WIRELESS ACCESS CHANNEL AND BROADBAND DYNAMIC REGULATION BASED ON LAN

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Abstract. As the wireless local area network developed from spare framework to centralized framework, wireless access points tended to interfere with each other, resulting in the fluctuation of network environment and properties. In order to improve such condition in the dense wireless local area network environment, this study calculated interference factors and evaluation factors of information channels, as well as explored channel allocation and interference coordination methods of wireless network based on multiple access controlprotocol and control and provisioning of wireless access pointsprotocol. Moreover, the study put forward to reduce the interference among wireless access points based on power control. At last, this study put forward a dynamic optimization and regulation scheme based on wireless access points and the scheme was tested. Test results indicated that, dynamic power control could further optimize the wireless local area network environment; the dynamic regulation scheme could effectively reduce the interference of access points as well as improve network performance, which could satisfy users' requirements.

Keywords: Dense, wireless network, wireless access points, information channel, regulation scheme.

1. Introduction

Wireless local area network (WLAN) is the production of wireless communication technique and computer networks [1]. It has constantly changed traditional inter-computer communication methods since the 20th century. With the development of Internet and the wireless communication technique, WLAN, which is featured by convenient usage, appropriate price and easy installation, has been regarded as the optimal broadband access method and widely applied to human life [2]. In addition, as peoples demand for consumption rises, the WLAN has tended to develop towards dense deploy [3]. In WLAN environment that contains dense wireless access points (AP), the network density improves continually and usable efficient resources are developed constantly, thus the user experience becomes worse and worse [4]. The dense AP deployment of WLAN gradually becomes the bottleneck of WLAN development. Moreover, with the development of users intelligent, individualized and diverse demands, the requirements on WLAN become higher [5]. The AP density has an increasing tendency, the coverage rate is high and the mutual interference among AP is severe. Therefore, it is of great significance for optimization of wireless network resources to study interference coordination techniques that can effectively reduce the interference in dense WLAN [6].

Kwon Y. M. et al. [7] put forward the least congested channel search (LCCS), i.e., scanning information channels of every AP one by one to monitor the data transmission of all channels and acquire the load status of each channel, thus to find out the channel with the lightest load (the least occupation of user terminals). De Kerret P et al. [8] analyzed the shared channelinterference model under the multiple input multiple output (MIMO) wireless communication system, and thus revealed the changes of system-wide capacity. Besides, they believed that the collaborative communication in densely deployed environment was more beneficial to improvement of system capacity. Ramaiyan V et al. [9] analyzed IEEE 802.11multiple access control (MAC) using the Fixed-point Theorem. On the basis of the channel access controlprotocol, this study coordinated interference through power control as well as put forward a regulation scheme based on AP coordination, aiming to provide theoretical basis and technical supports for improvement of internet environment and properties, and thus promote the scientific development of WLAN.

2. MAC protocol and CAPWAP protocol

2.1 MAC protocol

From the physical aspect, MAC ensures wireless nodes sharing media on a fair and orderly basis. Meanwhile, it also plays an important role in network performances. Broadband WLAN has two forms of network architecture: centralized control and distributed control forms. Deployment of MAC to channel resources includes resource utilization and free competition. The deployment of resource utilization is in the network architecture of centralized control, which is realized through a centrostigma (AP). The free competition method is suitable for distributed environment and the nodes in such method acquire the right to use channels through competition [10, 11].

2.2 CAPWAP protocol

The control and provisioning of wireless access point (CAPWAP) is the standard interface between access controller (AC) and AP, which is a protocol based on centralized WLAN architecture. Such protocol defines the control channel and data channel. AP and AC can make the control frame and data frame interact with each other through corresponding channels, thus to provide power controlled interference coordination with support [12].

3. Channel assignment strategy of dynamic wireless fidelity

The WLAN in current society is distributed densely and characterized by big data flow. Resources of information channels and broadband are limited, thus all AP can not work in different channels by current science and technology. Inefficient distribution of information channels can severely affect the communication performance of all WLAN. Therefore, in IEEE 802.11 20 MHz broadband channels, we distributed channels through channel assessment factors [13].

