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HYBRID SWARM OPTIMIZATION OF DEVICE-TO-DEVICE RESOURCE AND POWER ALLOCATION USING MULTI-OBJECTIVE PARTICLE SWARM OPTIMIZATION

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Abstract

The rapid growth of users in cellular networks influences resource allocation and degrades the efficiency of cellular communication. Device-to-device communication is an emerging communication model for wireless communication without interfering with the resources of cellular networks, which provide direct communication to secondary users. Device-to-device communication explores the potential of the cellular network for emerging communication systems such as the Internet of Things and edge computing. In device-to-device communication, the major bottleneck problem is the management of resources and interference. The management of resources in device-to-device communication applied various optimization algorithms. Recently, several authors proposed swarm intelligence optimization of resources in communication systems. This paper proposes a novel resource optimization method based on particle swarm optimization. The proposed algorithm applies the multi-objective constraints function for the selection of resources in communication mode. The proposed MOPSO algorithm simulates and tests standard parameters in MATLAB environments. The performance of the proposed algorithm compares with existing resource allocation and optimization algorithms such as the genetic algorithm, ant colony optimization, and particle swarm optimization. The analysis of the results suggests that the proposed algorithm is better than existing algorithms for optimization.

Keywords: - Wireless communication, D2D, Resource allocation, Optimization, Swarm intelligence

Introduction

The increasing rate of wireless network traffic increases network overhead and decreases the efficiency and resource capacity of cellular networks. The emerging technology of communication systems offers high-speed data and reliable communication. the high-speed data and reliability of communication achieved by device-to-device communication [1-5]. Device-to-device communication allows for direct communication without interfering with cellular network base stations. through the D2D network effectively frequently involves solving difficult radio resource management (RRM) issues, including choosing between shared and dedicated modes, managing interference to and from CUEs (cellular user equipment), allocating channels, and managing power, to name a few. Traditional algorithms for the

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aforementioned RRM issues in D2D networks presuppose an earlier prediction of the D2D channel gains. When only a portion of the distributed D2D channel gains is required, the full knowledge can be reduced to a partial knowledge on occasion [6-10]. However, even a limited understanding of the D2D channel gains entails a significant cost in the form of an additional signalling overhead on top of the one created by traditional cellular communications. In fact, since they are required for handover as well as user attachment, authorization, and traditional cellular communication purposes, cellular channel gains—i.e., channel gains between the UEs and the BSs—are frequently estimated by default. More specifically, the network must recognise even users who want to engage in D2D communications, and as a result, their cellular channel gains must be initially estimated. As a result, the BSs receive periodic reports about these cellular channels, which can be used with no additional overhead signalling. Data routing over various D2D relay nodes and achieving maximum throughput while ensuring minimal interference with the main network are additional challenges posed by D2D communications. Therefore, multi-hop routing is preferred between D2D nodes because it can offer higher data rates than single-hop direct communication [11-15]. The primary areas of D2D communication that the researchers focus on are interference and coverage, scheduling, resource allocation, and channel modelling. There have been a number of reported efforts despite the fact that D2D communications require multiple computing in resource allocation. The PSO algorithm was used in [10] to examine the channel allocation issues in situations where only two D2D pairs and one CUE could share a single frequency resource. To solve the joint channel and power allocation problem, [16,17,18] used the quantum particle swarm optimization (QPSO) algorithm. However, it placed restrictions on how many D2D pairs and CUEs could share a single subcarrier. However, the primary goal of their work is to increase total network throughput, which is the total throughput of all network users, including cellular and D2D users. In [8], a modified version of the PSO algorithm is put forth, in which the two GA operators are used to update the particle position. The crossover and mutation operators can increase generational diversity and prevent the swarm from convergent too soon. A multi-population genetic algorithm is used in [19] to solve the resource allocation problem for D2D communications in a multi-services scenario. In this paper, we propose a multi-objective particle swarm optimization algorithm for resource optimization. The multi-objective particle swarm optimization reduces the power allocation in the same channel of the spectrum. For the PSO algorithm's goal of resource encoding, the binary genetic algorithm is used. The proposed MOPSO algorithm investigates interference allocation as well as interference mitigation in cellular user equipment and user equipment. The remainder of the article is organised as follows: Section II contains related work; Section III contains proposed methodology; Section IV contains simulation of the proposed algorithm; and Section V contains conclusion and future work.

