Resource Allocation for 5G RAN—A Survey

G. Shanmugavel and M. S. Vasanthi

Abstract Resource allocation (RA) is a fundamental task in the design and management of wireless signal processing and communication networks. In a wireless communication, we must wisely allocate some available radio resources like time slots, transmission power, frequency band, and transmission waveforms or codes across multiple interfering links as to accomplish a better framework execution while guaranteeing user fairness and quality of service (QoS). In fifth generation (5G) of wireless communication system provides a better mobile service with improved QoS everywhere. Considering the dense deployment and more number of network nodes, RA and interference management are the important research issues in heterogeneous mobile networks. In this, we need to utilize the available radio resources efficiently, for that the RA is of much importance in future wireless communication systems (5G/6G). In this survey, we consider various resource allocation methods for different radio access network (RAN) architecture; several authors have implemented some techniques and algorithms to achieve better resource allocation with the help of existing literature survey, we explore ways to allocate the radio resources for next generation wireless communication.

Keywords 5G · Radio access network · Resource allocation · Reinforcement learning · NOMA · Markov decision process · Fog RAN · Cloud RAN

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1 Introduction

In fifth-generation (5G) mobile communication systems, in addition to provide a wide coverage, improved spectral efficiency, ultra–reliable low-latency communication, reduction in energy usage, more number of connected devices, improved accessibility, and also providing a very huge data rates in terms of giga-bit-per-second (Gbps) all the cell coverage area [1]. The cell coverage range and total sum capacity solutions are proposed for next generation mobile communication, beamforming, carrier aggregation, higher level modulation, and dense deployment of small cells [2]. For high bandwidth capacity in 5G, the millimeter wave communication is used [3]. Using multiple input and multiple output (MIMO) in 5G, it provides high spectral bandwidth efficiency and better energy saving. [4].To increase more IoT nodes or equipments in a cell, it is providing more traffic congestion to satisfy all user requirements; the cloud radio access network (C-RAN) is introduced to 5G mobile communication; the best powerful cloud controller (CC) in C-RAN network architecture has the remote radio units (RRU) and baseband units (BBU) [5, 6].

5G wireless communication requires more QoS and also wants to overcome the drawbacks of the previous generation mobile communication systems. Some of the research challenges like massive type communication (mMTC), enhanced mobile broadband (EMBB), and ultra-reliable low-latency communication (uRLLC) are required. These types of services are lead to find new RAN. Compared to C-RAN, the F-RAN provides the uRLLC, this type of service required in future generation wireless communication [7].

Delivery of huge value of date from UE to fog access point it need a large amount of bandwidth, and very high spectral bandwidth is demand in radio resources. For very high spectral efficiency, very low-latency requirement, and multiple access facility, NOMA is one of the best method [8]. In NOMA, SIC can used in F-AP to separate various user's signals. A general fact is that the F-AP usually do not have enough storage capacity and computing resources and may not meet large-scale users' services; therefore, the implementation scheme of NOMA will have great impact on F-RAN. There are various types of researches about NOMA and F-RAN [9]. Implementation of F-RAN based of NOMA RA technique it increase the QoS and reduce the latency [10]. In the transmitter and receiver section of NOMA system, the successive interference cancelation is implemented in receiver side. In [11], multiuser detection and decoding is implemented to optimize receiver ability. In [12], influence of error vector magnitude to various SIC in DL NOMA is very accuracy. In [13], the research challenges in multi-tier heterogeneous networks are resource allocation, dense deployment, huge network nodes, and interference management. The radio resource allocation issues in multi-tier OFDMA based in 5G LTE-A. Specifically, author introduced three novel methodologies for distributed RA in such networking ideas of message passing, distributed auction, and stable matching. In [14], the cloud node characteristics and 5G services are taken by the joint optimal virtual network functions (VNF).

To improve the system throughput of the used level resource scheduling algorithm, a slice level scheduling algorithm is proposed based on the requirements of wireless network slicing technology and the definition of functional scenarios. VNF provides better radio resource utilization and huge gain in network slicing for 5G communications. The slicing characteristics of every user and the scheduling method priority are calculated by PF algorithm [15].

