Journal of Theoretical and Applied Information Technology
31st October 2022. Vol.100. No 20

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

ENHANCED PARTICLE SWARM OPTIMIZATION BASED PILOT DESIGN WITH HYBRID BEAMFORMING POWER TRANSFER IN WSN-IOT APPLICATIONS

REGINALD JUDE SIXTUS J[1], TAMILARASI MUTHU[2]

[1]Department of Electronics and Communication Engineering, Puducherry Technological University,Puducherry,India

[2] Department of Electronics and Communication Engineering, Puducherry Technological University, Puducherry,India

E-mail: [1]iamjjude7893@gmail.com, [2]tamilrasim@ptuniv.edu.in

ABSTRACT

The major concern in IoT is that even if one of the sensors in the interconnection terminates connectivity due to its battery depletion, the whole IoT network suffers a failure. By employing a combination of novel techniques like simultaneous wireless information and power transfer (SWIPT) with non-orthogonal multiple access (NOMA) systems, achieving energy efficiency and spectrum efficiency become a reality without much complexity even with humongous users. Transmission power reduction in a multi-antenna wireless powered communication network (WPCN) using heterogeneous modulation schemes is investigated in this paper. A hybrid access point (H-AP), featuring several transmitters and receivers are utilized. In downstream, the H-AP transmits a power through power directional antennas which enhances the transmission efficiency. While transmitting the transmission power at the H-AP, the allocation time for downlink is determined to perform wireless energy transfer (WET). An innovative interference cancellation scheme using enhanced particle swarm optimization (PSO) algorithm is applied to avoid pilot allocation time for downlink is determined to perform wireless energy transfer (WET). An innovative interference cancellation scheme using enhanced particle swarm optimization (PSO) algorithm is applied to avoid pilot contamination. The proposed method is termed as PSO with hybrid beamforming power transfer (PSO-HBPT) and the parameters are validated. From the comparative analysis between the considered parameters it is observed that PSO-HBPT outperforms the existing, joint optimization sub-band expediency based Scheduling (JO-SES) method.

Keywords: *Enhanced particle swarm optimization, NOMA, SWIPT, hybrid access point*

1. INTRODUCTION

Rapid use of IoT appears to have a substantial influence in the society, it has also enhanced the standard of our daily routine [1]. The IoT is a group of interconnected objects that performs both centralized remote monitoring and user interaction through the Internet. Over 125 billion tiny sensors and intelligent systems are expected to be linked to the Internet by the year 2030 [2]. Intelligent systems, smart cities, e-health, and environmental monitoring are some of the applications where IoT can play a vital role. Apart from this, it is creating a lot of interest in the field of industry, education and economy [3]. The IoT includes various devices such as sensor operated equipment's and cloud computing networks to operate. The two major scarce resources in wireless networks that won't be exploited are energy and bandwidth [4]. Majority of Internet of Things (IoT) devices run on externally powered battery source and require large amount of energy source for communication and information transmission. Since these IoT devices are resource-constrained, energy distribution seem to be a suitable alternative for extending their lifespan. Establishing mass coverage and realizing secured connectivity in IoT networks seem to be a major challenge. The signal enabled transmission may significantly enhance the network performance due to its massive potential to extend coverage, enhance energy efficiency, and establish effective reliability [5]. The two relaying mechanisms that are most widely employed in cellular connections are amplify-and-forward (AF), decode-and-forward (DF) [6]. By utilizing relay assisted transmission and reducing reference usage, the productivity of IoT networks is enhanced [7].

Since the 5G infrastructure employs non-orthogonal multiple access, it has gained lot of

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

attention as a effective technique to boost spectral efficiency [8]. The main theme of NOMA differs from conventional orthogonal multiple access (OMA) approaches in which multiple access (MA) is implemented in the transmitter side as in the case of (frequency - division MA). The theory behind this approach is that NOMA might utilize bandwidth more effectively by precisely analyzing user's channel condition [9]. One of the prominent goals of the upcoming (5G/6G) technology is to effectively enhance spectrum utility as well as to incorporate NOMA. Due to the freshly awakened research interest in efficient power saving networks, there arises a need to utilize SWIPT technology as illustrated in [10]. Two practical modes, power splitting (PS) receiver and the time switching (TS) receiver, are developed with response to this issue for MIMO technique.

