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Research Article

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Spectrum Sharing Environment Using Deep Learning Techniques

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ABSTRACT

Recently, the satellite communication has main demand but still facing main problems which are the spectrum limited, both cognitive-radio (CR) and non-orthogonal-multiple-access (NOMA) methods are identified as a one of the potential solutions for these issues. Using the deep learning techniques with the CR and NOMA systems will be improvement in the spectrum effectiveness. One of the performance enhancements of the NOMA, the integration with the satellite-terrestrial-relay-network (ISTRN) in a spectrum-sharing context of several main-users (PUs) is examined. We specifically presented and given the interference limitation imposed by several nearby pus and its effect on each other's. The closed-form formulations are investigated the ergodic-capacity (EC) and outage-probability (OP). The asymptotic-analysis for OP at high SNRs is achieved to get additional insights. To support our research and reveal the effects of the significant characteristics on the quality of the system; the numerical data and analysis are provided with deep discussions.

Keywords: NOMA, Deep Learning, ISTRN, Relaying Network, CR and Cooperative Network

Introduction

Both cognitive-radio (CR) and the non-orthogonal-multiple access (NOMA) scheme have been identified as possible alternatives, particularly in light of the growing requirement for efficient satellite resource usage. Spectrum efficiency enhancement [1,2]. The precise and asymptotic outage-probability (OP) expressions of the amplify-and forward (AF) integrated-satellite- terrestrial-relaying network (ISTRN) with NOMA scheme were developed in and the authors of the efficiency of cooperative NOMA-based ISTRN with preferable relaying selection was investigated [3-7]. The NOMA technology utilized in the hybrid satellite-ground data transmission networks to increase spectral efficiency and minimize latency [8-9].

The recent papers described the investigations that are relating to the optimization strategies of spectrum sharing. Based on the study, the energy-consumption of spectrum- sensing using closed-form-solution and stochastic-method presented [10]. As in, the examination of the NOMA system with its outage likelihood by using randomly deployed users randomly; the mathematical model derived and done the analysis of the outage likelihood using mathematics [11]. Also, the optimization formula of the power and its channel distribution were given; the mathematical model based upon the matching theory for channel assignment and the water-filling approach for power distribution driven [12]. The optimization for the problem of power allocation discussed. The main clustering of deployed users with NOMA technique investigated by using mixed integer non-linear programming method then the performance of the system found [13]. Users scheduling scenario and optimizing the power, allocation considered by using global optimization techniques named Leverage of convex optimizer [14]. Findings the maximization of the lowest throughput for the possible users given by applying two-step combined beam forming then they considered developing of power allocation method [15]. Proportional fairness mathematical model for the user's side has been driven then find the optimization parameters; the joint user pairing methods proposed then applying the power allocation method [16]. The proposed system applied for improving the energy efficiency by using allocating resources techniques. Firstly, the problem of linear programming formulation found then applying the CPLEX optimization [17].

This article investigates the efficiency of ISTRN based on NOMA and CR in a spectrum- sharing-scenario with many primarily-users (PUs). We can explicitly create closed-form formulations of the examined system's OP and ergodic-capacity (EC) given

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the interference constraint proposed via many neighboring PUs. High SNR values are fulfilled at OP. We introduced a numerical data to improve our scenario and demonstrate how the essential elements impact system performance [3-5]. There are two ways to go about it. Firstly, the effects of a strong time-varying-communication distance on the operation of a satellite- terrestrial-transmission (STT) system in low-earth-orbit (LEO) are investigated. Secondly, the finite-state-Markov channel (FSMC) with the temporal discretization is used in our simulation system.

The effectiveness of adaptive transmission technologies such as power adaptive- transmission (PAT) and rate adaptive-transmission (RAT) is investigated. Scenarios have fixed the transmitted rate or power at LEO satellite to illustrate the applicability of the proposed framework.

Figure 1 depicts the creation and validation of a closed-form formula for delay of outage rate, efficiency of energy and throughput of the system under consideration in order to address the performance of outage rate, energy efficiency and capacity of the regarded LEO STT system using the suggested analytical structure.

