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An efficient least congested distributed channel selection algorithm with associated and interfering stations in WLAN

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Abstract -WLAN is widely used network that provides high data rate with less cost but channel assignment is major challenge for minimization of interference in IEEE 802.11 architecture. For that researchers have studied channel allocation schemes for this scenarios, these schemes are centralized and distributed as well. Various distributed channel selection schemes, where APs (access points) is responsible for selecting least congested channels among all available channels. However, the existing distributed channel selection schemes use only interfering STA (Station) to calculating least congested channel, but they are not considering the existence of associated stations with any particular AP that might affect the congestion in the network. In this paper, a distributed least channel selection algorithm is proposed which is in the basis of minimum interfering STAs as well as associated STAs by exchanging the beacon frames with neighbor APs. An additional optional field is defined in the frame for exchanging the information using beacon frame according to the IEEE 802.11 standard.

Keywords- Distributed channel allocation, Beacon frame, probe request/response frame, active channel scanning, IEEE 802.11 Standard.

1. INTRODUCTION

Wireless local area network (WLAN) is a wireless network scenario that links various devices using IEEE 802.11 standards within a limited range. With this we can move around a physical range of signals that hold us to be connected with network. A WLAN can also provide a connection to the high-speed Internet.Nowadays, Wireless local area network is a congested scenario, adjacent WLAN access points and STAs using the same frequency channel may reduce the network performance due to co-channel interference.

The IEEE 802.11 standard workgroup currently documents use in five different frequency ranges: 2.4 GHz, 3.6 GHz, 4.9 GHz, 5 GHz, and 5.9 GHz bands. Limited number of interference-free channels is used in unlicensed 2.4 GHz and 5 GHz bands. Due to increase in the number of APs and STAs, APs experience co-channel interference by their neighboring APs and STAs assign on the same frequency channel. Since IEEE 802.11b/g/n APs and STAs use the contention-based media access control (MAC) scheme. In current scenario due to the dense arrangement of APs, A set of n channels, either overlapping or non-overlapping, is available for WLAN. Channel Assignment can also defined as an allocation problem where one from the set of the n channels is allocated to each AP such that the interference generated by such allocation is minimum. Usually in the unsilenced 2.4 GHz band, 1, 6 and 11 are the only non-overlapping Channels. Selecting one or more of these channels is an important part of setting up network correctly. Now these days, many of access points automatically select the channel in the initial setup by default, depending on our wireless environment, that could lead to slow Wi-Fi speeds and interference.

Wireless channel allocation acting as acrucial role in the design of wireless network, as it highly influences the throughput and performance of the network. Channel allocation schemes can be divided in general into Fixed Channel Allocation schemes (FCA), Dynamic Channel Allocation schemes (DCA), and Hybrid Channel Allocation schemes, that is combining both FCA and DCA techniques. DCA schemes can be centralized or distributed [11]. The centralized DCA scheme includes a single controller selecting a channel for each AP. The distributed DCA scheme each AP is involved to assigns channel for communication across the network. In existing work there are various distributed channel allocation algorithm which are based on QoE oriented allocation[5] , self-managed allocation [4], coloring based [9], least congestion based [1].Our work is concentrated on the distributed channel allocation based on least congested channel.

2. RELATED WORKS

Several proposals for distributed channel allocation schemes applicable to independent network scenarios is presented below:

Achanta et al[2004][1]proposed a novel approach for channel allocation that is each AP in the network scan for the information about STAs associated with other APs using beacon frame, AP and the channel assign to that AP which is having the least number of associated stationsconsidered as least congested channel.Meanwhile, the LCCS scheme only checks the number of stations associated with the neighboring APs, it may determine the least congested channel by considering stations which do not interfere with APs. Hence, it is difficult to find a least congested channel in the LCCSscheme under WLAN environment where there is collision by both downstream and upstream transmission.

