Multi Channel Allocation Technology for large scale Connection Scenarios in Wireless Networks

Hua Tian¹, Ge Jiao²*, Xiao Yan Xu¹
¹Department of information and art design, ShanDong business institute, YanTai, 264670, China
²College of Computer Science and Technology, Hengyang Normal University, Hengyang, 421001, China

* jiaoge@126.com

Abstract. The existing wireless network multi-channel allocation technology has the defects of low throughput and large average delay. Therefore, this paper proposes a multi-channel allocation technology for large-scale connection scenarios. Through the wireless network architecture, the large-scale connection scenario is described. Based on this, the interference model of wireless network is built. In order to simplify the process of multi-channel allocation in wireless network, Kruskal algorithm is used to form the minimum spanning tree of wireless network topology, and the link load weight is calculated. Based on the calculation results, the wireless network multi-channel is allocated according to the link load weight from large to small. The multi-channel allocation of wireless network for large-scale connection scenarios is realized. Using the proposed technology to determine the value of link load weight, the multi-channel allocation scheme is obtained, and the simulation experiment is carried out. The experimental results show that: compared with the standard value, the proposed technology has large throughput and small average delay, which fully shows that the proposed technology has higher allocation performance.

Keywords: large scale connection scenario, wireless networking, multichannel, allocation
1. Introduction
In recent years, with the continuous development of the Internet, the number of mobile devices and data is exploding, for the needs of large-scale connection scenarios, higher requirements are put forward for the network, for example, to improve the throughput of the network and equipment acceptance capacity [1]. The emergence of wireless networking, a good solution to the above problems. Wireless networking is a multi hop autonomous system composed of a group of mobile nodes including wireless transceiver devices. It does not depend on the infrastructure. It has the characteristics of temporary, rapid deployment and strong invulnerability. It has a good application prospect in civil, military, civil and other aspects. It is one of the key research issues in the network field.

For the wireless network, its constituent equipment is connected through the wireless channel, forming a communication system [2]. In the application range of wireless networking, there is mutual interference between network nodes, which leads to the decline of network channel capacity. Therefore, the wireless network node is equipped with multiple radio frequency interfaces, and each radio frequency interface is allocated with different channels, which can greatly reduce the interference degree and improve the wireless network channel capacity. In the process of practical application, a channel is often occupied by multiple links, which leads to the decline of network performance and channel utilization. Therefore, it is particularly important to select an effective wireless network multi-channel allocation technology, which can maximize the performance of wireless network [3]. The existing wireless network multi-channel allocation technology has the defects of low throughput and large average delay. Therefore, this paper proposes a multi-channel allocation technology for large-scale connection scenarios.

2. Research on multi channel allocation technology in wireless network

2.1 Large scale connection scenario description
Wireless network includes multiple mobile devices. In a certain communication range, when the radio frequency interfaces of two mobile devices are assigned to the same channel, they can communicate. A mobile device can communicate with multiple mobile device nodes through multiple radio frequency interfaces channels. This scenario is called large-scale connection scenario, which is also the most widely used wireless network The general pattern. It can be seen from the above description that the large-scale connection scenario can not only reduce the channel competition conflict of mobile devices, but also effectively improve the throughput of wireless networking.

In wireless networking, due to the random movement of mobile devices, the topology of wireless networking will also change accordingly, which will lead to the narrowing of communication window between mobile devices and the decrease of network throughput. Therefore, large-scale connection scenario mode is used to avoid the above phenomenon.

The wireless networking architecture in the large-scale connection scenario mode is shown in Fig.1.
As shown in Fig.1, wireless networking is mainly composed of gateway, infrastructure and mobile devices. Different radio frequency interfaces of mobile devices use different channels for parallel communication, which is the development trend and direction of wireless networking at present and in the future.

2.2 Construction of interference model for wireless network
In the process of wireless network communication, adjacent channels will interfere with each other, which will affect the communication performance of wireless network. Therefore, the interference model of wireless network is built to lay a solid foundation for multi-channel allocation.

The interference model of wireless network is mainly divided into two types, namely physical interference model and protocol interference model [4]. In the first model, the threshold is set to ensure that the network nodes receive enough signals. In the practical application process, the physical interference model can not be favored by the public because of the complexity of the channel physical environment and the complexity and waste of time in the calculation process. However, the second kind of model has been widely accepted by the public due to its low application difficulty and simple implementation process.

The communication distance types of wireless networking nodes are as follows:
1) Node transmission distance refers to the maximum distance that two nodes can communicate without interference. The influencing factors are transmission model and node transmission power;
2) The carrier sensing distance of a node refers to the maximum distance that the node can capture the signal;
3) Node interference distance refers to the distance of the farthest node in the process of node interference. Under normal circumstances, the distance is the largest. The schematic diagram of node communication distance is shown in Fig.2.
As shown in Fig.2, if you want to achieve normal communication between two nodes, the distance between two nodes must be less than the transmission distance of nodes, and the same channel cannot be occupied by multiple nodes.

