query request from LA and the average cost in the query reply, respectively. Let freq be the number of times the query is accessed. Suppose C^{diss}_{ij} is the data dissemination cost. Then the average cost of the whole operation for TP can be defined as follows:

$$T_{cost} = (C_{ij}^{req} + C_{ij}^{rep} + C_{ij}^{diss}) \quad (15)$$

The cost of request is defined as the ratio of rate of request to the rate of requests arrival with frequency in a particular time interval. It can be defined as follows:

$$C_{ij}^{rep} = \frac{\mu}{\lambda} \times freq \quad (16)$$

Similarly, the cost of reply can be defined as the rate of request is serviced to the rate of requests arrival with Pr^B due to the presence of interference. Thus, the associated cost can be defined as

$$C_{ij}^{rep} = \frac{\mu}{\lambda} Pr^B \times freq \quad (17)$$

Then, the cost of data dissemination is the product of number of events θn and CUF. The events are the number of requests arrival and departure with the channel utilization, as follows:

$$C_{ij}^{diss} = CUF \times \theta^n \times freq \quad (18)$$

We then rewrite (16) as

$$T_{cost} = \left(\frac{\mu}{\lambda} + \frac{\mu}{\lambda} PrB + CUF \times \theta n\right) \times freq \quad (19)$$

The total cost defined in (20) is the total cost associated with request, reply, and data dissemination by the LA. The LA shares the information with other LA operating on MRs, which involve these three costs. These costs are used by the LA to perform any operation with other LA working on different MRs. This way, the operation of communication is collaborative, which various LA passes the information to each other for sharing the information.

IV. RESULT AND DISCUSSIONS

The proposed scheme is evaluated using ns-2 [34] in comparison with LACA [13] with respect various metrics such as number of successful transmissions, packet reception ratio, and end-to-end delay. We have used LACA approach for comparison with CLACA approach.

The following performance metrics are evaluated.

1) Throughput: The maximum data rate transferred between source and destination per unit time.
2) Data delivery ratio: The ratio of the number of packets successfully transmitted to the total number of packets transmitted.
3) Switching delay: The time taken in switching from one channel to another for allocation of request to a particular channel.
4) Channel effective utilization: How much is the channel utilized in a given time interval.
5) Available bandwidth: The total capacity available in terms of bandwidth after allocation of incoming requests to channels.

A. *Consequence of the Proposed Scheme on the Data delivery ratio*

Fig.2 and 3 shows the consequence of the proposed scheme on the data delivery ratio (%) by varying the traffic load and the number of traffic flows. By increasing the traffic load and traffic load, the data delivery ratio is increased more in CLACA than existing scheme of LACA. In the proposed scheme, LA selects the best CA based on the utilization ratio and CUF. Here the cost of reply, request and data dissemination, the topology is preserved.

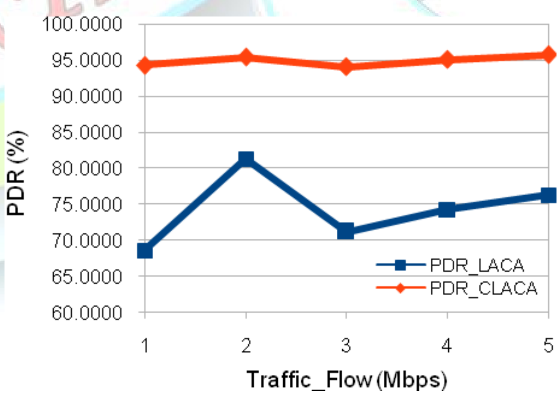

Fig. 2 Packet Delivery Ratio Vs Traffic Flow

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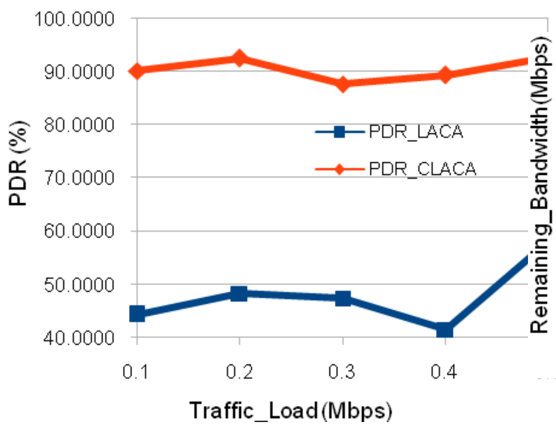

