Metaheuristic-Based Scheme for Spectrum Resource Schedule Over 5G IoT Network

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Abstract. Numerous international organizations agreed that future 5G must be an Ultra Dense Network (UDN) which includes machine to machine (M2M), device to device (D2D) and so on. Thus, how to increase the usage utility of spectrum and management of spectrum resources are the important research issues for 5G mobile communication. Following the requirement of 5G development organizations, this study adopts centralized cloud radio access network (C-RAN) architecture to design a novel mechanism for scheduling of all the M2M requests. The proposed metaheuristic-based scheduling mechanism guarantees that the final solution will not fall into the local optimum. Simulation results show that the proposed scheduling mechanism improves the spectrum resource utilization over 5G IoT network.

Keywords: 5G network · IoT · C-RAN · Metaheuristic scheduling mechanism

1 Introduction

Recently the new smart device technique is improved every day and the market demand bigger than a few years ago. The mobile communication network needs to support the high quality of service for devices; the 5G mobile communication network will be the solution. The 5G mobile network provides more high data rate, low latency, and the multi-input and multi-output (MIMO) technology. Communications for Internet of thing (IoT) and device to device (D2D) in the Ultra Dense Network (UDN) for 5G mobile network is also named the heterogeneity network [2]. The 5G mobile networks focus on the higher transmission speed. Besides, it supplies to improve the better quality of service. Hence, how to manage the network resource effective to enhance the network performance is a very important issue in the 5G mobile network. This study proposed an efficient spectrum resource scheduling scheme by using simulated annealing (SA) algorithm. The application needs more spectrum resource or high QoS, the value of weight will be larger. Second, the algorithm based on a given weight value will random schedule and calculate the number of the idle time slot. This study combines the meta-heuristic algorithm - SA algorithm to get the optimal solution.

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Y.-B. Lin et al. (Eds.): IoTaaS 2017, LNICST 246, pp. 117–125, 2018.
https://doi.org/10.1007/978-3-030-00410-1_15

This paper is structured as follows: Sect. 2 denotes the network resource management and scheduling mechanism of the 5G mobile network. Section 3 presents the problem definition. The description of the proposed method and detail algorithm are described in Sect. 4. The simulation results are demonstrated in Sect. 5. Finally; Sect. 6 marks conclusions of this work.

2 Related Works

The standards of 5G development and research have become ubiquitous in recent years, more and more studies focus on how to improve the QoS and increase the utility of resource allocation. The Virtual Network Embedding (VNE) is a key point that can manage the network resource efficient and improve the network performance [4]. Authors in this paper compared the three network management policies: Full SharingFull Split and Russian Dolls. By comparing three mechanisms that researchers can know the advantages and defects of how to select the management method. On the other hand, the authors analyze the network scenarios which resource mechanisms will be better. However, this study does not focus on the spectrum resource issues. In [5] mentioned the importance of spectrum resource allocation and management in the radio access network. To solve this problem, the method proposed here uses more task scheduling mechanisms to address this issue.

In [6–9], these studies described the proposed task scheduling mechanisms. In [6] authors proposed to use a task scheduling at distributed system architecture in C-RAN. One of the most important goals is to design the scheduling that throughput can be maximum. Authors will set the threshold for every BBU. Next, the BBU will start to do the task scheduling if the user s power gain of the channel is bigger than the threshold of BBU. Moreover, in another study with the issue of cloud computing resource allocation [7], authors proposed the task scheduling which is different traditional bandwidth methods. Most of those traditional methods considerate the hardware resource including CPU capacity, memory, etc. Also, they calculate the processing time of task and cost of communication. Given this, we know the spectrum resource is an issue that needs to focus. However, some smart devices do not fit in the same location, like the smart phone and vehicle device. If the device is mobile, we must care the situation for the whole network [8]. The main idea is using the friendship algorithm to solve this problem under the centralized network architecture. Finally, the authors using the Genetic Algorithm (GA) one of the meta-heuristic algorithms to solve the load balancing in the cloud computing and that can avoid the solution is the local optimal.

