가상화된 무선 네트워크에서 eMBB 및 URLLC를 위한 자원 할당 최적화

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Resource Allocation Opimization for eMBB and URLLC in a Virtualized Wireless Network

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Abstract

The network slicing in a virtualized wireless network is investigated in this work. The physical resources of base stations are virtualized and partitioned into enhanced mobile broadband (eMBB) and ultra-reliable low latency communication (URLLC) slices in a downlink orthogonal frequency division multiple access system. This work uses network slicing technology to overcome the difficulties of network spectral efficiency and URLLC reliability. It is formulated as a mixed-integer programming problem to maximize the system's spectral efficiency under the constraint of users' demand for two slices with a high probability for each user. The Teaching Learning Algorithm provides the optimum solution for network slicing. Furthermore, the suggested algorithm's competency is demonstrated by comparing it to other optimization techniques.

Keywords: IoT, Spectral Efficiency, Network Reliability, Optimization

1. Introduction

The mobile Internet and IoT are expected to be the primary forces driving the evolution of mobile communication in the future network. Massive IoT equipment, in particular, which is connected to sensors like humidity sensors and remote industrial robots, must deliver a variety of services [1]. The one-size-fits-all design idea is no longer practical for vertical sectors' multiservice requirements in the fifth generation (5G), and it is a promising solution to address the requirement of slicing one physical network into numerous logical networks based on diverse demands [2]. Network slicing is now one of the most cost-effective solutions for meeting the various needs of services with several logical networks. However, network slicing is critical for investigating multiservice problems in the virtual radio access network (RAN), particularly different service requirements in various scenarios such as enhanced mobile broadband (eMBB), ultrareliable low latency communication (URLLC), and massive machine-type communication (mMTC) [3]. Most researchers concentrate on the architecture of RAN slicing, and there is a scarcity of study on RAN slicing resource allocation optimization. Resource allocation among multiple slices in the RAN [4] is one of the main research projects. Teaching Learning Algorithm (TLA) is proposed in this paper for optimal allocation, which works on the movement of dust in blooming plants [5], in order to increase the efficiency of the searches. This work provides a new architecture for resolving the multiservice virtual resource allocation and management of the RAN slicing.

2. Problem Formulation and Proposed Strategy

2.1 System Model and network parameters

This work considers a wireless virtual network using a single cell downlink orthogonal frequency division multiple access (OFDMA) system, as depicted in Figure 1. The users k = {1, 2,..., K} are randomly distributed around the base station's service region (BS). One transmission time interval (TTI) is used for the allocation round. The system's total bandwidth is divided into 'N' subbandwidth 'B' on average during each TTI, and the associated subcarrier sets are s= {1, 2,..., N}. These resource blocks are shared by two slices, eMBB slice with user set K1 and URLLC slice with user set K2. When the network's spectral efficiency is maximized, the goal in this model is to ensure that the two types of slices meet distinct users' requirements.

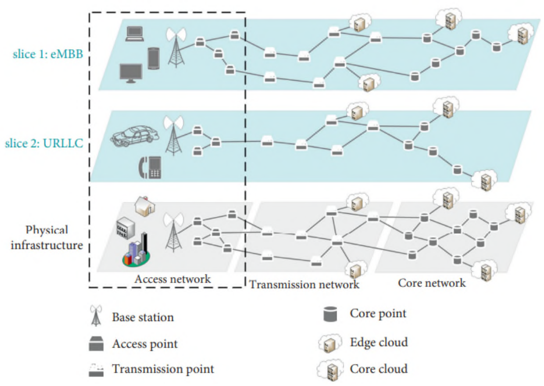

Figure 1. The multislice connection downlink transmission architecture

2.2 Objective of the proposed work

The main objective of the proposed work is to maximize the spectral efficiency of the network system, which is expressed in equation (1) along with the constraints (2)-(6).