Graph theory approach is used in their study by Anuresh Mishra et.al,[2005][9]for the channel assignment in WLANs as the approach of weighted vertex coloring problem and comes up with two scalable,efficient and fault-tolerant distributed algorithms that achieve better performance thanLeast Congested Channel scheme (LCCS). With simulations, they showed that techniques achieve up to 45.5% and 56 % decrement in interference for sparse and dense

topologies respectively with 3 non-overlapping channels (1, 6, and 11). But scheme needs more computational time to gain an optimal solution due to the NP-hard nature of the graph coloring problem.Marcel William Rocha da Silva et.al**,**"TDCS: A New Mechanism for Automatic Channel Assignment for Independent IEEE 802.11 Networks [2]" proposed a scheme forimproving the detection of changes in the interference pattern of the operating channel. This way, the channel selection scheme can reply faster, triggering adaptation through channel switches. Further that, the two versions are fully distributed and focuson selecting channels were interference caused by media access sharing and co-channel interference is minimized in the AP and its clients. They took the http and ftp traffic configuration to test the efficient channel allocation, and shows that TDCS perform 8% well by DCS, and 18% by Hminmax algorithm.

D.J. Leithet.al [2010] proposed aself-managed distributed channel selection algorithm for WLANs [4]that need not require direct communication between APs. The station periodically scan the channel quality. When the channel quality of satisfactory, stay using the same channel. Else, randomly choose a channel with the weighted probability based on past experience.

In the paper "Distributed QoE-aware channel assignment algorithms for IEEE 802.11 WLANs [5]",BehrouzShahgholiGhahfarokhi [2015] studiedtwo innovative distributed channel assignment algorithms thatmake use of learning automata toexplore the QoE measure of associated clients to locally formulate the optimization problem. Between two of proposed algorithmsfirst one LACAA1 requires no communication with other APs, while the second algorithm, LACAA2 is based on little bit communication with neighboring APs. After findingQoE level of the clients associated to the serving AP, the algorithms uses learning automata mechanism to enhanced the proposed performance index that maximize both users perceived quality and user-level fairness.A survey paper By SurachaiChieochan, et.al,[2010][10]explains different distributed and centralize schemes for channel allocation and AP placement are considered. Included this they had given a qualitative comparison matrices among different schemes in terms of algorithm scalability, complexity, and execution behaviors.

the base paper for our work, "Distributed channel selection approach based on interfering station" [6]by Young Min Kwon, et al, in this study allocation scheme work on the logic that APs select a channel as least congested channel among all available channels which having minimum number of interfering STAs. It is by making use of beacon frame and probe frames used in IEEE 802.11 architecture with some additional fields. This scheme having two phase of selecting the least congested channel initial phase and channel selection phase, initial phase for finding the number of interfering STAs with neighbor APs and channel selection phase for assignment of the channel to APs.

This scheme is not calculating the number of beacon frames and probe message is sent over the network at initial as well as channel selection phase because it might create congestion and collision with the increasing number of APs and STAs.

Related works in this area explain the different channel allocation strategies but in current scenario of WLAN architecture more factor and parameter have to be consider. Consideration of only associated STAs or only interfering STAs are not providing much effective result, so the necessity is that to marge the both factor associated STA as well as interfering STA for allocation of channel in more effective way. Another thing is to measure the complexity of channel allocation algorithm to implement in the WLAN scenario in term of number of massage are used for selecting a channel.

3. MODEL OF PROPOSED CHANNEL SELECTION SCHEME

Distributed channel selection scheme based on the number of interfering stations in WLAN [6] only taken the general case in which APs and their associated STAs are supposed to interfere with neighboring APs, in that case only they calculated the least congested channel for allocation. But suppose if the associated STAs for an AP are increasing in such a way that they did not interfere with any of the neighboring APs then it will also calculate the same result but due to increase in the number of associated STAs congestion might be increased on that channel.

3.1Beacon information Frame format for proposed scheme

Table.1 Beacon frame format

Element ID	Element ID indicates that a beacon frame includes channel load information in the frame body.
Length	Length includes the overall length of a channel information element.
Service set identifier(SSID)	Unique id for APs.
Channel number	Currently assign channel.
Channel load list	SSID of the neighboring AP Number of STAs detecting the neighboring AP. Number of associated STAs detecting the neighboring AP.

In our proposed scheme, we are using a beacon frame of the IEEE 802.11 standard with some additional field of channel load information which is to be exchanged with neighbor APs.The channel information element consists of five fields as shown in table 1.