Fig. 3 Packet Delivery Ratio Vs Traffic Load

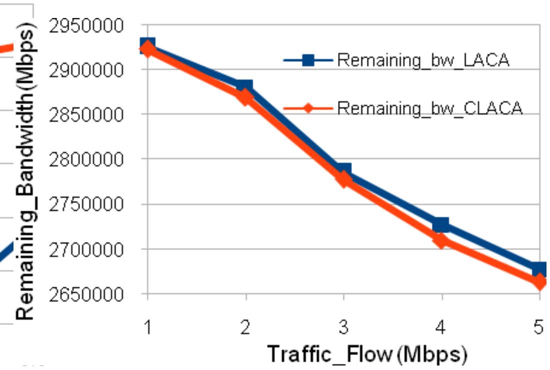

Fig. 6 Remaining Bandwidth Vs Traffic Flow

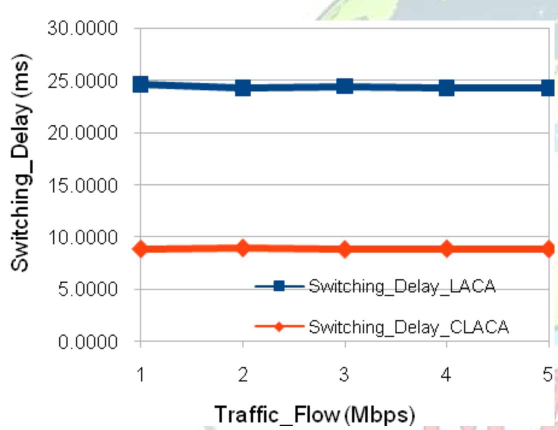

Fig. 4 Switching Delay Vs Traffic Flow

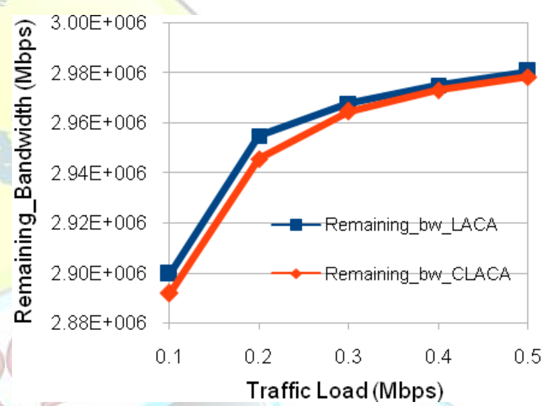

Fig. 7 Remaining Bandwidth Vs Traffic Load

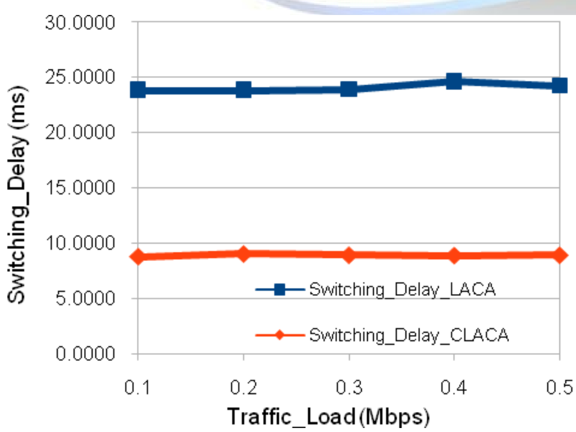

Fig. 5 Switching Delay Vs Traffic Load

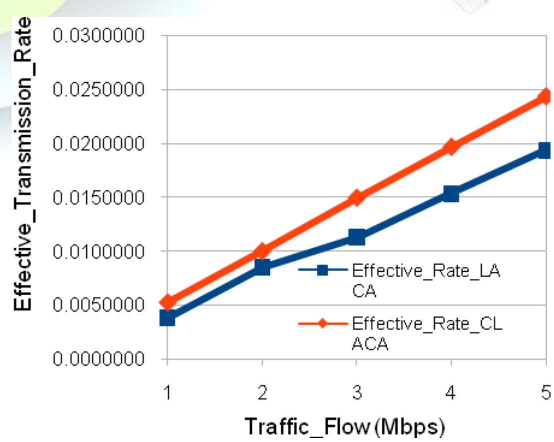

Fig. 8 Effective Transmission Rate Vs Traffic Flow

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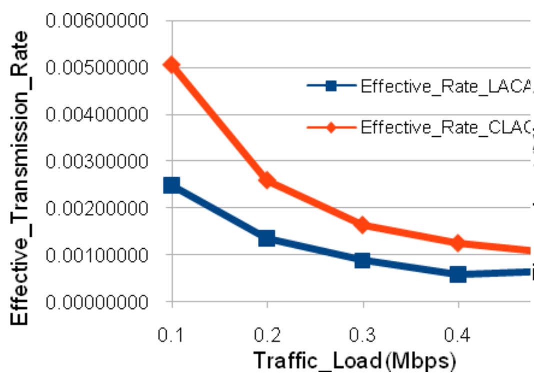