II. Related work

The advancement of intelligent algorithms improves the performance of D2D communication systems. Recently, several authors proposed swarm intelligence-based

resource optimization algorithms to minimise the impact of interference and maximise the utilisation of energy. Some major contributions by authors are described here. The author [1] investigate the D2D network performance, the technique employs the Rician model for the Line-of-Sight (LoS) component. When compared to other traditional methods, the algorithm improved throughput by 18.85 percent and energy efficiency by 10%, with a 19 percent reduction in network delay. The performance of the system is also evaluated in terms of traffic load, outage likelihood, and network sum rate. The author [2] propose an incentive mechanism for the distributed caching system, a Blockchain-based Cache and Delivery Market (CDM) is presented. Both D2D and MEC caching nodes' readiness to share caches is ensured by satisfying their expected return under the supplied incentive mechanisms. The proposed systems outperform standard solutions in terms of traffic offloading, content retrieval delay, and consensus latency, according to simulation results. The author [3] examine the trade-offs between scenario requirements and current semiconductor technology limitations in order to develop a technology roadmap for D-band wireless connectivity's next generation. The author [4] proposes the suggested method employs Belief Desire Intention (BDI) intelligent agents with extended capabilities (BDIx) to control each D2D node independently and autonomously, without the assistance of the base station. To demonstrate the aforementioned, this paper introduces the DAIS algorithm for determining transmission mode in D2D networks, which maximizes data rate while minimizing network power consumption while accounting for computational burden. Simulations suggest that BDI agents can be used to solve D2D problems. The author [5] used to improve the caching performance of D2D enabled wireless content caching networks objectively. The convergence performance of our proposed joint decision method, as well as its cache efficiency gains, are demonstrated by Monte-Carlo simulation results when compared to extensive benchmarks. The author [6] facilitate the cohabitation of rate-guaranteed cellular users with huge IoT devices, look into the multi-operator dynamic spectrum sharing challenge. Extensive numerical simulations show that the WSP and MNO payoffs are maximized and that the SE solution can be found. Meanwhile, when compared to the existing no-sharing approach, the suggested multi-operator dynamic spectrum sharing algorithm can support over 40% more IoT devices, and the gap is less than 10% when compared to the exhaustive technique. The author [7] propose a suitable access network based on quality-of-service needs, a two-stage fuzzy-logic-based VHO choice algorithm is proposed. Along with RSS, quality factors such as data rate and latency are provided as fuzzy inputs. The destination network's resource availability is also checked, which makes the decision more intelligent. The results of the simulations reveal that the suggested scheme outperforms traditional multi-attribute decision-making techniques. The author [8] proposes a virtual mesh networking system to facilitate multi-hop D2D communications in 5G networks. Routing and packet forwarding are split into two different systems in the control plane and the user plane, respectively, based on the 5G network architecture. The usefulness of multi-hop D2D communications using virtual mesh networking is demonstrated by the performance results. The author [9] seeks to reduce interference for better signal reception in D2D communication and to boost system throughput. As a result, a power control technique for the uplink channel in the mm-Wave spectrum is proposed in underlay mode. To demonstrate the suggested method's adequate performance, a detailed comparison of FI for the proposed scheme is made with other current approaches. The author [10] offers an adaptive resource block (RB) allocation mechanism in a trisected cell of the 5G WCN for adequate RB availability to every D2D pair. In 5G networks with high user density, cell sectoring effectively manages interference. Simulations have been used to verify the efficacy of the suggested adaptive strategy. The suggested method is a critical component of 5G WCN green communication. The author [11] Review of existing channel and power allocation approaches, as well as mathematical resource optimization solution techniques are presented. In addition, the paper analyses the obstacles of implementing an effective allocation strategy in mm wave D2D communication, as well as open research questions for further investigation. The author [12] presents a network-coding-based video distribution system For the D2D communication context. The findings of both simulations and actual experiments demonstrate that adopting network coding technology in video transmission can increase the quality of the video received. In our experiments, the successful decoding rate of the suggested technique is 46 percent higher than that of the standard scheme. The author [13] using the information provided by the estimated cellular channels between users