Research on Fair Scheduling Algorithm of 5G Intelligent Wireless System Based on Machine Learning

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Abstract. In the multi-user scenario of 5G intelligent wireless system, the users can't get the fair transmission opportunity because of the different service packet length, transmission delay and channel environment of each user equipment. This paper proposes an two-stage k-means machine learning algorithm, which can select the user equipment intelligently among different user's equipment to schedule, while guaranteeing the quality of service of each user's equipment, it can also take into account fairness.

Keywords: Intelligent wireless system · Machine learning · Artificial intelligent · Fair scheduling

1 Introduction

In view of the demand for broadband wireless access in the future, the EU, China, Japan, the United States and other countries have launched the research on the demand and key technologies of the fifth generation mobile communication system [1–5]. 5g has become a research hotspot in the field of mobile communication at home and abroad.

5g network is an intelligent wireless network, which can learn the past behavior patterns, output results and the behavior of similar entities on the unified network or other networks, and the decision quality of the network will continue to improve.

Machine learning and artificial intelligence are the best candidate technologies, which can provide more powerful complex decision-making ability for 5g intelligent wireless system. In 5g intelligent wireless system, there will be a variety of standards and user devices, such as 4G, 5g, Wi-Fi or satellite communication.

At the same time, the business types of user equipment with different standards and systems are also different, such as video business, live broadcast business, game business, etc., so what kind of machine learning algorithm can be used to intelligently select user equipment among user equipment with different delays for scheduling, which can not only ensure the service quality of each user equipment business, but also take into account the fairness, which is the research goal of this paper.

In this paper, a two-stage K-means machine learning algorithm is proposed for 5g intelligent wireless system, which can intelligently select user equipment among

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different conditions to schedule, and while ensuring the service quality of each user's equipment business, it can also take fairness into account.

2 System Model

The 5g intelligent wireless system base station uses the mass MIMO multi antenna system. This paper assumes that the base station is equipped with M antennas, the service cell has a total of A user equipment, each user is equipped with N antennas, and all users are evenly distributed in the cell. At the same time, it is assumed that the transmitter knows the channel information of the user. The system model is shown in Fig. 1.

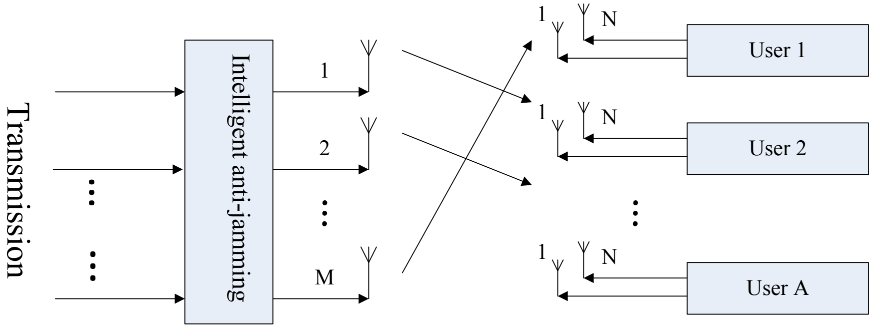

Fig. 1. System model diagram

Assuming that the transmission signal of device a in time slot t is $\mathbf{s}(t)$, the received signal can be expressed as:

$$\mathbf{r}_a(t) = \sqrt{\rho_t}\mathbf{H}_a(t) \cdot \mathbf{s}(t) + \mathbf{n}_a(t) \tag{1}$$

Where $\sqrt{\rho_t}$ is the emission power, $\mathbf{n}_a(t)$ is the complex Gaussian random variable with the mean value of independent identically distributed being 0 and the variance being N_0. $\mathbf{H}_a(t)$ is the system channel matrix. Defined h_{ij} as the channel coefficient between the receiving antenna i and the transmitting antenna j, then the channel matrix of the user a can be obtained as follows:

$$\mathbf{H}_a = \begin{bmatrix} h_{1,1} & h_{1,2} & \dots & h_{1,An} \\ h_{2,1} & h_{2,2} & \dots & h_{2,An} \\ \dots & \dots & \dots & \dots \\ h_{m,1} & h_{m,2} & \dots & h_{m,An} \end{bmatrix}_{m \times An} \tag{2}$$