Fig. 9 Effective Transmission Rate Vs Traffic Load

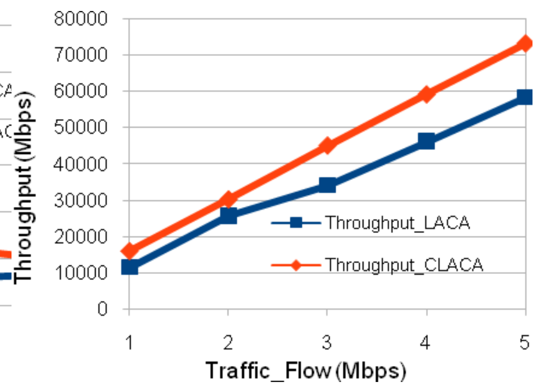

Fig. 12 Throughput Vs Traffic Flow

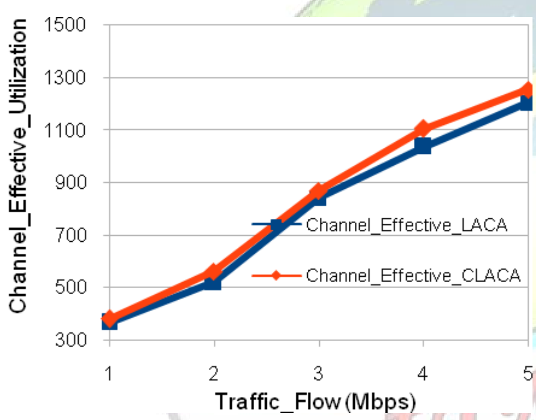

Fig. 10 Effective Channel Utilization Vs Traffic Flow

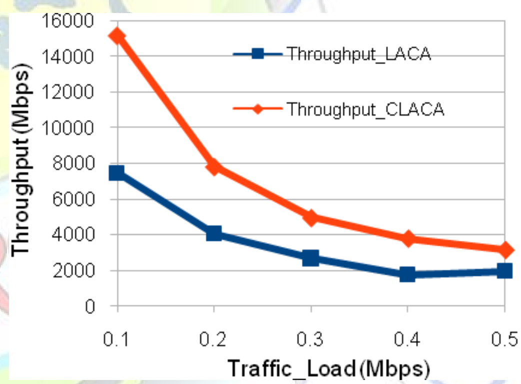

Fig. 13 Throughput Vs Traffic Load

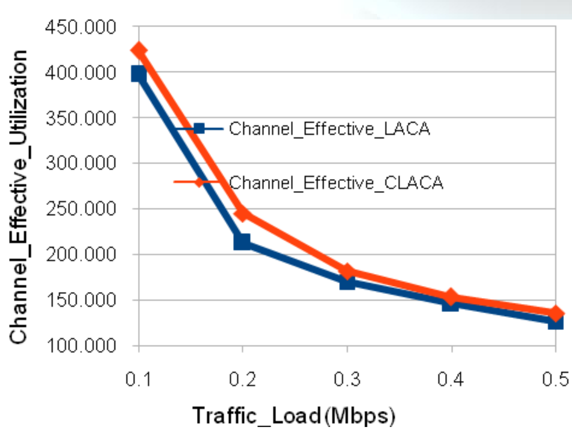

Fig. 11 Effective Channel Utilization Vs Traffic Load

B. Consequence of the Proposed Scheme on the switching Delay

Fig. 4 and 5 shows the consequence of the proposed scheme on switching delay. The switching delay is the time taken to switch the channels according to the need of requests from the clients. It may occur, when channels are overloaded at any time. Then the LA can take the decision that how much switching channel is required for the requiring of user's request. However, for incoming request, each MR maintains its own queue which is used by the LA, which is used to take decisions. When compared with the existing scheme, the proposed scheme in switching delay is decreased. If one of the channels is overloaded due to the large number of incoming requests, The LA used to adaptively switch to the next channel. As shown in Figs. 4 and 5 the switching delay is decreased by using CLACA when comparing with the existing scheme.

C. onsequence of the available bandwidth in proposed scheme

Fig. 6 and 7 shows the consequence of the proposed scheme on the available bandwidth of the channels after allocate the incoming requests to a particular channel based on CUF. The proposed scheme adaptively selects the particular channel based on CUF and here the occurrence of collision is less. Here network topology also preserved. The whole process are controlled and monitored by the LA. The proposed scheme provides the increased channel capacity than existing scheme.

D. onsequence of the effective transmission rate