2 Heterogeneous IoT and F-RAN

In C-RAN, the latency issue becomes very high, so it is not suitable for IoT services. For 5G need a very low-latency communication service, for that we move C-RAN to to F-RAN (Fig. 1).

The fog node provides heterogeneous low-latency requirements of the IoT application devices, and it is directly linked to the cloud network through fronthaul connections. Red lines mentioned a local service by fog node to fulfill low-latency needs.

A hybrid cloud supporting C-RAN system (see Fig. 2). A different set off requirements are provided by RRHs like massive machine type communications (mMTC), ultra-reliable low-latency communications (URLLC) and enhanced mobile broadband (eMBB), (see Fig. 3).

3 Resource Allocation Methodologies

The different resource allocation methods are considered from various existing possible techniques or algorithm like reinforcement learning (RL), cooperative edge computing, Marcov decision process (MDP), soft resource reservation mechanism, fixed power allocation (FPA), fractional transmit power allocation (FTPA), improved fractional transmit power allocation (I-FTPA), message passing (MP), stable matching (SM), distributed auction method, inter linear programming (ILP), and PF algorithms are considered to achieve better resource allocation. Here, we will see the merits, demerits, and improvement needed for the future research in next generation mobile communication systems.

3.1 RA in Fog RAN Using RL

In [16], in fog RAN, the reinforcement learning (RL)-based resource allocation provides the requirements of low latency. In fog RAN, the URLLC cannot consent more delay. In FN, the IoT application required low latency. The Markov decision