and neighbouring BSs, which are estimated anyhow for the network's normal operation. The genuine and expected D2D channel gains demonstrate a high degree of convergence in our results. During the offline training, we also demonstrate the robustness of the proposed system against changes in the environment and inaccuracies. The author [14] device-to-device (D2D) communication is quickly becoming a feasible mode of information sharing. It has an extremely low end-to-end latency and can boost a cellular network's spectral efficiency in a cellular network. This will offer D2D technologies a boost in terms of development and acceptance by mobile operators. The key aspects of D2D communication as defined in Release 12 and subsequent releases of 3GPP specifications are discussed and critically analysed in this work. The author [15] propose With regard to mode selection, power control, and resource allocation, concentrate on approaches for dealing with these difficulties. We explore these difficulties in light of some of the most recent research trends, as opposed to other recent books on the subject. In addition, we identify and categories some of the major obstacles of D2D communication in terms of existing and future cellular technology. The author [16] conduct the perspectives of power consumption and transmission performance, a comparison of the three D2D communication protocols is conducted. According to test results, BT uses the least amount of energy. As a result, when considering throughput and power consumption together, WFH is approximately equal to WFD. Using the 2.4 GHz spectrum as an example, the TCP throughput/power for each of them is 4.63 KB/mWs at the transmitter, and 6 KB/mWs at the receiver. The author [17] propose Various resource allocation algorithms and approaches have been thoroughly examined and assessed based on the degree of Base Station engagement in order to identify the research gap and give a solid theoretical foundation for resource allocation challenges in D2D communication. The author [18] evaluated latest D2D research, which focuses mostly on resource allocation, power consumption, and security, as well as the primary problems. In this article, the function of D2D communication technologies in healthcare is examined. The author [19] propose ML techniques may be used to improve the performance of D2D networks over using traditional methods after analysing existing D2D research directions and their existing conventional solutions. The increased potency of applying ML solutions over non-ML based ways for greatly enhancing the average throughput performance of mm Wave NDS will be highlighted in this case study. The author [20] propose the resource allocation for RIS-enabled D2D communication beneath a cellular network, in which a RIS is used to enhance desirable signals and minimize interference between paired D2D and cellular links, is investigated. When compared to standard underlay D2D networks without RIS, relay-assisted D2D networks, and other benchmarks, numerical findings show that the proposed design achieves considerable SE and EE improvements. The author [21] considers the D2D and UDN aspects in order to collaborate afterwards. Factors like as traffic congestion, idle mode capability, power consumption, and energy efficiency should all be considered when deploying big tiny cells. Basically, based on the identified potential issues, it is clear that the integration of D2D and UDN is a significant facilitator for a potential solution. Finally, the obstacles and open problems that have been described can be used to identify research gaps between UDN and D2D integration. The author [22] as a kind of direct connection between two mobile users that does not require the usage of a base station D2D communication is becoming more prevalent, as it improves communication capability while lowering communication delay and power usage. D2D communication is being considered as an emerging technology of the next generation networks in order to meet escalating subscriber expectations and supply them with satisfactory services. The author [23] proposes a resource allocation technique based on the selection of D2D connection modes To begin, divide D2D users into groups based on their geographic distribution. Users are then given modes based on the priority order of their communication needs, and resource allocation is optimized by comparing the signal-to-noise ratio in orthogonal mode, multiplex mode, and cellular mode. The author [24] proposes a resource allocation technique that solves the resource allocation problem by optimizing the utility function, which reflects system performance in terms of network throughput. Our simulation findings show that the suggested technique can achieve near-optimal performance and beats existing algorithms in terms of throughput. The author [25] create a distributed spectrum and energy efficient resource allocation algorithm by minimizing interferences and power consumption, based on a mathematical model for our problem as a mixed strategy non cooperative game. As a result, not only for D2D communicating couples, but also for other cellular network connections, performance is maximized. Finally, we examine and compare our simulation findings, as well as other system factors, to past solutions.