3.1 Channel interference factors

Channel interference factors (CIF) are mainly used to estimate the degree of interference of different channels [14]. The smaller the CIF, the lower the degree of interference, thus the channel quality is better and the transmission rate is higher. Calculation equations of CIF are:

$$CIF = T_\partial - T_\sigma \tag{1}$$

$$CIF = \frac{T_\beta - T_\sigma}{T_\partial - T_\sigma} \times 2^{10^{N/10} - 10^{N_0/10}} \tag{2}$$

T_β refers to the time duration when channels are busy;

T_σ refer to the time of data transmission;

T_∂ refers to the observation time, i.e., scanning and detection time of a single channel; N is the acquired digital noise floor; $N0$ is the smallest digital noise floor.

4. Channel assessment factors

Channel assessment factors (CAF) include known inference and potential inference, which are the sum of CIF and potential inference [15]. The calculation equation is as follow:

$$CAF_n = aCIF_n + \frac{\sum_i (b_i/P_{ni}^{\omega})}{1/P^{\omega}} = aCIF_n + b_i P^{\omega} \sum_i (1/P_{ni}^{\omega}). \tag{3}$$

n the equation, n refers to the channel number; P is the covering radius of AP; Pi is the distance between AP and other interfering AP within the AP covering; i refers to the number of interference AP; a is the proportion of interference channels; is the potential interference, the bigger the value, the bigger the potential interference; b is the overlap coefficient of different channels, the bigger the value, the bigger the interference; refers to the index of channel fading.

4.1 Channel allocation

Primary allocation of channels based on CAF

(1) Collection of AP data
(2) Calculation of CIF
(3) Report of received messages
(4) Sequencing based on CAF
(5) Work of AP in CAF0 channel

Channel reassignment based on CAF

(1) Collection of AP data
(2) Calculation of CIF
(3) If CIF is lower than the hold value, AP collect data for calculation of CIF
(4) Report of interference information, including CIF
(5) Calculation of CAF
(6) Sequencing is carried out based on CAF and CAFmin is selected for AP
(7) Channel switch of AP

5. Power controlled interference coordination

6. Power control

In dense WLAN, severe interference can greatly affect the throughput performance of Internet [16]. Therefore, based on known channel interference factors and assessment factors, how to effectively coordinate them affects the development of dense WLAN. Lots of researchers have already carried out studies on interference coordination. However, there are few researches are carried out aiming at AP interference coordination. Therefore, we coordinated interference through power control multiple AP.

As shown in figure 1, the optimal access point of point O is AP1; AP5 and AP6 are out of the covering radius, thus there is no interference. Within the covering radius, channels of AP2, AP3 and AP4 are overlapped. In order to

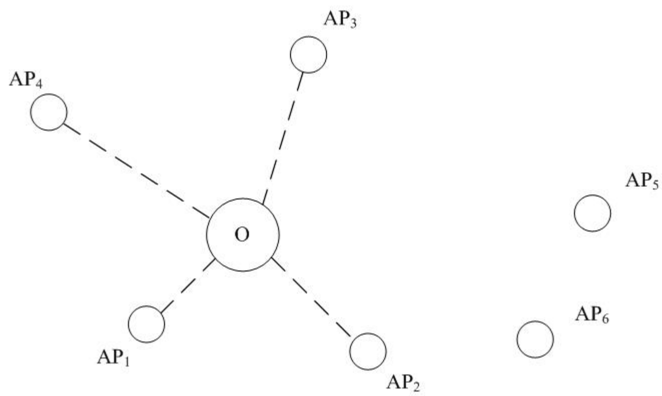

Figure 1: AP covering in dense WLAN

eliminate influence, the power control is necessary. During signal propagation, some factors can weaken the signals which are called path loss. Similarly, in propagation of frequency waves in the air, the filtering effect of air on signals can results in power loss. The path loss equation of TGn channel model (2.4 GHz $\sim$ 5 GHz) is:

$$Z(X) = Z_{\mu}(X_r) + 10n \lg(X/X_r). \tag{4}$$

In the equation, Z_{μ} refers to free-space loss and X_r refers to the distance between the endpoints.

