Research Article

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Research on the application of search algorithm in computer communication network

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Abstract: This article mitigates the challenges of previously reported literature by reducing the operating cost and improving the performance of network. A genetic algorithm-based tabu search methodology is proposed to solve the link capacity and traffic allocation (CFA) problem in a computer communication network. An efficient modern super-heuristic search method is used to influence the fixed cost, delay cost, and variable cost of a link on the total operating cost in the computer communication network are discussed. The article analyses a large number of computer simulation results to verify the effectiveness of the tabu search algorithm for CFA problems and also improves the quality of solutions significantly compared with traditional Lagrange relaxation and subgradient optimization algorithms. The experimental results show that with the increase of the weighted coefficient of variable cost, the proportion of variable cost in the total cost increases from 10 to 35%. The growth is relatively slow, and the fixed cost is still the main component. In addition, due to the increase in the variable cost, the tabu search algorithm will also choose the link with large luxury to reduce the variable cost, which makes the fixed cost slightly increase, while the network delay cost and average delay slightly decrease. The proposed method, when compared with the genetic algorithm, has more advantages for large-scale or heavy-load networks.

Keywords: search algorithm, harmony search algorithm, communication network, network optimization

1 Introduction

With the development of information technology, computer communication networks have been widely used in various fields. When designing and optimizing computer communication networks, link capacity allocation and message routing (i.e., link traffic distribution) are important issues that need to be considered [1]. Reasonably to solve the problem of capacity and flow distribution (CFA) in computer communication networks (Figure 1), it is of great significance for reducing network operating costs, reducing the average delay of the network, and improving the cost–performance ratio of the network [2]. With the rapid development of mobile communications, competition among operators has become increasingly fierce, and the pace of network construction is quite fast, so that part of the network is put into operation without

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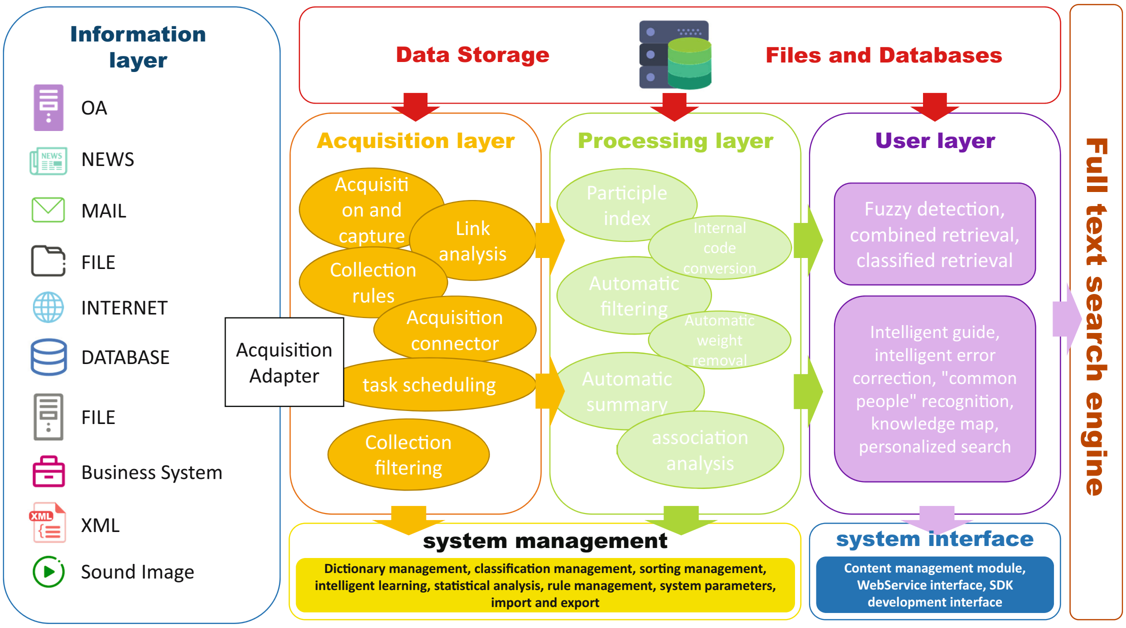

Figure 1: Capacity and flow distribution in the computer communication network.

adjustment; this causes some waste of resources or insufficient resource allocation, which affects the quality of the user's call. However, in mobile communication networks, the most important resource is the frequency resource. At present, the limited frequency resources are becoming tenser; therefore, the rational use of spectrum resources affects the development of mobile communications [3].

