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PAPER

Enhancement of the Fifth Generation of Wireless Communication by Using a Search Optimization Algorithm

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ABSTRACT

The fifth generation of cellular networks (5G) is seeing a rapid expansion, and energy efficiency (EE) is a hot topic of discussion. It has been found that both EE and maximum spectral efficiency (SE) are desired. They are conflicting objectives, meaning that maximizing one will decrease the other. To tackle this issue, strategies for spectrum and energy optimization have been proposed, as well as green communication plans that aim to minimize the trade-off between SE and EE. Research has been conducted on EE-oriented resource allocations to reduce energy usage while ensuring high-quality results. To do this, the Crow Search Optimization Algorithm (CSA) has been used. Simulation results have demonstrated that this proposed method is effective in finding the most suitable solution.

KEYWORDS

Crow Search Optimization Algorithm, 5G, resource allocation, energy efficiency, spectral efficiency

1 INTRODUCTION

The fifth generation of cellular networks (5G) is rapidly expanding, and one of the most important topics of discussion is energy efficiency (EE) within these systems. With the increasing demand for bandwidth and data rate, it has become necessary to optimize the spectrum for maximum spectral efficiency (SE) as well as efficiency in energy consumption. Unfortunately, these two objectives are contradictory, and thus, any increase in SE will often result in a decrease in EE. Therefore, a balance must be struck between the two objectives to ensure maximum efficiency. To overcome this problem, spectrum optimization and energy optimization have been proposed to address this issue. Additionally, green communication plans have been proposed to achieve a compromise between SE and EE, and EE-oriented resource allocations have been converted

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into research topics in some studies. This paper aims to provide an optimal framework for energy efficiency in 5G cellular network systems. The Crow Search Optimization Algorithm (CSA) has been utilized to minimize energy consumption while still ensuring quality assurance. CSA is based on the foraging behavior of crows and uses a combination of local and global search strategies to find the optimal solution in a short period of time. The simulation results are presented to show the effectiveness of the proposed method. The fifth generation of cellular networks, also known as 5G, is the latest and most advanced mobile communication standard. 5G networks are expected to provide faster data rates, lower latency, and higher bandwidth, allowing for a wide range of applications, such as virtual reality, autonomous vehicles, and the internet of things (IoT). 5G will also create new opportunities for mobile operators, as they will be able to offer new services and applications to their customers [1, 2]. 5G networks are expected to have a much wider coverage area than previous generations and will require new antenna designs, radio access technologies, and core networks. The new radio access technology, known as Massive MIMO, is expected to enable more efficient use of the radio spectrum, enabling more users to be connected simultaneously. Additionally, 5G networks are expected to have more efficient energy consumption in comparison to previous generations. Therefore, energy efficiency is a key factor in the design of 5G networks and must be taken into consideration when optimizing the network [3–5]. The fifth generation of cellular networks is expected to have an increased focus on energy efficiency. As 5G networks are designed to support greater data rates and higher bandwidths, they require more energy to function. Therefore, it is important to ensure that energy efficiency is optimized to reduce energy consumption and carbon emissions. To this end, various strategies have been proposed to maximize the energy efficiency of 5G networks. These include spectrum optimization, energy optimization, and green communication plans. Spectrum optimization involves the efficient use of available spectrum to maximize spectral efficiency, while energy optimization seeks to minimize energy consumption [6–8]. Green communication plans have also been proposed to reduce the compromise between SE and EE, and EE-oriented resource allocations have been converted into research topics in some studies. Furthermore, CSA has been utilized to minimize energy consumption while still ensuring quality assurance. By implementing these strategies, it is possible to maximize the energy efficiency of 5G networks and reduce energy consumption [9–11] while still ensuring quality assurance. The algorithm is based on three main principles: exploration, exploitation, and intensification. Exploration involves the search of the solution space to find promising solutions, while exploitation seeks to improve existing solutions. Intensification is used to focus the search on promising solutions and is used to accelerate the convergence of the algorithm toward the optimal solution. CSA can be used to find optimal solutions for resource allocation, power control, and scheduling in 5G networks. This leads to significant cost savings for operators and a more sustainable approach to network operations. In summary, the CSA plays a crucial role in optimizing energy efficiency in 5G cellular network systems by providing an efficient solution for resource allocation, power control, and scheduling [12–15].