Model	A	B	C	D	E	F
X_r	5	5	5	10	20	30
n before X_r	2	2	2	2	2	2
n after X_r	3.5	3.5	3.5	3.5	3.5	3.5
Shadow fading before X_r	3	3	3	3	3	3
Shadow fading after X_r	4	4	5	5	6	6

Figure 2: Path loss parameters of TGn channel models

In table 1, the received signal power of Model F is

$$P_{\theta} = P_{\rho} - Z(X) - Z_{shadow}. \tag{5}$$

In table 2, the minimum emissivity $Pmin$ of AP in 802.11 normal sensibility is:

$$P_{\rho\min} = P_{\rho} + Z(X_{mar}) + L_{shadow}. \tag{6}$$

Modulation	Coding rate	Minimum sensitivity
QPSK	0.5	-77
	0.75	-74
BPSK	0.5	-82
	0.75	-79
16-QAM	0.5	-70
	0.75	-66
64-QAM	0.5	-65
	0.75	-64

Figure 3: Receiving sensitivity of 802.11 standard signal

X_{mar} refers to the distance between the most marginal user and AP. In order to enable all users within the covering range to receive signals, the emissivity should be not lower than $P_{\rho\min}$.

Then the power is reported to AC through AP; the modulating power calculated by AC is the replied to AP; finally AP adjusts the emissivity.

6.1 Analysis of simulation performance

We carried out a simulation analysis to verify its validity and parameters were set up as follows:

Parameter setting	Value range
Channel	1-13,149,153,157,161,165 (China standard)
Channel width	20MHz
Frequency band	2.4GHz,5GHz
Default emissivity	16dBm (2.4GHz), 20dBm (5GHz)
Maximum emissivity	20dBm(2.4GHz),27dBm (5GHz)
Channel model	TGn
AP density	(5:5:30)*10-5
Radius	160
Channel interference factors	1,0.652,0.325,0.198,0.049,0.007

Figure 4: Values of simulation parameters

Table 3 and figure 2 show that, after AP power control based on channel allocation, the interference on AP is reduced. The intensity of interference signals is in direct proportion to the AP density, thus the lower the AP density, the weaker the intensity of interference signals. In low density, the larger the AP distance, the smaller the interference in the distance. After the emissivity is reduced, the weakening extent of interference intensity is low. In moderate AP density, the gain brought by power control is the maximum. In high AP density, the number of AP increases and the distance reduces, thus the interference intensity increases.

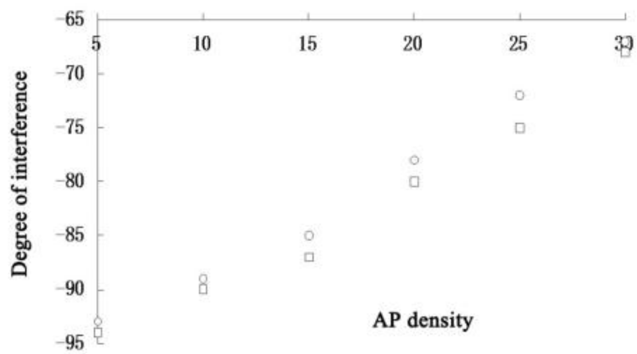

Figure 5: Relationship between interference and AP density

7. Dynamic regulation scheme based on AP coordination

During the AP run phase of this regulation scheme, the minimum broadband channel resources are used to satisfy users demands to an extreme. According to business requirements and environmental information, reasonable broadband extension (compression) schemes are dynamically selected and channel allocation is adjusted through network reconfiguration. The adjustment includes three steps.

7.1 Sensing the environment

The network environment is perceived through following parameters: AP throughput capacity, business volume and demand quantity and interference distribution [17].

7.1.1 Throughput capacity

The throughput capacity refers to the maximum serving rate of AP under the relatively static state.

7.1.2 Business volume and demand quantity

The business volume refers to the current world serving rate of AP. The network demand quantity is to predict users demand by combing the current information with historical information. The calculation equations are:

$$K_{m+1}^{pre} = K_m \times (1 + \Delta K_m^{tre})(1 + \frac{\sum_{i=m-k}^{m} \nabla Y_i}{k}), \tag{7}$$

$$\Delta K_m^{tre} = \frac{K_n - K_{n-1}}{Y}, \tag{8}$$

$$\nabla Y_m = \frac{K_m^{pre} - K_{n-1}}{K_n}. \tag{9}$$

In above equations, Y refers to the current business volume, predicted value and predicted time granularity. K_{m+1}^{pre} is the predicted value at the next moment; ΔK_m^{tre} is the actual business growth rate and ∇Y_m refers to the current forecast error.