Maxmize,

$$\eta_{spectral} = \frac{1}{N}\sum_{k=1}^{K}\sum_{n=1}^{N} a_{n,k}\log(1+\frac{g_{n,k}p_n}{N_0 B}) \qquad (1)$$

subject to,

$$\sum_{n=1}^{N} a_{n,k} r_{n,k} \geq \sigma_0 \qquad (2)$$

$$P_r D_k \geq D_{k,\max} \leq \epsilon \qquad (3)$$

$$\sum_{k=1}^{K}\sum_{n=1}^{N} a_{n,k} p_n = P_0 \qquad (4)$$

$$\sum_{k=1}^{K}\sum_{n=1}^{N} a_{n,k} = N \qquad (5)$$

$$\sum_{k=1}^{K} a_{n,k} \leq 1 \qquad (6)$$

where (2) assures that user k's transmission rate meets the rate requirement, and (3) ensures that user k in slice 2 has a low outage probability ϵ. For (4) - (6), we assume that all users use the subcarriers with the highest transmit power to the fullest extent possible, and that each subcarrier only has one user associated with it.

2.3 Proposed Teaching and Learning Algorithm

TLA [5] is a population-based algorithm that proceeds to the global solution through a population of solutions. The TLA, unlike other population-based algorithms such as GA, DE, PSO, and Hybrid-PSO, does not require any algorithm-specific parameters for searching and works on the effect of a teacher's inspiration on pupils. In particular, when compared to other algorithms for problems of varying degrees, the algorithm's success rate in delivering the global optimal solution is higher. The robust process is divided into two sections, one for the teacher and one for the learners.

(i) Teacher phase: In each cycle, the most extraordinary learner invariably becomes the teacher, who is the local community's most experienced, knowledgeable, and highly learned person.

(ii) Learners phase: Students study the course based on the teacher's quality and the quality of the students in the class. The teacher's course input and engagement with the class's co-learners motivates the motivated students.

3. Simulation Results

In this work, we assume that users in the same slice have the same throughput or delay requirements, but different CNRs, in order to describe the simulation results more easily. There are 16 total users, a total bandwidth of 5 MHz, and 20 subcarriers in the network system. To demonstrate the value of network slicing, we compare the reliability of a network system with only one slice (eMBB slice or URLLC slice) to a network system that supports both eMBB and URLLC slices.

Figure 2. Comparison of simulation results of different algorithms

The proposed algorithm enhances spectral efficiency more effectively, as can be seen. Adaptive Particle Swarm Optimization (APSO) and our proposed technique are close to the ideal relaxed solution when the total power is minimal. The spectral efficiency of APSO, Equal Subcarrier Allocation (ESA), and Equal Power Allocation (EPA) is not as great as the TLA when the total power is high.

Table 1 shows the spectral efficiency of the eMBB slice, the URLLC slice, and the entire network system when the eMBB slice is subjected to various user throughput requirements. When σ_0 rises, the eMBB slice's spectral efficiency nearly equalizes, but the URLLC slice's and the entire system's spectral efficiency falls. As a result, by focusing more on the eMBB slice, we may boost the consumers' throughput requirements properly.

Table 1. Performance under different rate requirements

Rate requirement (σ_0)	Spectral Efficiency (Mbps/Hz)		
	eMBB	uRLLC	Overall system
1	2.0	3.1	2.9
3	2.0	2.9	2.2
5	2.0	2.75	2.4

4. Conclusion and Future works

The spectral efficiency of the eMBB and URLLC slices for OFDMA virtual RAN was investigated in this research. The optimal allocation of resources in RAN is carried out through TLA. The simulation results show that the suggested algorithm increases the network system's spectral efficiency while also assuring that users' requirements for the eMBB slice and the URLLC slice are met with a high degree of certainty.

Furthermore, this work solved how to assign virtual network resources in two types of slices in a single cell in the article to ensure that admitted users meet the criterion while maximizing the system's spectrum efficiency. This work can be extended for slice admission and resource allocation for slices in many cells.

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