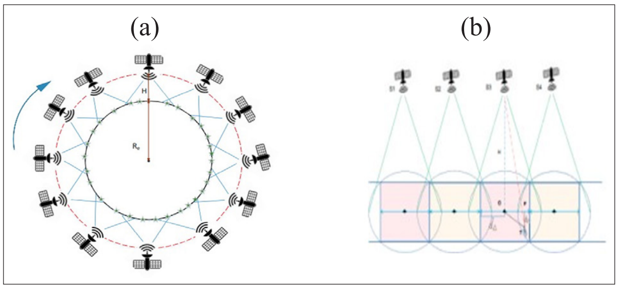

Figure 1: Illustrates the diagram for LEO satellite [10].

The second method of cooperative relay network using LEO satellite in order to serve the uncoveraged area via the node is shown in Figure 2.

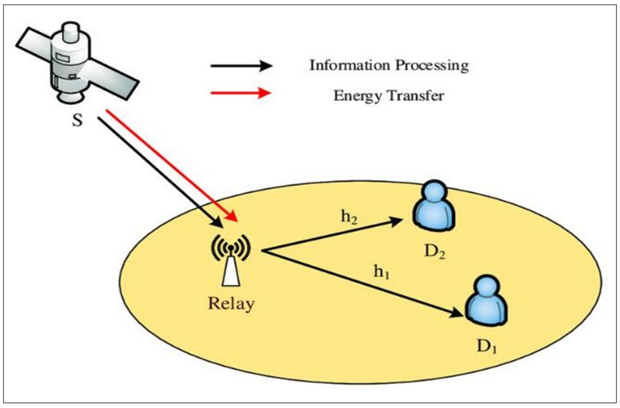

Figure 2: Exhibits the concept of relaying wireless sensor networks.

Where D1 and D2 are the user devices for far user and near user, respectively, and h1 and h2 are the channel factors for far and near users, respectively. In order to improve spectrum efficiency, the NOMA-based cognitive-radio ISTRN (CISTRN) system is introduced. The interference-power restriction under many PUs is then considered in order to calculate the right closed-form formulations of EC and OP. It is also possible to obtain the asymptotic expression of OP for high SNRs. The effects of major system factors are also examined. Numerical data is utilized to validate the validity of our theoretical approach.

The major novelties of our CISTRN based NOMA cooperative relay network are summarized as:

1. Three modern emerging technologies are integrated in our cooperative relaying model such as ISTRN, cognitive-radio and NOMA.
2. The noise and interference are considered and the successive- interference- cancellation method are utilized to remove the adjacent interference.
3. Two user with different distances are regarded.
4. Various channel models are supposed such as Rician and Rayleigh. The work is organized into four sections. Section 2 describes the problem statement and introduces our proposed design. The simulation setup and suggested algorithm are discussed in section 3. The numerical findings, analysis and system parameters are presented in section
5. The essential summarized points are revealed in section 5.

Problems Formulation and System Model Architecture.

We investigate a cooperative relaying network with two users and various distances. LEO satellite and cooperative relay work to serve uncoveraged area or dead zone. Also, our proposed relaying design can prolong the coverage area to cater the requirements of last-mile users. A CISTRN scenario with NOMA is considered in this model with M-primary users, S secondary-satellite, R relay, and SU1 and SU2 secondary terrestrial users make up the system. On each node, a single antenna is used. We hypothesize that due to the extreme shadow fading, S is unable to relay messages directly to SUi (i =1, 2). R assists S in communicating with SUi, as devoted in figure 3.

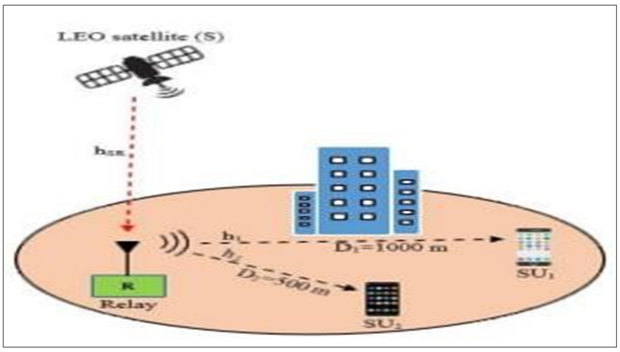

Figure 3: A schematic diagram for our proposed blueprint of LEO-CISTRN cooperative relay network to coverage the far and near users.

