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A Study of Channel Assignment Strategies used for Uncoordinated WLANs

Achal Badgujar, Swati Nikam

Abstract-Due to tremendous increase in use of WIFI, the efficient use of available frequency spectrum has been a challenging issue. Such WIFI which are managed by non-network specialists are called Uncoordinated WLANS. The performance of Uncoordinated WLANs can be greatly improved by efficient channel assignment. In this paper, we describe the various channel assignment schemes used in Uncoordinated WLANs. After describing each scheme we also provide a qualitative comparison of the schemes based on complexity, scalability and execution behaviors. The survey is concluded with various research issues open for further study.

Index Terms-Channel assignment. Co-Channel interference, Uncoordinated WLANS

I. INTRODUCTION

Today the use of WLANs commonly called Wi-Fi has increased greatly because of easily available low cost equipment's and unlicensed frequency band of operation, thereby increasing the difficulty in managing them. This problem is more severe in case of Uncoordinated WLANs because there is no central administrator, no topology planning. In contrast to centrally managed WLANs, the access points (APs) are also placed haphazardly by untrained system administrators. As the number of such WLANs is increasing the co-channel interference is also increasing. This reduces the performance greatly. One way of improving the performance of Uncoordinated WLANs is to reduce the co-channel interference. The co-channel interference can be greatly reduced by using efficient channel assignment in which a frequency channel is assigned to each AP for use for certain duration of time. This article gives a description of various channel assignment techniques used in Uncoordinated WLANs. A comparison is also provided between the various schemes. The article is concluded with several open issues for research.

II. CHANNELIZATION CONCEPT

A. Topology under Consideration

The topology we will consider is shown in Fig.1. In this topology an access point connects all clients associated with it to a wired LAN. All the communication can take place only through AP.A single instance of such topology is called Basic Service Set[BSS].In uncoordinated WLANS there are multiple BSS managed by different administrators.

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***** Correspondence Author (s)
Achal Badgujar*, EEE, Sri Krishna College of Engineering and Technology, Coimbatore, India.
Swati Nikam, EEE, Sri Krishna College of Engineering and Technology, Coimbatore, India.

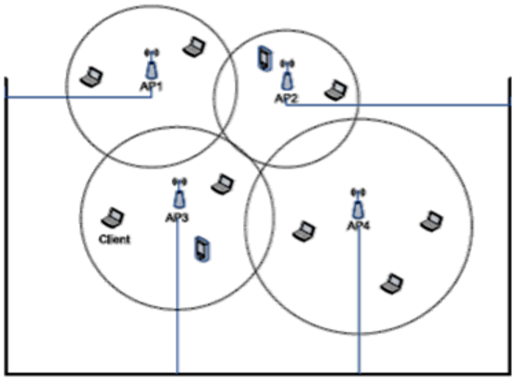

Fig 1:-Topology considered

B. IEEE 802.11 channels

There are two unlicensed frequency bands available for802.11 WLANS1) 2.4 GHz Industrial, Scientific, and Medical (ISM) band, and 2) 5 GHz Unlicensed National Information Infrastructure (UNII) band. The IEEE 802.11b uses 2.4 GHz band and IEEE 802.11a uses 5GHz band. There are 14 allowable channels each of which occupies a bandwidth of 22MHz.Different number of channels are used by different countries. Out of these channels maximum traffic is carried on channel 1,6,11 since they are non-overlapping channels. Fig 2 shows the frequency channels in 2.4 GHz band.

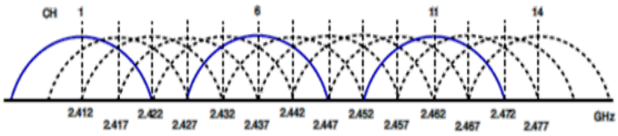

Fig 2:-802.11 channels in 2.4 GHz ISM Band

III. CHANNEL ASSIGNMENT SCHEMES

A. Least Congested Channel Search

In LCCS [1] every AP finds channel with least number of clients associated with it and switches to a channel with least number of clients .For this every AP scans each channel for beacons published by neighboring APs. Beacon is a management frame in IEEE 802.11 based WLANs containing information such as number of clients associated with each AP, traffic information etc. Based on this an AP comes to know the number of APs and the total number of clients associated with each channel. Then it switches to channel with least number of clients. Limitations of LCCS:- It cannot detect interference in some situations. For example as shown in Fig 3 AP1 and AP2 are not within transmission ranges of each other but clients associated with them interfere.

