

Load-aware Spectrum Allocation based on Interference Graph Adapting to Radio Characteristics

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Abstract: Nowadays, load-driven spectrum allocation in wireless networks is becoming more important since the surging mobile traffic are usually distributed quite uneven. Related approaches have been proposed to assign channels of different widths for APs in WLAN. But a challenge usually being ignored is that radio characteristics will affect the interference graph which is a key basis in the allocation process. In this paper, we explain influences of radio features on interference graph and give a simple method to estimate the more accurate interference graph accordingly. In addition, a load-aware spectrum allocation mechanism for APs is proposed. The mechanism firstly decides widths of channels required by APs and estimates the more accurate interference graph based on several characteristics like channel-width, central frequency. Then it arranges spectrum blocks for APs based on the new interference graph. Simulations and analysis show that spectrum allocation method using wrong interference graph will generate great spectrum overlaps between interfering APs, about 1350MHz. And our mechanism could improve spectrum utilization efficiency by nearly two times while generating only few overlaps, about 250MHz.

Key-Words: radio characteristics; interference graph; load-aware; WLAN spectrum

1 Introduction

In wireless networks, clients are often distributed unevenly and generate different amount of traffic. Therefore, some APs have to handle heavy load, while others remain underutilized. This load balancing problem is quite common in WLANs. The dramatic increase of intelligent terminals and mobile traffic has been aggravating the problem. Earlier works tend to mitigate the problem through cell breathing [1], association control [2], channel assignment [3], etc. These approaches can alleviate the problem to some extent rather than address it fundamentally. The reason is that in traditional WLANs, channels of same and fixed width are assigned to all APs in advance. Naturally, it is difficult for one AP to adapt spectrum width to load requirements. Hence, spectrum resource may be wasted and then overall capacity of the network is reduced.

In recent years, technical progresses of dynamic spectrum access bring new possibilities. KNOWS [4] is a prototype which detects white spaces in the TV spectrum and utilizes the available band opportunistically. In WLAN, channel width can be changed dynamically and purely through modifying the driver with very little overhead [5] on commodity hardware such as the Atheros chipset. To take advantage of the adaptability

of channel width, approaches are required for allocating appropriate central frequency and channel width for each AP. Moscibroda et al. [6] puts forward a load-aware spectrum assignment method which distributes non-overlapping channels of different widths to APs. The principle of spectrum allocation in the paper is that each AP shares the whole spectrum with its neighbors. Herein, neighbor APs mean that they will interfere with each other if using the same channel. Assume that AP_1, AP_2, \dots, AP_x are neighbor APs of AP_A . Spectrum demanded by AP_A is decided by the ratio of users on AP_A to total users on AP_A and AP_1, AP_2, \dots, AP_x . An example is shown in Fig. 1, in which the four neighbor APs shares spectrum of 80MHz. According to load-aware rule [6], spectrum of 40MHz (50%), 20MHz (25%), 10MHz (12.5%) and 10MHz (12.5%) will be allocated to AP1, AP2, AP3, and AP4 respectively.

A key point neglected in Moscibroda et al. [6] is that neighbor relationship in Fig. 1 (i.e. interference graph) will be affected by radio characteristics such as channel width, frequency and power of the APs. Some researches [5][7][8] begin to take channel width and central frequency into account. Chandra et al. [5] considers influences of channel width when assign spectrum for two nodes trying to communicate with each

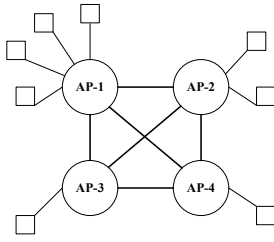


Figure 1: Client distribution of neighbor APs

other. Measurements in Rayanchu et al. [7] reveal that allocating channels of various widths will influence exposed links and hidden links in the network. The paper also extends the spectrum assignment method for single link [5] to multiple links, which requires huge amount of measurements of all links. Deb et al. [8] indicates that an interference graph of APs on one frequency can be used to infer the new interference graph of APs on another frequency. To sum up, since accuracy of interference graph is essential for spectrum allocation, influences of radio characteristics on interference graph require to be considered comprehensively.

The main contributions of this paper are summarized to following aspects.

1) We describe that interference graph is influenced by radio characteristics, such as spectrum width, central frequency, and transmitting power, etc. A simple method is presented to estimate the more accurate interference graph adapting to radio characteristics.