Two channel models are proposed such as Rician and Rayleigh for satellite-relay link and relay-user link, respectively. Furthermore, the decode-forward (DF) protocol is utilized on R with half-duplex mode. The primary transmitter (PT) is not expected to interact with R or SUi resulted the substantial distance among PT and SUi or R. Double time-slots are required to attain the transmission in the suggested model [18,19]. In the first time slot, S delivers messages to R using the NOMA scheme's superpositioncoding method (SCT) with two integrated signals. The sent signal to R is provided via [14]:

$$S =(\sqrt{Q_1 P_s s_1} + \sqrt{Q_2 P_s s_2}) \quad (1)$$

Where PS, s1, s2, β1 and β2 are the transmitted power of S, message to SU1, message to SU2, allocated power factor of SU1 and allocated power factor of SU2. We assume that without compromising generality, that R to SU1 has a worse channel condition than R to SU2; thus, we give D1 > D2. As a result, the received-signal via R is represented as [20-22]:

$$yr = hsr(\sqrt{Q_1 P_s s_1} + \sqrt{Q_2 P_s s_2}) + n_R \quad (2)$$

Where h_{SR} signifies the channel factor for S-R separation, SR refers Shadowed-Rician, n_R is AWGN noise at R with n_RCN (0, 2_R). Rician channel has a straight dominant component. The SCT and DF protocol are employed in R; the second time-slot sends the received signal to SUi, as written in [23].

$$yi = hsui(\sqrt{Q_1 P_s s_1} + \sqrt{Q_2 P_s s_2}) + n_i \quad (3)$$

Where PR represents R's transmission power and hSUi denotes the Rayleigh-fading affected channel coefficient. ni signifies the AWGN at SUi's receiver with n_Ri-CN(0, 2- 2). Rayleigh fading channel is multipath propagation with non-dominant component. R is subjected to successive-interference-cancellation (SIC) to decode si. R decodes s1 first and removes s1 from the received vector (yR) and then detects s2 and so on. We compute SINR of si in relaying antenna using Eq. (1).

$$\gamma_{s1} = \frac{I_{\gamma SR}\beta_1}{I_{\gamma SR}\,\beta_2+\gamma SP\sigma^2{}_R} \quad (3)$$

$$\gamma_{s2} = \frac{I_{\gamma SR}\beta_2}{\gamma SP\sigma^2{}_R} \quad (4)$$

(γ_{s2}) The signal to interference plus noise ratio (SINR) of s1
(γ_{s2}) The signal to interference plus noise ratio (SINR) of s2

Simulation Setup

One of the most common optimization techniques that has been using in recent year is the particle-swarm-optimization (PSO). In an effort to address a different problem, PSO have included many impractical solutions. It has a negative effect on how the calculation is displayed. The schematic diagram for the problem statement is devoted in below algorithm. In the PSO, the impractical solutions might be changed to make them feasible as discussed in the algorithm of general PSO structure exhibits as follows [24]:

The aforementioned calculation of PSO is proposed in our design, which is utilized to change the PSO's infeasible methods to the point where the chosen path is crash-free. Based on the above algorithm, if the molecular path encounters an impediment limit, it is moved to an environment outside of the obstruction. As the next step, the wellness value of each molecule is considered among its current and potential applications to determine the best position (p- best), and the molecule with the highest wellness value is selected as the global best, as indicated by the flowchart shown in figure 5