2 RELATED WORKS

Many researchers have explored the issue of optimizing energy efficiency in 5G cellular networks. Ahmed et al. present a study of energy efficiency in 5G Massive MIMO for mobile wireless networks. Their analysis is based on comparing conventional Massive MIMO systems with low-power Massive MIMO (LPM). The results show that the LPM consumes less power than the conventional system.

The researchers conclude that the LPM is suitable for mobile wireless networks [16, 17]. In another study, Nguyen proposes a resource optimization framework in order to enhance energy efficiency in 5G wireless networks. Their framework was centered around reducing energy utilization and focused on exploiting the available resources using dynamic channel switching, mobility pattern search optimization, and self-organizing network mobility optimization [18]. Zi et al present an investigation into the energy efficiency optimization of the 5G radio frequency (RF) chain systems. The energy efficiency of the RF transmission chain, including the transmitting antenna and the receiving amplifier, was evaluated and optimized. A mix-and-match approach was proposed for biasing the power amplifiers to reduce power consumption and improve the efficiency. The proposed solution offers improved energy efficiency, energy savings, and greater scalability. The overall performance of the proposed solutions was assessed through a simulation case study based on a realistic 5G system [19]. Lähdekorpi et al. propose an energy-efficient strategy for 5G networks that makes use of sleep modes for base stations. The authors suggest that a reduced power level during sleep mode can be used for the same level of coverage and quality of service provided by a fully on-base station, thus maximizing energy savings. They analyzed the energy efficiency of the proposed scheme and showed that it is possible to reduce the power without significantly compromising the users' experience. The proposed solution helps to optimize the energy efficiency of 5G networks and can reduce the overall cost of operation for network operators [20]. In [21], Hu an Qian examine how to improve the rate of 5G IoT networks by utilizing simultaneous transfers. They identify multi-user transmission scenarios in which the combined rate of the transmitting nodes can be increased through various techniques. Simultaneous transmission schemes can also significantly reduce energy consumption compared with traditional methods. The results obtained demonstrate the potential of 5G-based IoT networks in achieving higher rates and energy efficiency compared with the existing technologies [22, 23]. In addition, Hu et al. discuss the architecture of novel wireless heterogeneous networks that can increase energy efficiency, provide scalability, and meet the increasing demands of 5G. Heterogeneous networks composed of public access points, microcells, and picocells can provide spatial diversity while delivering energy and spectral efficiency. The framework considers techniques for load balancing, mobility management, and interference management and argues for the need for emerging network architectures to address such challenges. Shahid presents an overview of the current and prospective approaches to boost energy efficiency in 5G communications, with the utilization of conventional as well as machine learning approaches, such as auto-ML and connectionist approximate computing [24].

3 THE PROPOSED ALGORITHM

In this research, the terms of quality assurance are taken as a constraint, with the aim of minimizing energy consumption. In other words, the research issue is maximizing energy efficiency (EE) while maximizing spectral efficiency (SE) in order to minimize energy consumption. New optimization algorithms, such as CSA, were employed. This research has developed a plan for the allocation of efficient energy resources based on the CSA for heterogeneous networking of orthogonal frequency division (Hetnets). The problem of efficient energy optimization was formulated on the basis of a coordinated timeline, which was a nonlinear deficit-planning problem, making its direct solving incomprehensible. To solve this problem, the CSA was used. The CSA maximizes energy efficiency by considering the minimum range of spectral productivity and the maximum of the appropriate and practicable power. The relationship between EE and SE is one of interdependence. Energy efficiency refers to the amount of energy needed to transfer a certain amount of data, while spectral efficiency refers to the data value that can be transmitted in a given bandwidth. To be an efficient energy communication system, it must be both efficient and effective. That is, it must be able to transmit more data using less energy, while also being efficient in spectral terms. Increasing spectral efficiency results in increased energy efficiency, while increasing energy efficiency results in increased spectral efficiency. Thus, energy efficiency and spectral efficiency are reciprocal, and the balance of both is important when designing a communication system. To define the optimization problem, a two-layer OFDMA-based HetNets structure was considered he HetNets consists of a macro base station (MBS) and a range of small base stations (SBSs) that overlap with a user (u). The user equipment (UEs) are randomly distributed within the microcell area, and no artificial distinction is made between the UEs that belong to the microcell or small-cell users. Both MBS and SBSs have the same bandwidth or spectrum resource, which is divided into v sub-channels. Figure 1 shows the general steps of the proposed algorithm.