3 Problem Definition

In this section, we will use the independent linear program (ILP) to define the problem want to solve. This study should follow the 5G mobile communication network architecture to increase the credibility. Figure 1 is our network environment and architecture. Consider the IoT will be many devices in one area, at this time, we can define this number of devices is like the swamp. However, each small cell just can support the service for a fixed number of IoT devices and have the limited coverage range. In part of the base station, in C-RAN the radio remote heads were separated, and the base band unit (BBU) pool is responsible for computing and storage data. The BBU pool is not in base station but nearby it. When small cell collected the data from IoT devices, it will transmit the collected data to the base station through the method of wireless (fronthaul). The base station will do the scheduling to management the spectrum resource. Finally, the base station is using backhaul to connect the core network to finish the transmission.

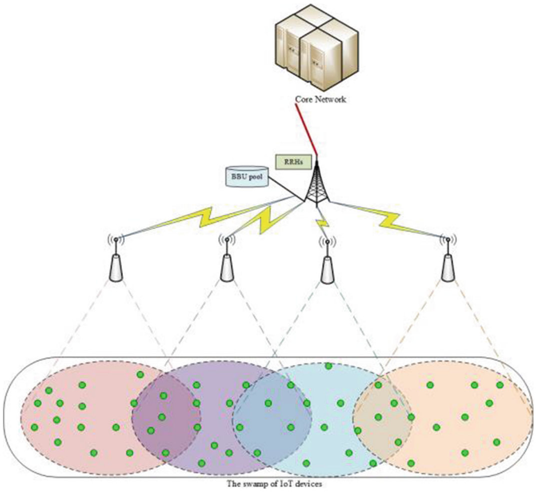

Fig. 1. The IoT with 5G mobile communication environment

At this part, we will focus on the defined our problem with using equation. For clearly to present the equation, here we will assume and define the important symbols that problem can be known easily. First, we assume there have some IoT devices N; the N is a set that presents N = 1,,n,,N. In this study, we assume there has the different type service of IoT devices even there are in same coverage range with small cell. Above this assumption, here we use the set M = 1,,m,,M to present the types of task in our network environment, and the T_n^m is the *nth* devices processing the task of type *m*. Next, consider the problem is how to manage the spectrum resource to improve the performance. We define the resource block of task, the m_r defines the demand resource block of T_n^m. On the other hand, we also use β to present the remainder resource blocks in the channel. Figure 2 shows the state of data transmission form IoT to the base station. As our assumption, the each small cell maybe services two type of tasks or more. The different type task requires different time to send the data to small a cell. At this situation the small cell can schedule the every task easily. But if all small cell uplink there task scheduling to base station, the collision will occurr at the same time slot. To avoid this situation, the base station need to do change the original schedule, but there has some task is real time data that cannot wait for long time. So how to schedule the task to reduce the waiting time is the main issue in this paper.

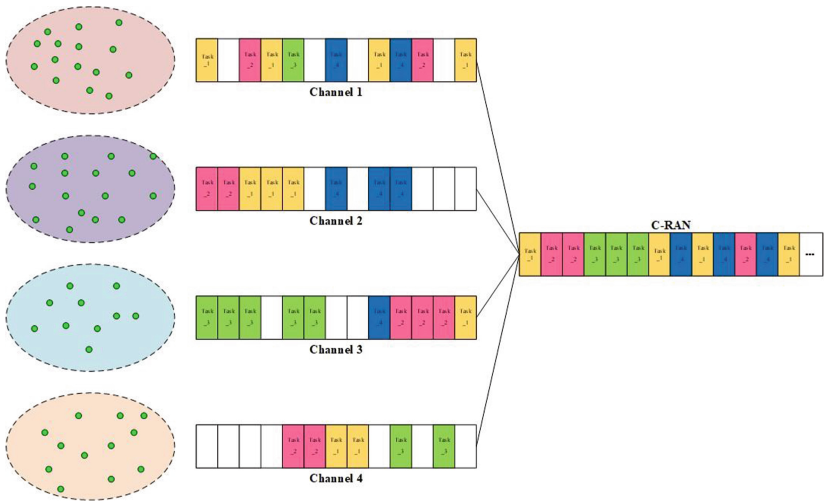

Fig. 2. The state of data transmission from IoT to base station

To define our problem, we need to consider the arrival rate for each task, the arrival rate we present the $p\left(T_n^m\right)$, the

