
Review

Resource Allocation Schemes For 5G Network: A Systematic Review

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Abstract: Fifth Generation (5G) communication technology is intended to offer higher data rates, outstanding user exposure, power consumption, and extremely short latency. Such cellular networks will implement a diverse multi-layer model comprising of device-to-device networks, macro-cells, and dissimilar categories of small-cells to assist customers with desired quality-of-service (QoS). This multi-layer model affects several studies that confront utilizing interference management and resource allocation in 5G networks. With the growing need and the lack of resources, the resource distribution problem desires to be focused capably to accomplish the traffic and to enhance network working. One of the utmost serious problems is to alleviate the jamming from the network in support of having a better QoS. However, there are limited review papers written on resource distribution, there is no particularize and organized review carry out in 5G resource allocation. Hence, this article covers and evaluates the argument using a classification of existing developing resource allocation schemes in 5G thoroughly by classifying the schemes to enhance the service quality. This survey comprises the discussion based on metrics used to evaluate the performance. It would also permit ahead beyond evidence on resource allocation methods in 5G and empowers the scholars to meet the present research areas to focus on.

Keywords: 5G, Resource allocation, Resource distribution, Congestion, 5G communication, Comprehensive, Review, Systematic.

1. Introduction

The marvelous progress in data communication has a radical influence on wireless networks. Predictably, the quantity of wireless apparatuses stays to raise at an enormous rate [1]. The globe has viewed plenty of technical improvement in the domain of transmission. Currently, mobiles have everything varying from the lowest size, video, and audio call support, enormous phone processors[2], and memory contending with the modern laptops in the marketplace [3].

This innovative trend of technical transformation is amending the method we live, work, and interconnect with everyone[4]. We can realize the appearance of extraordinary services and applications for example autonomous Vehicles, artificial intelligence [5], smart home, smart factories, smart cities, and drone-based delivery systems, etc. The collaboration of apparatus and human-based assistances will expand the forthcoming wireless environments with the challenges of cost effectiveness[6]. Recently upcoming, cell phone communication will saturate everywhere in the public and generate a several dimensional, consumer-related eco system.

Furthermore, an entire mobile-based linked environment is anticipated, which will be categorized through traffic size, a much wider span of running consequences, and an amazing volume of expansion in connectivity [7]. This extraordinary traffic enhancement

indicates that mobile networks might be desired to deliver approximately a thousand times the spectral effectiveness of the present structure of the current decade [8]. Furthermore, spectrum efficiency (SE) enhances 5 ~ 15 times related to mobile networks of the fourth generation (4G) [9].

The 5G network incorporates numerous technologies, for example, Internet-of-Things (IoT) [10][11], Software Defined Networking (SDN) [12], Device-to-Device (D2D) communications [13], vehicular networking [14], Machine-to-Machine (M2M) communications [15], Unmanned Aerial Vehicles (UAV) [16], Cloud Radio Access Networks (CRANs) [17], Mobile Edge Computing (MEC) [18], cloud computing [19] to make the traditional communication network to realize the internet of everything [20]. Preserving tempo with this extreme need will expect leading-edge technologies which rise enormous cellular capability envisioned in the admired 5G cellular structures.

To overcome this challenge, there is significant scholarly and industrialized research importance in wireless structures that offer improved spectral proficiency and broader bandwidth than present cellular networks via placement of several antenna components and/or reuse of frequency [21][22]. Throughout this moment, the IoT is ruling by enormous wireless apparatuses such as sensors, smartphones, tablets, and machines. To transfer enormous data traffic varying to 100 Gbps=km² through elevated enhanced mobility, such machines require supplementary well-organized and pervasive radio access technologies (RATs) [23].

Concerning the challenge of the anticipated explosive increase in the traffic sizes, the radio obstruction and resource management techniques of RAN in 5G systems will have to hold more than 1000x as compared to existing traffic sizes. this enormous size of traffic will have access to and distribution of data anytime, anywhere, by anything or anyone inside the 5G RAN and outside the performance enrichments of the 4G cellular pattern [24].

Hence, mobile network operators (MNOs) are projected to encounter tough environments to uplift the performance of the network. Furthermore, cutting-edge applications having various service prerequisites comprising energy consumption and latency[25]. From the last decade, scholars in the domain have been mainly worried about developing state-of-the-art, pioneering, along with messy ideas and technologies, following leaps and steps ahead of those of existing cellular systems and their identified drawbacks [9]. IoT is projected to empower an encouraging environment that will manipulate numerous characteristics of normal-life and professional applications and participate in the direction of the increasing world economy, beyond critical and massive IoT, liable on installed type of applications [26]. Immense applications of IoT require a huge figure of linked smart machines which might be installed in agricultural monitoring, shipping environments, smart health systems, smart cities, smart homes, etc.[27], which require common appraises to the cloud having cost efficiency. For example, visualize a situation in smart homes, where people will be capable of employ this application without human intervention for opening their garage door while coming to their houses, turn on the lights or precise part of it, regulate the weather system, turning on the coffee-maker to make early morning coffee, and many other smart applications for various purposes [28].

[29] As the user equipment, along with the service categories, continue to enormously expand the client's demand for excellence. The amount of data traffic has grown to be a serious problem. Hence, network traffic handling, mostly in the future 5G cellular dissimilar networks [30][31] and ultra-dense networks (UDNs) [32][33] is probable to be a dangerous problem due to the important pressure imposed on wireless communication networks via the rising capacity of large data traffic.

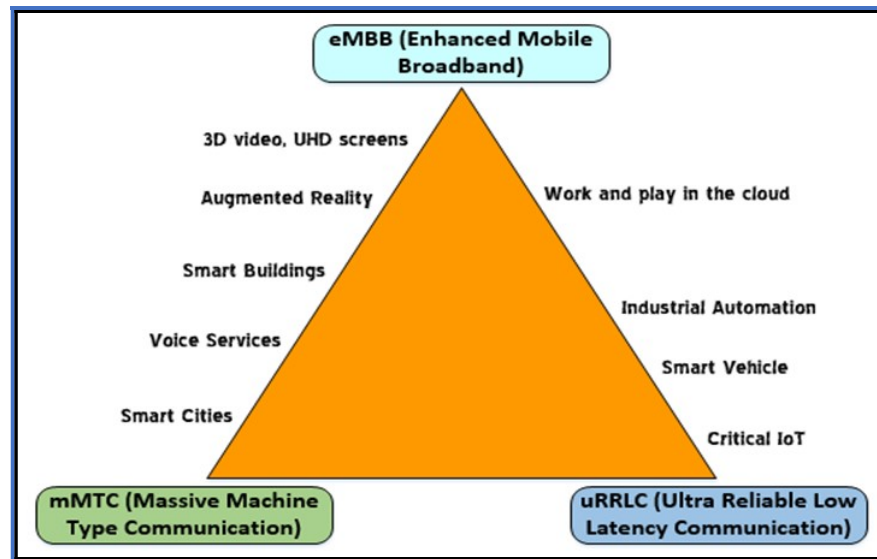


Figure 1. Usage scenario of IMT for 5G.

5G (CNs) has a cellular access way out for provision the satisfaction of broadband communication wirelessly [33][34]. In the international telecommunication unit (ITU), the 5G ITU-radiocommunication (ITU-R) operating class is functioning for the growth of 5G under international mobile telecommunication (IMT) 2020 [35].

The vision of this effort is to accomplish 1000x throughput enhancement, 100 billion associations, and reducing latency near to 0 [36][33]. In certain, 5G will uplift the enhanced mobile broadband (eMBB) through extended 100 Mbps data rates in the consistent spatial sharing by max bandwidth ranging from 10 to 20 Gbps [33][34].

Established compromise, 5G will not just offer the mobile facility, similarly, massive machine-type communications (mMTC), and latency dangerous facilities. In ultrareliable low latency communication (uRLLC), the reliability and latency requirement problems require attention [37]. In several situations, the consequent end-to-end (E2E) latency as small as 1ms desires to happen with consistency as distinguished as 99:99% [38].

In figure 2 the generic 5G network topological view is discussed.

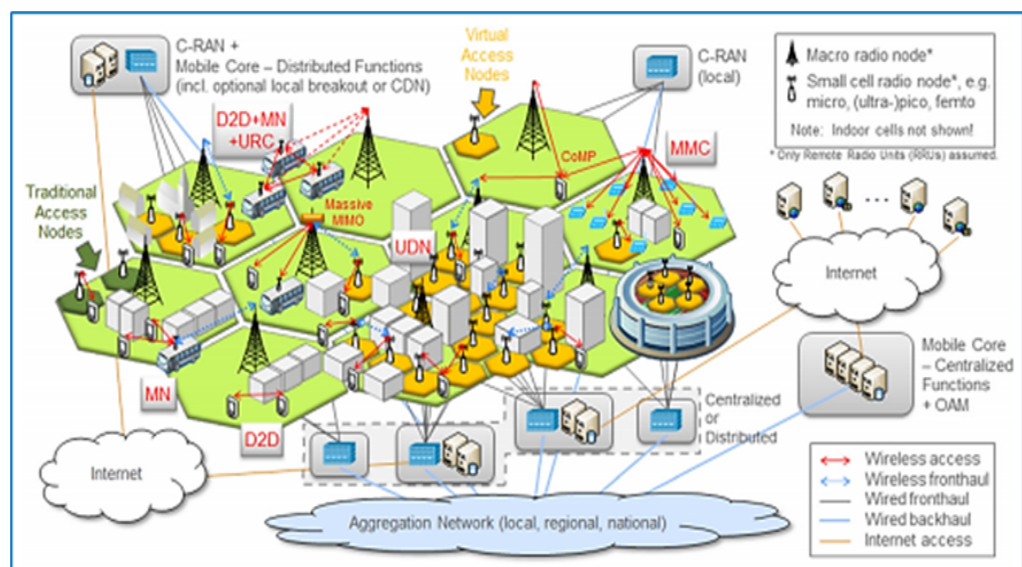


Figure 2. Generic 5G network design (high-level topological view) [39].