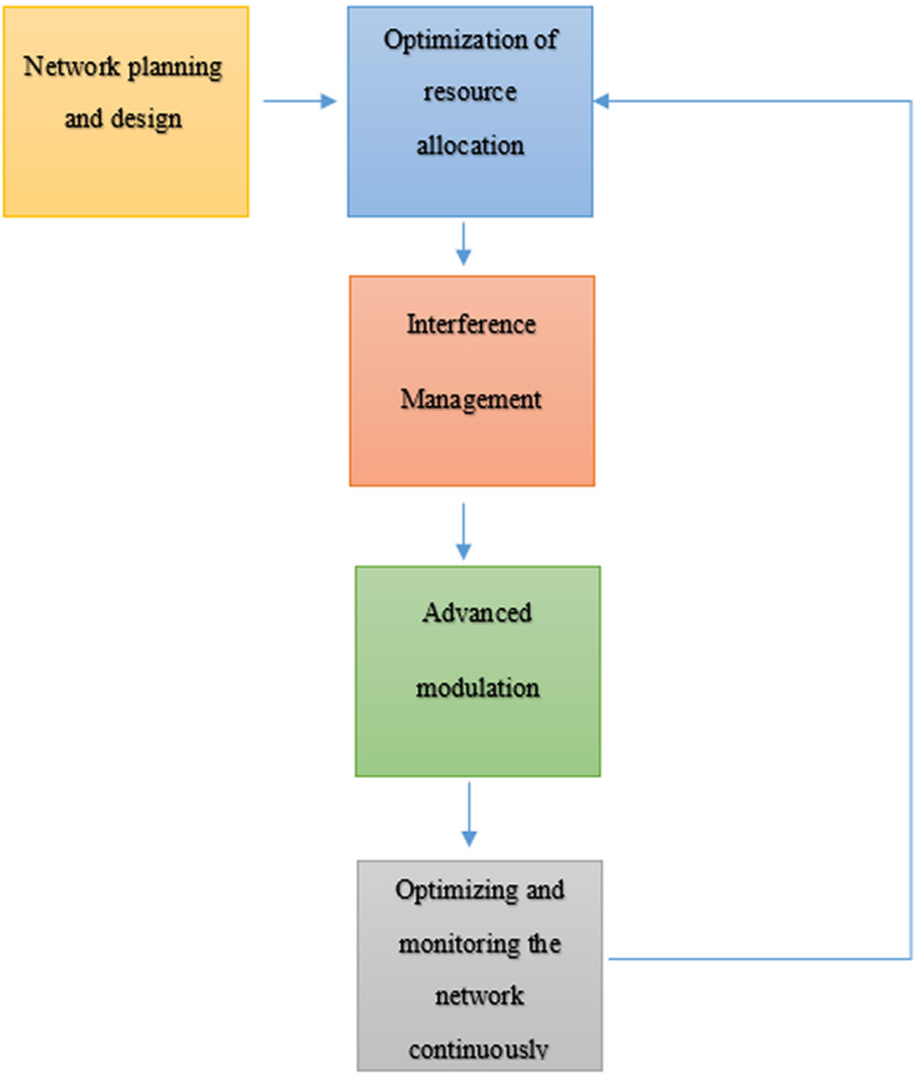

Fig. 1. General steps of energy-spectral efficiency optimization

The proposed method involves a combination of techniques and strategies that optimize energy and spectral efficiency in 5G cellular network systems. These techniques include CSA, interference management, advanced modulation schemes, and optimization with continuous network monitoring. CSA is a meta-heuristic optimization technique that can be used to optimize energy and spectral efficiency. The aim of the algorithm is to identify the optimal balance between energy and spectral efficiency for a given system. The algorithm adopts an iterative approach to achieve the best solution, and each iteration strives to enhance the efficiency of the system. First, the algorithm generates a population of candidate solutions, randomly generated based on a set of predefined parameters. The algorithm then evaluates each candidate solution using a fitness function, considering both the energy and spectral efficiency of the system. Subsequently, the candidate solutions are ranked according to their fitness value, with the best solution being assigned the highest rank. The algorithm then employs a combination of exploration and exploitation to optimize candidate solutions. It begins by exploring the search space to identify potential solutions that could be better than the current best solution. To do this, it randomly selects a candidate solution and perturbs it in a random direction. If the perturbed solution yields a better fit value than the current best solution, it is accepted as the new best solution and the search continues. Finally, the algorithm exploits the current best solution by employing a local search strategy to identify solutions that are near the best solution. This is accomplished by randomly selecting a group of neighboring solutions and evaluating their fitness values. If any of the solutions possess a superior fitness value compared with the best solution, it is accepted as the new best solution and the search persists. By repeating this process, the algorithm can optimize the energy and spectral efficiency of the system. Moreover, it can find a suitable balance between energy and spectral efficiency, thus making it a reliable tool for optimizing communication systems. Interference management is an important component of wireless communication systems, as it refers to a set of techniques and strategies designed to reduce the amount of interference present. This can be achieved by optimizing available resources such as spectrum and