In this study, if the interference distance of the node is 1.5 times of its transmission distance, then according to the protocol interference model, the link establishment condition is as follows.

\[ D(e_1, e_2) \geq 1.5R, \quad e_1, e_2 \in E \]  \hspace{1cm} (1)

In equation (1), \( D(e_1, e_2) \) represents the minimum distance between links and nodes, and \( E \) represents the link set of wireless network.

As shown in formula (1), if any node in one link is within the interference distance range of a node in the other link, it is called mutual interference node. If all the above nodes are within the mutual transmission distance, there is a virtual link between them. If the RF interfaces of two nodes are assigned to the same channel, it is considered that there is a logical link between the two nodes [5].

From the above description, it can be seen that if there are mutual interference nodes in the link and they are assigned to the same channel, the actual interference effect will occur, which will affect the communication performance of wireless network.

### 2.3 Minimum spanning tree of wireless network topology

In order to simplify the process of multi-channel allocation in wireless network, the communication distance of nodes in wireless network is set as 500m and the interference distance is 750m. All communication node pairs are obtained by calculation and connected. At the same time, it checks whether all nodes exist in the same wireless network coverage. If the test is successful, the gateway builds the minimum spanning tree of wireless network topology through Kruskal algorithm [6].

In the process of constructing the minimum spanning tree of wireless network topology, the path is selected according to the link power and the shortest distance. The minimum spanning tree of wireless network topology can not only guarantee the connectivity of wireless network, but also reduce the total communication distance between nodes, so as to reduce transmission loss.

The minimum spanning tree of wireless network topology constructed in this section is shown in Fig.3.
2.4 Multi channel allocation in wireless network

Based on the minimum spanning tree of the wireless network topology constructed above and the link load weight as the basis, the wireless network multi-channel allocation process is as follows.

In wireless networking, the closer the node is to the gateway node, the greater the expected traffic is, and the higher the priority is. Therefore, the channel with less interference should be allocated to this node [7]. In this study, the hop number from node to gateway node is used to calculate the distance. Based on this, the node priority PL is established, and then the load level of each node is calculated. The calculation formula is

\[ r_a = \sum_{c=1}^{N} I_{c,a} \]  

(2)

In formula (2), \( r_a \) indicates the load level of the node; \( c \) represents the number of nodes connected to the gateway through the node; \( N \) represents the total number of nodes in the wireless network; \( I_{c,a} \) is a parameter, When the node \( c \) is connected to the gateway through the node \( a \), the value is 1; otherwise the value is 0.

The calculation formula of node load factor is

\[ W_a = \frac{r_a + 1}{PL_a + 1} \]  

(3)

In equation (3), \( W_a \) represents the node load factor; \( PL_a \) represents the hop count from node to gateway node.
According to formula (3), the load factor of all nodes in wireless network is calculated, using normalization method to obtain node load weight $\omega_a$.

Based on the results of node load weight, the link load weight of wireless network is calculated, the calculation formula is

$$\omega_{lb} = \omega_a + \omega_b$$

In equation (4), $\omega_{lb}$ represents the load weight of the link $l_{ab}$; $\omega_b$ represents the load weight of the node $b$.

The calculation results of formula (4) are arranged in descending order, on this basis, the available channel bars are allocated to the first link with the largest link load weight.

Calculate the $n + 1$ link interference weight, the calculation formula is

$$\omega_{D_{ij,k}} = \sum [I_k (e_{ij} e_{uv}) (\omega_{e_{ij}} + \omega_{e_{uv}})]$$

In equation (5), $\omega_{D_{ij,k}}$ represents the interference weight of link $e_{ij}$ in channel $k$; $I_k$ indicates the number of links allocated by channel $k$; $e_{uv}$ refers to a link in the wireless network; $\omega_{e_{ij}}$ and $\omega_{e_{uv}}$ represent the load weights of link $e_{ij}$ and link $e_{uv}$ respectively.

According to formula (5), the interference weight of unassigned channel links in each available channel is calculated, the channel corresponding to the minimum value is assigned to the link, repeat the above steps, until the end of channel allocation [8].

Through the above process, the multi-channel allocation of wireless network for large-scale connection scenario is realized, which provides powerful help for the application and development of wireless network.

3. Put forward the technology application simulation experiment

3.1 Simulation scene settings
In order to verify the allocation performance of the proposed technology, MATLAB software is used to set the simulation scene to realize the multi-channel allocation of wireless network, so as to prepare for the proposed technical performance experiment.