In recent years, there is a continuous advancement in the IT sector with significant expansion in networking. There have been a large number of software as well as applications that play different roles in this domain [4,5]. Such applications are specifically data-driven, and the users are able to generate big data by using these applications. There is a rapid growth of data which is to be detected effectively [6].

The state-of-the-artwork in the field of data optimization has several shortcomings, like increased operational cost and reduced network performance. This article is highly motivated to mitigate these challenges by reducing the operating cost and improve the performance of the network. An efficient modern super-heuristic search genetic algorithm-based tabu search methodology solves the link CFA problem in a computer communication network that influences the fixed cost, delay cost, and variable cost of link on total operating cost. This work saves costs and improves profits, and it was decided to optimize the existing GSM network. The data of the computer communication network is analyzed, and the frequency resources are allocated reasonably according to the analysis results. The optimal carrier frequency allocation scheme can improve the utilization rate of wireless channels, save money, increase profits, and obtain the best benefits. A reasonable carrier frequency allocation scheme is of great significance to the optimization of the network. The design and optimization of computer communication networks and a large number of other nonlinear combinatorial optimization problems provide a new idea and method. In the planning, design, performance optimization, and evaluation of computer communication networks and other networks such as telecommunications, power, and transportation. It has important theoretical and practical value and broad application prospects. The article observes a large number of computer simulation results to verify the effectiveness of the tabu search algorithm for CFA.

2 Literature review

Peker et al. used the traditional Lagrangian relaxation and sub-gradient optimization algorithm to study the CFA problem [7]. Ma et al. made improvements to this algorithm [8]. However, Tanaka et al. believed that, in essence, the optimization of the CFA problem is a non-linear programming problem with multiple constraints; it belongs to the complete category of NP in combinatorial optimization using traditional mathematical optimization methods; the solution process is relatively complicated; and the quality of the solution is not ideal, which can no longer meet the needs of actual engineering [9]. In recent years, modern hyper-heuristic algorithms represented by simulated annealing, genetic algorithm, tabu search, and artificial neural network have been extensively researched and applied. He et al. used genetic algorithms to solve CFA problems and proved the feasibility of genetic algorithms, and a more satisfactory result was obtained [10]. Wei et al. believed that cellular mobile communication adopts frequency reuse technology, and the frequency utilization rate has been improved, the system capacity has been increased, and the network has realized handover and roaming functions; the scope of customer service has also expanded [11]. Therefore, Zhou et al. established a public system in order to allow mobile phones to be used uniformly [12]. Xu et al. proposed the concept of tabu search for the first time and then formed a complete set of algorithms; in recent years, it has been greatly developed and received much attention [13]. Changming et al. considered the tabu search algorithm to be a restrictive local search technique. Its basic idea is to record the local optimal points that have been reached through a taboo table, and in the next search, use the information in the taboo table to no longer or selectively search for these points in order to avoid the local optimal solution [14]. The current GSM network also introduces the General Packet Radio Service (GPRS), which is a brand-new data transmission service based on the existing (Group Special Mobile, GSM) network. Some devices have been added to the network, such as service GPRS support nodes and gateway GPRS support nodes, which can realize FTP file transfer, web browsing, and other services. With the rapid development of GPRS services, the existing transmission rate cannot meet the needs of services, so EDGE technology has also been introduced. The introduction of EDGE technology does not change the structure of the entire GSM network. This technology adopts a new modulation technology to make the data transmission rate faster.

Tabu search algorithm, an efficient modern super-heuristic search method, is used for the first time to solve the link CFA problem in the computer communication network. Then, the influence of fixed cost, delay cost, and variable cost of the link on the total operating cost in the computer communication network is discussed. Finally, a large number of computer simulation results not only verify the effectiveness of the tabu search algorithm for CFA problems but also improve the quality of solutions significantly compared with traditional Lagrange relaxation and subgradient optimization algorithms. This paper not only provides new ideas and methods for the design and optimization of computer communication networks, but also provides new ideas and methods for the planning, design, performance optimization and evaluation of telecommunications, power, transportation and other networks. It has important theoretical and practical value and broad application prospects.

3 Materials and methods

This section provides the description of the network communication optimization approach in search algorithms.