2. Background

As the demand for wireless technologies is increasing day by day, the coverage, data rate, spectral efficiency, and mobility also rising frequently [40]. It similarly demonstrates that the first-generation and second-generation technologies utilized circuit switching[41][42], while 2.5G and 3G utilized packet and circuit switching respectively besides the succeeding generations after 3.5G to nowadays i.e.[43], 5G which is suited to use packet switching. Besides these aspects, it correspondingly distinguishes between the unlicensed and licensed spectrum. All developing generations used the accredited range whereas Bluetooth, WiMAX and Wi-Fi are utilizing the unlicensed range.

An outline regarding the growing wireless technologies is discussed below: The 1G was named in the early 1980s. It consists of a data rate max to 2.4 kbps[44].

It takes a data rate capable of 2.4kbps. The main contributors were Total Access Communication System (TACS), Advanced Mobile Phone System (AMPS), and Nordic Mobile Telephone (NMT). It has various drawbacks corresponding to reckless handoff, par capacity, with no security and inferior voice associations, meanwhile, voice calls remained kept and played in wireless towers resulting in susceptibility of these calls on or after uninvited snooping by 3rd party growths [45][46].

The 2G was announced in the 1990s by utilizing digital equipment in 2G cellular phones. The leading ability of 2G was the intention to introduce Global Systems for Mobile communications (GSM) that were prominently utilized voice-over communication with a capable data rate of 64 Kbps. 2G mobile phone battery extended although the wireless signals have little power. These aforementioned services offer facilities similar to both electronic-mail and Short Message Service (SMS). Energetic well-known technologies were GSM, Code Division Multiple Access (CDMA), and Interim Standard (IS) 95 [47][48].

It normally subscribes to a 2G CN combined with General Packet Radio Services (GPRS) and extra facilities do not frequently award in 1G or 2G CN. A 2.5G CN mostly usages 2G system structures, nevertheless it pertains to circuit switching besides packet switching. It facilitates a capable data rate of 144kbps. The 2.5G key technologies remained CDMA 2000, Enhanced Data Rate for GSM Evolution (EDGE), and GPRS [49][50].

The 3G was launched in late 2000. It conveys a communication rate capable of 2Mbps. 3G structures combine extreme rate mobile access to services initiated on Internet Protocol (IP). Apart from of communication rate, progressive enhancement was prepared for keeping quality of service (QoS). Further services like worldwide roaming and enhanced voice property built 3G as an extraordinary generation. The key weakness for 3G phones is the requirement of some extra energy as compared to the majority of 2G brands. Besides this, 3G system strategies are beyond costly than 2G [49][50]. Meanwhile, 3G contains the operations of Universal Mobile Telecommunications Systems (UMTS) Wideband CDMA, Evolution-Data Optimized (EVDO), High-Speed Downlink Packet Access / High-Speed Uplink Packet Access (HSDPA / HSUPA), and CDMA 2000 equipment which have built a central wireless origination amongst 3G and 4G called as 3.5G employing better-quality data rate of 5 to 30 Mbps [49].

Long-Term Evolution (LTE) and Static Worldwide Interoperability for Microwave Access (WiMAX) 3.75G is the upcoming mobile data amenities. Both Static WiMAX and LTE can increase the ability of the system and deliver a comprehensive variety of high-speed facilities like peer-to-peer file distribution, merged web facilities, and on request video to a considerable quantity of customers having the ability of entree. Besides herewith, the associated range is achievable to recognize the operators to accomplish their system and highlighted the improved exposure having better quality within minimum cost [47][50].

4G is normally discussed as the successor of the 2G and 3G levels. The 3rd Generation Partnership Project (3GPP) is regulating LTE Advanced as 4G level beside WiMAX. A 4G structure advances the existing transmission systems by conveying a whole and

consistent answer built on IP. Facilities such as data, multimedia, and voice will be communicated to subscribers on each stage and all over containing much more bandwidth as associated with previous creations. Appliances having a built-in 4G network are High-Definition TV content, video chat, Digital Video Broadcasting (DVB), mobile TV, and Multimedia Messaging Service (MMS) [48].

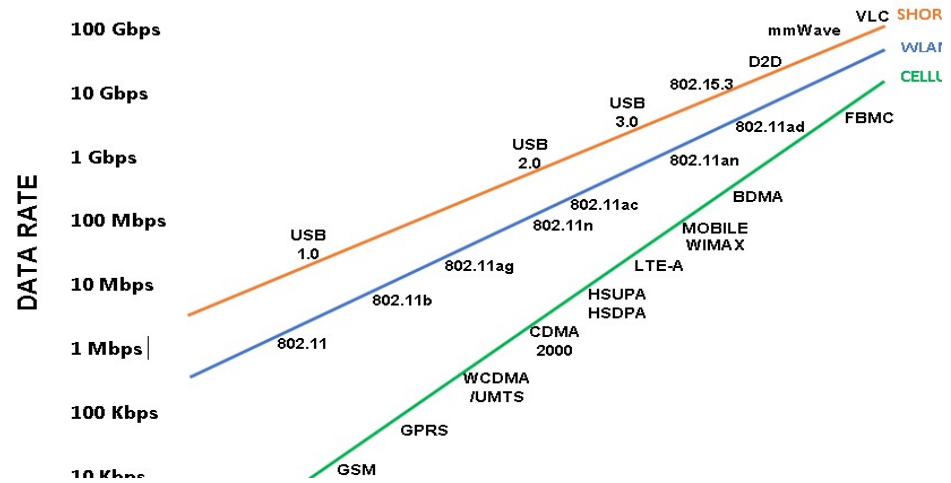


Figure 3. Data Rate VS Technology 1G to 5G [53].

Through a tremendous growth in the need of the consumers, 4G would be upgraded to 5G through an innovative technology called Beam Division Multiple Access (BDMA), Filter Bank multi-carrier (FBMC), or non- and quasi-orthogonal [51]. The idea behind the BDMA method is described because of the situation having interaction among mobile stations and base stations. Here in the transmission, an impertinent beam is associated with every mobile station, and the method of BDMA split that probe beam corresponding to positions of the cellular stations aimed at providing numerous entrees to the cellular stations, which compatibly increases the size of the structure [52].

In the upcoming days, to entertain the assumptions and challenges of the recently established wireless networks will have to improve in several aspects. Current technology ingredients long-term evolution (LTE) and high-speed packet access (HSPA) are presented as a part of the enhancement of existing wireless technologies. However, supporting apparatuses may found upcoming novel wireless-established technologies, which might assist the future growing technologies. A variety of these innovative technology apparatuses have distinct approaches of retrieving spectrum and significantly advanced frequency limits, the beginning of enormous antenna organizations, ultra-dense locations, and direct device-to-device interaction [54].

The 5G system is expected to support huge traffic of data and an enormous figure of wireless connectivity [55] as shown in figure 4. Dissimilar data traffic has distinct QoS prerequisites. 5G mobile system aims to tackle the limits of preceding standards which are a potentially important enabler for upcoming IoT. 5G systems provision to alleviate a broad span of applications for example multimedia and entertainment, Industrial IoT (IIoT), mission-critical applications, smart health, drone operations, autonomous driving, and smart home [56]. Nowadays industry 4.0 is alleviated due to the upcoming rising and evolving technologies such as biotechnology, quantum computing, and artificial intelligence, etc. [57].

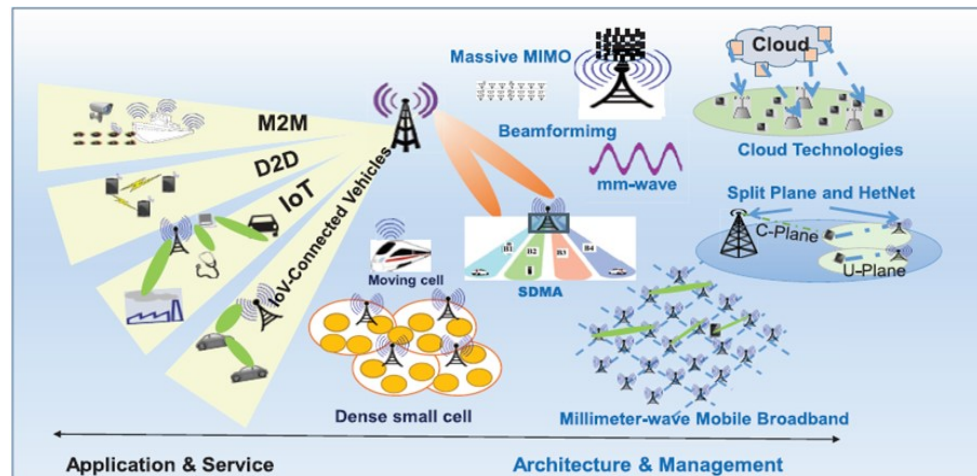


Figure 4. 5G design and applications [33].

This innovative evolving trend has changed our working style and living environment where we relate to everyone and everywhere. We might realize the development of extraordinary support of applications such as smart factories, drone-based delivery systems, autonomous vehicles, smart homes, and artificial intelligence, etc. The presence of both apparatus and human-centric facilities would be distinguished by the upcoming wireless ecosystems[58]. Soon, communication using cellular connectivity will penetrate all public segments and create a multi-dimensional, customer-centric information atmosphere. Furthermore, a completely mobile and associated society is expected to have an incredible quantity of growing volume of traffic, connectivity, and a far wider variety of handling circumstances [7].

3. Related Work

As 5G empowers network connectivity amongst a huge sum of apparatuses. This incredible evolution in the sum of apparatuses needs a big amount of spectrum resources to assist a kind of application and as well put down an enormous load on the BS. The best allocation of resources for example spectrum, time, and power may increase the functioning of the system. This survey discusses and concentrations the existing resource allocation methods in 5G.

The author [59] précises the current signs of progress of the performance investigation and radio resource allocation (RRA) in F-RANs. Mainly, the adaptive model selection methods and progressive edge cache are described to enhance SE and EE in taking care of a short latency stage. The RRA approaches to enhance SE and EE in F-RANs are correspondingly suggested. Some open problems in terms of the F-RAN established 5G pattern and the social-awareness method are recognized too.

In [60], the author discussed the various algorithms related to resource allocation and deeply analyzed the methodologies for the evaluation founded on the involvement of Base Station for the sake of research scope and to offer theoretical support to the problems associated with resource allocation having the environment of D2D communication.

The authors [61] proposed resource allocation having social awareness in 5G with device-to-device multicast communication. At first, they design a multicast cluster formation scheme in D2D that creates accounts based on the physical distance for communication and societal trusties among the mobile users. These considering aspects in physical and social areas guarantee the rationality and availability of D2D multicast links, which are the main origin for resource allocation.

