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LINK UTILIZATION FOR IOT QUALITY OF SERVICE USING HYBRID SWARM IN WIRELESS SENSOR NETWORKS

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Abstract

The wireless sensor networks (WSN) that find its use in various applications of internet of things (IOT) have been regarded as the norm of today's world. The wireless sensor networks (WSN) as its name suggests have nodes or sensory nodes that have limited energy for operation, because of their limited battery life and their use in certain unreachable places and hence they have been termed as energy-constrained devices. In order to overcome such restrictions, it is need of hour to develop such approach whose focus must be on power optimization by using cross-layer coding and also in turn maintaining the quality of service in data trafficking. The data communication with a high level of accuracy in a wireless sensor network has been required, in order to achieve it, it is a necessary condition to have optimal coding which helps us in achieving a maximum level of intelligence with minimum computation. In order to achieve this, we have developed a technique based on particle swarm optimization (PSO), which helps in bettering the link parameters that consists of bit error rate (BER), loss, energy and signal to noise ratio (SNR) and side by side restrains, the utilization of energy by wireless nodes. The infrastructure which has been obtained by this, will consist of a low number of sensors, have low cost, can be deployed fastly, having long lifetime, along with low maintenance, and also have high quality of service (QOS). The method used by us has been tested on two channels like additive white gaussian noise channel (AWGN) and Rayleigh channel, that shows better quality of service and hence also improves the utilization of link up to a great extent.

Keywords: WSN, IOT, BER, SNR, PSO.

1. Introduction

For technology disappearing from the consciousness of the user, the Internet of Things demands: (1) a shared understanding of the situation of its users and their appliances,(2) software architectures and ubiquitous communication networks to process and convey the contextual information to where it is relevant, and (3) the analytical tools in the Internet of Things that aims for autonomous and smart behavior [1].The wireless sensor network (WSN) forms part and parcel of (IoT) for different applications as discussed above and therefore can be widely utilized in various application scenarios of the Internet of Things (IoT) in modern societies, such as smart intelligent agriculture, environmental monitoring, intelligent medical treatment, early warning of natural disasters, etc. The WSN is an important implementation of IoT and the architecture of such a network based on WSN usually comprises various dynamic nodes and base station (BS), which cooperates to perform different works as data acquisition, data processing, and transmission tasks. Each node in a network is mainly composed of a sensor unit, wireless transmitting module, power module, data processing, and storage unit. Usually, the nodes are embedded micro-devices with limited processing, storage, and communication capabilities along with limited power for operation, which is the most critical challenge in other terms referred to as energy limitation. Simultaneously, it is difficult to replenish the extra energy demand of the deployed nodes. Hence, the exhaustion of energy means the "death" of those nodes [2]. Apart from power components and communications, IoT systems are mainly consisting of sensors and actuators. Sensors are known as the system's sensory organs that sense the particular physical condition such as temperature, pressure, or simply used for video/audio recording in this particular case senses the changes in the environment.

2. Literature survey

Yinggao et al. [1] The fault tolerance mechanism used in the route optimization of the mobile wireless sensor network (MWSN) proved to be more fruitful, in this particular method we analyze the routing fault tolerance between nodes and then establish an intelligent fault-tolerant routing model for MWSN. It has also been proposed to develop a novel fault-tolerant routing algorithm for a MWSN which are based on an artificial bee colony (ABC) optimization and particle swarm optimization algorithm (ABC-PSO), and this optimized technique i.e., ABC-PSO algorithm is then applied to study the optimal construction strategy of an alternate route. Then proposed using path coding, the ABC algorithm optimization, the collaborative updating and the evolution of the principal and subordinate swarms, also particle selection, provides much faster overall convergence performance and much more accurate solutions for the network optimization.

Mohsen et al. [2] In diversity combining at the receiver, the output signal-to-noise ratio (SNR) can be maximized by using the maximal ratio combining (MRC) provided that the channel is entirely estimated at the receiver. However, channel estimation is rarely perfect in practice, by virtue of which results in deteriorating the system performance. In order to counter this an imperialist

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competitive algorithm (ICA) has been proposed and compared with two other evolutionary based algorithms, namely particle swarm optimization (PSO) and genetic algorithm (GA), in order to get diversity combining of signals travelling across the imperfect channels. The proposed algorithm is used to adjust the combiner weights of the received signal components in such a way that maximizes the SNR and minimizes the bit error rate (BER).