3.1 Network communication optimization in search algorithms

Network optimization refers to the investigation and analysis of network data after the existing network is officially put into operation, and then the network is reasonably adjusted according to the analysis results. Through the collection of traffic data of the base station, voice test, drive test, carrier frequency planning of the cell, etc., to investigate. Then it carry out statistics, analysis and summarization on the acquired data. This work finds out the problem that affects the quality of the network and works out the corresponding network adjustment plan. Then adjust the parameters of the base station and switching network according to the plan. The ultimate goal is to make the operation of the network reach the best state, so that the existing network resources can be better and fully utilized, and the best benefits can be obtained [15]. Traditional network construction ideas are divided into three stages: planning, engineering construction, and maintenance; the most important part of maintenance is network optimization, and it is the work carried out on the basis of daily maintenance. It is different from planning and engineering construction, but it is closely connected with planning and engineering construction. Network optimization is a very complex and recurring task. All expansions and network adjustments since the network was successfully constructed and put into operation, all are part of network optimization. With the expansion of the network scale and the increase in the number of users, the construction of indoor stations and the introduction of micro-cell technology, the task of network optimization is even more arduous [16].

The main process of network optimization is to conduct system investigation, data collection and analysis, formulate an optimization plan, and implement an optimization plan, and the process is shown in Figure 2.

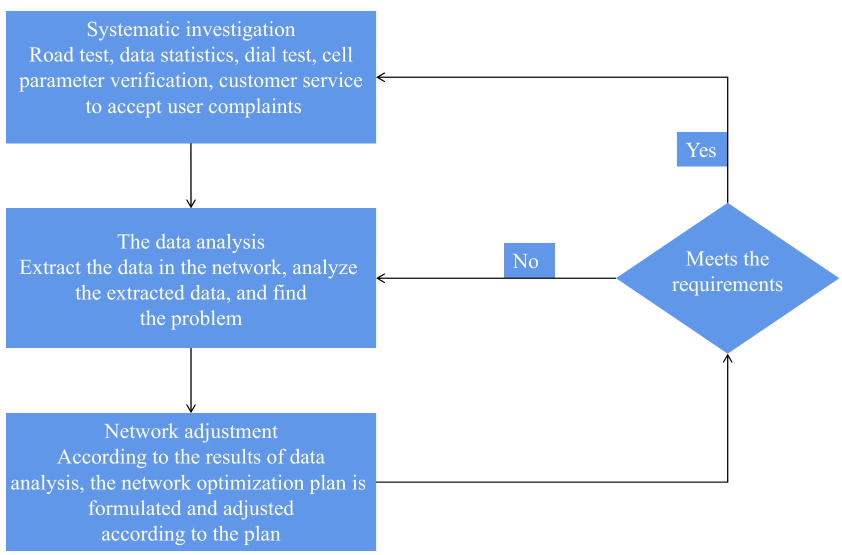

Figure 2: Network optimization process.

In the mobile communication network, an index to judge the quality of a network mainly include connection rate, channel utilization, drop rate, congestion rate, traffic volume, carrier frequency configuration number, traffic volume per line, etc.; these are the key points of data collection for traffic statistics [17]. Taboo table plays a very important role in taboo search. A long T_{max} queue, as shown in Figure 3, is used to represent a taboo table.

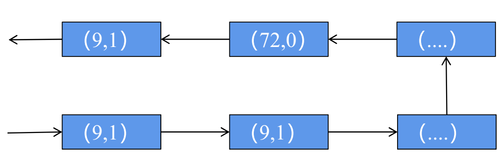

Figure 3: The structure of the taboo table.

1. OMC data collection

   Collect relevant data about BSS and NSS in OMC, such as the number of base stations, system messages, neighbor cell configuration, power control, and other data.
2. Other data collection

   If you want to fully understand a network, in addition to collecting the above-mentioned data, it also requires mobile phone calls to test, drive test, antenna data, and customer service to accept customer complaints. Combining all the data can make a comprehensive analysis of the status of the network.

3.2 Search algorithm

The basic harmony search algorithm is continuous, however, for a typical combinatorial optimization problem such as channel allocation is a discrete space [18]; therefore, it is necessary to use the harmony search algorithm to allocate the channels, and the harmony search algorithm must be discretized. Among them, the harmonic generation operation in the discrete domain is shown in formula (1):

$$X' = \mathrm{HMCR} \otimes (gX^1, X^2, \cdots X^n), X^n), \tag{1}$$

where X' stands for the temporary solution, $h(x)$ represents a new individual generated by exchanging information between two harmony variables, and g means that all the solutions in the harmony memory bank interact to produce a new harmony.