The authors [62] focus on the models of 5G network slicing based on resource allocation and its principles. At first, they enlighten the core ideas of NFV and SDN in ac-

cordance with network slicing and they also studied its MO design in detail, which offers an essential framework for resource allocation algorithms. Afterward, the types of resources in accordance with isolation levels in CN and RAN slicing are simultaneously examined. Moreover, they categorized the algorithms of resource allocation having their mathematical models founded by their main ideas and explained them with examples.

In [63], the authors present the details about scheduling mechanism and resource allocation on the behalf of comparison among modes 3 and 4. They focused on the dissimilar properties of both 1 and 2 modes to deal with reliability and latency requirements using scheduling with resource allocation, respectively.

The authors [64] precisely presented the issues regarding cooperative radio resource management in H-CRAN by presenting a detailed and compact precise structure for the execution of real-time development. Their study focuses on enabling malleable balance among fairness and throughput metrics according to the dire need of network operator and illustrate striking pros while comparing in contrast to the various strategies of multi-radio resource allocation.

In [65], the authors present a 5G model of resource allocation for virtual networks in the paradigm of heterogeneous cloud infrastructure. As per this model, every network slice has a separate vector of resource demand for virtual network operations. At first, they examine the collaborative slices system then evaluate the resource allocation like a convex escalation issue to increase the performance of the entire system. Furthermore, they recommend a scattered solution for resource allocation by introducing an auction of resources among data centers and slices. They illustrate the selfish behaviors of individual separate slices which influence the overall fairness conduct of the system.

The essential part of these studies is that they never analyzed the current resource allocation techniques and addressed the solutions of existing resource allocation problems. It is also required to review the literature systematically according to the typical aspect of resource allocation in 5G and its classification. In this study, four questions are formulated to unambiguously demonstrate the significance of the resource allocation for 5G, keeping an eye to improve its consideration for future perspectives.

3.1. Design of Research

This part of the study focuses on the structure used to perform this systematic literature review based on the instructions guided by [66] to perform SLR with specific emphasis on 5G resource allocation. The formation of research questions is the main part of SLR, along with the factors of motivations that are presented in this portion. These articles have been chosen from multiple data sources. Specifically, a research strategy is also created to cater to the articles related to a specific domain, which is mentioned in this section as well. Later the research papers are collected for study based on evaluation criteria by considering exclusion and inclusion criteria. Motivations and research questions are formulated to critically identify the state of the art of resource allocation in 5G.

3.1.1. Research Questions

The following are the focused research questions that have been discussed and analyzed in this study:

- 1-What are the existing state-of-the-art challenges in 5G?
- 2-What is the importance of resource allocation in 5G?
- 3-Which current policies, strategies, and algorithms are being used for resource allocation in 5G?
- 4- Which metrics and parameters are considered during resource allocation in 5G?
- 5- Which open issued and research trends are unaddressed in resource allocation in 5G?

3.1.2. Search Criteria

A systematic resource allocation analysis was completed over well-known research. The main emphasis is on 5G, as this is more connected to IoT, to improve monitoring and network performance. Although, there was no compact research performed in the area, therefore the articles taken for consideration of this SLR are from 2015 to onward. Depending on the research questions and the proposed theme, we portrayed the watchwords for seeding purposes to find out the initial string for search purposes. The scholars countered the terms for searching like “5G communication”, “resource allocation” nominated for main keywords. We applied the “OR” and “AND” logical operators for connecting the important watchwords. Later, after performing limited tests, we picked and chose the associated search string which provides us sufficient related research articles by utilizing the keywords to frame the search string mentioned below in Table 1.

Table 1. List of Keyword and Strings.

String	B1	B2
Sting 1 (S1)	Fifth Generation	Resource Allocation
Sting 2 (S2)	Fifth Generation	Resource Distribution
Sting 3 (S3)	Fifth Generation Network	Resource Reservation
Sting 4 (S4)	5G	
Sting 5 (S5)	5G Network	

3.1.3 Data Sources

For this SLR, many diverse data sources were investigated. The articles were mostly examined for conferences and journal papers of Google Scholars, Scopus, magazines, and Books as a database for the extraction. The quality publisher articles such as Springer, IEEE, Wiley, Science Direct, Sage, Google Scholar, MDPI, ACM digital library, etc. are accumulated for review as shown below in Table 2.

Table 2. Data Sources.

Publisher	URL
MDPI	https://www.mdpi.com
Science Direct	https://www.sciencedirect.com
Wiley Online Library	https://onlinelibrary.wiley.com
Springer	https://link.springer.com
Sage	https://journals.sagepub.com
Google Scholar	https://scholar.google.com
ACM	https://www.acm.org
IEEE	https://ieeexplore.ieee.org

3.1.4 Article Selection Process

The perspective of research is a prominent way through which several quantitative kinds of research are applied. Quality assessment principles are applied to certain articles for exclusion and inclusion of research articles. The tactic used to select the articles starts with formulating the research questions as mentioned above. Outlining the string of searches supports the search and selection procedure. Only English language writing articles are studies for this review. For the review procedure, the PRISMA flow diagram [67][68] is followed, which is shown in Figure 5. After getting the research articles based on the strings and keywords, a review on resource allocation schemes in 5G communication is done in this research. The search procedure finishes in every aspect by classifying the resource allocation scheme to ensure the comprehensiveness of this study. Several papers were separated due to a mismatch of their title as per the fortitude measures. On the contrary, abstracts were not considered to be identified in this study.

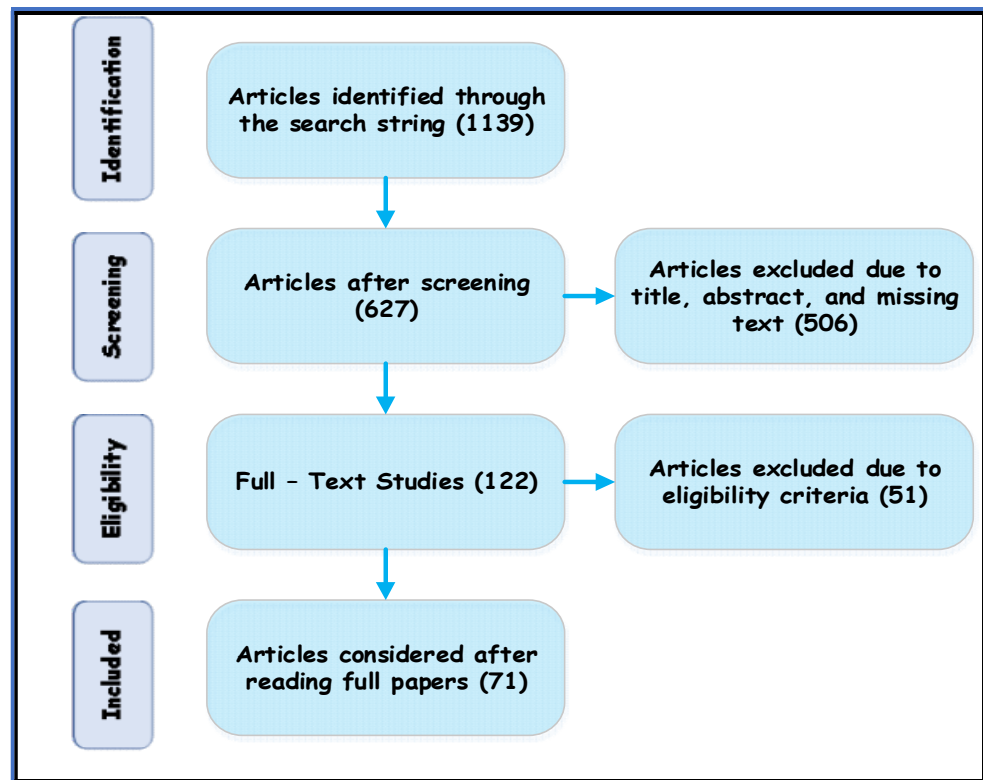


Figure 5. Article's selection procedure.

As presented in figure 5, a sum of 1139 research articles was collected using search string, on the behalf of underlying inquiry, which is published from the year 2015 to 2020 in various quality publishers, as discussed in table 2. For the selection of compelling research articles, the criteria of inclusion and exclusion are connected, as mentioned in Table 3, to reduce it to 627. Based on the abstracts and titles the selection was considered to 122 articles related to the selected domain. From this point onward, these 122 articles were examined, and to categorize the resource allocation techniques as conventional or artificial intelligent in 5G communication, 71 articles were finalized.

Depending on the selected criteria, the most relevant articles based on abstracts, title, and comprehensive research are selected which ensure that the results are relevant to the research work as desired.

3.1.5 Inclusion and Exclusion Criteria

The articles that have been chosen for this study are shown in Figure 6 which is presenting the year-wise articles selected for this review. While Figure 7 is showing the selected articles based on famous and well-reputed research journals from the year 2015 to 2020. The selection of these articles is classified publisher-wise, and the methods used for resource allocation in 5G.

In the end, the articles considered for this study of 5G resource allocation were 71. These articles were taken from various well-known research journals named IEEE, Springer, Elsevier, Wiley, MDPI, ACM, and some other publishers.

Table 3. Inclusion and exclusion criteria.

Criteria	
Inclusion	<ul style="list-style-type: none"> ➤ The articles were published in well-reputed journals and conferences. ➤ The article is peer-reviewed. ➤ The article was written in English only. ➤ The study focuses on resource allocation in 5G. ➤ The article published by the above-mentioned publishers
Exclusion	<ul style="list-style-type: none"> ➤ The articles from keynote speeches, editorials, and white papers. ➤ The articles are other than the English language. ➤ The articles are not peer-reviewed. ➤ The articles are focused on other than resource allocation in 5G.

4. Discussion

The literature review has exposed several findings across each research question as discussed below:

Q1. What are the existing state-of-the-art challenges in 5G?

The followings are the challenges in 5G communication which came to know after studying several research papers.