Concept of NOMA has advantage of combining a user with favorable channel condition for user defined bandwidth along with the least favorable channel condition [11]. The prime motive of multi-way transmission in NOMA structure is that all the users are subjected to sequential interference cancellation, thus allowing them to take cognizance of nearby users. In this aspect, to interact with far users the users that are located nearby are employed as DF relays. This paper analyses the outcome of SWIPT-NOMA integration, where SWIPT is limited to nearby NOMA users in order to ensure the effectiveness for the far NOMA users without utilizing the energy of near NOMA users. Thus the SWIPT-NOMA integration ensures that the network is efficient in terms of energy and spectrum. The observations from the literature indicate that further research is required to completely evaluate the effectiveness of multiple input single output IoT systems, as well as efficient use of total transmitted power when the ancillary aspects are taken into consideration.

- Enhanced particle swarm optimization algorithm is employed to optimize pilot symbols to perform channel estimation in WSN.
- Hybrid beamforming with NOMA is performed in hybrid access point (H-AP) which comprises of multiple users and antennas for efficient power transmission.
- Diversity order of the system is analysed and the expressions for uplink and downlink are generated for improved transmission rates.

This paper, is organized as follows: The literature findings of SWIPT and best pilot design are examined in section 2, along with its shortcomings. The system model for effective power transmission is described in section 3. Section 4, provides the comparative study for various parameters. The concluded findings of the research are briefed in section 5.

2. RELATED WORKS

A novel SWIPT architecture for IoT is proposed in [12]. The architecture improves the performance of energy amplifiers by distributing power connections over an unamplified raised wave form (CW), in contrast to the classic time switching (TS) and power splitting (PS) strategies. A transceiver is exclusively designed to minimize hardware complexity and power consumption for the processor unit on receipt of SWIPT impulses.

Non-Orthogonal multiple access (NOMA) broadcast approach, [13] offers a hybrid algorithm for a millimetre wave (mm Wave) massive MIMO downstream. The analog precoder is employed to orthogonalize the multichannel vectors of the users in transmission systems by reducing the inter symbol interference. To mitigate intersymbol interference, the precoding employs a zero-forcing precoder. To overcome limitation of sharing frequency among users, NOMA is employed to impartially share the spectrum and ensure fairness amongst users.

NOMA, that has numerous advantages, was formulated in [14]. In addition to it SWIPT, enhances the transmission power by dividing the power in the receiver side without affecting the data. In addition, to the above technologies, the hybrid precoding approach with user cooperative algorithm and power allocation procedure were also analyzed.

To combat the limitation in coverage Whale Optimization Algorithm (WOA), a meta-heuristic technique is suggested in [16]. Four different procedures are indicated for the reinforcement notations in WOA. This optimization algorithm is consequently integrated with the channel estimation method, known as CS-WOA, particularly for allotting pilots in OFDM systems.

Pilot placement management for the measurement matrix construction in terms of decreased mutual coherence (MC) is briefed in [17]. Investigations on how the stochastic OFDM prototype sequence handles a multi-objective problem. The positioning of the OFDM pilot pattern can be modified using this technique. Performance study shows that the suggested method can create a matrix with a lower MC and efficiency may be greatly enhanced when compared to conventional simulated annealing or probabilistic technique.

For the LS channel estimation approach using comb-type pilot colours in millimeter wave systems, PSO is discussed in [18], for optimizing layout and intensity of the pilot tones. Numerical simulations show that the optimization technique outperforms perpendicular and randomized pilot tones. Analysis were conducted on streams with differing Doppler shift rates to ensure the impact of the changes on the completion of various pilot tones.

2.1 Proposed optimal pilot design with efficient power transfer

The block diagram in figure 1, represents the ideal pilot design with effective power transmission. The system model and channel model are taken into consideration while designing the WSN-IOT architecture. Considering the uplink and downlink limitations, the power transfer analysis is done between the nodes, antenna, and the users. After examining analyzing the constraints, an effective SWIPT is performed by employing hybrid beam forming in MIMO-NOMA. The Enhanced Particle Swarm Optimization technique is used to select the best pilot at that instant. The ideal pilot is prepared to switch for improved channel estimation.[19-22]

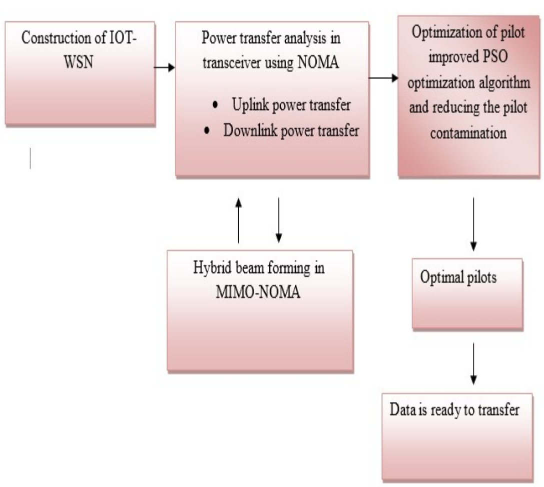

Figure 1: Block diagram representation of pilot design with efficient power transfer