In the discrete domain, the harmonic disturbance operation is performed according to equation (2):

$$X' = \mathrm{PAR} \otimes F(X^m) = \begin{Bmatrix} F(X^m) & \text{if } (r < \mathrm{PAR}) \\ X^m & \text{otherwise} \end{Bmatrix}. \tag{2}$$

Among them, the function $F(X')$ represents the perturbation operation of the individual independent variable.

Because the basic harmony algorithm has unstable convergence, and it is easy to fall into the defect of local optimal solution, in order to improve the stability of the searched global optimization solution [19], at the same time, the robustness and universality of the algorithm are enhanced, and the following improvements are made to the discrete harmony search algorithm:

Dynamically adjust HMCR and PAR according to formulas (3) and (4).

$$\mathrm{HMCR} = \mathrm{HMCR}_{\min} + \frac{\mathrm{HMCR}_{\max} - \mathrm{HMCR}_{\min}}{\mathrm{NI}} \times n, \tag{3}$$

$$\mathrm{PAR} = \mathrm{PAR}_{\max} - \frac{\mathrm{PAR}_{\max} - \mathrm{PAR}_{\min}}{\mathrm{NI}} \times n. \tag{4}$$

The steps for applying the improved harmony search algorithm to the frequency allocation problem are as follows:

(1) Initialize the parameters, set the size HMS of the harmony library, the number of iterations Ite, the maximum $\mathrm{HMCR}_{\max}$ and minimum $\mathrm{HMCR}_{\min}$ of the retention probability of harmony memory, the maximum value $\mathrm{PAR}_{\max}$ and minimum value $\mathrm{PAR}_{\min}$ of the syllable adjustment probability.

(2) Initialize the population, calculate fitness according to the objective function, if the calculation result is 0, exit and output the result. Otherwise step 3 will be executed.

(3) Use the three rules of HMCR, PAR and random selection to generate each harmony variable.

(4) Calculate the fitness value again. If the calculation result is 0, exit the algorithm and output the result. Otherwise, repeat step (3).

(5) The algorithm ends when the conditions for the end of the algorithm are met.

4 Computer simulation experiment results and discussion

4.1 Computer simulation experiment

For the sake of comparison, the experimental objects adopt ARPA net and RING net, the number on the link is the length in km, and the number in the box represents the node number [20]. The ARPA network has 21 nodes (420 communication node pairs), 26 links, and the communication volume between each node pair is 4 packets/s; The RING network has a total of 32 nodes (992 communication node pairs), there are 60 links, and the communication volume between each node pair is 1 min/s and 4 packets/s, respectively. The candidate routes between each pair of nodes are selected as five, which are generated in advance by the route generation program, and numbered from 0 to 4 according to the path length. Table 1 shows the candidate link capacity and its cost.

Table 1: Link capacity and its cost

Link capacity (bps)	Fixed cost (yuan)	Distance cost (yuan km^{-1})	Traffic cost (yuan bps^{-1})
4,800	650	0.4	0.360
9,600	750	0.5	0.252
19,200	850	2.1	0.126
50,000	850	2.1	0.030
10,800	2,400	4.2	0.020
232,000	1,300	21	0.017
460,000	1,300	60	0.023

4.2 Analysis of simulation results

Table 2 shows the different packet lengths, experimental results of computer simulation with network operating expenses. Among them, D = 2,000 yuan/(month group), $G = V = 1$. The network delay cost and the total network cost obtained by the author's method are both small, that is, the performance–price ratio of the entire network is higher; especially in the RING network [21], the total network cost is reduced by 60%. Comparing the results, in the ARPA network, the result of the author's method is similar to the optimization result of genetic algorithm; and in the RING network, the network delay cost and the total network cost are both small, and the total network cost is reduced by 5%. It can also be seen from the table that the algorithm is more superior to large-scale or heavy-loaded networks.