The 5G communication challenges are:

- Deployment of MIMO: 5G will require a shift of paradigm which incorporates huge bandwidth having very high-frequency spectra as a carrier, excessive densities of a base station, and a remarkable number of antennas to provision the massive growth on the behalf of traffic.
- mm-Wave: millimeter waves are transmitted with frequencies between 30 to 300 GHz, comparing the bands traditionally used for mobile devices which are below 6. This technology guarantees huge data capacity as compared with the one which is being used nowadays. However, mm-waves face one main drawback i.e., traditionally higher range of frequencies is not sufficient due to blockage and high propagation loss due to raindrops and high buildings for outdoor applications [69].

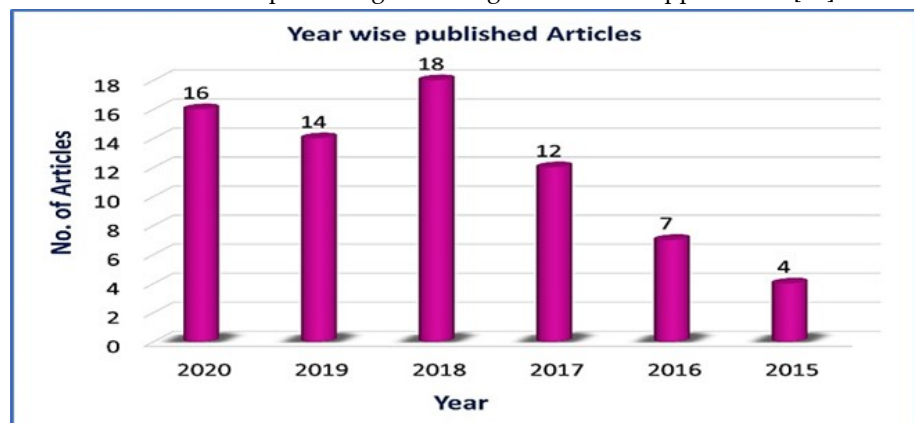


Figure 6. Year-wise selection of articles for review.

- Pilot contamination and channel estimation/feedback: Channel State Information (CSI) is critical for attaining the benefits of multi-antenna in MIMO systems. CSI has become more demanding in massive MIMO systems because of the massive number of antennas. Furthermore, a massive MIMO system needs a massive amount of pi-

lots for both times–division duplexing (TDD) and frequency–division duplexing (FDD) [70].

- The trade-off between computation power and transmission power: Across the 5G network, the additional BSs power relies on the transmission and computation power of BSs. When extra power is added to BSs and combined with the transmission and computation power of BS, then the 5G network's energy efficiency is also calculated by the BSs transmission and computation energy [71].
- Mobility: 5G network must work with speed up to 1000 km/h. a substantial investigation is needed to obtain the issues related to the selection of optimum beam and the development of methods/schemes which enhanced the requirement for the response for CSI to the transmitter. So, massive MIMO performance is very delicate to speed, due to this the computational load can make multiuser solutions unaffordable [39].

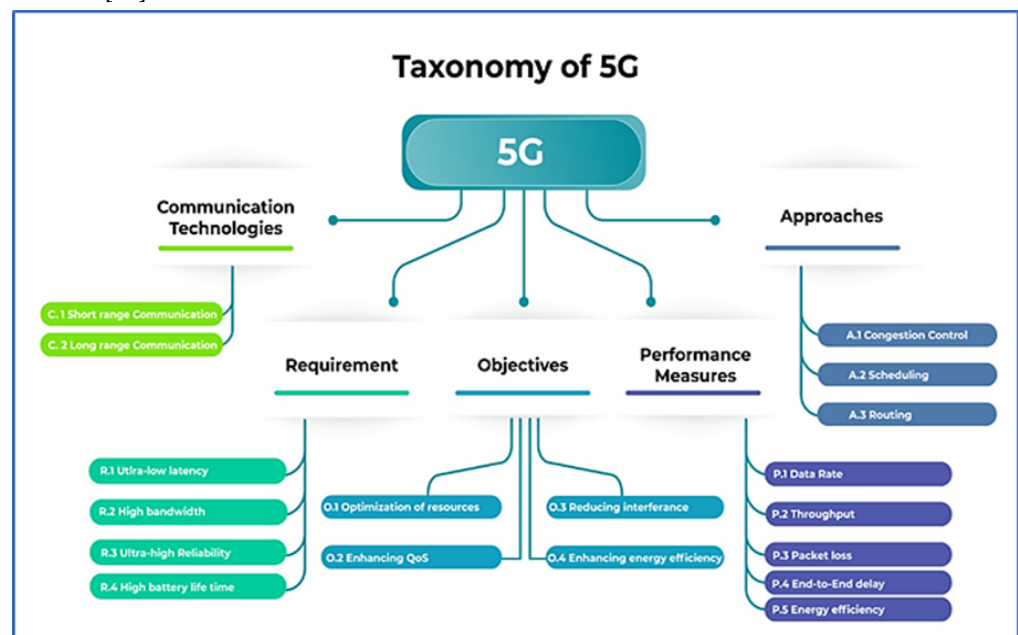


Figure 7. Taxonomy of 5G.

- Mixed-Numerology interference: As per the divergent demands of mMTC and URLLC, service configuration contrasts vigorously from the perspectives of the physical layer [72]. Specifically, mMTC is characterized by sampling rate having low baseband for supporting huge connectivity and small sub-carrier spacing with narrowband transmission and reduced consumption of power and extensive coverage having low-cost. On contrary, URLLC mostly requires spacing for many subcarriers to deal with the rigorous requirement for latency and sampling rate for high baseband. These diverse configuration discrepancies in RF and baseband predictively lead to considerable interference [73], [74] in crucial mMTC.
- 5G UE's testing challenges: The problems that appeared in testing 5G UE are like the issues that happened in traditional systems having power control, extreme power output, and sensitivity behavior of receiver as measurement matrices. Therefore, the demand for using SC-FDMA for the uplink and OFDMA scheme in the downlink in LTE-A/LTE-B based 5G systems, along with assistance for instantaneous links having harvesting capabilities for energy provisioning, need novel ideas of measurement for supporting required trials. For suitable RF measurements, trial equipment must consider automatically operate signaling protocols utilizing parameters defined by the user (like channel number). The UE operational testing should integrate

signaling protocol, handover testing, and end-to-end throughput. The main challenge faced in 5G UE testing is to guarantee to meet the response of state-change requirements [75].

- **Dynamic heterogeneous resource optimization:** It is difficult to endorse data transmission efficiency for the services getting URLLC as a top priority in mMTC. Due to the lack of radio resources, it is mandatory to consider their co-presence by combining their conflicting requirements and specifications concerning latency, reliability, density, and bandwidth. Therefore, the arrangement of the resources efficiently in the wireless environment using dynamic and intelligent ways over various stages of service requirements is a demanding job [76].
- **Efficient and realistic measurement:** As the data measurement is critical for the required modification/extension of current transmission models, the approach of measurement should cover various ranges of frequencies, spherical waves, 3D (elevation), spatial consistency, along with new paradigms of communications like small cell and M2M/D2D communications. Furthermore, measurements must be capture for mm-wave (i.e., 60 GHz and over) for outdoor and indoor criteria, and mention feasible real-life scenarios (like vehicle to vehicle/ roadside communication, crowded areas, etc.) [77].
- **Isolation among Network Slices:** In a 5G network, many services have unique requirements. Consequently, the resources of a dedicated virtual network are required to certify the quality service at every slice. It needs high-performance isolated slices for each other. Through control plane and data plane isolation this network slices isolation can be obtained. Generally, the slice control function can be distributed between various slices, whereas some of the services like mission-critical communications the resource sharing provide various benefits for infrastructure benefactors while it brings some challenging issues like slice isolation. Slice requires its control functionality. Moreover, the effective isolation for each network slice confirms that a security attack or any other failure does not alter other's slice operations. Therefore, the mechanism of slice isolation is a prominent challenge while employing network slicing [78].
- **Privacy protection:** Obscurity services of 5G demands huge attention as compared to the previous cellular networks. The exclusive data rate of 5G carries a huge amount of data flow that contains private and sensitive information like identity, private content, and position. In few situations, the leakage of privacy may lead to extreme consequences. Such as leakage of health observing data may expose the private information of a person and routing data of the vehicles may reveal the position of a vehicle and [79]. Due to the application's privacy requirements, the protection of privacy is a challenging issue faced by 5G wireless networks.
- **Coordinated multiple points (CoMP):** CoMP having 5G massive MIMO will portray a critical part in enhancing the quality of communication, coverage, EE, and throughput of the network [80]. More on, mobile users can use relatively better quality and performance while locating in the other cell zone. Therefore, the CoMP system having 5G massive MIMO still have some open challenges like, backhauling, processing, and cooperative framework which demand more attention to study, in turn, to achieve maximum benefits of the network for the operator keeping the cost in control.

Q2. What is the importance of resource allocation in 5G?

Resource allocation has an important aspect of wireless network systems. In a 5G communication network, it is very important that the system must be wiser and more dynamic to satisfy multiple network requirements. Power control, bandwidth allocation, deployment strategies, and association allocation are assigned resources in the system

[81]. Resource allocation is an important aspect of any cellular network environment. it plays a significant part to keep friendly access for end-users, business partners, customers of cellular-based applications. Resource allocation has great benefits for the cellular network environment. The performance relies on the level of fairness for the network's resource allocation. The fairness level has a strong correlation with the network performance level. The fairness levels of resource allocation are fair, perfect, unfair, and unbalanced. The levels of network performance are poor, less good, good, and perfect [82]. One main challenge in 5G is resource allocation as it relates to the performance of the long-life battery power devices and the service quality of the application. The users demand effective resource management and allocation. The ossified services and closed infrastructure of prevailing networks lead to inefficient and complex resource allocation. The existing network resources in wireless communication networks especially the 5G wireless network are user-centric that demand effective resource allocation to acquire Quality of Services (QoS). Therefore, effective resource allocation is the main challenging issue for the growing need for 5G cellular network. The wireless communication network resources are specifically defined in terms of power, spectrum, channel, etc. which must be allocated as per the user requirements. A mobile network may suffer from spectrum resources shortage due to a massive increase of users and the connected devices on the network [83].

Q3. Which current policies, strategies, and algorithms are being used for resource allocation in 5G?

This review paper is classified as per the methods used for resource allocation in 5G based on the articles which are being reviewed from various multiple sources.