II. Proposed Methodology

The proposed resouce optimization and allocation employed in downlink transmission of a D2D communication underlying an cellular network in a single cell. There are N subchaanels and several active cellular users and D2D pairs. The proposed approach applies on pairing of D2D communication reuse frequency resouce of CUE. The system model of D2D communication have thre pairs of D2D. the resouce allocated to CUE-1 can be shared with pair1 and pair2 or paor2 and pair3. Pair2 sharing the same frequency resouces with pair1 is better than sharing with pair3

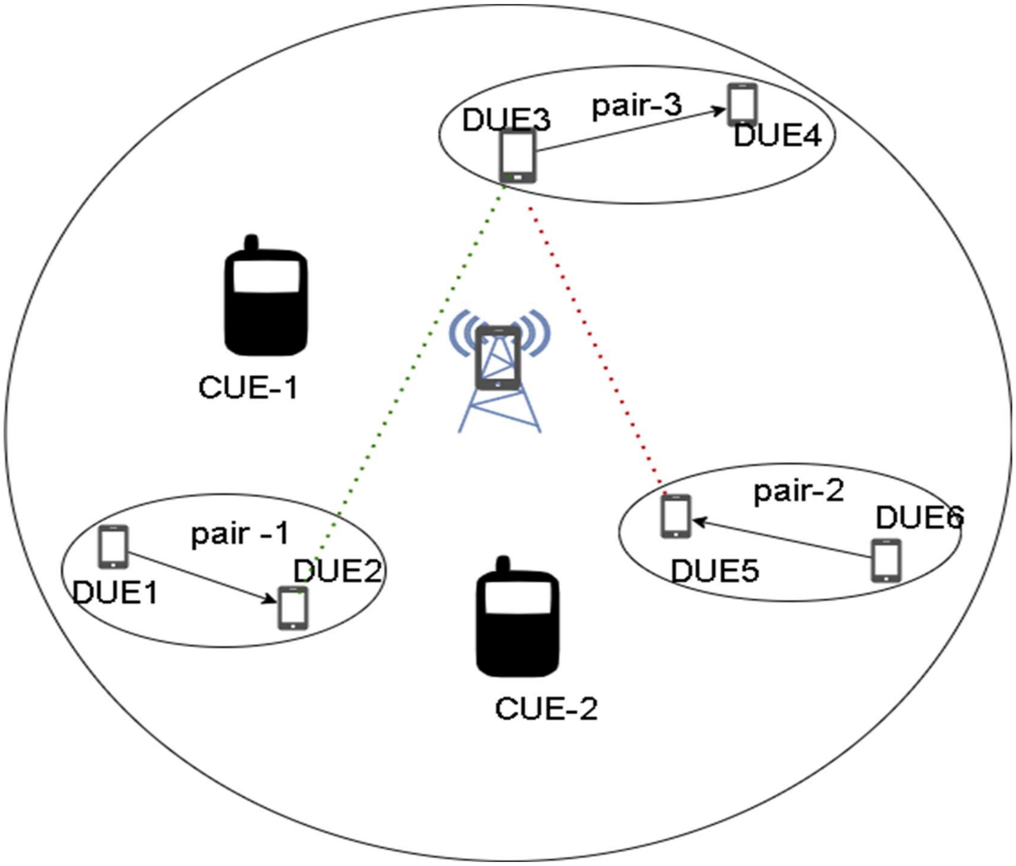

Figure 1 system model of D2D communication

Consider is a set of C={C1,…………..,Cj} for the CUEs and a set of D={D1,…………,Dk} of the pairs. Howerver the set I={ C1,……,Cj,D1,………..,Dk} is a set of all the CUEs and D2D pairs. Now Xi,n as the resouce allocation process, here I is the index of all the mobile devices including CUEs and D2D pairs, and N is the index of the frequency resouce of the OFDMA system. Here Xi,n is binary variable. When Xi,n equal 1 that menas frequency resouce n is allocated to user I and when Xi,n equal 0, the frequency resouce is not allocated. Now Xi,n as the matrix of resouce allocation.

Methodology

The proposed multi-objective particel swarm optimization algorithm is derivation of partilce swarm optimzation. The MOPSO algorithm handle the ducal condtaints function for the allocation of resocue in terms of freqeuncy and power. The processing of channel allocation in D2D communication systems as pairwise in single cell unit. The description of algorithm is describes in three section. In firest section describes the fitness functions of resouce allocation and optimzation.

1st section

The process of resouce optimization method use folowing fitness functions

$$Max \sum_{i} \sum_{n} Xi, nRi, n, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Such that

$$\sum_{c}^{j} Xc, n \leq 1, \sum_{d}^{k} Xd, n \leq 2, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Here the equation (2) repreent each channel up to one cellular user can select cellular mode and up to tow pairs can select D2D mode.

2nd section

The selection of resource in between CUEs and DUEs of same unit of frequency define the multi-objective function and control interference of signals. The process of channel selection describes as

The fitness function for N channel is