Fig.8 and 9 shows request arrival and departure on effective transmission rate. The transmission rate of the proposed scheme is increased by request and departure rate is increased. During the departure rate is increased, that time more and more traffic flows are transmitted to the channel, the channel effective utilization is increased. Here, using CLACA scheme the better effective transmission rate is produced than LACA. Here the result is taken by the accordance of as with the increase of request departure rate, the blocking probability of the traffic flow is decreased. This is used to increase the effective utilization rate at channels.

E. onsequence of number of LA on Effective Channel Utilization

Fig. 10 and 11 shows the consequence of number of LA on effective channel utilization. When the request arrival rate and number of LA is increased, the blocking probability is deceased. Hence the effective channel utilization is increased in results. If the number of LA is increased, there are more chances to correct the CA as where are more data is available from the different LA. Here the LA used to share the data with collaborative manner. Hence the number of LA and the request arrival rate is increased, there is the effective channel utilization also increased.

F. onsequence of the Proposed Scheme on the Throughput

Fig. 12 and 13 shows the consequence of the proposed scheme on the throughput with varying the traffic flow and traffic load. The figure shows as the traffic flow is increasing, the throughput is increased substantial in both two schemes. A similar observation has been taken by varying the number of traffic Load, and then throughput is increased. Although, the proposed scheme called CLACA performs better than the existing schemes in the throughput Cachieving with an increase in load. In this, CLACA performs the CA based on the CUF and it is cost associated with the channel. There is the throughput is increased of 40% in the proposed scheme compared with the existing scheme that is LACA. The LACA scheme has no selection process for a channel based on the load and utilization. But the proposed scheme has the random initial selection for channels.