Resource allocation Techniques in 5G: This systematic review is explored based on the resource allocation algorithms and techniques executed by numerous investigators and organized them as per the methodologies, which are being catered by any of these techniques.

As per the criteria, 71 research articles are being selected for this systematic study as mentioned above in Figure 5. Every article is studied on the behalf of the problem which is being addressed and its pros and cons. In the current part, the results are swotted to achieve resource allocation in 5G. The issues are resolved through hybrid models, swarm intelligence, genetic modeling, rule-based systems, and case-based reasoning. Resource allocation based on artificial intelligence techniques is utilized to resolve issues as a hybrid problem-solving approach. The main goal behind the study is the base to select and/or improve a particular technique in the future to allocate the resource in the 5G network.

Table 4. Characteristics of selected resource allocation techniques in 5G.

Ref	Algorithm / Scheme / Strategy	Problem Addressed	Improvements / Achievements	Limitations / Weakness
[84]	Cooperative Online Learning Scheme	Extreme interference between the multi-tier users	<ul style="list-style-type: none"> Maximize spectral efficiency data rate by ensuring QoS. 	<ul style="list-style-type: none"> Limited to tier and for downlink.
[85]	Game-theoretic approach	Cross-tier interference	<ul style="list-style-type: none"> Improved spectral efficiency. Energy efficiency. Sum rate. 	<ul style="list-style-type: none"> Limited to two tiers only. Does not support up-link.
[86]	Genetic Algorithm Particle Swarm Optimization-Power	The allocation of power in heterogeneous ultra-dense networks	<ul style="list-style-type: none"> Reduces the system outage probability. 	<ul style="list-style-type: none"> Solve non-linear optimization.

Ref	Algorithm / Scheme / Strategy	Problem Addressed	Improvements / Achievements	Limitations / Weakness
	Allocation (GAP-SO-PA)			
[87]	Estimation of Goodput based Resource Allocation (EGP-BASED-RA)	Enhance Goodput (GP): (a specific metric of performance)	<ul style="list-style-type: none"> The performance of the UPMC system was boosted. 	<ul style="list-style-type: none"> Limited to a particular packet format.
[61]	The social-aware resource allocation scheme	D2d multicast grouping, Ineffective d2d links	<ul style="list-style-type: none"> Fairness. Throughput. Has substantial benefits over other algorithms. 	<ul style="list-style-type: none"> Working on limited parameters.
[88]	PGU-ADP algorithm	Dynamic virtual RA problem. Expansion of the total user rate	<ul style="list-style-type: none"> Drastically minimize the outage probability. Enhance user data rate. 	<ul style="list-style-type: none"> Consider specific slice rate. Slice state. Downlink only.
[89]	Efficient Resource Allocation Algorithm	Enhance system capacity and maximum computational complexity	<ul style="list-style-type: none"> Improved system capacity. Minimize complexity performance. 	<ul style="list-style-type: none"> Power allocation is done on the sub-carriers of the fixed group. Limited parameters.
[90]	GBD Based Resource Allocation Algorithm	Enhance allocating algorithm's efficiency	<ul style="list-style-type: none"> Total throughput achieved 19.17%. Average computational time 51.5%. GBD with no relaxation by 30.1%. 	<ul style="list-style-type: none"> Parameters are not suitable in all circumstances.
[91]	Multitier H-CRAN Architecture	Lacking intelligence perspective using existing C-RAN methods	<ul style="list-style-type: none"> Manages spectral resources efficiently. Enhanced control. End-to-end optimization. Ensures QoS by 15%. 	<ul style="list-style-type: none"> Necessary to improve bits of intelligence.
[92]	Bankruptcy game-based algorithm	Resource allocation and inaccessibility of wireless slices	<ul style="list-style-type: none"> Enhance resource utilization. Ensures the fairness of allocation. 	<ul style="list-style-type: none"> Focused on the cloud-ran. Limited to specific parameters and slices.
[93]	BVRA-SCP Scheme	Enhancing service demands like low latency, enormous connection, and maximum data rate.	<ul style="list-style-type: none"> Beneficial resource utilization. Low computational complexity. Support dynamic IoT. 	<ul style="list-style-type: none"> Limited to dynamic IoT-specific metrics.

Ref	Algorithm / Scheme / Strategy	Problem Addressed	Improvements / Achievements	Limitations / Weakness
			slicing architecture. • Improves efficiency and flexibility.	
[94]	VNF-RACAG Scheme	Settlement of virtualized network functions (VNF)	• The gain in end-to-end delay.	• Limited parameters.
[95]	Hybrid DF-AF scheme	Promising to incorporate various wireless networks to deliver higher data rates.	• Attain the concave envelope of the maximum between AF rate and DF rate. • Substantial gains for RFDRC.	• Limited parameters are considered.
[63]	Cooperative resource allocation and scheduling approach	Scheduling and resource allocation problems	• Decreases transmission collision probability. • Enhanced the reliability of upcoming 5g. • Enhanced vehicle-to-everything (ev2x) communications.	• Only for URLLC traffic. • Consider limited parameters.
[96]	SWIPT framework	Low energy efficiency and high latency	• Maximize energy efficiency. • Effective capacity.	• Limited to downlink. • Consider limited metrics.
[97]	The device-centric resource allocation scheme	Declining of network throughput and raises delay in resource allocation.	• Reduces load at the BS up to 35%. • Better performance.	• Improvement is required in intelligent resource allocation. • Power efficiency was neglected.
[98]	Distributed Resource Allocation Algorithm	Resource allocation and interference management in 5g networks	• Efficient higher data rate results.	• Limited to uplink only. • Limited parameters were used.
[99]	Unified cross-layer framework	Physical layer modulation format and waveform, resource allocation, and downlink scheduling	• Enhanced spectral efficiency using FBMC/OQAM.	• Limited to specific parameters and frequency.
[100]	Dynamic joint resource allocation and relay selection scheme	Relay selection and downlink resource allocation	• Low computational complexity.	• QoS neglected. • Limited metrics are considered.
[101]	Low-Complexity Subgrouping	Radio resource management of multicast trans-	• Improve the Aggregate Data Rate (ADR).	• Focused on data rate only.

Ref	Algorithm / Scheme / Strategy	Problem Addressed	Improvements / Achievements	Limitations / Weakness
	scheme	missions	<ul style="list-style-type: none"> Ensuring performance up to 9%. 	<ul style="list-style-type: none"> QoS neglected. Limited parameters.
[102]	Joint Edge and Central Resource Slicer (JECRS) framework	Requires distinct resources from the lower tier and upper-tier	<ul style="list-style-type: none"> Satisfy latency and resource requirements. Guarantee communication and computing. 	<ul style="list-style-type: none"> Need to support the NFVO
[103]	TCA algorithm	MTC devices are battery restricted and cannot afford much power consumption needed for spectrum usage.	<ul style="list-style-type: none"> Less complex. Achieves better performance. 	N/A
[104]	IHM-VD algorithm	Power allocation and channel allocation issue	<ul style="list-style-type: none"> Outperforms energy efficiency. QoS requirements. 	<ul style="list-style-type: none"> Focus on specific parameters and particular domain.
[105]	Centralized approximated online learning resource allocation scheme	The inter-tier interference among macro-BS and RRHS, and energy efficiency	<ul style="list-style-type: none"> Ensures interference mitigation. Maximizes energy efficiency. Maintains QoS requirements for all users. 	<ul style="list-style-type: none"> Limited to inter-tier interference mitigation. Limited to specific parameters.
[106]	Spectrum resource and power allocation scheme	Emphasize on a fair distribution of resources in one cell	<ul style="list-style-type: none"> Boost system performance. 	<ul style="list-style-type: none"> Limited to user interference in a single cell. Not suitable for multiple cell interference. QoS neglected.
[107]	Tri-stage fairness scheme	Resource allocation problem in UDN having caching and self-backhaul	<ul style="list-style-type: none"> Improved flexible access and backhaul link resource allocation. 	<ul style="list-style-type: none"> Particularly use caching. Limited parameters are used. QoS is neglected.
[108]	Fronthaul-aware software-defined resource allocation mechanism	Overhead generated using a capacity-limited shared fronthaul	<ul style="list-style-type: none"> Throughput enhancements. Delay reductions. 	<ul style="list-style-type: none"> Limited to in-band fronthaul. Limited parameters are used.
[109]	Heterogeneous statistical The QoS-driven resource allocation scheme	Heterogeneity issues	<ul style="list-style-type: none"> Efficient QoS across MIMO-OFDMA based CRNS. 	<ul style="list-style-type: none"> Domain-specific Limited parameters are used. Limited to effective capacity.

Ref	Algorithm / Scheme / Strategy	Problem Addressed	Improvements / Achievements	Limitations / Weakness
[110]	Nondominated sorting genetic algorithm II (NSGA-II)	Unable to get optimal results concurrently.	<ul style="list-style-type: none"> • Performance. • Analyze computational and convergence complexity. 	<ul style="list-style-type: none"> • Limited to ultra-dense network. • Limited to downlink.
[111]	Joint access and fronthaul radio resource allocation	Downlink energy efficiency (EE) and millimeter-wave (MMW) links in access and fronthaul.	<ul style="list-style-type: none"> • The system sum-rate is enhanced up to 50%. • Using PD-NOMA and comp the sum rate was enhanced up to 40%. 	<ul style="list-style-type: none"> • Limited parameters. • RAN-based only. • Limited to downlink.
[112]	Double-sided auction-based distributed resource allocation (DSADRA) method	Inter-cell and inter-tier interference	<ul style="list-style-type: none"> • User association satisfaction. • Maximum output 	<ul style="list-style-type: none"> • QoS not consider. • Limited for small cell only
[113]	Joint power and reduced spectral leakage-based resource allocation	Interference from D2D pairs	<ul style="list-style-type: none"> • Reduce spectral leakage to nearby RBS. • Ensures maximize signal-to-interference-and-noise ratio (SINR). • Enhance overall throughput. 	<ul style="list-style-type: none"> • QoS neglected. • Limited parameters.
[114]	Branch-and-bound scheme	Latency-optimal virtual resource allocation	<ul style="list-style-type: none"> • Enhance serviceability. • network load balance. 	<ul style="list-style-type: none"> • Limited to backhaul. • Limited parameters. • Neglect energy efficiency.
[115]	The learning-based resource allocation scheme	To achieve high system capacity better performance in terms of effective system throughput.	<ul style="list-style-type: none"> • More efficient in terms of system performance. 	<ul style="list-style-type: none"> • Limited to user's position information.
[116]	Resource allocation method with minimum interference for two-hop D2D communications	Interference which reduces network throughput.	<ul style="list-style-type: none"> • Enhance interference and throughput. 	<ul style="list-style-type: none"> • Limited parameters. • Priority-based allocation block.
[117]	Multiband cooperative spectrum sensing and resource allocation framework	Energy consumption for spectrum sensing	<ul style="list-style-type: none"> • Satisfy the QoS requirement. 	<ul style="list-style-type: none"> • Channel fading changes over time. • Mobile IoT nodes do not consider.