2.2 System Model

Consider a graph 'Gra' and hence it can elaborate as follows W(Gra,x)W*(Gra,x') andW**(Gra,x,x') which is termed as vertex, edge and index form respectively. These graphs are constructed with respect to Wiener indices, which is given as

$$W(Gra,x) = \tfrac{1}{2} \sum_{x \varepsilon V(Gra)} \sum_{y \varepsilon V(Gra)} x(x)x(y)d(x,y) \quad \text{---(1)}$$

$$W*(Gra,x') = \tfrac{1}{2} \sum_{e \varepsilon E(Gra)} \sum_{f \varepsilon E(Gra)} x'(e)x'(f)d(x,y) \quad \text{---(2)}$$

$$W**(Gra,x,x') = \sum_{x \varepsilon V(Gra)} \sum_{e \varepsilon E(Gra)} x(x)x'(y)d(x,e) \quad \text{---(3)}$$

Let e = xy be an edge of Graph(Gra), X is the subset of vertices of V (Gra)presents near to x and y when compare with X and Y. These notations X and Y indicates the vertices of the link which is given as follows:

X = {v ∈ V (Gra),dGra(x,v) < dGra(y,v)} ---(4)

Y = {v ∈ V (Gra),dGra(y,v) < dGra(x,v)} ---(5)

Where dG(u,v)indicates the length among two vertices of the graph

Let G[X]= (X,E1)and G[Y]= (Y,E2),n1(e)= |E1|,n2(e)= |E2|. here, n1(e) is the total amount of edges present when comparing x must be greater than y and n2(e) is the total amount of edges present when comparing y must be greater than yx.

Channel model

The channel model for the mmWave MIMO system is constructed based on the sparse channel propagation trends with consideration of line-of-sight (LoS). In the mmWave MIMO system, LoS path includes the correlated line-of-sight with strong attenuation frequencies with high path loss (nLoS) with sub-frequency of 6GHz. With consideration of LoS of mmWave channel is defined in equation (6) as follows

H= H_Los+H_nLos ---- (6)

In the above equation LoS is stated as follows:

H_Los= = ρLoS · αLoS (Tx+Rx) ----(7)

In the MIMO – NOMA model optimal pilot design is enhanced by Enhanced Particle Swarm Optimization (PSO). With the inclusion of a coding scheme, each signal exhibits a variation of 1-bit. In

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

(8) variation in a signal transmitted in terms of sine and cosine is presented as follows:

$$g_n(t)=\sqrt{\frac{2S_e}{D_s}}\cos\left(2\pi f_c t+(2n-1)\frac{\pi}{4}\right), n=1,2,3,4 \quad \text{--(8)}$$

Here, gn(t) represents the time of the signal, the signal power is denoted as Se, the signal duration for the symbol is represented as Ds and the baseband signal is stated as fc.

Simultaneous Wireless Information and Power Transfer analysis using NOMA

Every single frame separates the wireless information transmission stage for in the uplink from the wireless power transmission stage for in the downstream, which transmits a unique wireless transmission signal which includes every user throughout the downstream WPT period, in toT milliseconds. In general, to be normalised as, (0 to 1) frames length; the nth user then drains power from transmitter signals during the uplink phase. Figure 2 displays the time frame, t1, t2,...,tn, such that each user may employ to deliver a sequence during the uplink stage. For simplification purpose in the upcoming sections of this study, T is normalised as T = 1 while maintaining applicability.

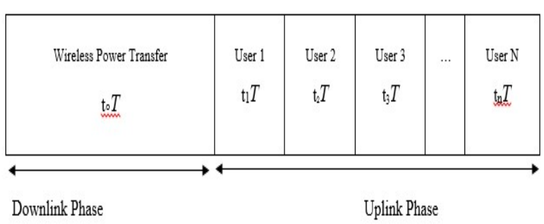

Figure 2: Time slot for downlink and uplink phase

Downlink Wireless Power Transfer

Under this phase, each node transfer an arbitrary power signal, namely x0 to all the users, which is given by

$$x0 = ws_d \quad \text{------(9)}$$

w∈Ϲ^(M×1)Is the energy beam formers again for broadcaster, and s_d is the observed data power-carrying randomized waveform with mean zero. The downstream transceiver can be represented asE[x0]=w^2, with such a broadcast sum-power limitation p_t giving us w^2,≤p_t. The downlink signal received by the nth receiver is then represented as

$$y_n = h_n^J w s_d + z_n \quad \text{------(10)}$$

The effective communication between node and the nth users is denoted byh_n ϵϹ^(M×1).