Gurbinder et al. [3] The main problem is to identify the dead nodes and to choose another suitable path in order that the data transmission must become smoother and less energy is conserved. In order to resolve such issues, an algorithm which is based on directional transmission and energy aware routing protocol named as PDORP. This proposed protocol PDORP has the characteristics of both Power Efficient Gathering Sensor Information System (PEGASIS) and DSR routing protocols. In addition to that, hybridization of Genetic Algorithm (GA) and Bacterial Foraging Optimization (BFO) has been applied to proposed routing protocol to identify energy efficient optimal paths.

Tarunpreet et al. [4] A systematic review on the QoS mechanisms that have been employed by routing protocols and also highlights the performance issues of each mechanism. Afterwards, a comparative analysis of computational intelligence based QoS-aware routing protocols with their strengths and limitations. The new QoS provisioning techniques include multi-constrained routing, clustering, multipath routing, multiple sinks, and mobile sink. With the quick expansion of computational intelligence (CI) over the past decade, routing protocols which are based on particle swarm optimization (PSO), ant colony optimization (ACO), artificial bee colony (ABC), evolutionary algorithms (EA), fuzzy logic (FL), reinforcement learning (RL), and bee mating optimization (BMO) have been proposed which provide the application-specific QoS assurance in WSN.

Lazarescu et al. [5] The functional design of a WSN is based on the implementation of a complete WSN platform which in turn can be used for a variety of long-term environmental monitoring IoT applications. The main requirement of application is in terms of low cost of full implementation using high number of sensors and how fast they have been deployed, how long is their life, having low maintenance, and high quality of service are the factors considered in the stipulation and design of the platform and all of its components. Low-effort platform reuse has also been considered which starts from the specifications and at all levels of design for a wide range of related monitoring applications.

Carlos et al. [6] The optimal energy that is required by a wireless channel link in order to attain the best link condition, and thus having better quality of the signal given by the minimum bit error rate (BER). With computer simulation support by building a network real time environment, the study of different radio frequency elements in wireless communications, model of propagation and bit error rate in accordance with the signal to noise ratio. This in turn helps in improving suitable control channel power assignment and minimum bit error rate which is required for defining the number of bits sent. This experimental characterization and validating the design of mathematical model with different technological advancements using over a wide range of network conditions which in turn deploy a real-world environmental monitoring application having a multi-point network to measure signals that guarantee the quality of service by the factors as: packet delivery rate, throughput, latency, and energy consumption.

Ramesh et al. [7] Data transmission in applications as environmental, security, and health monitoring had required both quality of service (QoS) and quality of equipment (QoE) aware network in ensuring efficient use of resources and effective access. In wireless video sensor network by using hybrid optimization (RAS-HO) algorithm. Firstly, the formation of clusters is done by modifying the behaviour of animal migration through optimization algorithms, which enhances the consumption of energy to its minimum value. Secondly, resources have been allocated efficiently by performing a glowworm swarm optimization which is based on a decision-making algorithm. Simulation results thus shows that the proposed scheme had achieved the required resources much better than existing schemes in terms of QoS metrics which are energy efficient, delay fairness and throughput, also QoE metrics having peak signal to noise ratio and structural similarity.

Omprakash et al. [8] The framework for optimizing fault tolerance in virtualization in WSNs, focuses on heterogeneous networks for service-oriented IoT applications. The optimization problem has been formulated which considers fault tolerance and communication delay as two opposing objectives. The adaptive non-dominated sorting based genetic algorithm (A-NSGA) has been developed to solve the optimization problem. The major components of A-NSGA include chromosome depiction of fault tolerance and computational delay, crossover and mutation, and non-dominance-based sorting. Analytical and simulation based relative comparison of performance evaluation has been carried out. From the analysis of results, it has been found that the framework had effectively optimizing fault tolerance for virtualization in WSNs.

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Wen-Tsai et al. [9] wireless sensor network with applications like real-time remote identification by using the Android study of things (HCIOT) platform used in community healthcare. For this improved particle swarm optimization (PSO) method has been proposed to efficiently boost physiological multi-sensors data fusion measurement precision in the Internet of Things (IOT) system. This particular application uses Improved PSO (IPSO) consisting of: inertia weight factor design, shrinkage factor adjustment which allows in improving PSO algorithm data fusion performance. The Android platform has been employed to build multi-physiological signal processing and timely medical care of things analysis. Wireless sensor network signal transmission and Internet links hence allows community or family members to have timely medical care network services.