Firstly, AP learns and processes the surroundings. Then the serving rate is monitored and the maximum throughput capacity of periodic AP is calculated; data are then sent to network resource management (NRM). Then the AP system processes users perception reports and builds environmental information. The environmental information, business volume and throughput capacity are sent to NRM. After that, NRM learns and processes received information, thus to predict the business demand quantity and determine the decision-making time of trigger.

7.2 Decision-making process

The decision includes extension strategy and compression strategy. This study put forward four kinds of strategies: free adjacent channel, free channel selection, adjacent AP channel coordination and broadband compression.

7.2.1 Strategy of free adjacent channel

Suppose there are mutually independent 20 MHz free channels, then the broadband extension can be realized by directly binding free channels.

7.2.2 Strategy of free channel selection

Suppose there is a pair of mutually independent 20 MHz channels and they make up 40 MHz of free channels. Then AP can be applied for transferring to the channel.

7.2.3 Strategy of adjacent AP channel coordination

Suppose a pair of mutually independent 20 MHz channels is occupied by adjacent AP, then adjacent channels that have fewer reconstitution costs are selected as the spreading channel for coordination.

7.2.4 Strategy of broadband compression

Suppose the AP business demand quantity is reduced, then the broadband compression strategy is carried out to save frequency and power resources.

7.3 Network reconfiguration

Network reconfiguration refers to reconstitute AP in order by NRM according to decision results. Different strategies have different reconstitution methods [18]. In strategy of free adjacent channel, the network is reconstituted by changing broadband and mode switch at the same time. In strategy of free channel selection, channel migration and mode switch of AP and users are carried out at the same time. The method of adjacent AP channel coordination strategy is more complicated than above two: firstly, AP and TRM are given coordinated restructuring; then the method of free adjacent channel is used. In broadband compression strategy, AP is used to directly realize broadband changing and mode switch.

7.4 Simulation analysis of the dynamic regulation scheme

7.4.1 Setting of the simulation environment

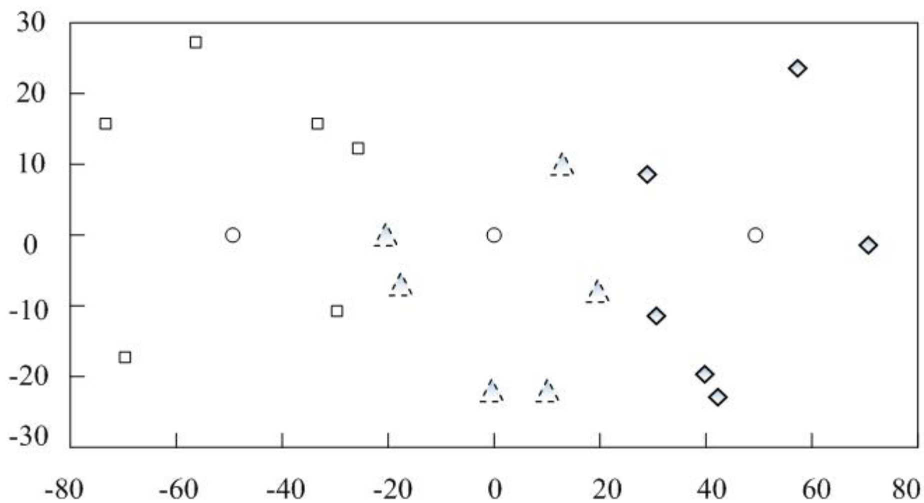

Figure 6: Linear distribution of three AP

As shown in figure 3, the business demand quantity under three AP is big. In traditional mode of distribution, such characteristic can be fully reflected by the method of mixing $20MHz$ and $40MHz$.

7.4.2 Analysis of simulation results

As shown in figure 4, in such network environment, the scheme put forward in this study can improve the actual business throughput capacity of network and the satisfaction of users better compared with that of traditional broadband allocation method.