Consider x=(n1, n2,……..,nm)∈ $N, N \cap R^{n}\ where\ n\ is\ thechannel\ \ of\ Resouce\ \ R$

Min y=f(n) = [f1(n), f2(n),….., fm(n)]

Such that $gi(n) \leq 0, i = 1,2, \ldots, M$

$$hj(x) = 0, j = 1,2, \ldots, q$$

where Y1= (f1, f2,….,fn) ∈ Y is the objective function , Y is the objective variable space, gi(x) is the i-th inequality constraints and hj(x) is the j-th equality constraints the MPSO set the dual function for the resource allocation. The process of optimization describes here [15].

```
1. Define the population of particle as channel C
   (a) For i= 0 to M where M is maximum of particle
   (b) Initialize A[i]
2. Define the speed of particle
   (a) For i= 0 to M
   (b) Velocity[i]=0
3. Estimate particle in M
4. Reallocate the position that represents the resource of CUEs.
5. Generate search space R
6. Define memory o each particle
7. Compute the speed of particle
Velocity[i]= W*Velocity[i]+R1*(Pbset[i]-M[i])+R2*(attribute[h]-A[i])
 Where the range value of R is[0,1]
8. Estimate new position of particle
A[i] =A[i] +velocity[i]
9. Measure current position of particle
Pbest[i] =A[i]
10. Increment of counter
11. End
```

```
3rd section Algorithm
Define variables
I number of iterations of MOPSO algorithm
M number of particles of MOPSO \
Xm position of one particle, m=1,…………………,M
Vm Velocity of one particle ,m=1,……………………..,M
$P_m^v$ local best solution, m=1,………,M, u=1,………..I
$G^u$ global best solution, u=1,……….,I
Xi,n resource matrix
A genetic operator
Qf fitness of enach iteration
Begin
    Initialize particles Xm and Vm
    For =1: I do
        For m=1:M do
            Resource mapping process
            Estimates fitness constraint function equation (2)
        End for
        Update position of resource
        If u>1 and |Qf-Qu-1|<A
            Call operator of genetic algorithm
        End if
    End for
Exit
```

IV. Experimental Analysis

To validate the proposed algorithm for the D2D communication model, use MATLAB software. MATLAB has well known computational and communication software for the analysis of the algorithm. The system's hardware configuration is an I7 process and 16GB Ram and 1TB HDD with windows operating system. The simulation process carried on randomly distributed D2D users in network environments—the location of the base station situated in the centre of D2D users and cellular users with a certain distance—the rest of the simulation parameters mentioned in the table[1, 7, 8].