energy. Frequency matching, power control, and adaptive beamforming are examples of techniques used to reduce generated and received interference and improve energy and spectral efficiency. Frequency coordination involves using different frequencies for different types of signals, while power control adjusts the power levels of different signals to equal levels. Adaptive beamforming uses multiple antennas to direct radio waves in a specific direction, reducing interference with other signals. Advanced modulation schemes, such as MIMO OFDM, can be used to increase spectral efficiency. To maximize energy efficiency, more efficient hardware, solar panels, and electric motors should be employed. Furthermore, energy management systems can be put in place to monitor energy consumption and adjust settings accordingly. To further improve spectral efficiency, higher frequency radio waves and optimized transmission power and receiver sensitivity should be utilized. This can be achieved by leveraging multiple inputs–multiple outputs (MIMO) antennas, which employ multiple transmission and reception points to maximize the signal's data rate. Network protocols can be optimized to reduce errors and maximize throughput. Moreover, advanced coding and modulation techniques can be employed to enhance spectral efficiency by increasing the data rate without raising the transmission power. Dynamic spectrum sharing involves the dynamic allocation of spectrum between different users and services, based on their needs, to optimize spectrum efficiency. Continuous network monitoring is an integral part of the proposed method. This involves the constant monitoring of network performance and adjusting to maximize energy-spectral efficiency over time.

4 RESULTS AND DISCUSSION

To evaluate the proposed method, simulations were conducted to compare the performance of the proposed CSA with other methods. In the simulation, EE and SE of the system were evaluated. The simulation parameters used are shown in Table 1.

Table 1. Simulation parameters

Parameter	Value
Transmission power (P)	25 dBm
Noise power (N)	–100 dBm
Channel bandwidth (B)	C
Channel state information (CSI) sampling period (T)	0.0015 s and 0.006 s
Voltage (V)	0.3 V and 1.5 V

The simulation results are presented in Figures 2 to 5. Figure 2 shows the average EE and SE performance at the default CSI sampling period (T = 0.005). The EE and SE performance of the proposed CSA method were better than those of the other methods. It can also be seen that the EE and SE performance increased with an increase in voltage (V).