Ref	Algorithm / Scheme / Strategy	Problem Addressed	Improvements / Achievements	Limitations / Weakness
[118]	Channel-time allocation PSO Scheme	To acquire gigabit-per-second throughput and low delay for achieving and maintaining the QoS	<ul style="list-style-type: none"> • Encounter the growing requirements of applications. • Converged and high-capacity networks such as 5G. 	<ul style="list-style-type: none"> • Especially for Multi-media traffic. • Certain metrics are considered.
[119]	Heterogeneous (high density)/hierarchical (low density) virtualized software-defined cloud RAN (HVSD-CRAN).	Density of users	<ul style="list-style-type: none"> • Encounters variety of tradeoffs in resource management objectives such as cost, power, delay, and throughput. 	<ul style="list-style-type: none"> • Limited resource allocation in dense users. • Certain parameters are used.
[120]	Mini slot-based slicing allocation problem (MISA-P) model,	The probability of forming 5G slices	<ul style="list-style-type: none"> • Spectral efficiency and feasibility. 	<ul style="list-style-type: none"> • Limited parameter. • Support single slot-based model. • Limited for EMBB and URLLC traffic.
[121]	A joint resource allocation and modulation and coding schemes	Requirement of extremely low latency and ultra-reliable communication	<ul style="list-style-type: none"> • Achieve very low error rates. • Minimize resource consumption. 	<ul style="list-style-type: none"> • Only for URLLC traffic. • Reserve resources for the first transmission.
[122]	QoS/QoE-aware relay allocation algorithm	Neglect temporal requirements for optimum performances	<ul style="list-style-type: none"> • Better performance for mean time to failure (MTTF). • Average peak signal-to-noise ratio (PSNR) • Average energy consumption. 	<ul style="list-style-type: none"> • Working based on different priorities. • Consider specific parameters.
[123]	The learning-based resource allocation scheme	Interference coordination complexity and significant channel state information (CSI) acquisition overhead	<ul style="list-style-type: none"> • Better effective system performance. 	<ul style="list-style-type: none"> • Accuracy is varying as per user positions. • Neglect throughput and QoS.
[124]	Device-to-device multicast (D2MD) scheme	Improving spectrum and energy efficiency and enabling traffic offloading from BSs to device	<ul style="list-style-type: none"> • Throughput enhanced. 	<ul style="list-style-type: none"> • Lack of attention on mobile users. • Neglect selection of sharing mode and content caching in

Ref	Algorithm / Scheme / Strategy	Problem Addressed	Improvements / Achievements	Limitations / Weakness
				D2MD.
[125]	Constrained deferred acceptance (DA) algorithm and a coalition formation algorithm	The interference management among D2D and current users	<ul style="list-style-type: none"> • Enhance performance. • Throughput, fairness, and admitted users. 	<ul style="list-style-type: none"> • Limited coverage area. • Neglect reliability and security.
[81]	Novel resource allocation schemes (hybrid resource management)	Energy efficiency and consumption	<ul style="list-style-type: none"> • QoS threshold and power budget are ensured. 	<ul style="list-style-type: none"> • Lack of attention on delay and overhead.
[126]	Orthogonal multiple access (OMA) and relay-assisted transmission schemes.	Jointly optimize the block length and power allocation for reducing error probability	<ul style="list-style-type: none"> • Improved performance. 	<ul style="list-style-type: none"> • Emphasis on short packet transmission only. • QoS is neglected.
[127]	Joint user association and Power Control algorithm	Optimizing power control and user association schemes	<ul style="list-style-type: none"> • Achieves higher energy efficiency performance. 	<ul style="list-style-type: none"> • Lack of attention on Fairness and channel state information.
[128]	Successive convex approximation (SCA) based alternate search method (ASM)	Raise the total sum rate of users	<ul style="list-style-type: none"> • Enhance the performance of the system. • Ensures the potential of SCMA. 	<ul style="list-style-type: none"> • Lack of attention on fairness. • Limited parameters are used.
[129]	An online learning algorithm for resource allocation	Inter-tier interference among RRHS and macro-BSs, and energy efficiency	<ul style="list-style-type: none"> • Enhance the energy efficiency. • Maintains users' QoS. 	<ul style="list-style-type: none"> • Priority-based allocation of the resource block. • Limited parameters are focused.
[130]	Joint resource block (RB) and power allocation scheme	Enhance fairness in data rate among end-users	<ul style="list-style-type: none"> • Low complexity. • Higher spectral efficiency. 	<ul style="list-style-type: none"> • Limited to femtocell only. • Interference inside femtocell not considered.
[131]	Hybrid multi-carrier non-orthogonal multiple access (MC-NOMA)	Achieve the SE-EE tradeoff having minimum rate requirement of each user	<ul style="list-style-type: none"> • Outperforms both NOMA and OMA. • Enhance the tradeoff between system efficiency and user fairness. 	<ul style="list-style-type: none"> • Decrease performance while adding more users. • Complexity.

Ref	Algorithm / Scheme / Strategy	Problem Addressed	Improvements / Achievements	Limitations / Weakness
[132]	Stackelberg game model	High inter-cell interference (ICI) and less energy efficiency	<ul style="list-style-type: none"> • Feasible and promising. 	<ul style="list-style-type: none"> • Focus on limited parameters. • Neglect intra-cell interference.
[133]	Virtual code resource allocation (VCRA) approach	Reducing the collision probability	<ul style="list-style-type: none"> • Reduce the collision probability. • Enhancing efficiency. 	<ul style="list-style-type: none"> • Improve the code. • Access to devices is according to priority.
[134]	Deep reinforcement learning -unicast-multicast resource allocation framework (DRL-UMRAF)	High-quality services and achieving green energy savings of base stations	<ul style="list-style-type: none"> • Improve energy efficiency. • QoS requirements. 	<ul style="list-style-type: none"> • Limited services framework. • Limited to the number of cells and layers.
[135]	Deep reinforcement learning-based intelligent Up/Downlink resource allocation	The high dynamic network traffic and unpredicted link-state change	<ul style="list-style-type: none"> • Performance improvement. • Packet loss rate and network throughput. 	<ul style="list-style-type: none"> • Lack of attention on overhead. • QoS neglected.
[136]	Joint computation offloading and resource allocation scheme	Complete network information and wireless channel state.	<ul style="list-style-type: none"> • Outperforms energy consumption. 	<ul style="list-style-type: none"> • Limited to a specific parameter. • QoS is neglected.
[137]	Deep neural network-Multi objective Sine Cosine algorithm (DNN-MOSCA)	Achieving better accuracy and reliability	<ul style="list-style-type: none"> • Better performance • Improved fairness, throughput, and energy efficiency. 	<ul style="list-style-type: none"> • Spectral efficiency was neglected.
[138]	The improved resource allocation algorithm	Improving QoS requirements in MTC	<ul style="list-style-type: none"> • Expressively improve the outage and success probability. 	<ul style="list-style-type: none"> • Prioritized access for MTC devices. • Limited parameters are considered.
[139]	Resource Allocation Algorithm	The interference to 5g cellular users (CUs) related to QoS	<ul style="list-style-type: none"> • Improve the cellular users' channel capacity. • Guaranteeing QoS of the CUs. 	<ul style="list-style-type: none"> • Limited parameters are considered. • Only for uplink.
[140]	Genetic algorithm-intelligent Latency-Aware Dynamic Resource Allocation Scheme (GI-LARE)	Efficient radio resource management	<ul style="list-style-type: none"> • GI-LARE outperformed these other schemes. 	<ul style="list-style-type: none"> • Divide traffic into 2 categories. • downlink only • Specific parameters were used.

Ref	Algorithm / Scheme / Strategy	Problem Addressed	Improvements / Achievements	Limitations / Weakness
[141]	A Low-complexity centralized packet scheduling algorithm	Downlink centralized multi-cell scheduling	<ul style="list-style-type: none"> • Improves URLLC latency. • Achieves gains of 99% and 90% URLLC latency. 	<ul style="list-style-type: none"> • Neglect inter-cell interference. • Consider only URLLC traffic.
[142]	Smart queue management method	QoS of end-to-end real-time traffic	<ul style="list-style-type: none"> • Confirms better end-to-end communication QoS of the real-time traffic. • The average end-to-end communication delay was reduced. 	<ul style="list-style-type: none"> • Not for all IoT critical services. • Neglect other relevant parameters.
[143]	Proposed Optimal Resource Allocation Algorithm	The optimization problem in mixed-integer nonlinear programming (MINLP).	<ul style="list-style-type: none"> • Improve throughput. • Guaranteed QoS of wi-fi user equipment. 	<ul style="list-style-type: none"> • Wi-fi or LTE only. • Limited parameters are used. • Good in one scenario only.
[144]	A novel packet delivery mechanism	Issues related to using CoMP for URLLC in C-RAN architecture.	<ul style="list-style-type: none"> • Resource utilization. • UE satisfaction. 	<ul style="list-style-type: none"> • Limited for URLLC traffic. • Lack of attention on overhead.
[145]	Distributed joint optimization algorithm for user association and power control	Improve total energy efficiency and reduce the inter-cell and intra-cell interference	<ul style="list-style-type: none"> • Effective and robust dynamic communication environment. 	<ul style="list-style-type: none"> • Limited to two-tier. • Lack of attention on overhead.
[146]	Pol-laczek-Khinchine formula based quadratic optimization (PFQO)	Inaccurate transmission recovery delay of URLLC multi-user services	<ul style="list-style-type: none"> • Bandwidth saving. • Packet length distributions. 	<ul style="list-style-type: none"> • Lack of attention on retransmission timing. • Specific parameters.
[147]	An outer approximation algorithm (OAA)	Multiple interferences, imbalanced user traffic load	<ul style="list-style-type: none"> ○ Mitigating interference. ○ Traffic offloading to address traffic imbalances. ○ Sum-rate maximization. 	<ul style="list-style-type: none"> ○ Lack of attention on QoS. ○ Latency.
[148]	Joint Power and Subcarrier Allocation	URLLC reliability and network spectral efficiency.	<ul style="list-style-type: none"> • Improve the spectral efficiency. • URLLC reliability. 	<ul style="list-style-type: none"> • Limited to a single cell. • Not allocated slices in multiple cells. • Neglect overhead.
[149]	Weighted Majority Cooperative Game	Increase interference, improper utilization of re-	<ul style="list-style-type: none"> • Power consumption decreases up to 30%. 	<ul style="list-style-type: none"> • Fairness is not considered.