The channel h_{ij} can be expressed as:

$$h_{ij} = Normal(0, \sqrt{\frac{S_n}{2}}) + j \cdot Normal(0, \sqrt{\frac{S_n}{2}}) \tag{3}$$

The mean value S_n is equal to the path loss and the variance is σ_n.

As mentioned before, in 5g intelligent wireless system, there will be multiple standards and user equipment with multiple systems. The service packet transmission delay of each user's equipment will be different, which will bring fairness to user scheduling.

In this paper, a multi-user intelligent fair scheduling algorithm suitable for 5g intelligent wireless system is proposed. K-means unsupervised learning algorithm is used in machine learning algorithm.

The traditional K-means algorithm is very sensitive to the selection of initial centroid, which may lead to local optimal solution. In order to overcome this problem, we improved the traditional K-means algorithm, and proposed a two-stage k-means method. The selection of K value is not randomly selected, but pre-processing training is carried out at the beginning of scheduling. During a period of scheduling, the scheduling priority of user equipment is calculated according to the channel environment, service data length and average transmission delay of all user equipment to be scheduled in the system (the average transmission delay will be dynamically updated in the training stage), and the scheduling priority is sorted according to the priority, The first k user devices are selected as the initial clustering points, and the pre-processing training phase is over. Then the new user devices to be scheduled are clustered according to the normal k-means algorithm until convergence.

3 Intelligent Fair Scheduling Algorithm Based on Two-Stage K-Means

3.1 Pretreatment Stage

In order to overcome the problem that the traditional K-means algorithm is very sensitive to the selection of the initial centroid, which may cause the problem of the local optimal solution, using the preprocessing method, the selection of K-means algorithm is not randomly selected, but the preprocessing training is carried out at the beginning of scheduling, in a period of scheduling time, the scheduling priority of user equipment is calculated according to the channel environment, service data length and average transmission delay of all user equipment to be scheduled in the system (the average transmission delay will be dynamically updated in the training stage), and the first k user equipment are selected as the initial clustering points, and the pre-processing training stage ends.

Firstly, the equalization matrix G is defined to estimate the transmitted signal:

$$\mathbf{y} = G\mathbf{r} = \sqrt{\rho_t}\mathbf{G}\mathbf{H}_p \cdot \mathbf{s} + \mathbf{G}\mathbf{n} \tag{4}$$

According to Eq. (4), the user's SNR can be estimated:

$$\gamma_{n,m} = \frac{E_s \left| g_{n,m}^* h_{n,m} \right|^2}{N_0 \left\| g_{n,m}^* \right\|^2 + E_s \sum_{j \neq m} \left| g_{n,m}^* h_{n,j} \right|^2} \tag{5}$$

Where $g_{n,m}^*$ is the m-th row of matrix G and the m-th column of matrix H_P. Es is the received signal power. The equilibrium matrix G can be obtained from the following formula:

$$G = \left[H_p^* H_p + \frac{N_0}{E_s} I \right]^{-1} H_p^* \tag{6}$$

From Eq. (5), the transmission rates R_a that the user device a can achieve under the SNR can be obtained as follows:

$$R_a = \log_2(1 + \gamma_{n,m}) \tag{7}$$

Assuming the service data length of the user device a is $F_i, (i = 1, 2, \ldots, A)$, the waiting transmission delay of a is:

$$T_i^a = \max_{i \neq j} (\frac{F_j}{R_j}) \tag{8}$$

Where F_j is the service data length and R_j is transmission rate of other user's equipment.