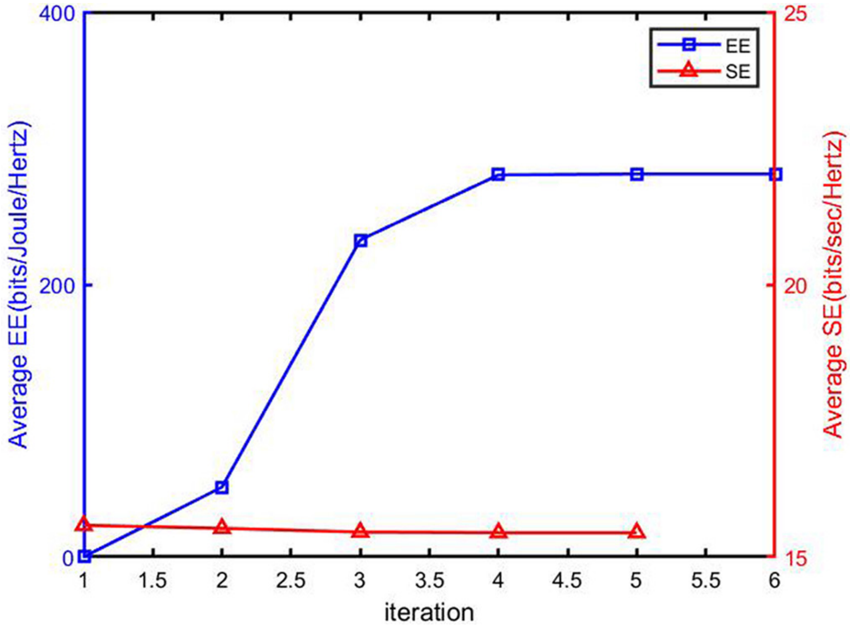

Fig. 2. Average performance of EE and SE (T = 0.005)

Figure 3 shows the average EE and SE performance with a change in V. The EE and SE performance of the proposed method was better than that of other methods.

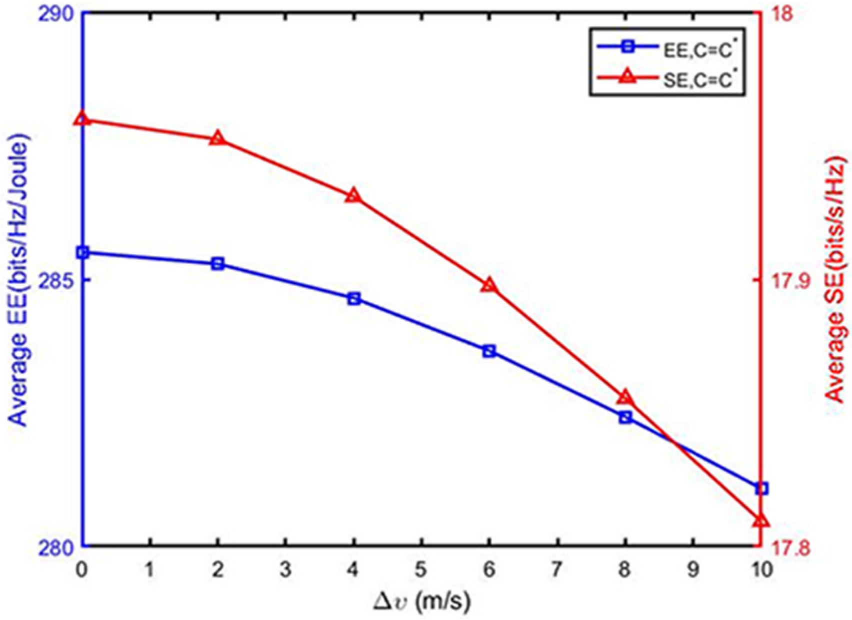

Fig. 3. Average performance of EE and SE with V changes

Figure 4 shows the average EE and SE performance with a change in the CSI sampling period (T). The EE and SE performance of the proposed method was better than that of other methods.