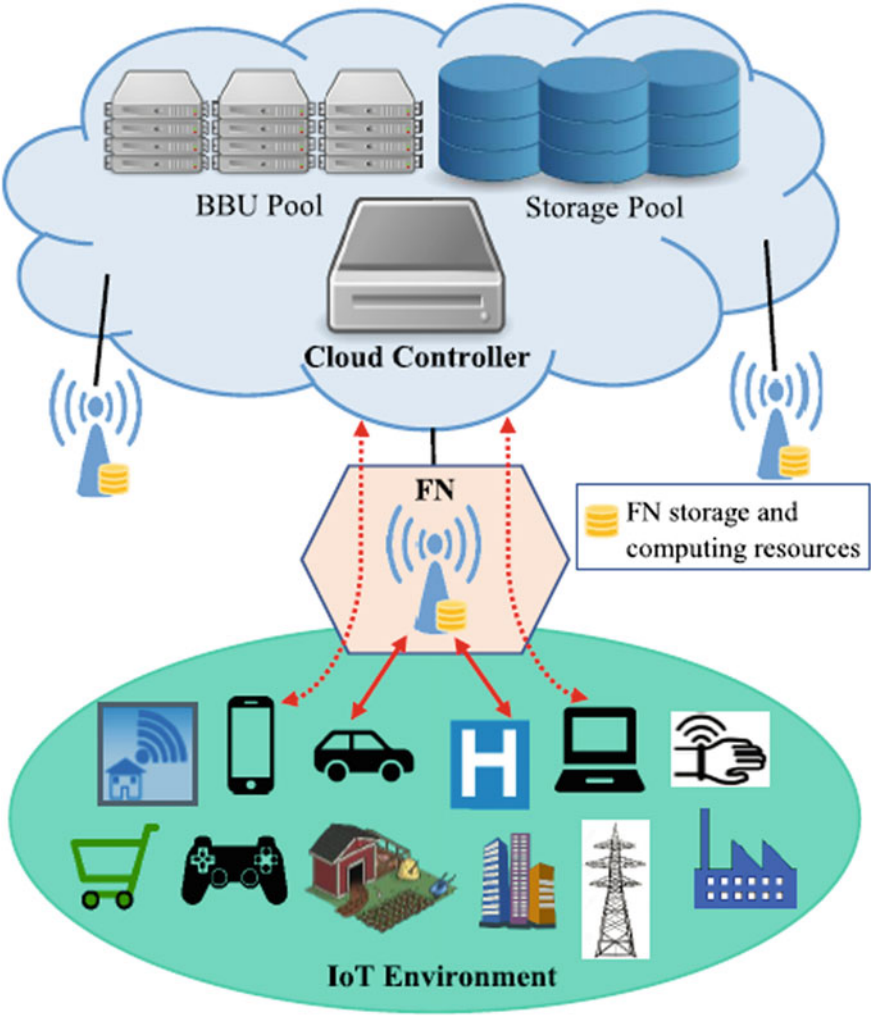

Fig. 1 Fog-RAN architecture

process (MDP) provides a low-latency communication in fog RAN. Like Q-learning, SARASA, expected SARASA, and Monte Carlo method are to solve MDP problem.

The objective of IoT applications in a FN the MDP provide the service to N number of resource blocks with perfect timing. The problem in MDP the FN getting services from the IoT side, after that the service will be continue or drop. The optimum policy utilizing Monte Carlo algorithm in the IoT environment if done initially, then the next algorithm for MDP by SARSA and QL.

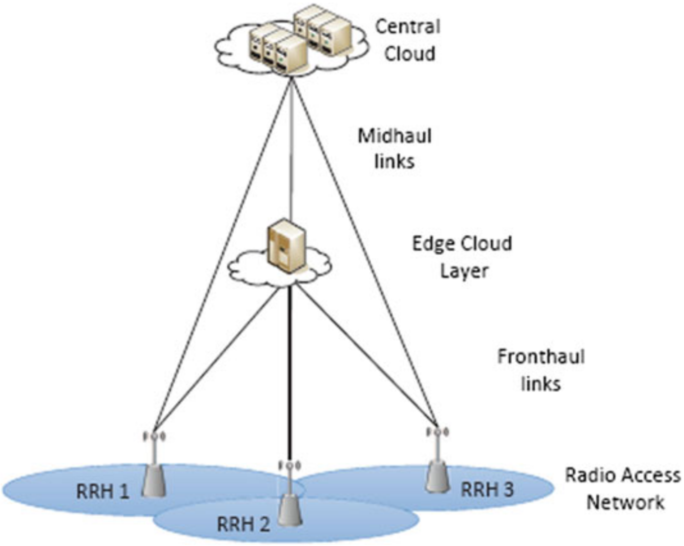

Fig. 2 C-RAN architecture with hybrid cloud

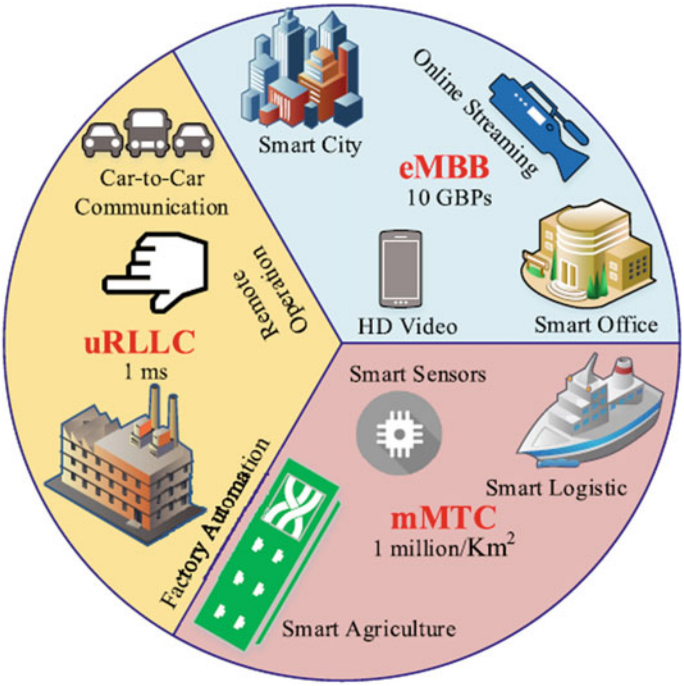

Fig. 3 5G mobile communication service categories

3.2 NOMA-Based Fog RAN Channel Power Allocation

In different RAN architectures in fog RAN [17] to increase the QoS and reduce the delay service is getting by edge computing. According to various power factor assignment of each and every NOMA user information is multiplexed through the corresponding data, and the receiver side the SIC is used to receive the signal. At the transmitting side, a three user multiplexing system is implemented.