The node load weight is calculated according to the minimum spanning tree of wireless network topology in Fig. 3. The calculation results are shown in Tab.1.
Based on the data in Tab.3, the wireless network channel allocation is obtained, as shown in Fig.4.

| Node serial number | Load rating | Node hops | Load weight |
|--------------------|-------------|-----------|-------------|
| 1                  | 21          | 0         | 0.5036      |
| 2                  | 4           | 1         | 0.0572      |
| 3                  | 4           | 1         | 0.0572      |
| 4                  | 4           | 1         | 0.0572      |
| 5                  | 5           | 1         | 0.0687      |
| 6                  | 3           | 2         | 0.0305      |
| 7                  | 2           | 3         | 0.0172      |
| 8                  | 1           | 4         | 0.0092      |
| 9                  | 0           | 5         | 0.0038      |
| 10                 | 3           | 2         | 0.0305      |
| 11                 | 2           | 3         | 0.0172      |
| 12                 | 1           | 4         | 0.0092      |
| 13                 | 3           | 2         | 0.0305      |
| 14                 | 2           | 3         | 0.0172      |
| 15                 | 1           | 4         | 0.0092      |
| 16                 | 0           | 5         | 0.0038      |
| 17                 | 0           | 5         | 0.0038      |
| 18                 | 4           | 2         | 0.0382      |
| 19                 | 2           | 3         | 0.0172      |
| 20                 | 0           | 3         | 0.057       |
| 21                 | 1           | 4         | 0.0092      |
| 22                 | 0           | 5         | 0.0038      |

**Tab.1 Calculation results of node load weight**
The above process completes the setting of simulation scenarios. Based on this, simulation experiments are carried out to verify the allocation performance of the proposed technology.

3.2 Analysis of experimental results

Based on the wireless network channel allocation obtained by the proposed technology, the simulation parameters are set to reflect the performance of the proposed technology through throughput and average delay.

The setting of simulation experiment parameters is shown in Tab.2.

| Parameter name            | numerical value | Company   |
|---------------------------|-----------------|-----------|
| Interface queue           | Priority queue  | -         |
| Working frequency         | 1.8 GHz         |           |
| Channel bandwidth         | 2 MHz           |           |
| Communication distance    | 500 m           |           |
| Jamming distance          | 750 m           |           |
| Start time                | 1 s             |           |
| End time                  | 10 s            |           |
| Packet size               | 1000 byte       |           |

Tab.2 Simulation experiment parameter setting table

According to the data in Tab.2, the simulation experiment is carried out. During the experiment, data packets are sent from nodes 9, 16 and 17 respectively, and the throughput and average delay data are tested at node 1.

The throughput data obtained by simulation experiment is shown in Tab.3.

| Data rate (Mb/s) | Throughput (Mb/s) |
|------------------|-------------------|
|                  | Propose Technology | Standard value |
| 0.1              | 0.40              | 0.35           |
| 0.3              | 0.85              | 0.50           |
| 0.5              | 1.23              | 0.87           |
| 1                | 1.89              | 1.12           |
| 2                | 1.89              | 1.10           |
| 3                | 1.89              | 1.10           |
| 4                | 1.89              | 1.10           |
| 5                | 1.89              | 1.09           |

Tab.3 Throughput data table
As shown in Tab.3, with the increase of data rate, the throughput first increases and then remains unchanged. Through comparison, it is found that the technical throughput is generally higher than the standard value.

The average delay data obtained by simulation experiment is shown in Fig.5.

![Fig.5 Average delay data chart](image)

As shown in Fig.5, with the increase of data rate, the average delay increases at first, and then remains unchanged. By comparison, it is found that the average delay is generally lower than the standard value.

The experimental data show that: compared with the standard value, the proposed technology has high throughput and small average delay, which fully shows that the proposed technology has high allocation performance.

4. Conclusion
In this paper, the multi-channel allocation technology of wireless network in large-scale connection scenario is studied. The experimental results show that the proposed technology improves the throughput and average delay of wireless network, and provides an effective means for the application and development of wireless network.

Acknowledgement
This work is partly supported by the Scientific Research Fund of Hunan Provincial Education Department(19B082), the Science and Technology Development Center of the Ministry of Education-New Generation Information Technology Innovation Project(2018A02020), the research supported by Science Foundation of Hengyang Normal University(19QD12), the Science and Technology Plan Project of Hunan Province(2016TP1020), the Application-oriented Special Disciplines, Double First-Class University Project of Hunan Province(Xiangjiaotong [2018] 469), the Hunan Province Special Funds of Central Government for Guiding Local Science and Technology Development(2018CT5001), the Subject Group Construction Project of Hengyang Normal University(18XKQ02).
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