Uplink Wireless Information Transfer

The nth user provides the information using the obtained power during the downstream stage and generated power during the upstream stage. In the upstream stage, the median transmission power accessible for the nth users to convey data is represented by

$$p_n(w,\tau_0,\tau_n) = \frac{E_n}{\tau_n} = \frac{\rho_n \tau_0 [h_n W]}{\tau_n} \quad \text{----(11)}$$

Each nth user sends a unique transmission, x_n=√(ρ_n.s_n), inside a slot τ_nwith power ρ_n, where s_n ndenotes the nth user's data signal, which would be presumed to be unsystematic notation having square error and constant dispersion. The nth user's signal is passed at the nodes as well as delivered in the nth uplink slot is represented as

$$y_n = h_n x_n + \alpha \quad \text{-----(12)}$$

Where α is a compound Gaussian dispersed stochastic process having null value of mean and deviation, and is the disturbance at the base station.

3. HYBRID BEAM FORMING IN MIMO-NOMA

Considering the downlink MIMO–NOMA in a macro cell with a radius of 500m as shown in Fig.3. The BS provides p_bs transmit power, and equally distributes it among the N antennas.As a result, BS broadcasts a superimposed signal based on NOMA's properties. All M UEs are randomly distributed in a cell to create a MIMO–NOMA scenario.

(2)

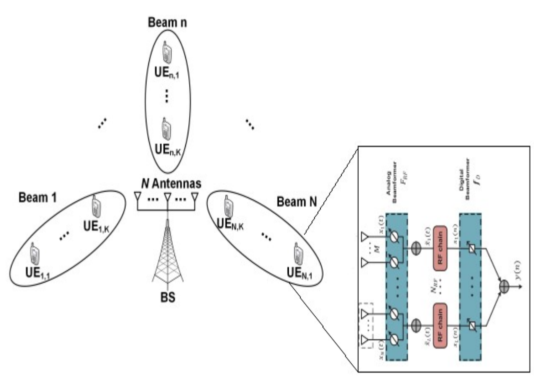

Figure 3: System Model for MIMO-NOMA Data Transmission Flow Among Users

Journal of Theoretical and Applied Information Technology
31st October 2022. Vol.100. No 20

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

The formula for a monopole band's absorbed energy is p n=p bs/N. In MIMO-NOMA, the UE nearest to the BS may employ SIC to reduce interference. In this scenario the SIC is designed to function with little errors. The BS is also responsible for grouping the UEs and figuring out how much power each UE can broadcast.BS broadcasts the signal that is superimposed, it is represented as

$$x_n = \sum_{k=1}^{K} \sqrt{\propto_{n,k}}\, p_n\, s_{n,k} \quad \text{----(12)}$$

Where $s_{n,k}, \propto_{n,k}, and\ p_n$ indicates the transferred signal to base station, power coefficient and transferred power on every beam adopted on K number of users respectively. The signal received by the$UE_{n,k}$:

$$y_{n,k} = h_{n,k} \sum_{n=1}^{N} w_n x_n + n_{n,k} \quad \text{-----(13)}$$

Where$h_{n,k}$indicates fading channel in Rayleigh form under each base station with $UE_{n,k}$.$w_n$indicates the precoding vector of every beam, hence the matrix format is given by$w = [w_1, w_2, \ldots..w_n], where\ w_n \in c^{1\times N}$ and $n_{n,k}$is the AWGN and $h_{n,k}$can be expressed as,

$$h_{n,k} = h_{n,k}\sqrt{d_{n,k}^{-\delta}} \quad \text{-----(14)}$$

Where$d_{n,k}$is the length amongst each base station. Following the principle of NOMA, the power allocation coefficient, $\beta_{u,v}$ ateach UE is expressed as,

$$0 \le \beta_{u,v} \le 1,\ \sum_{k=1}^{K} \beta_{u,v} = 1, \beta_{u,v} \in \forall \quad \text{---(15)}$$

Where$\forall$ denotes the set of feasible power allocation coefficients. As a consequence, the output of the x_l (t) sub-array is given as

$$x_l(t) = \sum_{m=0}^{M-1} s_d(t) e^{j2\pi fct(t-(\frac{\sin\theta_d}{2\pi fc}.\tau_d)} + \sum_{m=0}^{M-1} i_k(t) e^{j2\pi fct(t-(\frac{\sin\theta_k}{2\pi fc}.\tau_k)} + v(t) \quad \text{----(16)}$$

Where d indicates the amount of distance between every antenna element, which is considered as 0.5τ. Moreover, the propagation delay, also calibratesτ_d, τ_k with k-th interference correspondingly. The total number of reference points also considered for all the antenna elements.The notation c is the total speed of light. After the analog beam forming, the signal$x_l(t)$ with $(l = 1,2,3 \ldots.L)$passes through L and end up in finalized baseband signal form with L subset of users.