$$p\left(T_n^m\right) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-(\beta-\mu)^2)}{2\sigma^2}}, \tag{1}$$

$$E\left(T_n^m\right) = p\left(T_n^m\right) * \gamma_m, \tag{2}$$

we use σ to present the standard deviation of β. μ defined the average of m_r. The γ_m is the weight of *mth* task type, and the $E\left(T_n^m\right)$ is expectation value. We know the arrival rate of the task, we also need to evaluate the service time when the job in the channel.

$$s_m^n = e^{\frac{m}{1+m}}, \tag{3}$$

the s_m^n defined the service time in our study. Above this equations, the waiting time of device n with type m task in the channel at this schedule can calculate,

$$w_m^n = \frac{1}{E\left(T_n^m\right) - s_m^n}. \tag{4}$$

Therefore, for improved the spectrum resource management and enhances the performance, the main goal is to find the optimal scheduling methods which have the minimum waiting time for this schedule. The Eq. (4) shows the total waiting time of task in the channel,

$$W = \sum_{n=1}^{N} w_m^n. \tag{5}$$

At the least of this section, Table 1 shows the ILP model in this study.

Table 1. ILP model

Minimize $\sum_{n=1}^{N} w_m^n$
s.t.
$\sum_{m=1}^{M} \gamma_m = 1$
$p(T_n^m) \in [0, 1]$

4 SA Based Weight of Task Scheduling (SWTS)

At the previous section, this paper defined the problem to solve. The most important issues are how to schedule the spectrum, and manage resource efficiently, and minimize the waiting time of the task in the system. At first, when IoT devices transmit the data to a small cell, there have different type tasks and different timing. The small cell will schedule these tasks with the first in first out (FIFO) method. Next, if all the small cells send the data to the base station; the collision will happen. To avoid this situation, we defined the weight for whole task types. Moreover, the transmission information contains fixed form data and real-time data. This paper defines the task type of real-time information with a high weight. In our proposed method, if the task has high weight, the scheduling order should be handled with high priority compared with the low weight task.

The situation of the same weight at the same time maybe happen if we use the weight of task. For this study, we will use the simulation annealing (SA) algorithm to help us find the solution. If using the weight to decide the how to do scheduling the solution have to chance is local optimal not global. The SA algorithm is one of the metaheuristic algorithms; it will randomly change the one or more task type for original scheduling and calculate the solution. If this solution is better than original solution, it will substitute the initial solution and become a new optimal solution. The SA algorithm will process this active still find the optimal global solution. However, for finding the solution can be fast, the SA algorithm has a threshold can help find the optimal solution speed. If the template small than the threshold, it can replace the solution too. The template T changes at every iteration. Here we use the $W_{optimal}$ to present the optimal solution, and ψ is defined the value of the threshold. Algorithm 1 is proposed mechanism in this paper.

Algorithm 1 SA - based on Weight of Task Scheduling (SWTS) Algorithm

Input: N, M, γ
Output: $W_{optimal}$ Parameter: T, ψ, δ
Randomly the weight for task type;
Initial the network environment;
Doing the scheduling with weight value;
Calculate the waiting time W and this is solution is optimal solution $W_{optimal}$;
Randomly changes the task type and calculate the solution W;
If $W < W_{optimal} \ || \ T < \psi$
$W_{optimal} = W$;
else if
return
End
$T = T * \alpha$;

5 Simulation Results

5.1 Simulation Setting

In this section shows the SWTS simulation results. The simulation tool is MATLAB R2012a, and our compare method is a greedy algorithm. Here the greedy algorithm method stands for the scheduling will satisfy the high weight of tasks at the channel first of view. On the other hand, Fig. 1 is the simulation network architecture, and Table 2 is relevant parameters in our simulation. We assume the IoT devices just send the one task in the one-time slot and the resource blocks of the channel just satisfy the complete tasks needed. The simulation parameter here we set some IoT devices (N) is 100–500, and there have 5 types of task (M). Moreover, each type of task has corresponded weight and demand number of resource blocks. In this paper, the weights and demand number of resource blocks generation is random. Table 2 is the relevant parameters in this article.