2) We present a load-aware spectrum allocation mechanism adopting above estimation method of interference graph. In this way, the amount of overlapping spectrum allocated to neighbor APs will be decreased.

3) We analyze that non-overlapping allocation scheme [6] may waste spectrum and not efficient in dense-deployed networks. Therefore, neighbor APs are allowed to use some overlapping spectrum in our mechanism. There is a trade-off between overlapping spectrum and available spectrum for APs.

4) We take dynamic characteristic of network load into consideration. Our mechanism adjusts the spectrum allocated for APs locally when load condition changes.

The remaining content of this paper is organized as follows. Section 2 states method of inferring interference graph comprehensively. Rules for allocating spectrum in our mechanism are illustrated in section 3. Section 4 gives the spectrum allocation algorithms. Section 5 illustrates simulations. At last, section 6 concludes the whole paper.

2 Dynamic Interference Graph

Interference graph is an essential basis for spectrum allocation process in order to reduce interference. A general definition of interference graph is given in [6]. **Definition:** Given a collection V of APs, the interference graph $G = (V, E)$ is formed as follows. The vertex set V is simply identified with the set V . The set of edges E is constructed as the union of those pairs V_i, V_j of vertices, that correspond to APs V_i and V_j that would interfere with each others traffic should they be assigned to use the same channel.

In traditional channel assignment mechanisms, interference graph is built through monitoring results sensed by APs at beginning stage. Since channels are of fixed width and almost same central frequencies, the interference graph will hardly change significantly. However, if width and central frequency of spectrum allocated to APs can be regulated dynamically, then the interference graph will be changed dynamically. Two examples are listed in following figures to show the probable changes of interference graph. In Fig. 2(a), each AP uses a channel of 20MHz width on 2.4GHz. AP1 is a neighbor of the other 3 APs and the relationship is depicted by directed edges in Fig. 2(a). If AP1 changes its working frequency to 5.8GHz with the same channel width, AP1 may be not sensed by the other 3 APs anymore, thus the interference graph changed into Fig. 2(b). The reason is that propagation range of signal on higher frequency is shorter. Next, Fig. 3 shows the potential influence of channel width. In Fig. 3(a), each AP works on a channel of 20MHz. AP1 is a neighbor of AP4, while there is not neighbor relationship between AP2 and AP3. Then, channel width of AP1 is increased to 40MHz and channel width of AP2 is reduced to 5MHz. As indicated by Chandra et al. [5], energy per Hz of wider band is less than that of narrower band if the transmitting powers are same. Therefore, signal on narrower band could transmit for longer range. Then in new interference graph Fig. 3(b), AP3 and AP4 will not be interfered by AP1. But AP2 may become a new interfering neighbor of AP3.

$$\Delta Pr_{ij} = 10lg \frac{Pr_{ij}(Pt_1, f_1, B_1)}{Pr_{ij}(Pt_2, f_2, B_2)} = 10lg \left(\frac{Pt_1}{Pt_2} * \frac{f_2^2}{f_1^2} * \frac{B_2}{B_1} \right) \quad (1)$$

We adjust transmitting power, frequency and channel width of one AP in our lab room without obstacles. RSSIs (received signal strength indicator) received by a laptop with AirMagnet Analyzer (a professional measurement tool for WLAN) and collected and showed in Fig. 4. Fig. 4(a) and Fig. 4(b) depict that the RSSI gap between signal on 2.4GHz and