Here, the LA can select the best channel to allocate a particular channel by using the CUF. This is used to reduce the causes of collisions, which results also increase in throughput.

C

CONCLUSION

In this paper we proposed a new CLACA method which has the easiest way to assigning the channel in multichannel environment. Based on this approach, the blocking probability of the incoming requests was computed. Automation is deployed at each MR, which performs its action of CA. For each action taken by LA, a penalty or a reward is provided by the environment where the LA operates. Based on the feedback provided by the environment, the LA updates their action probability vector and decides their next action to be taken. The performance of the proposed scheme was evaluated with respect to the various metrics such as effective channel utilization, effective transmission, switching delay, throughput, and Cdata delivery ratio by varying various parameters. The obtained results show that the proposed scheme is better than the existing schemes with respect to these metrics.

REFERENCES

[1] Neeraj Kumar and Jong-Hyouk Lee," Collaborative-Learning-Automata Based Channel Assignment With Topology Preservation for Wireless Mesh Networks Under QoS Constraints", IEEE SYSTEMS JOURNAL, VOL. 9, NO. 3, SEPTEMBER 2015.

[2] H. Cheng et al., "Nodes organization for channel assign-ment with topology preservation in multi radio wireless mesh networks," Ad Hoc Netw.,vol. 10, no. 5, pp. 760–773, Jul. 2011.

C[3] F. Li, Y. Fang, F. Hu, and X. Liu, "Load aware multicast routing metric in multi radio multi channel wireless mesh networks," Comput. Netw.,vol. 55, no. 9, pp. 2150–2167, Jun. 2011.

[4] S. Kim, D. Kim, and Y. Suh, "A cooperative channel assignment protocol for multi channel multi rate

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wireless mesh networks," Ad Hoc Netw.,vol. 9, no. 5, pp. 893–910, Jul. 2011.

[5] Anjum Naveed, Salil S. Kanhere and Sanjay K. Jha, "Topology Control and Channel Assignment in Multi-Radio Multi-Channel Wireless Mesh Networks", Comput. Elect. Eng., vol. 40, no. 6,pp. 1981–1996, Au.

[6] N. Kumar, M. Kumar, and R. B. Patel, "Capacity and interference aware link scheduling and channel assignment in wireless mesh networks,"J. Netw. Comput. Appl., vol. 34, no. 1, pp. 30–38, Jan. 2011.

[7] Muthukumaran, N & Ravi, R, 'Quad Tree Decomposition based Analysis of Compressed Image Data Communication for Lossy and Lossless using WSN', World Academy of Science, Engineering and Technology, Volume. 8, No. 9, pp. 1543-1549, 2014.

[8] K. Ramachandran, E. Belding, K. Almeroth, and M. Buddhikot, "Interference aware channel assignment in multiradio wireless mesh networks," in Proc. IEEE INFOCOM, Barcelona, Spain, Apr. 23–29, 2012, pp. 1–12.

[9] J. Tang, G. Xue, and W. Zhang, "Interference aware topology control and QoS routing in multi channel in wireless mesh networks," in Proc. ACM MOBIHOC, Urbana-Champaign, IL, USA, May 25–28, 2012,pp. 68–77.

[10] N. Kumar, S. Misra, and M. S. Obaidat, "Collaborative learning automata-based routing for rescue operations in dense urban regions using vehicular sensor networks," IEEE Syst. J., 2014,DOI: 10.1109/JSYST.2014.2335451.

[11]J. Torkestani and M. Meybodi, "Mobility-based multicast routing algorithm for wireless mobile ad-hoc networks: A learning automata approach," Comput. Commun., vol. 33, no. 6, pp. 721–735, Apr. 2010.

[12] A. Raniwala, K. Gopalan, and T. Chiueh, "Centralized channel assignment and routing algorithms for multi channel wireless mesh networks," ACM SIGMOBILE Mobile Comput. Commun. Rev., vol. 8, no. 2, pp. 50–65, Apr. 2010.