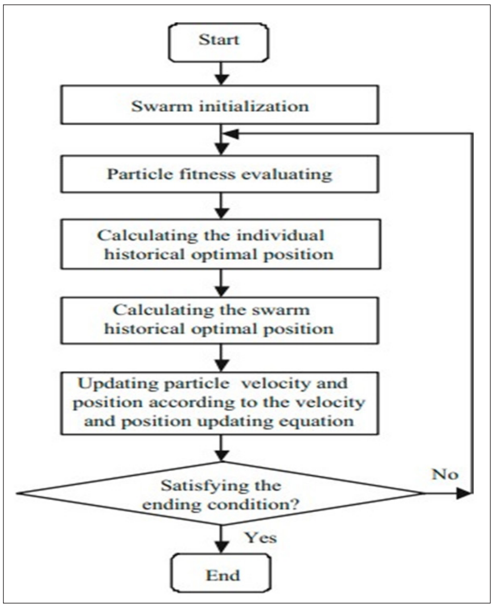

Figure 4: General PSO structure [24],

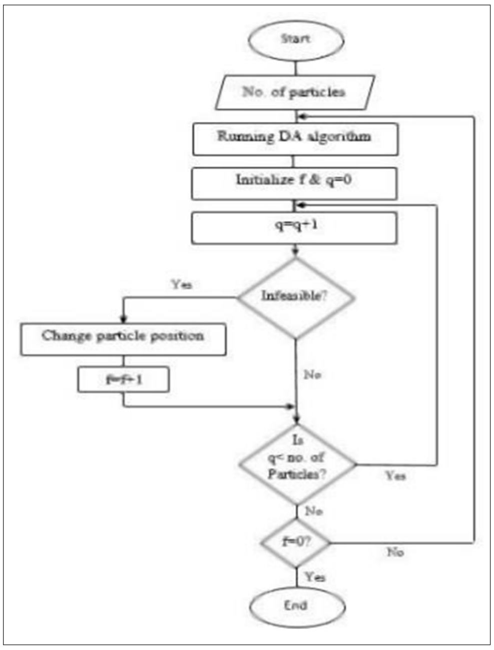

Figure 5: Portrays the PSO exact optimization findings.

First of all, we start with certain number of particles. Then, the paths will be evaluated via distinguish-algorithm (DA). So, two register counters are supposed for path and position particles with zero initial states. As a result, if the path is infeasible, the particle position is changed. Otherwise, the number of particles are examined and compared with the value of path counter. Finally, the number of iteration loop will be checked to end the simulation.

Simulation Results

This section uses the proposed power-control technology and evolutionary algorithm to assess the performance of the NOMA uplink scenario. During the simulation step, the suggested solution's outcome is determined by using MATLAB tool, which is also utilized to look at the proposed scheme's SE-EE tradeoff. Table 1 listed the simulation parameters in terms of number of users and the distances, attenuation coefficient, number of iteration and power allocation factor.

Table 1: The value, symbol and description of the key parameters.

Symbol	Description	Value
S	Kind of satellite	LEO
BS	Distances of users from base station	D1=1000m (for far user) and D2=500m (for near user)
α	Path loss exponent	4
N	Number of Monte carlo simulation	10^5
β	Power allocation factor	0<β<1

Figure 6 shows the simulation results the obtained capacity of far and near users. It is obviously denoted that the transmitted data rate (R2) of near user (user2) is more than others. Thus, high spectral efficiency is achieved.

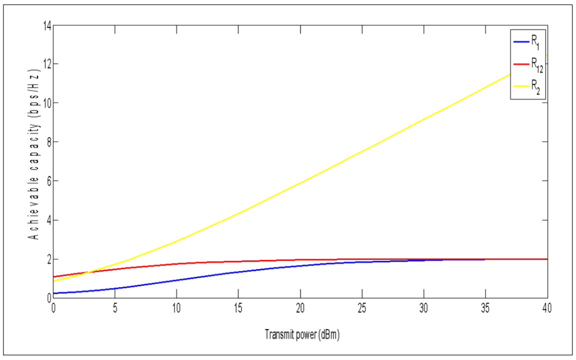

Figure 6: The achievable capacity vs. the transmit power.

The power plays important role for device lifetime. The initial allocation power is almost same for both users. High power is allocated to represent the huge amount of bits. The transmitted data rate (R1) for far user and the transmitted rate from user 1 to user 2 (R12) are steady states of data transmission. Meanwhile, the transmitted data rate (R2) via user2 (near user) is highly increased capacity to enable directly relaying messages with assisting secondary terrestrial relay. Figure 7 visualizes the outage probability for both users.

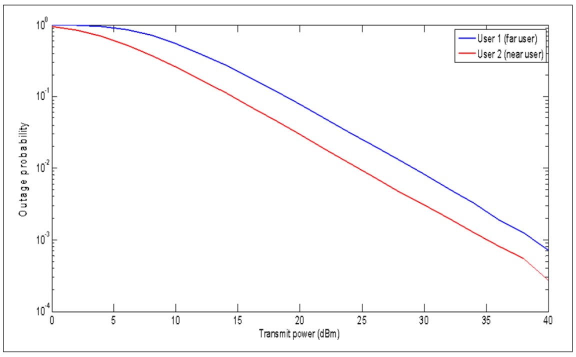

Figure 7: Outage probability vs. transmitted power.