Figure 5 indicates that resources among each AP flow interactively. The resource allocation method put forward in this study can increase the use ratio of resources and take full advantage of channel resources as well as increase the throughput capacity of network. The good use of channel resources can

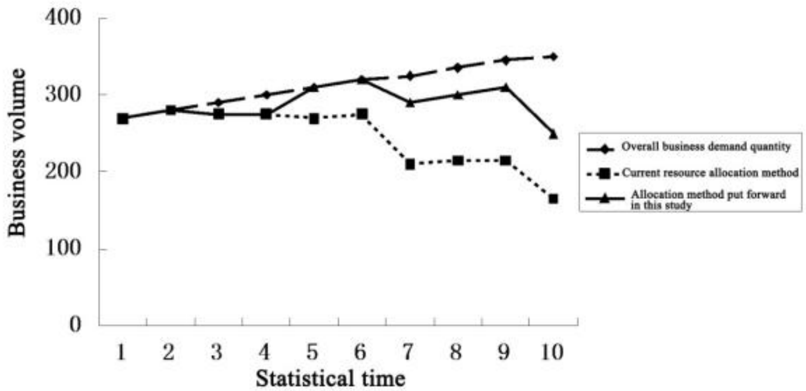

Figure 7: Overall business volume

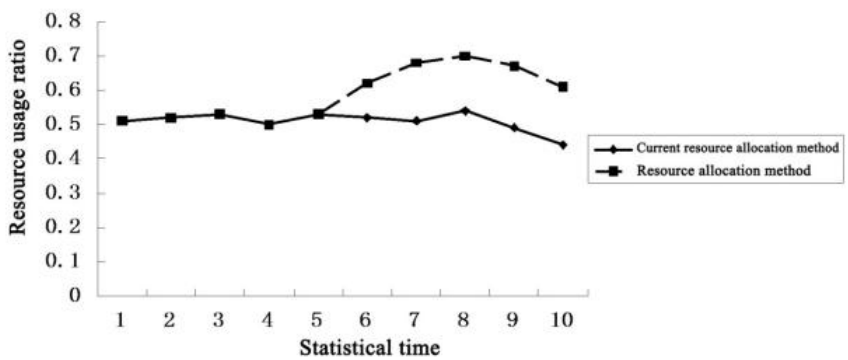

Figure 8: Resource utilization of different channel allocation

reduce the probability of free channel resources, thus the resources can be used effectively.

Figure 6 shows that, the broadband allocation scheme put forward in this study can improve the service ability of network as well as users' degree of satisfaction.

8. Discussion and conclusion

With the rapid development of WLAN, the deployment of AP becomes more and more dense. Thus the interference among AP is severe, which can lead to fluctuation of network environment as well as affect users experience. In recent years, researchers in China and abroad begin to study the reasonable allocation of network resources in large-scale dense WLAN environment [19].

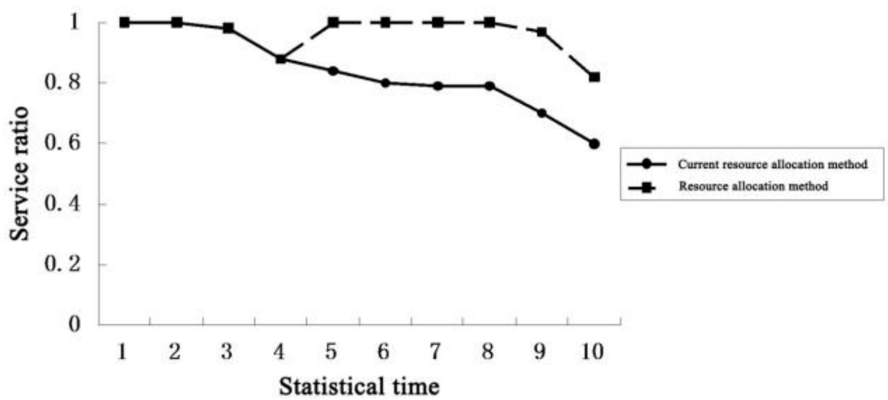

Figure 9: Satisfaction of business requirements

Under the impetus of IEEE802.11n new standard, the 802.11n high throughput mode comes out, which provides new technical supports for resource allocation of large-scale dense WLAN. On the basis of MAC and CAPWAP protocol, channel interference factors are determined and channel assessment factors are calculated to evaluate the quality of channels. The optimal transmitting power is determined by control intervention of power. Relevant frequency resources are allocated according to AP business demand and the resource use ratio is improved under the premise that the business demand is satisfied, which realizes green energy saving and such scheme is feasible. There are also many assumption factors in this study. The interference analyzed in this study belongs to internal interference and the external interference is not analyzed. Therefore, this study should be further improved in the future.

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