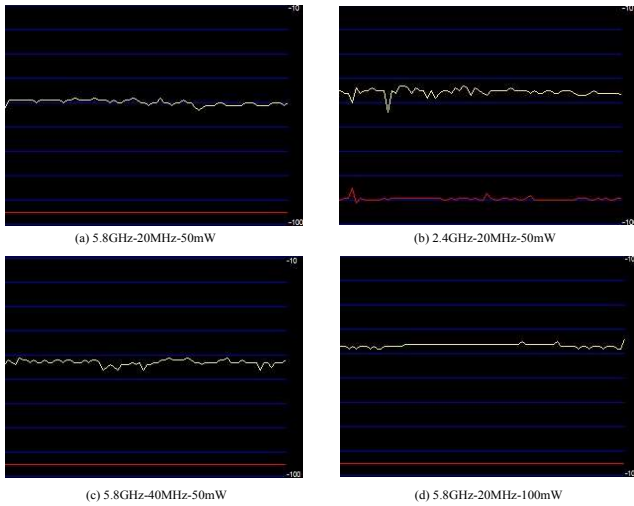


Figure 2: RSSIs(in dB) from an AP with different settings

5.8GHz is about 5dB to 6dB. The theoretical value got by formula (1) is about 7dB. Fig. 4(a) and Fig. 4(c) depict that the RSSI gap between signal on channel of 20MHz and 40MHz is about 2dB to 3dB, while the theoretical value is 3dB. Fig. 4(a) and Fig. 4(d) reveal that the RSSI gap between signal of different transmitting power (50mW and 100mW) is about 2dB to 3dB, while the theoretical value is 3dB. On the whole, results show that the inferring method is reasonably accurate in open spaces. We use it to estimate interference graph in all spaces roughly in this paper.

3 Spectrum Allocation Rules

In this section, we state several rules in our spectrum allocation mechanism and analyze the complexity of the mechanism.

3.1 Rule 1: Load-aware

We depict the method to compute desired channel-width of each AP and performance metrics which are originally defined by Moscibroda et al. [6]. Our mechanism tries to assign a spectrum of B_i for AP_i , and B_i is the smallest value in $Width_Set$ that complying with formula (2). B_{total} is the total spectrum width, L_i represents load on AP_i , $N(i)$ contains neighbor APs of AP_i . $\alpha \in [0, 1]$ is a factor reflects tolerable unfairness in the network. The $Width_Set$ includes available channel-widths.

$$B_i \geq \alpha * (L_i / (L_i + \sum_{j \in N(i)} L_j)) * B_{total}, B_i \in Width_Set \quad (2)$$

- Metric-1: total spectrum utilization T_{sys} , $T_{sys} = \sum_{i \in V} T_i$, V is the set of APs and T_i is the channel width used by AP_i . T_{sys} could indicate the reusing amount of the spectrum.

- Metric-2: local spectrum per-load fairness $Local-SPF(L-SPF)$, for AP_i , $L-SPF_i$ is the ratio of spectrum obtained by the AP ($Alloc_B_i$) over desired spectrum by the AP, which is shown by following equation (3).

$$L-SPF_i = \frac{Alloc_B_i}{(L_i / (L_i + \sum_{j \in N(i)} L_j)) * B_{total}} \quad (3)$$

3.2 Rule 2: Interference graph aware

Formula (2) means that the desired channel-width of an AP is computed according to information of its neighbor APs. Therefore, an initial interference graph is required to provide neighbor relationship. How to select an initial interference graph is the first problem needs illustration. After obtaining desired channel-widths of APs, we can estimate that the interference graph will change since radio configuration of APs will be changed, like channel-width. Thus, the spectrum allocation process should base on the new interference graph rather than the initial one.

3.2.1 Selection of initial interference graph

In first stage, a reasonable initial interference graph is chosen for computing desired channel-widths of APs. There are some hints for the selection of desired interference graph. To maximize the utilization of spectrum resource, the interference graph with least edges (neighbors) can be used. Assume that all APs are working on the highest frequency with largest spectrum width, and then APs can sense least neighbors. Under this condition, edges are less and more spectrum can be allocated to APs according to load-aware rule mentioned above. The drawback of using this interference graph as initial interference graph is that there may be more edges after allocation, which will make neighbor APs use overlapping spectrum. On the contrary, using the interference graph with most edges will reduce spectrum overlaps but cannot utilize the spectrum fully. In our mechanism, the interference graph with least edges will be used to improve spectrum utilization. And some local optimizations will be designed to reduce spectrum overlaps after the global allocation.

3.2.2 Allocating spectrum based on new interference graph

After computing required channel-widths of APs based on the initial interference graph, we will arrange which AP uses which block of the spectrum. According to the required channel-widths of APs (central frequency is ignored in current mechanism), new interference graph is estimated. Compared with the initial interference graph which expresses neighbor relationship while APs using channels of maximum width, the new interference graph reflects neighbor relationship while APs using their desired spectrum. Thus the new interference graph should be used when allocating spectrum blocks for APs to ensure that neighbor APs get overlapping spectrum blocks as few as possible.