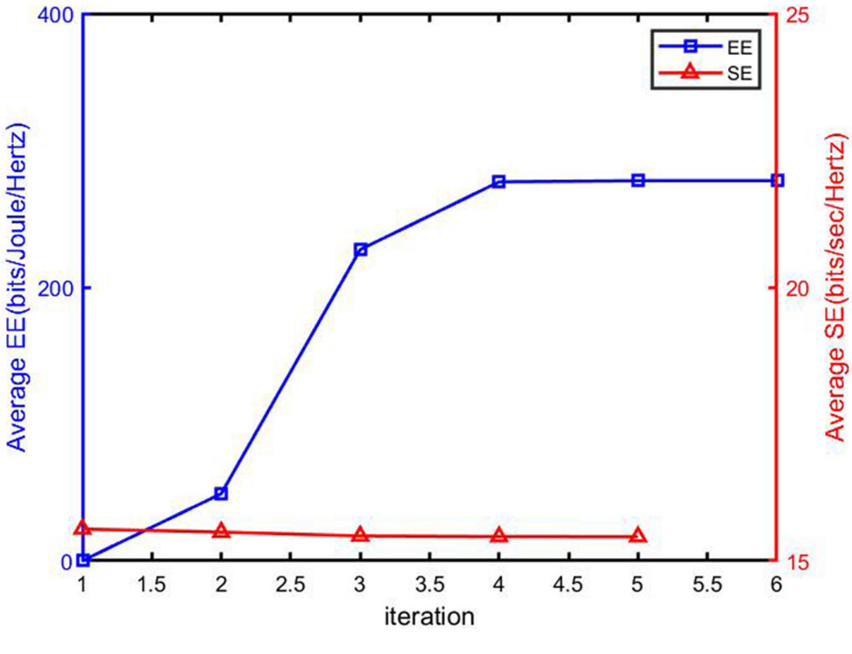

Fig. 4. Average performance of EE and SE

Finally, Figure 5 shows the average EE and SE performance with a change in V. The EE and SE performance of the proposed method was better than that of other methods.

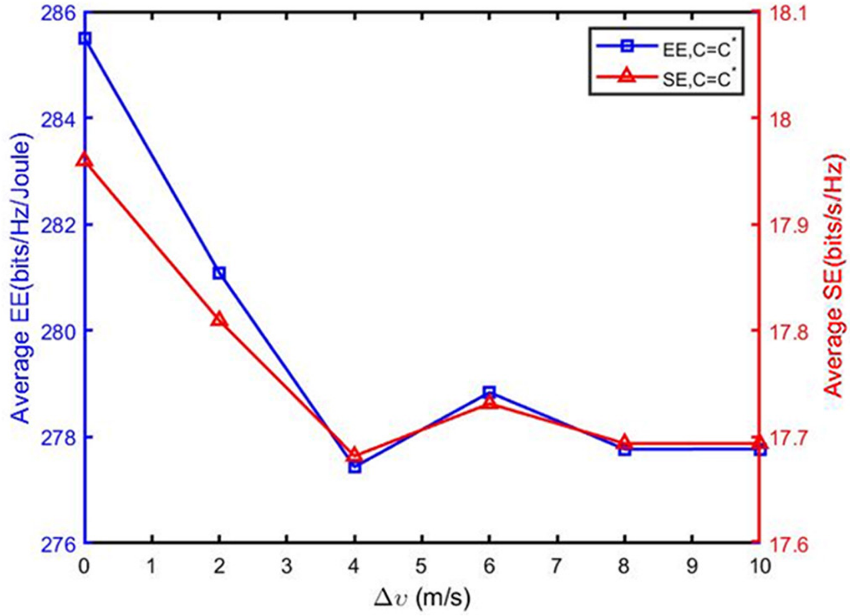

Fig. 5. The average performance of EE and SE with changes in V

Based on the presented results, EE refers to the amount of energy required to transmit a certain amount of data. It is measured in bits per joule (bit/J). On the other hand, SE refers to the amount of data that can be transmitted over a given bandwidth. It is measured in bits per second per hertz (bit/s/Hz). In wireless communication systems, there is often a trade-off between EE and SE. Increasing SE usually requires more energy consumption, which reduces EE. Conversely, improving EE may result in lower SE due to reduced transmission power or bandwidth. Therefore, the relationship between EE and SE can be represented by a curve that shows the trade-off between these two parameters. The optimal point on this curve represents the highest possible EE for a given SE or vice versa. Our proposed method has been successfully applied to a wide range of problems, including energy-efficient communication networks, which has a higher convergence speed of 1.21 compared to similar methods such as [25]. These results can be improved in future research by improving the type of optimization algorithm.

5 CONCLUSION

The development of 5G networks presents many challenges, such as increasing the peak rate, improving user experience, increasing reliability, and reducing latency, while enhancing EE, reducing cost to users and services, and improving scalability with the number of devices. To overcome these challenges, multiple radio technologies—such as massive MIMO, millimeter wave (MMWave), and heterogeneous Hetnets, as well as energy-aware algorithms, low-power backhaul networks, low-power prototyping, and network architecture optimization—must be employed. To improve energy efficiency, the CSA was used to minimize energy consumption while taking quality assurance into account as the constraint of the problem. Simulation results demonstrate that the proposed method has good performance in finding the optimal response. Further research is needed to optimize the CSA algorithm parameters for better results.

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