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This situation is called hidden interference problem which is not detected by LCCS.

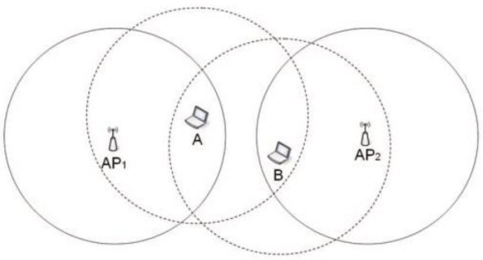

Fig 3:-Hidden Interference Problem

B. Hminmax

In Hminmax [2] algorithm the channel assignment problem is modeled as a weighted graph coloring problem. In the graph, node represents AP and color represents channels. An edge between two APs represents conflict in between two APs due to physical proximity or interference. Every edge has a weight associated with it. This algorithm mainly tries to minimize the objective function Lmax.

$$Lmax(G,C) = \max_{\forall\epsilon=(api,apj)\in E} I(api,apj)\, W(api,apj) \qquad (1)$$

This minimizes maximum I value of AP. This simply means that the algorithm tries to minimize maximum impact of interference among all APs. Here W(api,apj)-denotes normalized weight of edge (api,apj)-It indicates number of clients associated with two corresponding APs that are affected if these two APs are assigned to same channel. I(api,apj)-It is called I factor .It denotes the interference between colors assigned to the same channel. Itsvalue is zero for conflict free edges. Ivalue=W(api,apj) x I(api,apj)-It denotes total effect of interference on all clients that fall in overlapping region between two APs. This algorithm assumes that AP perform greedily i.e. each AP tries to reduce its own Interference level. For calculation of weight a distributed technique called site report is used. Every AP chooses a client with low activity to perform site report. This client scans channel passively and generates list of APs that are in direct communication range of client performing scan.

W(api,apj)-Numapi(apj)/Num(api) (2)

Where Num(api)-Number of site reports conducted by clients of AP api.Numapi(apj)-Number of site reports that reported interference with api. Each AP minimizes interference by choosing color that minimizes Lmax(G,C,api).

C. MinMax

In MinMax[3] approach the focus is mainly on downlink traffic since it affects network performance. It is assumed that the network uses CSMA protocol to detect whether the channel is busy or idle. The AP ready to transmit, verifies whether the channel is busy or not. This is done by detecting the received power. If power is greater than some threshold value(mostly -76 dbm), the channel is busy. The MinMax approach creates mainly two classes for each AP say i namely Ci(1) called ClassI interferers. I(1)is a set of interfering APs in which transmission by only one APcan cause interference to make channel busy for APi. Ci(2) called classII interferers in which transmission by a pair of APs can make channel busy for APi.The same notion can be extended for Ci(3) and so on but mostly Ci(1) and Ci(2) are only considered.To generate the classes Ci(1) and Ci(2) we need to know signal path loss between each pair of AP network.

So we consider two terms

pi-Transmission power of APj

hij-Signal path loss from APjto APi.

For APj to belong to Ci(1) then it should satisfy following condition

$$h_{ij} p_j \geq \alpha \qquad (3)$$

Similarly, if AP pair *m* and *n* belong to Ci(2), we have

him pm □□*hinpn* ≥ α (4)

Let *ρ*i be the offered traffic load for APi. Its assumed that each AP is assigned with one and only one channel. Xij=1 if APi.is assigned to channel 1 or else 0.The effective channel utilization U is the fraction of time channel is sensed busy or used for transmission by APi.

$$U_i \equiv \rho_i + \sum_{k=1}^{N} X_{ik} \left[\sum_{j\in Ci(1)} \rho_j X_{jk} + \sum_{(m,n)\in Ci(2)} \rho_m \rho_n X_{mn} X_{nk} \right] \qquad (5)$$

Here main objective function is to minimize U at most loaded AP.Minimize Max(U1,U2,….Um),considering m APs. This problem is NP Complete. The heuristic algorithm performs random channel assignment which is considered the best at that time. V=max effective channel assignment ie V=max{Ui}Based on this identify AP with max U say , APi. Then for api, for each available channels n from 1..N such for each co-channel say apj in Ci(1) modify channel assignment so that only APj assigned to n. Recompute max(U) from above mentioned formulas which is denoted by Wjn. Compare each W and V. If W<V then replace V by W and then the corresponding channel assignment is considered to best channel assignment. If W>V, then it is concluded that local optimum is reached.