3.3 Rule 3: Partial overlap allocation

80MHz total spectrum is distributed to APs in non-overlapping way by previous algorithms [6]. Two sets of allowed channel-widths are used: {5, 10, 20, 40}MHz and {3, 5, 6, 7, 10, 12, 14, 20, 24, 28, 40}MHz. The first set is chosen in this paper since more flexible channel-width means more complexity of devices.

In this part, we discuss that whether non-overlapping allocation principle is efficient in large-scale networks. From the practical view, APs are deployed densely in recent years. SNMP data of our campus wireless network show that some APs even have more than 20 neighbor APs. On average, one AP has more than 10 neighbor APs. If spectrum overlaps are not allowed, 10 neighbor APs with same load can only get 5MHz band for each according to formula (2). But if some overlaps are acceptable in the global allocation process, each AP could obtain spectrum of 10MHz. Furthermore, the overlaps can be eliminated by local optimization. In this way, the spectrum utilization can be improved sharply. Theoretically, spectrum of 80MHz can ensure non-overlapping assignment only if total demands of any AP and its neighbors are no more than 40MHz. The reason is that APs prefer to take up a continuous chunk of spectrum to reduce complexity of implementation [6][10]. Without the limitation of continuous allocating, required spectrum for non-overlapping assignment is $\delta = \text{MAX}_{u \in V} (b_u + \sum_{v \in N(u)} b_v)$. b_u is the spectrum width demanded by AP_u . Considering the constraint of continuous allocating, spectrum of $2 * \delta$ width is required [6].

According to above analyses, we can find that non-overlapping allocation may waste some spectrum and limit the network capacity. Hence, in our mechanism,

spectrum overlaps of neighbor APs are allowed. In global allocation process, the objective is to minimize total overlaps when assigning required spectrum for APs. The amount of total overlaps is defined as another metric, $T_{overlap}$.

• **Metric-3:** $T_{overlap}$ is the amount of total overlaps in the network which computed by $T_{overlap} = \sum_{i \in V} t_{overlap}(i)$. Set V contains all APs. And $t_{overlap}(i)$ of AP_i is the amount of spectrum overlaps between AP_i and all its neighbors.

3.4 Rule 4: Imbalance-driven adaption

Rule 1 gives the load-aware principle for allocating spectrum for all APs at a time. Since loads in network is dynamically changing, the spectrum allocation mechanism has to be adapt to the changes. It is expansive and unnecessary to adjust the spectrum used by all APs when only loads on several ones change. Thus, the adaption scheme should be local process.

3.5 Complexity

According to the rules presented previously, the objectives of our mechanism are to decide channel-widths required by APs and arrange the specific spectrum blocks for APs while minimizing total overlaps. The time complexity of the channel-width deciding process is $O(V^2)$ and V is the number of APs. The process of arranging spectrum blocks, which is also called packing blocks, is more complex because of the continuous allocation limitation. Proof 1 shows that the arranging problem is NP-complete.

Proof 1: Firstly, the goal of minimizing total overlaps is transformed to judging whether the overlaps are below a certain value, here the value is 0 which means non-overlapping allocation. Assume that all APs require the same amount of spectrum B , and the total spectrum S is divided into S/B non-overlapping blocks. Then the judging problem is transferred to judging whether the graph $G(V,E)$ can be colored by S/B colors. The coloring problem is proved to be NPH for general graphs [9]. Therefore, the judging problem is also NPH. If a scheme of arranging blocks is given, it can be judged that whether the overlaps are below a certain value in polynomial time. Thus, the judging problem is NP. On the whole, the problem is NPC.

4 Spectrum Allocation Algorithms

From the overall view of point, our mechanism contains three processes including deciding channel-

widths of APs, estimating new interference graph and arranging spectrum blocks for APs. The first two processes are performed according to Rule 1 and Rule 2 stated in section III. In this section, algorithms to arrange spectrum blocks for APs are discussed. As is analyzed previously, the arranging problem is NPC, thus we design a greedy algorithm to pack desired blocks into the whole spectrum.

4.1 Greedy Packing for Overlapping Spectrum (GPO)

Two packing intuitive rules (R1 and R2) are exploited in the spectrum allocation algorithm GR-MCF [6], which are also taken over in our algorithm. Since R1 means that most congested APs will be dealt first, our algorithm is also denoted by GPO-MCF in accord with the GR-MCF. R3 is a new rule for considering that dealing APs with more neighbors first may help to reduce overlaps.