Table 1: Simulation parameters of proposed D2D communication systems.

PARAMETER	VALUE
Number of devices	30-100
Max. communication range (Rmax)	5m
Transmission power	10dbm
BW(bandwidth)	20 MHz
Number of rounds	40

ND2DU	4
UmaxP	250 mW
Cpc	100 mW
Simulation iteration	1000

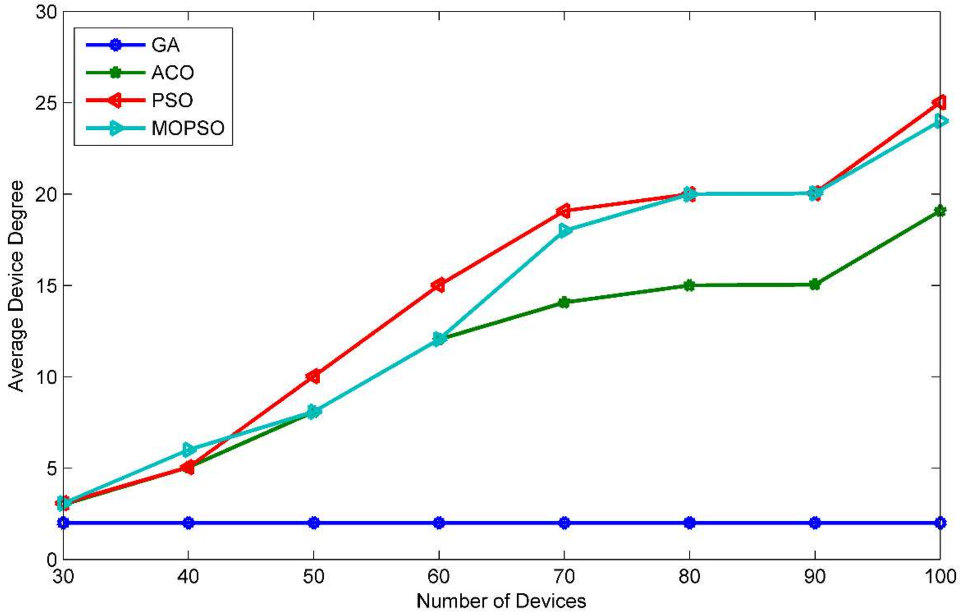

Figure 2 performance of average degree of device using GA, ACO, PSO and MOPSO algorithm