Table 2: Experimental results of computer simulation under different packet lengths

Network type	Packet length/bit	Total network cost	Fixed costs	Delay fee	Variable cost
ARPA	200	180,920	36,184	113,900	30,756
	300	234,638	49,274	140,783	44,851
	400	308,129	71,785	184,674	51,199
	500	341,427	75,900	204,084	63,443
RING	300	211,976	44,807	232,268	27,842
	400	248,614	57,585	156,429	34,600
	500	280,602	53,695	186,975	39,632
	600	306,929	56,494	205,034	43,642

Figure 4 shows that when the units are grouped in the RING network, the impact of the change in the weighting coefficient of the delay cost on the various operating costs of the network, the average packet length is 400 bits, and $G = V = 1$. As can be seen from Figure 4, with the increase of the weighting coefficient

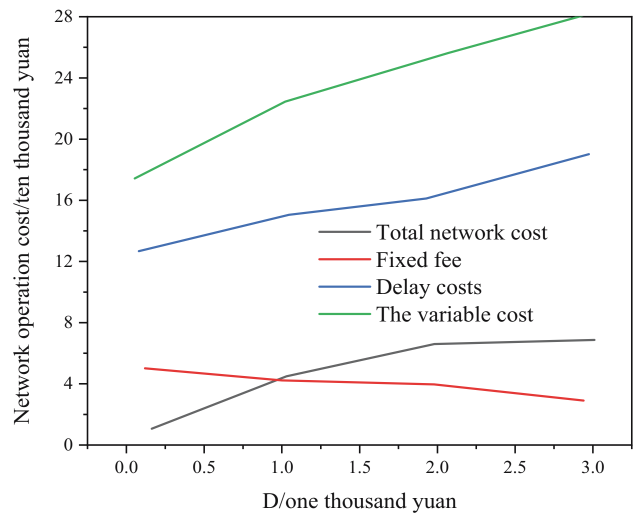

Figure 4: Computer simulation results of the weighting coefficients of different unit grouping delay costs.

of the unit grouping delay cost, the total network cost, delay cost, and fixed cost are also increasing [22]. When the weighting coefficient is very low (such as 0), it means that the packet delay, that is, the real-time performance of the network is not important; therefore, in the optimization process, the tabu search algorithm will select a link with a smaller capacity, in order to reduce the fixed cost of the link, the average delay of the network is very high. When the weighting coefficient increases, too high delay will increase the delay cost; at this time, the algorithm will select a large-capacity link, in order to reduce the increasing network cost due to the increase of delay cost [23–25]. At the same time, due to the increase in link capacity, the fixed cost will increase, the average delay of the network will continue to drop, and the real-time performance of the network will be improved. In the process of increasing the weighting coefficient of the unit grouping delay cost, the proportion of latency costs to the total network costs continues to increase, increase from 0 to about 20%; fixed link costs still account for the main share, but its proportion dropped slightly from 75 to about 65%. The variable cost has not changed very much, but due to the gradual increase in link capacity, through route optimization, the traffic of the link is reduced, and the variable cost is also slightly reduced.

Figure 5 shows the changes in the weighting coefficient of fixed costs in the RING network, the impact on network costs. Among them, D = 2,000 yuan/(month group), the average packet length is 400 bits, and

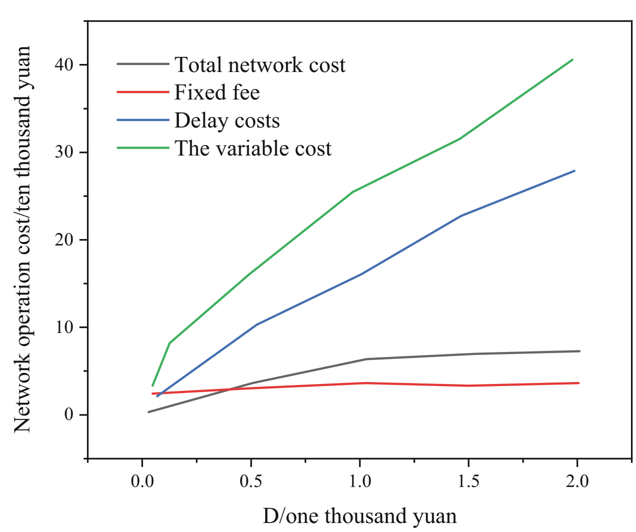

Figure 5: Computer simulation results of different weighted coefficients of fixed costs.