Ref	Algorithm / Scheme / Strategy	Problem Addressed	Improvements / Achievements	Limitations / Weakness
	Theory Based Clustering	sources	<ul style="list-style-type: none"> SINR and spectral efficiency are increased. up to 40% and 45% respectively. 	<ul style="list-style-type: none"> Prioritized small cells based on weight.
[150]	Bee-Ant-CRAN scheme	Design a logical joint mapping among RRHS and User Equipment (UE) and RRHS and BBUS too.	<ul style="list-style-type: none"> Improves the spectral efficiency as well as the throughput. 	<ul style="list-style-type: none"> Neglect the effect of virtual BS. Lack of attention on energy efficiency.
[151]	Noncooperative game theory-based user-centric resource optimization scheme	Enhance the coverage probability and sum rate	<ul style="list-style-type: none"> Improves the sum rate. Outage probability. 	<ul style="list-style-type: none"> Limited to single macro cell scenario. Neglect energy efficiency.

Q4. Which metrics and parameters are considered during resource allocation in 5G?

The following are the metrics used in 5G resource allocation in this review.

Table 5. Metrics used in 5G Resource Allocation.

Metrics	References
Response Time	[112]
End-To-End Delay	[94] [142]
Delay	[88] [96] [97] [99] [108] [109] [117] [118] [119] [141] [146]
Throughput	[61] [84] [90] [91] [92] [97] [99] [100] [101] [103] [108] [113] [114] [115] [116] [117] [118] [119] [124] [130] [135] [137] [143] [151]
Packet Loss	[135] [140]
Latency	[63] [96] [102] [108] [114] [121] [126] [140] [141] [144]
Overhead	[89] [107] [115] [123]
Jitter	[90]
Availability	[61] [114]
Spectral Efficiency	[84] [85] [87] [89] [91] [98] [105] [106] [110] [120] [129] [130] [131] [148] [149] [151]
Fairness	[61] [84] [90] [92] [99] [100] [106] [107] [125] [130] [131] [137]
Outage Ratio	[84] [84] [88] [138]
Sum Rate	[85] [88] [95] [96] [106] [111] [128] [139] [147] [151]
Energy Efficiency	[81][85] [91] [96] [103] [104] [105] [107] [111] [111] [117] [127] [129] [131] [132] [133] [134] [137] [145]
System Performance	[86] [89] [93] [94] [95] [98] [101] [106] [110] [115] [125]

Low Complexity	[86] [89] [90] [92] [93] [100] [101] [103] [107] [110] [123] [125]
Power Allocation	[61] [81] [86] [87] [88] [89] [91] [103] [104] [106] [111] [112] [113] [127] [132] [139] [145]
Reliability	[63] [117] [121] [126] [148]
Time Required for RA	[97]
Scalability	[101]
Interference	[105] [106] [112] [113] [132] [139] [145] [147] [149]
Power Consumption	[119] [149]
Feasibility	[121]
Energy Consumption	[122] [136]

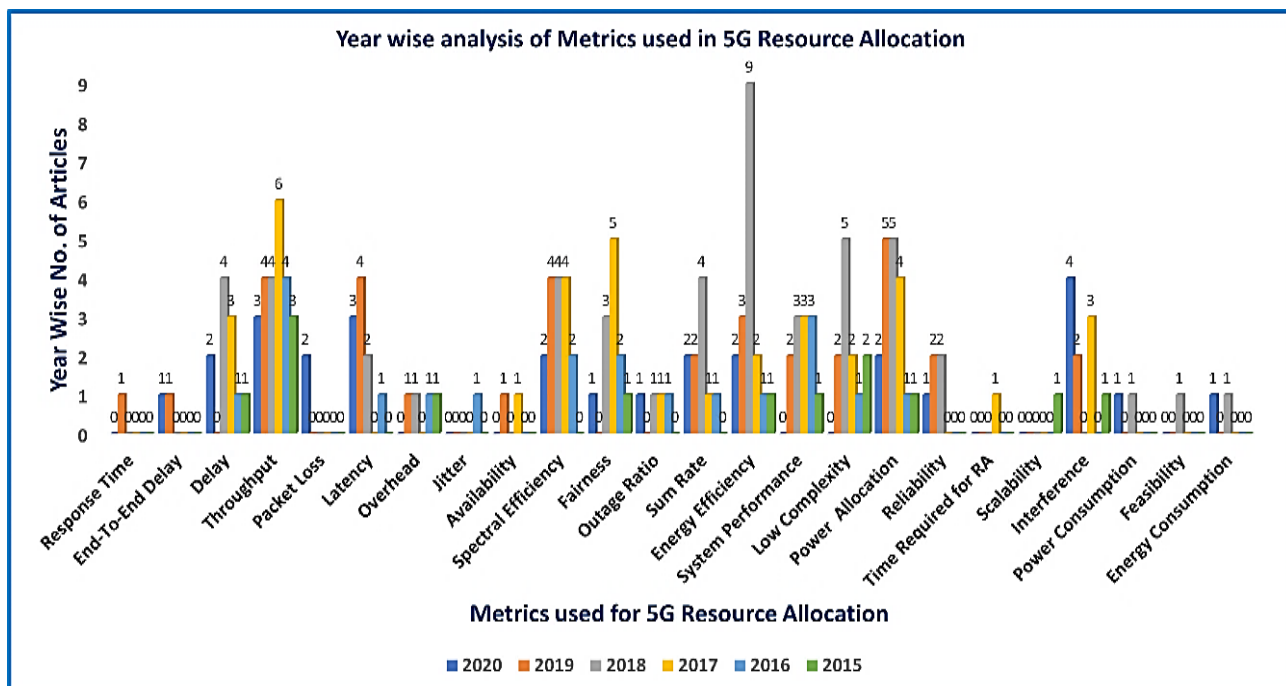


Figure 8. Year-wise analysis of metrics used in 5G Resource Allocation.

The metrics used in the literature reviewed in these articles are considered as packet loss, throughput, delay, latency overhead, jitter, response time, availability, spectral efficiency, fairness, outage range, sum rate, energy efficiency, system performance, low complexity, end to end delay, power allocation, reliability, the time required for resource allocation, scalability, interference, power consumption, feasibility, and energy consumption.

In this extensive systematic review, we noticed that these metrics are used by researchers in many research papers like the papers in which they discussed response time are 01, for an end to end delay: 02, for throughput: 24, packet loss: 02, delay: 11, latency: 10, overhead: 04, jitter: 01, availability: 02, spectral efficiency: 16, fairness: 12, outage range: 04, sum rate: 10, energy efficiency: 18, system performance: 12, low complexity: 12,

power allocation: 18, reliability: 05, the time required for resource allocation: 01, scalability: 01, interference: 10, power consumption: 02, feasibility: 01, and energy consumption: 01 as shown in figure 9. The year-wise analysis of metrics that are being used in this extensive literature is shown in figure 8.

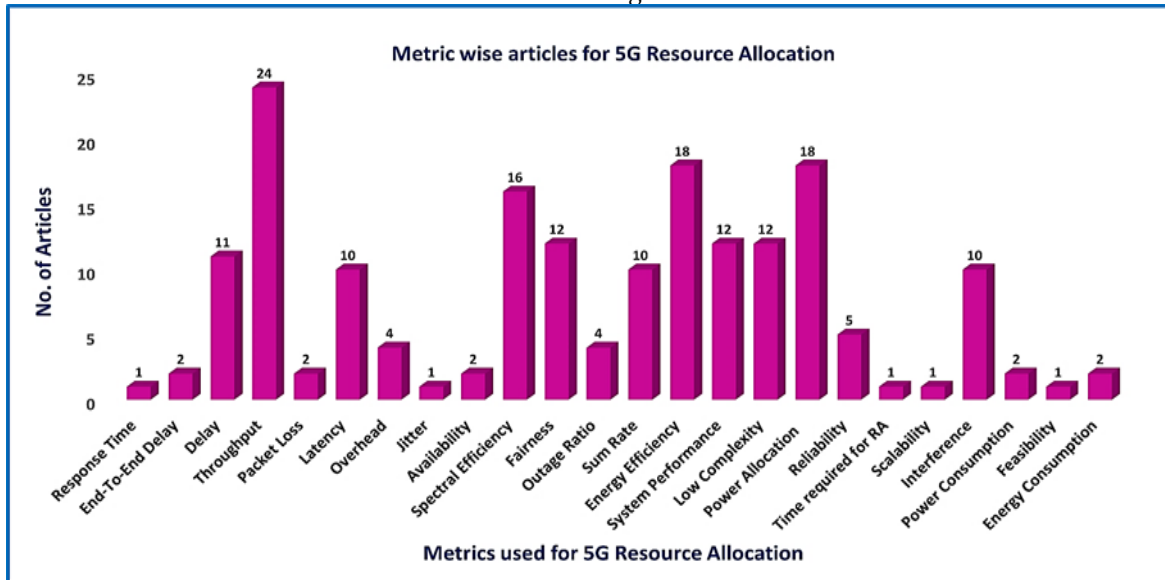


Figure 9. Analysis of metrics used for 5G Resource Allocation.

Table 6. Uplink Downlink with Domains.