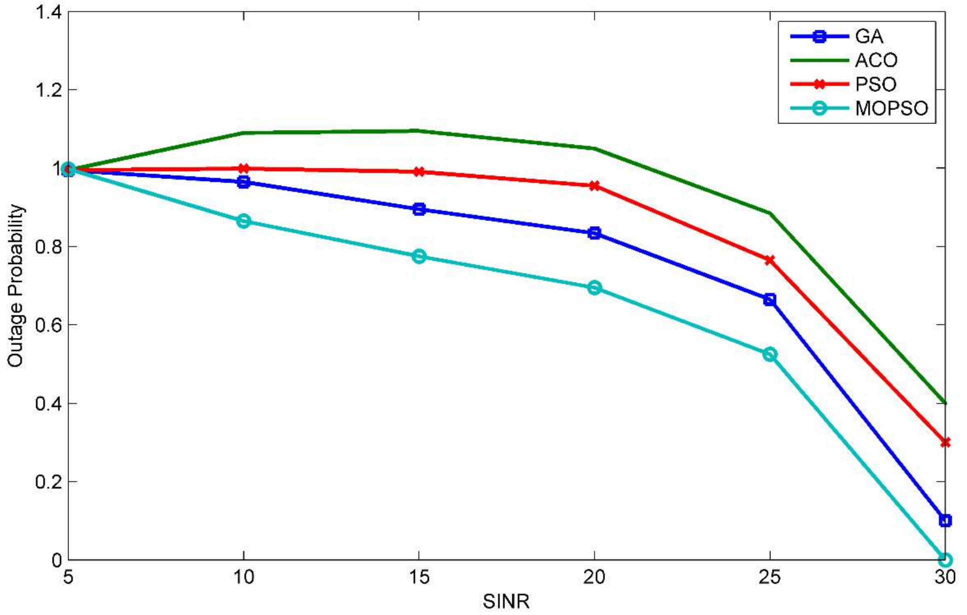

Figure 3 performance of outage probability using GA, ACO,PSO and MOPSO algorithm

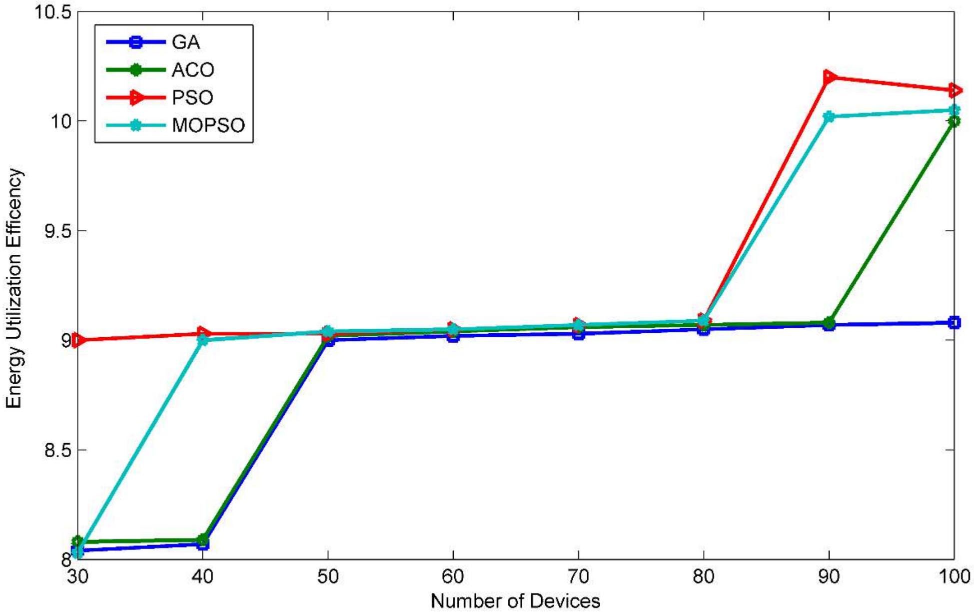

Figure 4 performance of energy utilization efficiency using GA, ACO, PSO and MOPSO algorithm