3-Motivation and proposal:

The primary objective of such an approach is to develop a methodology for power optimization using cross-layer coding and maintain the quality of service in data trafficking. Wireless sensor nodes are inherently energy-constrained devices. Furthermore, most of the time, these devices are deployed in hard-to-reach areas where recharge or replacement of batteries is not possible. Therefore, energy conservation through efficient utilization of available energy helps to prolong the operation of the network. Wherein data communication in a wireless sensor network is required with a high level of accuracy, it is necessary to have optimal coding to achieve a maximum level of skill with minimum computation. Complex coding is present to overcome the interference effect in wireless sensor networks; the coding demands a high level of resources to perform the calculation. Hence, requiring massive power consumption minimizing the node life. In such a system, power could be optimized during coding, forwarding, or receiving. Wireless signal quality because applications can fulfill their requirement if communication through the reliable operation, this was done based on the functional design and implementation of a complete WSN platform that can be used for a range of long-term environmental monitoring IoT applications. The infrastructure was low cost, low number of sensors, fast deployment, long lifetime, low maintenance, and high quality of service was allowed for in specification and design of the platform and all its components.

The main object of this research is based on the followings principles of the wireless sensor networks used in internet of things (IoT) applications as discussed below in the following points:
To improve the quality of service of wireless communication in a different type of noise channel like AWGN, Rayleigh.
Additive white Gaussian noise (AWGN) is a basic noise model that is used in information theory to mimic the effect of many of the random processes that occur in nature. The modifiers denote specific characteristics:
Additive because it is used to add any noise that might be intrinsic to the information system.
White It refers to the idea that it has a uniform power across the frequency band for the information system. It is homologous to the white color because it has uniform emissions at all frequencies in the visible spectrum.
Gaussian As it has a normal distribution in the time domain having an average time domain value of zero.
The AWGN channel has been represented by a series of outputs yi which is at a discrete time event index i. yi is considered as the sum of the input xi and noise zi, where zi has been independent and identically distributed and has been drawn from a zero-mean normal distribution with variance N (the noise). The zi has been further assumed as not be correlated with the xi.

$$z_i \sim N(0,\ n) \qquad (1)$$
$$y_i = x_i + z_i \qquad (2)$$

The capacity of the channel has been considered as infinite unless the noise N is nonzero, and the xi has been sufficiently constrained. The most common constraint on the input is "power" constraint, that requires a codeword (x1, x2, ...,xk) which would be transmitted through the channel, we have:

$$\frac{1}{k}\sum_{i=1}^{k} x_i^2 \leq p, \qquad (3)$$

where p can represent the maximum channel power. Therefore, the channel capacity for the power-constrained channel has been given by:

$$C = \max_{f(x)\ s.t.\ E(x^2) \le p} I(X;Y) \qquad (4)$$

Where $f(x)$ is the distribution of X. Expand $I(X;Y)$ which is writing it terms of the differential entropy:

$$I(X;Y) = h(y) - h(y/x) = h(y) - h(x+z/x) = h(y) - h(z/x) \qquad (5)$$

But X and Z are independent, therefore

But X and Z are independent, therefore

$$I(X;Y) = h(y) - h(z) \qquad (6)$$

Evaluating the differential entropy of a Gaussian gives:

$$h(z) = \tfrac{1}{2} log\,(2\pi e N) \qquad (7)$$

Because x and z are independent and their sum gives y

$$E(y^2) = E((x+z)^2) = E(x^2) + 2E(x)E(z) + E(z^2) = P + N \qquad (8)$$

From this bound, we can infer from a property of the differential entropy that

$$h(y) \le \tfrac{1}{2} log\,(2\pi e(P+N)) \qquad (9)$$

Therefore, the channel capacity can be given by the value of highest achievable bound on the mutual information:

$$I(X;Y) \le \tfrac{1}{2} log\,(2\pi e(P+N)) - \tfrac{1}{2} log\,(2\pi e N) \qquad (10)$$

Where I (X; Y) is maximized when:

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$$x \sim N(0, P) \qquad (11)$$

Thus, the channel capacity C for the AWGN channel is given by:

$$C = \frac{1}{2} log\,(1 + \frac{P}{N}) \qquad (12)$$

Rayleigh fading It is a statistical model which shows the effect of a propagation environment on a radio signal, such as that used by wireless devices.