$$x(n) = F_{RF}^{H} As(n) + F_{RF}^{H} v(n) \quad \text{-----(17)}$$

Where, F_{RF}^{H} is the diagonal of the matrix with a phase shift, $As(n)$ is the input to the analog beamforming part and $v(n)$is the noise vector. After the application of digital beamforming vector $f_D \in C^{N_{RF}\times 1}$, in the digital beamforming section, equation (18) becomes,

$$y(n) = f_D^H F_{RF}^H As(n) + f_D^H F_{RF}^H v(n) \quad \text{--(18)}$$

By changing the digital beamforming vectorf_D, could reduce the signal amplitude, phase, or both.

Enhanced PSO pilot design

Most of the optimization issues are non-convex and hence, traditional convex optimization techniques are not effective. Therefore, in this paper, the Enhanced PSO technique is adopted to overcome it

Initially, a group of intervals with x_p is computed i.e.,$X = \{x_{p,i}\}$, i=1,2,....K, with the particle $x_{p,i}$. The particle swarm modifies the particle $x_{p,i}$ placement pbesti and the optimal solutions solution gbest fitness evaluation value. In the t th loop, the trajectories of particles $x_{p,i}$are defined as following:

$$v_i^t = wv_i^{t-1} + c_1 r_1(pbest_i - x_{p,i}^{t-1}) + c_2 r_2(gbest_i - x_{p,i}^{t-1}) \quad \text{----(19)}$$

$$x_{p,i}^t = x_{p,i}^{t-1} + v_i^t \quad \text{--- (20)}$$

Where v_i^{t-1} and $x_{p,i}^{t-1}$denote the particles velocity and position $x_{p,i}$ in the (t − 1)-th iteration, which would be employed to keep the particle's move inertia constant so that it can increase the subspace. In general, the velocity profile is dynamically modified for each iteration based on the optimizing findings. The training parameters c1 and c2 refer to the particle's stride length as it

Journal of Theoretical and Applied Information Technology
31st October 2022. Vol.100. No 20

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

moves towards the ideal place. In [0, 1], r1 and r2 are equally dispersed.

The particle trajectories $x_{p,i}$ in the (t − 1)th iteration are denoted by v_i^{t-1} and $x_{p,i}^{t-1}$. W is the weight vector, which would be employed to keep the particle's movement inertia constant so that it can increase the search area. For instance, the parameter is dynamically modified within every iteration based on the minimization findings. The training variables $c1$ and $c2$ refers to the subatomic particle stride length as it moves toward this ideal place. In [0, 1], $r1$ and $r2$ were equally dispersed.

4. PERFORMANCE ANALYSIS

The experimental analysis for the proposed PSO-HBPT is carried out and its corresponding result is generated using MATLAB software .The parameters used for analysis are Outage Probability (OP), Average Sum Rate (ASR), BER.

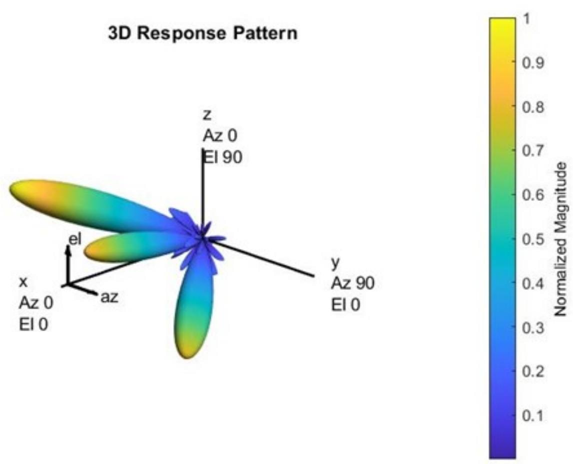

Figure 4: 3D Response Beam Forming

The information set's linear amplitude wide beam pattern is shown in Figure-4. Here, the zenith degrees downward to 120 were obtained by proper analysis. The variation among the top and bottom hemispheres is observed as a minor step for determining the positional accuracy during the regression analysis. The 3D response pattern indicates the total amount of beam formers.