Then the priority of the user equipment to be dispatched is calculated according to the following formula:

$$k = \arg\min(\frac{T_i^a}{\overline{T_i^a}}) \tag{9}$$

Where $\overline{T_i^a}$ is the average transmission delay of the selected user, which can be updated adaptively and dynamically according to the following formula:

$$\overline{T_i^a}(t + \Delta t) = (1 - \frac{1}{T})\overline{T_i^a}(t) + \frac{1}{\overline{T_i^a}} T_i^a(t + 1) \tag{10}$$

Where T is the time constant, which is the length of the sliding time window. It reflects a user's tolerance for data transmission, which will allow a long time to wait until the user's channel quality becomes better, which is conducive to the improvement of system capacity, but may lead to the increase of delay.

According to formula (9), the scheduling priority of each user is obtained, and the first k user devices are selected as the initial clustering points, and the pre-processing training phase is over.

The K initial clustering points selected after preprocessing are obtained according to the fairness criterion, which ensures that the clustering results of K-means algorithm are divided according to the fairness, and avoid the local optimal solution problem caused by random selection of initial clustering points.

3.2 K-Means Algorithm

After K initial clustering points are obtained by preprocessing, the new user devices to be scheduled are clustered according to the normal k-means algorithm until convergence. The algorithm steps are as follows:

(1) The coordinate values $c_0, c_1, \ldots, c_{k-1}$ of K initial clustering points are recorded. Here, the waiting transmission delay T_i^a and the average transmission delay $\overline{T_i^a}$ of users are used as the coordinate values $c_0(T_0, \bar{T}_0), c_1(T_1, \bar{T}_1), \ldots, c_{k-1}(T_{k-1}, \bar{T}_{k-1})$;

(2) According to the channel environment and the length of traffic data, the waiting transmission delay T_i^a and the average transmission delay $\overline{T_i^a}$ of users are calculated for the new user equipment to be scheduled, and the coordinate value $x_0(T_0, \bar{T}_0), x_1(T_1, \bar{T}_1), \ldots, x_{n-1}(T_{n-1}, \bar{T}_{n-1})$ of the new scheduling user is obtained. Then the distance between the user and each initial cluster point is calculated, and the user equipment is assigned to the cluster point with the smallest distance to form K clusters. Common distances include Euclidean distance and Manhattan distance. The project adopts the Euclidean distance:

$$D = \sqrt{(T_i - T_j)^2 + (\bar{T}_i - \bar{T}_j)^2}, (i = 0, 1, \ldots, n-1, j = 0, 1, \ldots, k-1) \tag{11}$$

(3) Recalculate the coordinates of cluster points:

$$\begin{aligned} T_i' &= \sum \frac{T_m}{M}(m = 1, 2, \ldots, M) \\ \overline{T_i'} &= \sum \frac{\overline{T_m'}}{M}(m = 1, 2, \ldots, M) \end{aligned} \tag{12}$$

M is the number of user devices in each cluster. The number of user devices in each cluster is different.

(4) Repeat steps (2) and (3) until the cluster does not change or the maximum number of iterations is reached.

(5) The user devices are scheduled according to the clusters.

Based on the improved k-means machine learning algorithm, the user equipment can be intelligently selected for scheduling among the user equipment with different delay, which can guarantee the service quality of each user equipment business and take into account the fairness.

At the same time, in order to overcome the problem that the traditional K-means algorithm is very sensitive to the selection of the initial center of mass, which may cause the problem of local optimal solution, using the preprocessing method, the selection of K-means algorithm is not randomly selected, but carries out the preprocessing training at the beginning of scheduling to ensure that the global optimal solution can be obtained, which makes the machine learning algorithm convergence.

4 Conclusion

In the multi-user scenario of 5g intelligent wireless system, due to the different service packet length, transmission delay and channel environment of each user's device, the user cannot get the transmission opportunity fairly. This paper proposes an improved k-means machine learning algorithm, which can intelligently select the user's device to schedule among the user's devices under different conditions. While ensuring the service quality of each user's equipment business, it can also take into account the fairness.

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