Table 2. Important parameters with simulation

Parameters	Values
Number of IoT devices	100–500
Number of task types	5
Iteration	500
Temperature	900
α	0.9

5.2 Results

At this part, we will show the simulation results. First, we compare the waiting time with the proposed method-SWTS algorithm and greedy algorithm in Fig. 3. Our method is better than the method of using greedy. This is because the greedy algorithm just considers the weight of task. Because the high priority (weight) tasks might be spending more time to transmission and processing the task, the low priority tasks need more time to wait the maximum weight tasks finish the transmission. In other words, the greedy method is not fair which the tasks have a low weight. However, at our method, the SA algorithm can randomly change the tasks at original scheduling. The tasks which have the low weight might be transmission sooner than great weight tasks; it can reduce the waiting time very efficiently.

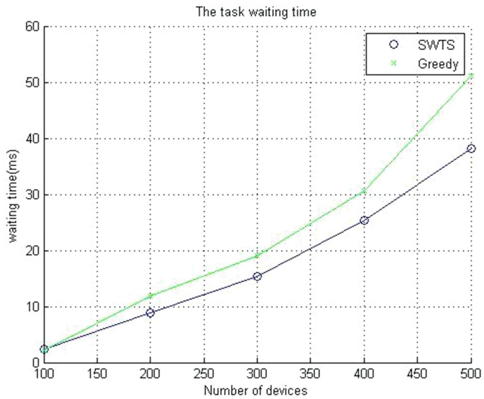

Fig. 3. The waiting time with SWTS and greedy algorithm

Finally, we consider the computing time in our method. Due to the SA algorithm is one kind of metaheuristic algorithm, it needs too much time to do the optimal scheduling. Also, it is unrealistic in 5G C-RAN communication network. In this paper, the number of change bits will add some IoT devices.

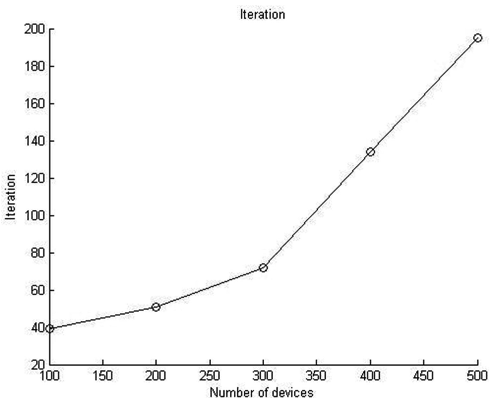

Fig. 4. The number of iterations with IoT devices

Figure 4 shows our experimental result. We can see the number of convergence does not increase very soon. Moreover, it represents our proposed method is suitable for task scheduling.

6 Conclusion

How to manage the spectrum resource is a major issue with IoT application in 5G C-RAN. The IoT might have the more different missions in this ultra dense network. In this study, we proposed the new method SA - based on the weight of task scheduling (SWTS) algorithm. We give the weight for different task types to help us to do the scheduling firstly. Moreover, we combined the SA- algorithm to get the optimal scheduling let we can reduce the waiting time with limitation spectrum resource to improve the QoS. The simulation results show our proposed method is much better than greedy algorithm. The 5G should be a heterogeneity network; this study only considers the network of IoT devices. At the future, we will design the method it can effect to do the resource allocation in heterogeneity network.

Acknowledgments. This research was partly funded by the Ministry of Science and Technology, R.O.C. under grants MOST 105-2221-E-197 -010 -MY2, MOST 106-2511-S-259 -001 -MY3 and MOST 105-2221-E-143 -001 -MY2.

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