R1. Pack large items first

R2. Try to fill up the spectrum from one end

R3. Pack item of AP with more neighbors

As is shown in algorithm 1, we try to arrange a spectrum item for the AP to minimize $T_{overlap}$, while complying with the packing rules as possible.

Algorithm 1 GPO-MCF

INPUT: Order set O : APs in descending order of load

Spectrum block set: $C = \{c_1, c_2, \dots, c_M\}$

Desired blocks of APs: $B = \{B_1, B_2, \dots, B_N\}$

OUTPUT: Allocated blocks for each AP_i , $[c_x, c_{x+B_i-1}]$

for each AP_i in O **do**

for $c_k = c_1, c_2, \dots, c_{M-B_i}$ **do**

 Assign $[c_k, c_{k+B_i-1}]$ to AP_i if the assignment achieves minimum $T_{overlap}$

end for

end for

all APs. Another side-effect of it is that more edges will be generated in the interference graph, then new spectrum overlaps may be caused. Therefore, adjusting channel-width of several APs locally is the better choice to reduce spectrum overlaps. Adjusting spectrum of APs locally is an intricate issue which has not been discussed in previous works. Cutting down the spectrum provision for one AP will influence the interference graph around the AP. The AP maybe becomes a new neighbor of some other APs which means that the overlaps of other APs may increase. Taking these factors into consideration, we describe a local adjustment algorithm, algorithm 2 which try to lower the channel-width of several APs to the next rank of available width only if APs follows R4, R5 and R6.

R4. The AP is experiencing overlaps above a threshold

R5. Overlaps of the AP will be cut down by using fewer spectrum blocks (based on the new interference graph)

R6. Reducing spectrum of the AP will not make new APs conform to R4 (based on the new interference graph)

Algorithm 2 Local Adjustment for Reduce Overlaps

INPUT: Reduce set Ω : APs with unacceptable overlaps

Available width set: $W = \{w_1, w_2, w_3, w_4\}$ blocks

Desired blocks of APs: $B = \{B_1, B_2, \dots, B_N\}$

OUTPUT: Assigned blocks for AP_i in Ω , $[c_x, c_y]$

for each AP_i in Ω **do**

if $B_i == w_k$ and $k! = 1$ **then**

for $c_j = c_1, c_2, \dots, c_{M-w_{k-1}}$ **do**

 Assign $[c_j, c_{j+w_{k-1}-1}]$ to AP_i if the assignment achieves less $t_{overlap(i)}$ and no more APs will be added in Ω

end if

end for

end for

4.2 Local adjustment to reduce overlaps

In algorithm of GPO-MCF, spectrum overlaps between an AP and its neighbors are allowed. If overlaps of some APs are unacceptable, there are two ways to reduce the overlaps. One way is to decrease the channel-widths in the global allocation process by decreasing α in formula (2) for all APs. The other one way is to cut down channel-widths of some certain APs. The first way will reduce the spectrum of

5 Evaluation

In this section, we evaluate our mechanism based on operation data of the Tsinghua campus wireless network. Two kinds of operating data in one main teaching building containing 115 APs are extracted. Firstly, neighbor APs sensed by every AP and the corresponding signal strengths (RSSI) are obtained. Since this kind of information is used to infer interference graph, it must be clarified that we used the sensing signals on

channels of 20MHz width in 2.4GHz. And the number of users associated with APs is the second kind of data, which will be relied on to compute desired channel-widths of APs.

Evaluation can be divided into three parts. To begin with, we will look into the influences brought by radio characteristics, like channel-width on interference graph. Then simulation results of our algorithm GPO-MCF and GR-MCF [6] on the operation data are depicted and compared. At last, results of local adjustment for reducing overlaps are shown.

5.1 Influence of channel width on interference graph

In this part, we will estimate the influences of channel-width on interference graph. According to load distribution, desired channel-width of each AP is obtained depending on formula (2). Combining the desired channel-widths and the initial interference graph, new interference graph could be inferred according to equation (1). The new interference graph is compared with the initial interference graph (all APs use channel of largest width). Results are displayed in Fig. 5. It can be found that there are much more neighbors of APs in the new interference graph adopting various channel-widths (5MHz, 10MHz, 20MHz, 40MHz) than that in interference graph using fixed and widest channel width (40MHz).