The lower outage probability is fulfilled for higher transmitted power of both users. It is displayed that near user has lower values of outage probability because it is a near user with less distance than far user. According to, the path loss is proportionally increased with distance square [25]. The outage probability for both users are progressively decremented through transmitted power. Figure 8 shown exactly how the power factors effect on the bit-error-rate of the system.

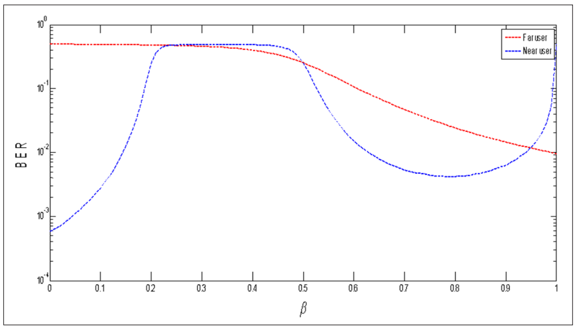

Figure 8: BER performance vs. Power allocation Factor for both users.

We deduce that the near user has got more power allocation factor (β) than the far user because the difference of the distance between them. It is a normal situation that the power is decreased with the propagating path. Consequently, less power allocation can be obtained. The far user (user1) has roughly a constant quality for β<0.4. Then, the log (BER) performance are gradually decreased to reach around -2 at β=1. BER performance of near user (user2) is exponentially grown for β<0.2. It is remain steady state until reach 0.5 then the performance is sharply declined to get the bottom at 0.8 of β. The BER performance is exponentially increased to attain β=1. However, in order to keep the performance within wireless-communication- requirements, the far user should send less data rate with low modulation index than the near one.

We infer that the near user has five folded of capacity compared with far user. Moreover, near user has less values of outage probability and BER because it has half distance of far one from the relaying cooperative antenna.

Discussion and Conclusion

We looked into the effectiveness of NOMA technique based CISTRN with various PUs in this work. In particular, the OP and EC's closed-form expressions were developed. Based on the suggested setup, it was also possible to generate asymptotic OP expression at large SNRs. It is evident that the system's performance increased as PUs were reduced. Furthermore, the performance of the system was significantly impacted by rate thresholds and power distribution variables. Furthermore, we discovered that EC dropped with increasing β1 at low SNRs and β1 had multiple ideal values to minimize OP depending on the system parameters. In addition, OP would rise as rate thresholds increased. The simulation findings visualize that the near user has superior the far user in terms of capacity, outage probability and BER performance. This is because it has half path loss of far user. Our proposed relaying scenario are recommended for next-wireless-access-networks, IoTs, healthcare centers, etc.

Declarations

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Ethical Approval: We would like to declare that this paper has been well written, and it don't have any Plagiarism or copy right from other research, it has valuable subject indeed.

Consent for participate and publication: The authors declare consent to participate and consent to publication.

Availability of data and materials: The authors declare no data were used to support this study. My manuscript has no associated data.