In Fig. 4, user equipment (UE) first user is a near the user, this user is near the base station, second user is a mid-user this user some distance away from the base station, and third user is more away from the base station or an edge user. The sender signal or data of first user ($i = 1,2,3$) is Xi and signal power assign to each user is Pi. As indicated by power allocation (*PA*) of NOMA [19], since the third user getting a very low signal strength so the more transmitter power is assign, then the second user getting moderate signal strength so the required power is allocated, and in the first user getting high signal power so the assignment of transmitter power is very small as required.

The user power allocation is important thing. The various methods of PA algorithms are: (i) fixed power allocation (FTP), (ii) fractional transmit power allocation (FTPA), and in [17], the method of improved fractional transmit power allocation (I-FTPA) was implemented.

The FPA depends upon the channel gain of the each and every individual user the different fixed power is allocated; in the poor channel gain user, the more power is allocated; in high channel gain user, minimum power is assigned. FPA does not have any specific power allocation strategy for every individual user which depends upon their channel gain. The main drawback for FPA is that it does not perform to allocate the power according to randomly varying nature of channel gain.

In I-FTPA planned for taking care of the above issue in FPA, the fractional transmit power allocation (FTPA) is implemented based on signal decay factor [18]. Author proposed an Improved fractional transmit power allocation (I-FTPA) calculation.

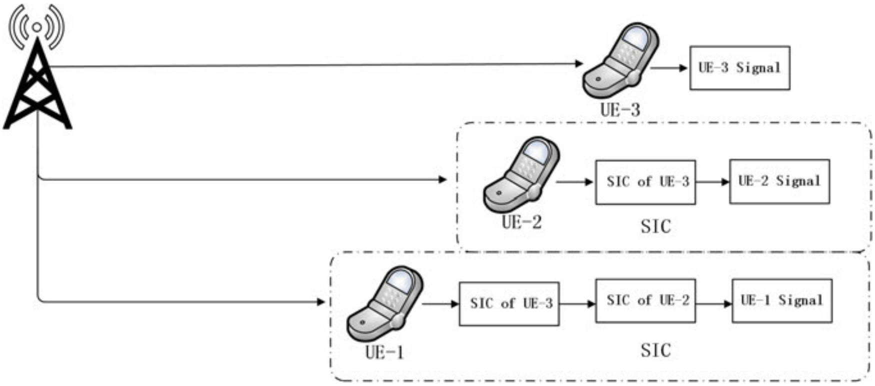

Fig. 4 Simple NOMA system

Contrasted with FTPA, this has just a signal degradation factor for power allocation, and I-FTPA has distinctive fluctuating signal degradation factor to modify every client's channel gain, which gives advantageous to change transmitted power as per channel changes consequently. The estimation varying the decay factor is somewhere in the range of 0 and 1.

Successive Interference Cancelation is applied at the receiver end in order to decode the user signal. For better receiving in the receiver end, the symbol lever SIC (SLIC) and code-word level SIC (CWIC) are used. Important variation between these two methods is: CWIC demodulation and decoding will be done; it does not reduce the error propagation at the cost of complexity.

3.3 Optimal Resource Allocation and Virtual Network Function Using in a Hybrid CRAN

In [14], a join optimal arrangement of virtual network functions (VNFs) and the RA in a hybrid cloud environment gives the requirement of next generation system of the cloud access point. The relationship between computational requirements, latency constraints, and design an integer linear programming (ILP) these all are completed by fixed assignment system.