Domain	References
Fronthaul	[61] [84] [85] [88] [89] [93] [95] [96] [97] [98] [99] [100] [102] [103] [104] [106] [107] [108] [110] [111] [113] [116] [117] [122] [81] [126] [127] [130] [131] [132] [133] [135] [137] [138] [139] [140] [142] [143] [145] [146] [147] [148] [149] [151]
C-RAN	[90] [91] [102] [104] [105] [111] [112] [115] [119] [123] [128] [136] [141] [144] [150]
H-CRAN	[91] [125] [129] [136]
Backhaul	[93] [103] [104] [107] [126] [140]
Uplink	[90] [91] [93] [97] [98] [102] [103] [104] [106] [112] [113] [116] [117] [122] [133] [135] [136] [138] [139] [142] [143] [146] [147] [149] [150] [151]
Downlink	[84] [85] [88] [89] [90] [91] [93] [95] [96] [97] [99] [100] [102] [104] [105] [107] [108] [110] [111] [113] [115] [119] [122] [123] [125] [81] [126] [127] [128] [129] [130] [131] [132] [135] [136] [137] [140] [141] [142] [144] [145] [146] [147] [148] [150]

Table 6 illustrates the domains used for this literature review consisting of fronthaul, C-RAN, H-CRAN, backhaul.

Figure 10 is describing the percentages of papers reviewed in this extensive literature for discussing downlink and uplink resource allocation with the perspective of fronthaul, C-RAN, backhaul, and HC-RAN. The percentage of reviewed papers is 59% of fronthaul, 24% of CRAN, 9% of Backhaul, and 8% of HC – RAN for downlink schemes while the uplink schemes papers reviewed are 65%, 20%, 9%, and 6% respectively.

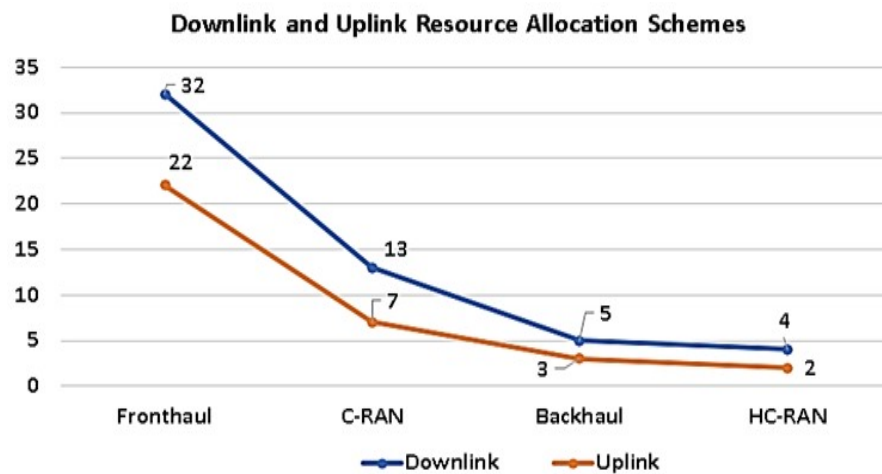


Figure 10. Articles studied for downlink and uplink resource allocation schemes.

Q5. Which open issued and research trends are unaddressed in resource allocation in 5G?

By the evolutionary enhancement in IoT and data requirements, the entire wireless communication system has also completely altered, like M2M communication or V2V network.

RA is still facing enormous challenges at each level. Therefore, many challenges like communication security, network infrastructure, spectral efficiency, and energy efficiency need to be addressed in near future by researchers. For efficient next-generation communication in the future, it is observed that some main challenges such as lifetime operation network and availing green communication for the goal of saving energy from the consumption of energy will be a challenging task. For example, the issues related to resource allocation for achieving energy harvesting networks and green communication networks are attention seekers in near future.

It is observed that spectral resource (SR) is a limited resource and precious for wireless communication. therefore, there is a need to develop some useful methods to enhance the SE. dynamic RA and spectrum detection capacity are very significant issues in resource-sharing cognitive networks. The dishonest probability may focus on some new upcoming issues for RA in various cellular networks (CNs).

Networks move towards the development of a more powerful function, higher data rate, better transmission efficiency, and so on from the perspective of network structure. Due to this, how to achieve multiuser diversity optimization and joint antenna selection for multiuser MIMO networks is a challenging issue. Since both ultra-intensive users and multi-antenna systems are in development trend, the scarce SR and limited bandwidth bring several challenges for the structure and practical application of RA in cellular networks.

Information security is very essential for a communication system from the perspective of information transmission, specifically in cellular networks. Even though CNs can acquire multinet network integration and fulfill various user requirements, there may be security problems, eavesdropping situations, and information leakage. As a result, RA having the consideration of security limitations is very essential in multiuser CNs owing to complex communication scenarios, like RA for physical layer security in CNs.

RA has various problems for various application situations. The optimization problem can be a multivariable one. Our focus is to obtain computation offloading and caching optimization in the communication system. In this way, we must focus on the complicated and practical application environment. More on, from the solution process perspective, self-optimization, and more intelligent algorithms should be introduced and

developed for upcoming future CNs, like machine learning for wireless communication applications. The surrounding scenes can be matched adaptively by these machine learning algorithms. The training system can vigorously adjust its parameters of optimization to acquire the wireless network requirements. The RA challenges in CNs will acquire a better solution in the future by using these intelligent algorithms.

5. Open Research Issues and Trends In 5G

There are still some areas that need to be explored by the researchers. Here, some of the open issues are discussed below:

5.1. Joint Resource Allocation Techniques

Sophisticated and advanced allocation schemes are needed broadly due to the requirement of additional computing resources. One main challenge is to develop resourceful compression algorithms for fronthaul links. From this end, it is essential to inquire and analyze the latency effect on the upper layer's performance of the fronthaul. More on, optimal resource allocation having constrained fronthaul requires more attention to investigating. The fronthaul link experiencing packet loss can be one more thought-provoking topic. The fronthaul network is predictable to be extremely diverse having latency and various link capacities, which demand the requirement of re-configuration of fronthaul that can be altered based on traffic load and network topology.

5.2. Fronthaul/Backhaul/C-RAN Issues

The performance achieved in sum-rate can be enhanced using the adaptive before/after-precoding method. For this purpose, it is very essential to inquire and analyze the precoding problem which uses minimum backhaul. Similarly, the users' accurate profiling is a very important breakthrough to examine suitable approaches for the development of backhaul re-configuration in CRAN. Furthermore, effective algorithms need to be developed to increase the performance of the existing system depending on traffic load and user profiles to evaluate the optimal backhaul.

Additionally, the BS performance investigation with clustering (specifically having large size clusters), while keeping in mind the reconfigurable backhaul ultra-dense BSs deployment can be an auspicious research gap in the future. Furthermore, the study in this domain should emphasize examining effective resource optimization methods by keeping in mind the limitations of both backhaul and fronthaul links while considering the user-side demands.

5.3. Minimization of Latency

The number of transmission delays may enhance by increasing the number of BSs. It is very essential to inquire about the scheduling delay and effect of transmission as these can particularly contribute to the proposed schemes for real-time processing capability. It is also very essential to discuss the trade-off between delay and performance triggered by coding across multiple-fading blocks.

5.4. Energy efficiency

In this regard, it is very essential to inquire and analyze the tradeoff among application's performance and familiarizing power allocation as a power-saving mode on cellular devices. Additionally, analyzing the effectiveness of beamforming algorithms across a large scale demands more attention. The energy harvesting application from renewable resources of energy caters the attention for the investigation to excel the ultra-dense CRANs performance from the perspective of energy efficiency. It is also imperative to enquire about efficient RRH switching-off schemes to minimize the consumption of energy using fewer traffic scenarios.

5.5. Network scalability

The channel state information (CSI) has been always required to improve. Though the stochastic beamforming scheme has been discussed in the previous literature to minimize the CSI acquisition excess, still it requires the demand for a more effective algorithm for large-scale networks. Moreover, the uplink compression techniques can be improved to enhance the sum-rate capacity. Heuristic algorithms should also be inquired for effective Infrastructure Deployment and Layout Planning (IDL) on a large scale. Furthermore, heuristic algorithms for time efficiency demand more attention for minimizing the complexity challenge of network scalability.

5.6. Mobility management

Offering continuous and robust connectivity over various cellular technologies of communication is crucial for moving automobiles. In this regard, it is essential to examine the utility operations and improved algorithm designs having the least complexity depending on network operator or user-based necessities.

As the patterns of mobile call correlation develop extreme with the patterns of identical BS at the same time in the coverage area and designing mobility-aware adaptive techniques for effective optimization is an attention seeker direction for future research.

5.7. Management of Services

It is very essential to calculate the network parameters like traffic conditions and sparsity in network topology therefore the signaling design for the better performance of the CRAN system could be modified accordingly.

5.8. Network virtualization

To improve the end-to-end performance, it is necessary to investigate wireless network virtualization. Communication having one user in a virtual cell is not a suitable approach. This will result in interference while coming closer to the users. However, keeping the benefits of minimizing the interference by the multiuser cooperative transmission, it is essential to examine reliable virtualization techniques to avail of multiuser cooperative transmissions. Evolving network slicing strategies can also be examined on the top to facilitate 5G heterogeneous services containing low-latency and ultra-reliable communications, massive machine-type communications, and enhanced mobile broadband.

5.9. Appropriateness in practical situations

It is essential to deploy and segregate the proposed schemes for field tests from the literature to examine their appropriateness in practical situations. Furthermore, ML techniques and aggregation tactics for online learning-based guidelines could be examined for genuine situations for unknown parameters of the network and differ across time. Therefore, it is extracted from the literature that most theoretical studies need to be confirmed practically, so it is a demanding need for future research in real-world measurement-based analysis and developing experimental prototypes.

6. Conclusion

This review paper specifies an organized examination of resource allocation schemes and techniques which are discussed by different researchers. Our review also addresses the problems, policies or algorithms, and improvement in results. Based on several readings studied in this research paper, we investigated those numerous methods that did not take into consideration several essential standards, and boosting the proficiency of the current methods is important. This finding permits researchers to carry out further exploration in the upcoming research to enhance the competence of resource allocation in 5G. 5G is a developing technology that would professionally allocate the re-

sources for enhancing QoS and system accomplishment. Additional work on allocating resources is desirable. Likewise, broad investigation on resource allocation methods disturbing the green optimization of the base station is admired. This survey intends to carry an achievable track for more study in resource allocation for 5G.

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