D. MinMax II

The proposed technique [4] is similar to above mentioned MinMax approach. But this approach[4] assigns channel in an adaptive manner to a set of APs such that channel utilization at most overloaded AP is minimized. The channel utilization in MinMaxII is based on dynamic MAC model. Here active clients are taken into account. Active clients are those clients that are associated with AP of interest and those that are under neighboring co-channel APs. This algorithm is dynamic because it estimates active clients based on real time channel assignment. Also the network performance is measured against predefined QOS threshold. The APs independently perform optimization of channel assignment. Limitation of this algorithm is that it may not be scalable for larger network.

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E. PICK RAND I

This describes [5]a dynamic channel allocation algorithm that minimizes channel interference between APs. This method defines an overlapping channel interference factor Wij,to be relative percentage increase in interference as a result of two APs I and j using overlapping channel.

$$Wij=\begin{cases} 1-|Fi-Fj|xC & if\ Wij \geq 0 \\ 0 & otherwise \end{cases} \quad (6)$$

Each AP in turn picks its own channel that minimizes amount of interference it receives from its neighbor. As one Ap changes its own channel, it would impact interference on APs of which it is a neighbor. Two 999999999versions of algorithm are used for analysis. VersionI (Pick Rand) randomly break ties between channels that yield same performance and randomly yield channel for assignment. VersionII (Pick First) picks the smallest channel number from channels that yield the same performance and assigns that to the AP.

F. Pick Rand II

This approach[6] deals with load balancing along with channel assignment. This technique adjusts transmitted power of beacon packets of most congested AP.Here auto-rating is avoided. This algorithm first computes RSSI(Received Signal Strength Indicator) at each user from each AP using a path loss model. Associate users with APs with highest RSSI. Then MCAP is identified. There is a binary association matrix. Foreach user we assign 1 in matrix if RSSI for it exceeds a threshold value otherwise 0 is assigned. Then redistribution of users takes place. Then transmitted power of beacon packet at MCAP is decremented. This is repeated until there is at least one user that can't be assigned to any AP. This algorithm returns the best load of APs.Once optimal power levels and user associations are obtained then Pick Rand and Pick First algorithms described above are invoked for channel assignment.

G .Channel Hopping Approach

In [7], a distributed channel assignment algorithm based on the concept of channel hopping is specifically proposed for an uncoordinated WLAN. In particular, each AP is assigned a unique sequence of channels, and hops through this sequence over time so as to average out the throughputs of all APs in a long run. Each AP is within the transmission ranges of three other APs. Each AP hops to the next channel at the end of each time slot. Suppose that only three non-overlapping channels, namely,1, 6 and 11, are available for assignment, and that each AP always has data to transmit. The goal is to average out the throughputs of all APs in a long run

IV. CONCLUSION

This paper mainly provides an overview of the various channel assignment strategies used for Uncoordinated WLANs. A lot of work is being carried out in this area. Adaptive techniques which consider network dynamics are considered. Ways of continually monitoring network dynamics are being worked on. Real time traffic is being considered. Clients are being involved in the process of channel assignment. Work is also carried out in areas of joint optimization of channel assignment and power control

Table 1.A Comparison of various schemes

Schemes	Static Adaptive	Uncoordinated Central	Heurictic ILP	Scalable
LCCS	x	x	x	Yes
Hminmax	x	x	x	Yes
Min-Max	x	x	x	No
MInMaxII	x	x	x	Yes
Pick-RandI	x	x	x	Yes
Pick-RandII	x	x	x	Yes
Channel Hopping	x	x	x	Yes

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