An analysis of least computational rate is needed to fulfill every VNF necessity, by constant assigned edge or central access point. At that point, utilizing this information, author can arrange an integer ILP that optimizing the using of cloud VNFs.

VNF provides the least computational rate to fulfill its low-latency and computational needs to depend on this or that it is in the common cloud of its neighboring VNFs.

3.4 Distributed Resource Allocation

The large number of network nodes, [13] resource allocation, and interference management are the important research challenges in multi-tier heterogeneous networks. In OFDMA-based 5G cellular network, the three novel resource allocation methods are implemented, namely: (i) stable matching, (ii) message passing, and (iii) distributed auction method. Here, the matching theory permits a low-complexity algorithmic control to give a decentralized self-sorting solution to the resource allocation problems. In matching-based resource allocation, each of the agent's radio resources and transmitter nodes ranks the other using a preference relation. The solution of the matching concept is fix an available sources to the sender based on the selection.

Table 1 Characteristics of RAN and resource allocation algorithms

Characteristics	C-RAN	Fog-RAN
Storage [13, 16]	Centralized	Centralized and distributed
Communication [13, 16]	Centralized	Centralized and distributed
Backhaul interference [17]	CN	CN and BBU pool
Fronthaul complexity [17]	Low	Medium
Data processing [13]	Cloud data center	Near to device
Transmission delay [16]	Long	Low
Latency [16]	High	Low
Reliability [13]	Medium	High
Energy consumption [13]	Medium	Low
Resource allocation algorithm's and techniques used	• Reinforcement learning [16] • Markov decision process [16] • Improved fractional transmit power allocation [17] • Message passing, stable matching and auction-based RA [13] • Integer linear programming [14]	

In resource allocation using a message passing is produces a polynomial time complexity solution by assigning the calculated load among the access point of the system. In the RF source distributing issue, the decided authority system to the radio sources and the sender form a virtual graphical system. Every access point can exchanges some information with nearby access points to get the solution of RA.

Auction-based resource allocation algorithms provide polynomial complexity solutions, which are shown to output near nodes. The method of tender is the one of the best system to assign the service of the service provider. The unused spectrum is bids for all service provider agents. Who is coat a high value that agent or service provider can get the spectrum.

Through this survey, we tabulated the characteristics of different types of RAN architecture and what are all the algorithms and techniques were used by different authors are listed in Table 1.

4 Future Research Direction

In [16], several RL, methods are considered for the better solution of optimal system. A better action over a filtering method based of network slabbing. In future research to expanding the present RA framework is limited to fixed FN system. In [17], implementation of NOMA to F-RAN and the three user multiplexed transmitter and CWIC receiver is implemented. By varying the signal decay factor depending upon the channel gain, the better power allocation is assigned which depends upon the user requirement. In this the multiplexed transmitted and receiver, they considered the single transmit and single receive antenna method. In future research, the design of multi-transmit antenna where use the diversity gain which will be increase in user equipment's. It may improve the SINR to provide a better QoS to using the I-FTPA. In [14], the issue of the optimal RA method and network slab usage is in a hybrid cloud environment which is considered and systemized by inter linear programming. Considering a hybrid cloud with respect C-RAN system, composed only in a central access point, in the service of low latency needed. Some of the future research work progress is based on usage of VNF. In [13] stable matching, message passing and auction-based resource allocation methods are implemented. Future research work to develop and implement an advanced game model resource allocation problems and analyses the response of 5G system with the data rate and spectrum and energy efficiency.

5 Conclusion

With the dramatically increasing end user amount, we want to improve the resource allocation for the future 5G/6G wireless communication. Due to spectrum on demand like, we want to utilize the available radio resources, and we did a survey with different resource allocation problems in existing wireless communication systems. In future research work, we want to overcome a problems faced in existing resource allocation algorithms and techniques discussed in this paper; these identified problem are given to invent a novel RA algorithm. An idea to implement the artificial intelligence for RA in 5G RAN will give the optimal solutions for better resource allocation the next generation wireless communication systems.

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