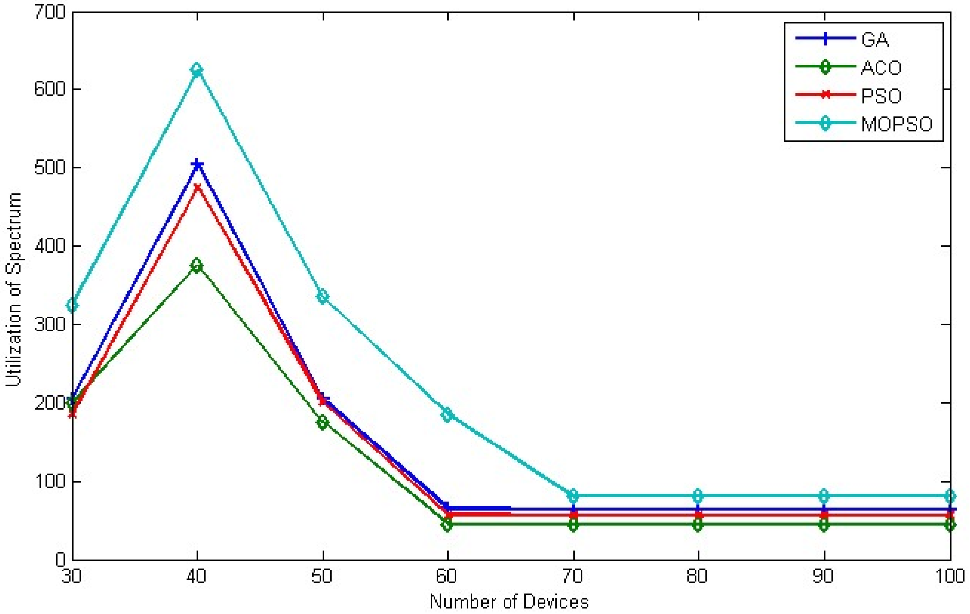

Figure 5 performance of utilization of bandwidth using GA, ACO, PSO and MOPSO algorithm

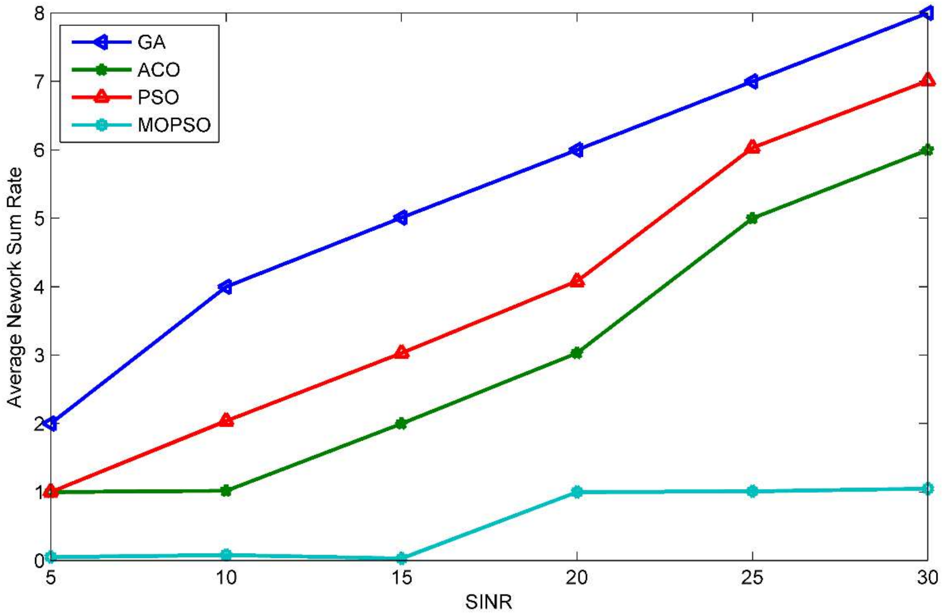

Figure 6 performance of network sum rate of communication using GA, ACO, PSO and MOPSO algorithm

V. Conclusion & Future Work

The objective of this paper is to enhance the performance of device-to-device communication within the cellular network. The proposed algorithm enhances the performance of data quality in terms of outage probability. The proposed algorithm also increases resource utilization in terms of bandwidth and power. The multi-objective particle swarm optimization fitness process constrains resource mapping in the channel search space. The experimental analysis of the simulation justifies the efficiency of the proposed algorithm instead of the GA, ACO, and PSO algorithms for resource optimization and allocation in D2D communication. It is impossible to ignore the interference between D2D pairs and CUEs that use the same frequency resource, so an effective interference avoidance strategy needs to be put in place. After the MOPSO algorithm's mapping process, a mode selection scheme should be used to determine whether the D2D pair should utilize the CUE's frequency resource. The proposed algorithm can improve particle diversity by preventing local optimum. The proposed algorithm increases spectral efficiency while reducing interference between D2D pairs and CUEs. Results from simulations indicate that the proposed algorithm performs better in terms of system throughput and interference reduction.

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