$V = 1$. As can be seen from Figure 5, the fixed cost weighting coefficient has a great influence on the total network cost. When this weighting coefficient is very low, the delay cost accounts for a considerable proportion of the total cost, in order to reduce the total cost in the optimization process, the tabu search algorithm, tend to choose large-capacity links to reduce network delay costs, this also reduces the average delay of the network, real-time performance is improved. When this weighting factor increases, the fixed cost of the link continues to rise, the proportion is gradually increasing, in order to reduce the total cost, the algorithm can only select links with small capacity, by reducing the fixed cost, the total cost is reduced, but at the same time, the average delay increases and the real-time performance of the network deteriorates. At the same time, the reduction of link capacity will lead to an increase in the traffic cost coefficient. At this time, the traffic volume in the link will increase relatively, and the variable cost has a slight upward trend, but the change is not significant. This shows that the routing strategy is not greatly affected by the weighted coefficient of the fixed cost. With the increase in the weighting coefficient of fixed costs, the proportion of fixed costs in the total network costs is increasing, the proportion of delay costs is gradually decreasing, and the proportion of variable costs has declined. In these two networks, when the fixed cost weighting coefficient is 0.1, delay fees, fixed fees, and variable fees account for 23, 35, and 42% of the total cost, respectively, when the coefficient increases to 2.0, its proportions are about 19, 70, and 11%, respectively.

Figure 6 shows the RING network, the impact of the change of the variable cost weighting coefficient on various network costs, where $D = 2{,}000$ yuan/(month group), the average packet length is 400 bits, $V = 1$. As can be seen from Figure 6, with the increase of the variable cost weighting coefficient, the proportion of variable cost in the total cost has increased from 10% to about 35%, the growth is relatively slow, fixed costs are still the main component. In addition, due to the increase in the proportion of variable costs, the tabu search algorithm will also choose a larger amount of extravagant links to reduce the variable cost, which makes the fixed cost slightly increase; the delay cost and average delay of the network showed a slight downward trend. However, in general, the change of the weighting coefficient does not have a great impact on the delay cost, fixed cost, and average delay, increasing this coefficient will not cause the redistribution of the entire network traffic, that is, the routing strategy will not undergo major adjustments. Obviously, the variable cost in Figure 6 has a roughly linear growth relationship with its weighting coefficient, while the growth of the total network cost is basically due to the increase in variable costs.

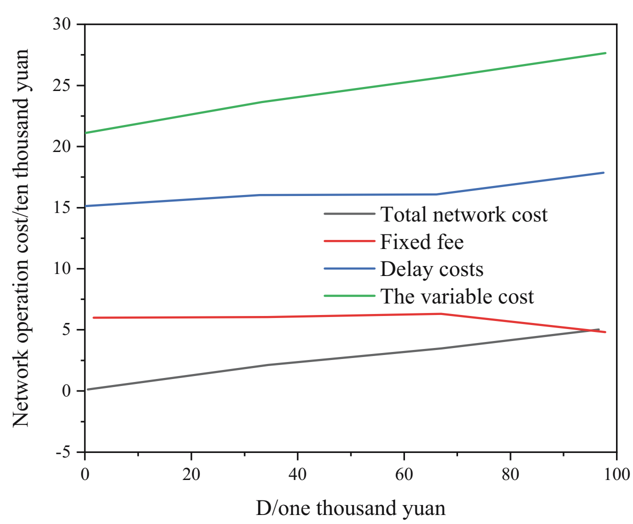

Figure 6: Computer simulation results of different variable cost weighting coefficients.

5 Conclusion

This article proposes an efficient modern super-heuristic search method which is used for the first time to solve the link CFA problem in the computer communication network. The influence of fixed cost, delay cost, and variable cost of link on total operating cost in computer communication network is discussed. This article uses a large number of computer simulation results not only to verify the effectiveness of the tabu search algorithm for CFA problems but also to improve the quality of solutions significantly compared with traditional Lagrange relaxation and subgradient optimization algorithms. The design and optimization of computer communication networks and a large number of other nonlinear combinatorial optimization problems provide a new idea and method. Moreover, in the planning, design, performance optimization, and evaluation of computer communication networks and other networks such as telecommunications, power, and transportation, it has important theoretical and practical value and broad application prospects.

This paper has successfully improved the artificial fish swarm algorithm and the harmony search algorithm and applied it to the problem of frequency allocation and achieved good results. However, as a new algorithm, it is not very mature, so its development will take a long time, and there is still a lot of room for improvement. Based on the previous experimental results, the following conclusions are drawn:

(1) The two improved algorithms proposed in this paper are used in the problem of frequency allocation and have strong solving ability.
(2) However, the future scope of this article lies in the development of an optimized approach, which further provide improved network performance, and there is still a lot of room for development.

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Informed consent: Informed consent was obtained from all individuals included in this study.

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