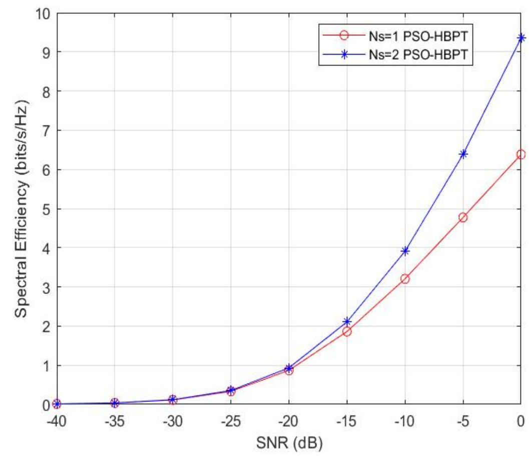

Figure 5: Analysis of spectral efficiency

The analysis of spectral efficiency for the suggested technique is depicted in figure 5,where the comparison is observed between Ns=1 and Ns=2 and it is inferred from the simulated findings that the spectral efficiency is highest for Ns=2,which justifies the theoretical concept of NOMA, that ensures fairness among users irrespective of the number of users.

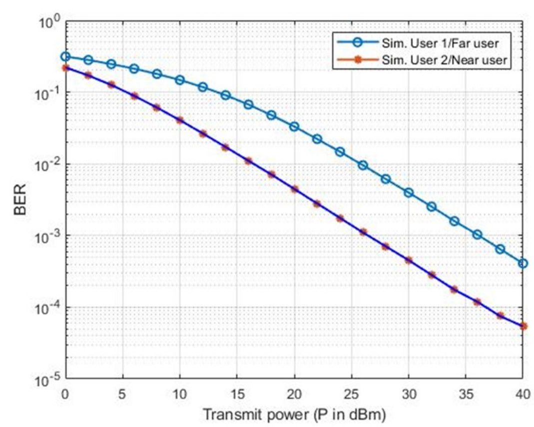

Figure 6: Analysis of Bit Error Rate (BER)

Figure 6 illustrates the analysis of BER for the proposed method between different users. The BER value of $10^{-2.5}$ is taken as reference, the observation from the comparison indicates that user 2 / near user gains 17 dBm of transmit power and user 1/far user gains 25dBm.The average estimated BER is observed as 10^{-4}, which is significantly acceptable range of the data transmission in the network.

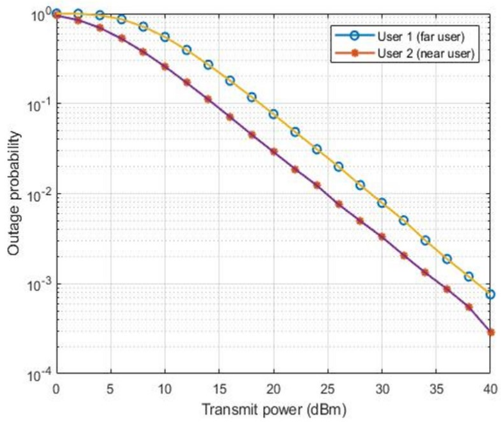

Figure 7: Analysis of outage probability

Figure 7, exhibits the comparative analysis of transmit power and outage probability for near and far user. For analysis, 10-2 is considered as reference value of outage probability and it is observed that user 1(far user) achieves a gain of 28 dBm and user2 (near user) achieves a gain of 25 dBm . The simulated findings indicate that the suggested PSO HBPT offers the lowest outage probability.

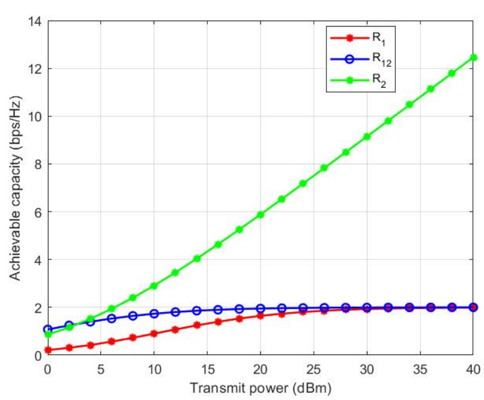

Figure 8: Analysis of average sum rate

In Figure 8, the analysis of the average sum rate between the suggested PSO-HBPT based for the mmWave MIMO - NOMA environment is depicted. It is noted that the suggested PSO-HBPT's spectral efficiency is measured at 9 bits/sec/Hz of average sum rate, where in the existing JO-SES method computes the average sum rate of 7 bits/sec/Hz

.