3.2 Information capturing phase

Proposed scheme uses the beacon frame and probe request/response frame for capturing the channel information with additional fields. Beacon frames are generated by the APs that broadcast9 periodically in the network and probe frames are used to take the adjacent APs information.In fig.1-There are sequence of step to collect channel load information:

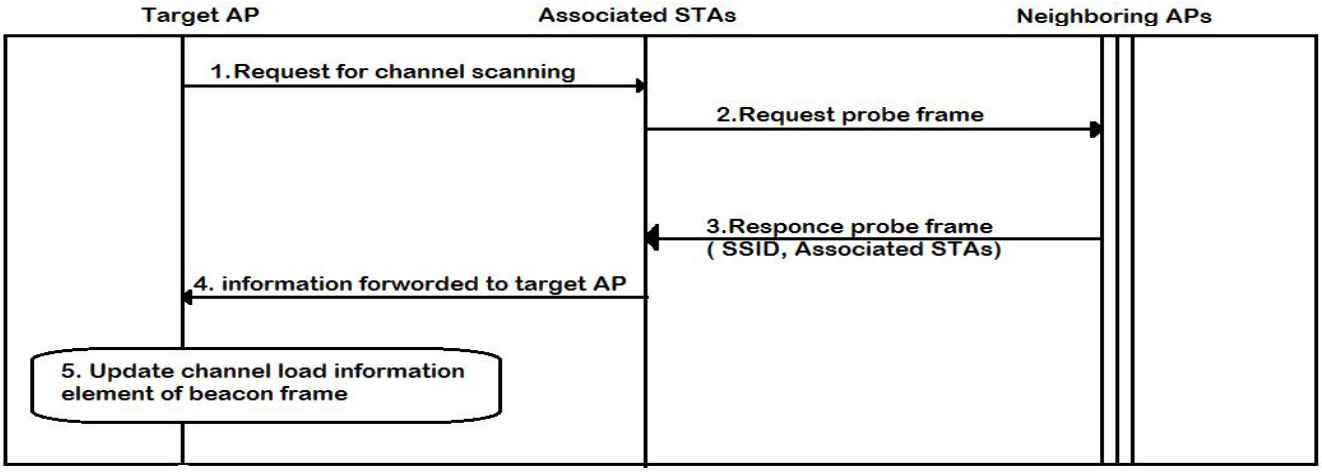

Fig 1: Information exchanging phase

1. When an AP are turned on.It sends the beacon frame with empty channel load list field to associated STAs for active scanning of channel.
2. STAs capture these beacon frames and create probe request frame for the nearby APs, and send probe request to adjacent APs.
3. APs which are in the range gives proberesponse frame back to the STAs along with two important field SSID, and number of associated stations currently with AP.
4. EachSTAreportsthechannelscanninginformationalong withtheSSIDs toits associatedAP.
5. Target APcheckstheSSIDofchannelscanninginformationandcountsthenumberofSTAsreportingtheSSID.Then,theAP updatestheSSIDoftheneighboringAPandthenumberofSTAsdetectingtheneighboringAP subfieldsinthechannelloadlist field, and for counting the associated STAs to the neighboring AP it takes the average of information comes from probe frames.

3.3 Least congested Channel selection algorithm

When active scanning is done.
AP (I), number of interfering station.
AP (A), number of associated station.

1. **begin**
2. if
   (AP (A) = = 0) // no one can scan for AP
3. Stay on the same channel;
4. else

Proposed algorithm uses both number of associated stations as well as interfering stations with an AP, and calculate the least congested channel from the set of available non-overlapping channels.

Two APs might calculate the same channel as least congested, and if both are adjacent to each other they will choose channelfrom the set of partially overlap channel.

5. calculate( ); // assign least congested channel
6. if
7. (two adjacent AP having same channel with least Congestion)
8. Select channel which is partially interfered with LeastCongested channel;
9. else
10. Select the least congested channel;
11. **end:**

Calculate ( )

1. Evaluate the average of AP (I) and AP (A) of each neighbor AP.
2. Select neighbor AP with minimum average value;
3. **if** (two or more neighbor AP having same minimum average value)
4. then
5. Select the neighbor AP with least AP(A) value;
6. **if** (two or more neighbor AP having equal AP(A) value)
7. then
8. select the neighbor AP with least AP(I) value;
9. **if** (two or more neighbor AP having equal AP(I) value)
10. then
11. stay on the same channel ;
12. **else**
13. Select channel of AP which having minimum AP (I) value as least congested channel;
14. **else**
15. Select channel of AP which having minimum AP (A) value as least congested channel;
16. **else**
17. select channel of AP which having minimum average value;
18. Return;

4. CONCLUSION

In this paper, an algorithm for assigning least congested channel to AP with associated and interfering stations in WLANis proposed which will be implemented in future with C and to be simulated in the network simulator tool.

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