Because of lack of considering the influence of channel-width on interference graph, the inaccurate interference graph is used in the spectrum allocation algorithm GR-MCF. We run the GR-MCF algorithm on right and wrong interference graph respectively. Since it is a non-overlapping allocation scheme, there are not any spectrum overlaps while running on the right interference graph. But the allocating results based on the wrong interference graph will result in overlaps ($T_{overlap}$) of 1350MHz. The reason is that APs have more neighbor APs in the right graph which are not deemed as neighbors in the wrong graph. From the results, we can conclude that estimating and using correct interference graph are quite necessary when allocating spectrum.

5.2 Comparison of GPO-MCF and GR-MCF

The GPO-MCF and GR-MCF algorithms are simulated in this part. According to the description of GR-MCF, when the required spectrum blocks of APs cannot be packed into the whole spectrum in non-overlapping way, it would try to allocate narrower bands for APs and pack again. In our algorithm GPO-

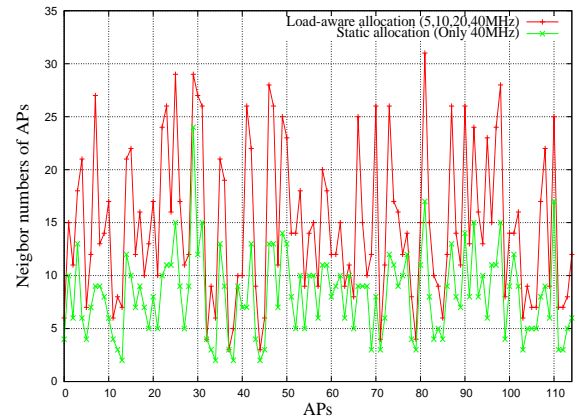


Figure 3: Neighbors in initial and estimated interference graphs

MCF, the packing process is executed only once and some overlaps are allowed to be generated. Certainly, the overlaps could be decreased by cutting down the spectrum supply for APs. It has been indicated that AP_i requires spectrum of B_i , $B_i \geq \alpha * (L_i / (L_i + \sum_{j \in N(i)} L_j)) * B_{total}$. If α of all APs are set to a value

less than 1, the spectrum supply for APs are reduced which means that overlaps may be decreased. We evaluate GPO-MCF with different α which is denoted by GPO-MCF- α . The performance metrics including T_{sys} , $T_{overlap}$ and L-SPF mentioned in section 3 are evaluated. Fig. 6 shows CDF of L-SPF when running GR-MCF, GPO-MCF-1 and GPO-MCF-0.8. L-SPF represents the ratio of spectrum obtained by an AP to the spectrum that the AP requires. From the figure we can find that about 98% of APs can get all the spectrum that they desire in GPO-MCF-1, while the percent is 80% in GPO-MCF-0.8, 40% in GR-MCF. The reason is that GR-MCF requests non-overlapping allocation which is difficult to realize in a dense network, thus the channel-bandwidths allocated for APs have to be reduced to avoid spectrum overlaps.

Two aspects in the figure that easily cause confusions are explained here. As can be seen, several APs have high L-SPFs even to 10. The reason is that those APs bear quite a few users and the proportional value computed by $L_i / (L_i + \sum_{j \in N(i)} L_j)$ is too small, which

makes the required spectrum less than 1MHz. But each AP could at least achieve 5MHz spectrum, thus the L-SPF is high. Another point is that GPO-MCF-1 will allocate B_i for each AP_i without decreasing spectrum supply, but L-SPF of several APs in GPO-MCF-1 is less than 1. The reason is that some APs require more than 40MHz spectrum, but they can get 40MHz spectrum at most.