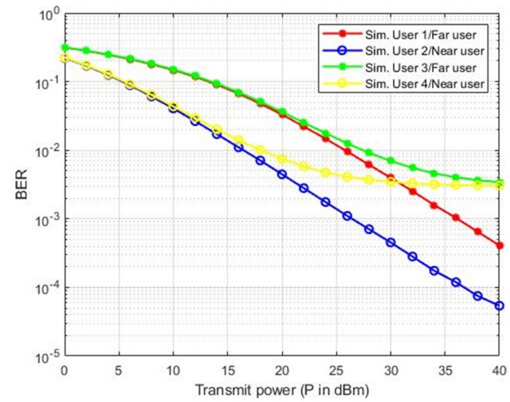

Figure 9: Comparison of Bit Error Rate for various users

The comparative analysis between bit error rate and transmit power for various users are illustrated in figure 9. The analysis is performed by considering 10^{-2} as reference BER value and the from the simulated findings it is observed that user 1/far user achieves 26 dBm. User 2/near user achieves 16 dBm, user 3/far user and user 4 / near user, gains 27 dBm and 20 dBm respectively. The observations clearly indicate that the proposed PSO-HBPT achieves less BER with optimal level of transmit power

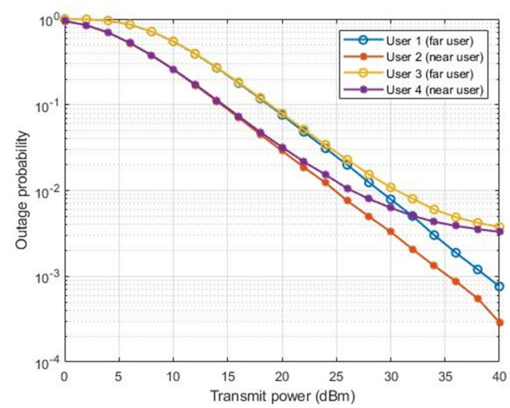

Figure 10: Comparison of outage probability for various users

The comparative analysis of outage probability for various users is depicted in figure 10. The analysis is performed by considering 10^{-2} as outage probability reference value and from the simulated findings it is observed that user 1/far user achieves 28 dBm. User 2/near user achieves 25 dBm, user 3/far user obtains 30 dBm and user 4 / near user, achieves 26 dBm respectively. The observations from the simulated findings clearly indicate that the proposed PSO-HBPT attains lower outage probability.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

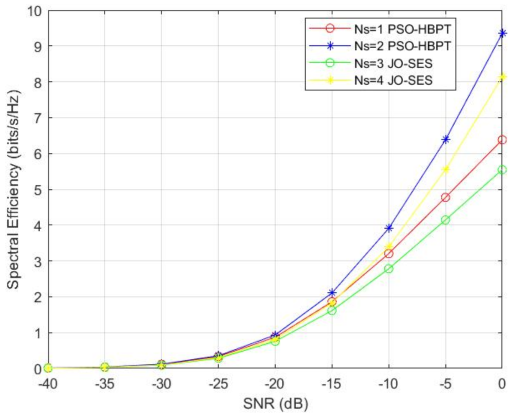

Figure 11: Comparison of spectral efficiency

The comparison of spectral efficiency for various users is depicted in figure 11. Considering Ns=1 in PSO-HBPT , for comparative analysis ,reference values for SNR is selected randomly and the observations are noted as follows, the spectral efficiency is observed to be 0.4 bits/s/Hz, when SNR is -5 dB the spectral efficiency is observed to be 4.6 bits/s/Hz. Considering Ns=2 in PSO-HBPT when SNR is -20 dB the spectral efficiency is 0.92 bits/s/Hz, and when SNR is -10 dB the spectral efficiency is 3.9 bits/s/Hz, the findings from the observations indicate that on an average, the proposed PSO-HBPT achieves spectral efficiency of 9 bits/s/Hz. The existing Joint Optimization Sub-band Expediency based Scheduling (JO-SES) method achieves spectral efficiency of 7 bits/s/Hz

5. CONCLUSION

This research paper, proposes a WSN-assisted IoT network with composite beam forming that employs the combination of the novel technologies, SWIPT and NOMA to achieve high level of spectral and energy efficiency . Enhanced version of Particle Swarm Optimization along with the combination of Hybrid Beamforming Power Transfer (HBPT) is employed to achieve optimal pilot design. The comparative analysis based on the considered parameters is performed between PSO-HBPT and Joint Optimization Sub-band Expediency based Scheduling (JO-SES) technique. The outcome of the simulated results clearly indicate PSO-HBPT outperforms JO-SES and has achievement benefits in terms of spectrum efficiency ,outage probability, average sum rate and bit error rate.

REFERENCES:

[1] Whitmore A, Agarwal A, Xu LDA. The Internet of things-a survey of topics and trends. InfSyst Front. 2015; 17(2):261-274.

[2] Mistarihi MFA, Mohaisen R, Sharaqa A, Shurman MM, Darabkh KA. Performance evaluation of multiuser diversity in multiuser twohop cooperative multi-relay wireless networks using maximal ratio combining over Rayleigh fading channels. Int J Commun Syst. 2015; 28(1):71-90.

[3] Wang S, Ji H. Distributed power allocation scheme for multi-relay shared-bandwidth (MRSB) wireless cooperative communication. IEEE Commun Lett. 2012; 16(8):1263-1265.