Code availability: Not applicable

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References

1. Chiti F, Fantacci R, Tarchi D, Kota S, Pecorella T. QoS provisioning in GEO satellite with onboard processing using predictor algorithms. IEEE Wireless Communications. 2005. 12: 21-27.
2. Kourogiorgas CI, Lyras N, Panagopoulos AD, Tarchi D, Vanelli-Coralli A, et al.,"Capacity Statistics evaluation for next Generation broadband MEO satellite systems," IEEE Trans. Aerosp. Electron. Syst. 2017. 53: 2344-2358.
3. Guo K, Lin M, Zhang B, Zhu W, Wang J, et al. On the performance of LMS communication with hardware impairments and interference. IEEE Trans. Communication. 2019. 67: 1490-1505.
4. Ruan Y, Li Y, Wang CX, Zhang R. Energy efficient adaptive transmissions in integrated satellite-terrestrial networks with SER constraints. IEEE Transactions on Wireless Communications. 2017. 17: 210-222.
5. An K, Lin M, Liang T, Wang JB, Wang J, et al. Performance analysis of multi-antenna hybrid satellite-terrestrial relay networks in the presence of interference. IEEE Transactions on Communications. 2015. 63: 4390-4404.
6. Huang Q, Lin M, Zhu WP, Chatzinotas S, Alouini MS. Performance analysis of integrated satellite-terrestrial multiantenna relay networks with multiuser scheduling. IEEE Transactions on Aerospace and Electronic Systems. 2019. 56: 2718-2731.
7. Guo K, Zhang B, Huang Y, Guo D. Performance analysis of two-way satellite terrestrial relay networks with hardware impairments. IEEE Wireless Communication letters. 2017. 6: 430-433.
8. Guo K, An K, Zhang B, Huang Y, Guo D, et al. "On the performance of the uplink satellite multi-terrestrial relay networks with hardware impairments and interference". IEEE Syst. J. 2019. 13: 2297-2308.
9. Guo K, Lin M, Zhang B, Wang JB, Wu Y, et al. Performance analysis of hybrid satellite terrestrial cooperative networks with relay selection. IEEE Trans. Veh. Technol. 2020. 69: 9053-9067.
10. Arienzo L, Tarchi D. Stochastic optimization of cognitive networks. IEEE Trans. Green Communication Network. 2017. 1: 40-58.
11. Wang J, Peng Q, Huang Y, Wang H, You X. Convexity of weighted sum rate maximization in noma systems. IEEE Signal Processing Letters. 2017. 24: 1323-1327.
12. Sindhu P, Deepak KS, KM AH. A novel low complexity power allocation algorithm for downlink noma networks. In 2018 IEEE Recent Advances in Intelligent Computational Systems (RAICS). 2018. 36-40.
13. Zeng M, Yadav A, Dobre OA, Poor HV. Energy - efficient power allocation for mimo - noma with multiple users in a cluster. IEEE Access. 2018. 6: 5170-5181.
14. Zhai D, Du J. Spectrum efficient resource management for multi- carrier -based noma networks: A graph-based method. IEEE Wireless Communications Letters. 2018. 7: 388-391.
15. Sedaghat MA, Mller RR. On user pairing in uplink noma. IEEE Transactions on Wireless Communications. 2018. 17: 3474-3486.
16. Ruby R, Zhong S, Yang H, Wu K. Enhanced uplink resource allocation in non-orthogonal multiple access systems. IEEE Transactions on Wireless Communications. 2018. 17:1432-1444.
17. Lv G, Li X, Shang R, Xue P, Jin Y. Dynamic resource allocation for uplink non-orthogonal multiple access systems. IET Communications. 2018. 12: 649–655.
18. Zhang X, An K, Zhang B, Chen Z, Yan Y, et al. Vickrey auction- based secondary relay selection in cognitive hybrid satellite terrestrial overlay networks with non -orthogonal multiple access. IEEE Wireless Communication Letters. 2020. 9: 628-632.
19. Yan X, Xiao H, Wang C, An K. Outage performance of NOMA- based hybrid satellite– terrestrial relay networks. IEEE Wireless Communication Letters. 2018. 7: 538-541.
20. Yan X, Xiao H, An K, Zheng G, Tao W. Hybrid satellite terrestrial relay networks with cooperative non - orthogonal multiple access. IEEE Communication Letters. 2018. 22: 978-981.
21. Zhang X, Zhang B, An K, Zhao B, Jia Y, et al. On the performance of hybrid satellite - terrestrial content delivery networks with non-orthogonal multiple access. IEEE Wireless Communications Letters. 2020. 10: 454-458.
22. Sharma PK, Upadhyay PK. Cognitive relaying with transceiver hard ware impairments under interference constraints. IEEE Communication Letters. 2016. 20: 820-823.
23. Miridakis, Vergados DD, Michalas A. Dual - hop Communication over a Satellite Relay and Shadowed Rician Channels. IEEE Trans. Vehi. Tech. 2015. 64: 4031-4040.
24. Ardizzon G, Cavazzini G, Pavesi G. Adaptive acceleration coefficients for a new search diversification strategy in particle swarm optimization algorithms. Inf Sci. 2015. 299: 337-378.
25. Al-Khaffaf, Dhurgham Abdulridha Jawad, Ali M. Alsahlany. 60 GHz Millimetre wave / 10 Gbps Transmission for Super Broadband Wi - Fi Network. J. Communication. 2019. 14: 261-266.