We also compare T_{sys} (total spectrum utilization) and

Table 1: Performance metrics of the algorithms

Algorithms \ Metrics	GR-MCF	GPO-MCF-1	GPO-MCF-0.8
T_{sys}	950MHz	1785MHz	1455MHz
$T_{overlap}$	0MHz	530MHz	160MHz
Average L-SPF	1.43	1.84	1.62

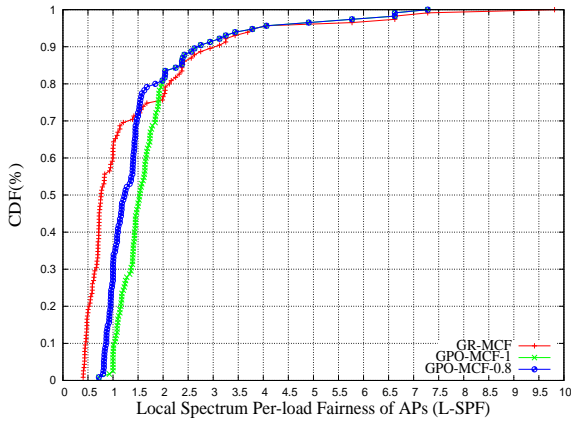


Figure 4: L-SPF of different algorithms

$T_{overlap}$ (total overlaps) of the algorithms which are given in table 1. The results reveal that GPO-MCF-1 could improve the total spectrum utilization drastically but it brings in certain amount of spectrum overlaps. The overlaps could be decreased by GPO-MCF-0.8 which cuts down spectrum supply slightly for all APs.

5.3 Results of local adjustment algorithm

It has been argued before, to reduce spectrum overlaps, adjusting spectrum allocation for some APs locally is more reasonable than decreasing spectrum supply for all APs. Here the local adjustment algorithm is executed once and the results are compared with those of GPO-MCF-0.8 which is deemed as a global adjustment method to reduce overlaps. The threshold of acceptable overlaps in rule R4 is set to 20MHz. And there are 8 APs that experiencing unacceptable overlaps after applying GPO-MCF-1. Six of them are adjusted after running the local adjustment algorithm. L-SPFs of the six APs after running GPO-MCF-1, GPO-MCF-0.8 and local adjustment algorithm are presented in Fig. 7. Local adjustment will reduce the L-SPFs of all the six APs while GPO-MCF-0.8 decreases L-SPF of 4 APs. But the advantage of local adjustment is that L-SPF of other APs will not be influenced, since only the six ones are changed compared with GPO-MCF-1. While in GPO-MCF-

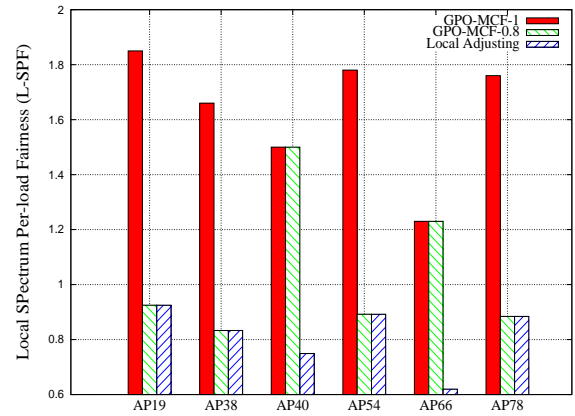


Figure 5: L-SPF of local and global adjustment

0.8, spectrum widths of other APs besides the six ones may be reduced.

T_{sys} , $T_{overlap}$ and average L-SPF of the three algorithms are listed in table 2. What can be observed is that local adjustment reduces nearly half of total overlaps generated by GPO-MCF-1 with minor influences on spectrum utilization (T_{sys}) and spectrum supply of APs (L-SPF). From comprehensive view, local adjustment method performs better than the global adjustment method (GPO-MCF-0.8) in reducing spectrum overlaps.

6 Conclusion

In this paper, we indicate that radio characteristics like channel width, central frequency and transmitting power, etc. have influences on interference graph which is a basis for spectrum allocation. This is a special and important feature of dynamic spectrum access, which is usually ignored in previous works. We give a simple method to estimate interference graph adapting to radio characteristics. Based on the estimated interference graph, greedy algorithms of arranging proper continuous blocks for APs are designed, which includes the global arranging algorithm and local optimization algorithm. At last, analysis and simulations verify that our mechanism could improve spectrum utilization efficiency while generating much fewer spectrum overlaps compared with previ-

Table 2: Performance metrics of the algorithms

Algorithms \ Metrics	Local Adjustment	GPO-MCF-0.8	GPO-MCF-1
T_{sys}	1710MHz	1455MHz	1785MHz
$T_{overlap}$	250MHz	160MHz	530MHz
Average L-SPF	1.79	1.62	1.84

ous methods.

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