[4] Phan KT, Ngoc TL, Vorobyov SA, Tellambura C. Power allocation in wireless multi-user relay networks. IEEE Trans Wireless Commun. 2009; 8(5):2535-2545.

[5] Mo Z, Su W, Batalama S, Matyjas JD. Cooperative communication protocol designs based on optimum power and time allocation. IEEE Trans Wireless Commun. 2014; 13(8):4283-4296.

[6] Rauniyar A, Engelstad PE, Osterbo N. On the performance of bidirectional NOMA-SWIPT enabled IoT relay networks. IEEE Sensors J. 2021; 21(2):2299-2315.

[7] Xia X, Zhang D, Xu K, Ma W, Xu Y. Hardware impairments aware transceiver for full-duplex massive MIMO relaying. IEEE Trans Signal Process. 2015;63(24):6565-6580.

[8] I. Krikidis, S. Sasaki, S. Timotheou, and Z. Ding, “A low complexity antenna switching for joint wireless information and energy transfer in MIMO relay channels,” IEEE Trans. Commun., vol. 62, no. 5, pp. 1577– 1587, 2014.

[9] Z. Ding, I. Krikidis, B. Sharif, and H. V. Poor, “Wireless information and power transfer in cooperative networks with spatially random relays,” IEEE Trans. Wireless Commun., vol. 13, no. 8, pp. 4440 4453, 2014.

[10] Z. Ding and H. Poor, Cooperative energy harvesting networks with spatially random users, IEEE Signal Process. Lett., vol. 20, no. 12, pp. 1211 1214, Dec 2013

[11] Liu, C.F.; Bennis, M.; Debbah, M.; Poor, H.V. Dynamic task offloading and resource allocation for ultra-reliable low-latency edge

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

computing. IEEE Trans. Commun. 2019,67, 4132–4150

[12] Choi, K. W., Hwang, S. I., Aziz, A. A., Jang, H. H., Kim, J. S., Kang, D. S., & Kim, D. I. (2020). Simultaneous wireless information and power transfer (SWIPT) for Internet of Things: Novel receiver design and experimental validation. IEEE Internet of Things Journal, 7(4), 2996-3012.

[13] Alraddady, F., Ahmed, I., &Habtemicail, F. (2021). Robust Hybrid Beam-Forming for Non-Orthogonal Multiple Access in Massive MIMO Downlink. Electronics, 11(1), 75.

[14] Hussein, M. K., &Khamiss, N. N. (2020). Cooperative millimeter wave MIMO-NOMA based on hybrid beamforming for 5G networks. Solid State Technology, 63(5), 6881-6890.

[15] Nguyen, T. L., Ha, D. H., Tin, P. T., &Vinh, N. V. (2021). SWIPT-Based Nonorthogonal Multiple Access under Arbitrary Nakagami-m Fading with Direct Links. Journal of Computer Networks and Communications, 2021.

[16] Jiang, R., Wang, X., Cao, S., Zhao, J., & Li, X. (2019). Joint compressed sensing and enhanced whale optimization algorithm for pilot allocation in underwater acoustic OFDM systems. IEEE Access, 7, 95779-95796.

[17] Jiang, Y. (2020). Deterministic Pilot Pattern Placement Optimization for OFDM Sparse Channel Estimation. IEEE Access, 8, 124783-124791.

[18] Muhammet Nuri Seyman and NecmiTaspinar, "Particle Swarm Optimization for Pilot Tones Design in MIMO-OFDM Systems", EURASIP Journal on Advances in Signal Processing, Vol. 2011, pp. 1-10, 2011.\

[19] Neenavath Veeraiah and B. Tirumala Krishna "Trust-aware Fuzzy Clus-Fuzzy NB: intrusion detection scheme based on fuzzy clustering and Bayesian rule," *Wireless Networks*, vol.25, no.07, pp.4021-4035,2019,

[20] Neenavath Veeraiah and B. Tirumala Krishna "An approach for optimal-secure multi-pathrouting and intrusion detection in MANET," Evolutionary Intelligence, vol.15, pp.1313-1327,2022.

[21] Neenavath Veeraiah and B. Tirumala Krishna "Intrusion Detection Based on Piecewise Fuzzy C-Means Clustering and Fuzzy Naïve Bayes Rule," *Resbee Publishers Multimedia Research (MR)*, vol.01, no.01,pp.27-32,2018

[22] Neenavath Veeraiah and B. Tirumala Krishna "Selfish Node Detection IDSM Based Approach Using Individual Master Cluster Node" Proceedings of the Second International Conference on Inventive Systems and Control (ICISC 2018) ISBN: 978-1-5386-0807-4.