Rayleigh fading has been viewed as a reasonable model for tropospheric and ionospheric signal propagation as well it shows the effect of heavily built-up urban environments on radio signals. Rayleigh fading is much suitable when there is no dominant propagation along a line of sight between the transmitter and receiver. If there is a dominant line of sight, Rician fading may be more applicable. Rayleigh fading has been viewed as a special case of two-wave with diffuse power (TWDP) fading.

The multipath fading results because of the fluctuations of the signal amplitude and the addition of signals that arrive with different phases. This phase difference has been caused because the signals have traveled different distances by traveling along different paths. Since the phases of the arriving paths have been changing rapidly, the received signal amplitude thereby undergoes rapid fluctuation that is often being modeled as a random variable with a particular distribution.

The most commonly used distribution for multipath fast fading is the Rayleigh distribution, whose probability density function (pdf) is given by:

$$f_{ray}(r) = \frac{r}{\sigma^2} exp(-\frac{r^2}{2\sigma^2}),\ r \geq 0 \qquad (13)$$

Here, it has been assumed that all signals suffer nearly the same attenuation, but they arrive with different phases. The random variable which corresponds to the signal amplitude is r. Here 2 is the variance of the in-phase and quadrature components. It has been considered theoretically that the sum of such signals will result in such an amplitude which has the Rayleigh distribution of the above equation. This can be also supported by measurements at various frequencies. The phase of the complex envelope of these received signals has been normally assumed to be uniformly distributed in [0,2π].

When strong LOS signal components also exist, the distribution is found to be Rician, the pdf of such function is given by:

$$f_{ric}(r) = \frac{r}{\sigma^2} exp(\frac{-(r^2+A^2)}{2\sigma^2}) I_o(\frac{A}{\sigma^2}),\ r \geq 0, A \geq 0 \qquad (14)$$

Where 2 is regarded as the variance of the in-phase and quadrature components. A is considered as the amplitude of the signal of the dominant path and Io is the zero-order modified Bessel function of the first kind. Normally this dominant path has been seen to significantly reduce the depth of fading, and in terms of bit error rate (BER) Ricean fading provides superior performance to Rayleigh fading. The probability of having line-of-sight (LOS) components is dependent on the size of the cell. The smaller the cell the higher its probability of having LOS path. If there is a situation of having no dominant path then the Rician pdf reduces to Rayleigh pdf. When A is large as compared with σ, the distribution is then approximated to Gaussian. Thus, since Ricean distribution covers also Gaussian and Rayleigh distribution, thus mathematically the Ricean fading channel can be considered to be a general case. To propose an approach for reduction of power consumption. Energy in Wireless Sensor networks (WSNs) represents an essential aspect in areas such as designing, controlling and operating the sensor networks. Minimizing the consumed energy in WSNs applications has been regarded as a crucial issue for the network effectiveness and efficiency in terms of lifetime, cost and operation. Number of algorithms and protocols have been proposed and implemented to decrease energy consumption. WSNs operate with battery powered sensors. Sensor batteries are not easily rechargeable because of their places of use, even though they have restricted power. It has been seen that network failure occurs due to the sensor's energy insufficiency. MAC protocols in WSNs have achieved low duty-cycle by employing periodic sleep and wakeup.

To improve Loss and Bit Error Rate by swarm intelligence approach. It has been done by joint antenna combination and symbol detection. More specifically, this new approach simultaneously determines the transformation weighting for antenna combination to lower the RF chains which are called for and to design the minimum bit error rate (MBER) detector which is used to effectively mitigate the impairment caused due to interference. The joint decision statistics is highly nonlinear and the particle swarm optimization (PSO) algorithm has been employed to reduce the computational overhead.

To analyze the comparison of proposed and existing approaches using QAM modulation. Quadrature Amplitude Modulation or QAM is a form of modulation that has been widely used for modulating data signals onto a carrier and then used for radio communications. QAM, when used for digital transmission in radio communications applications, it has been seen that it was able to carry higher data rates than ordinary amplitude modulated schemes and phase modulated schemes. This approach can be analyzed with the following parameters as:

• BER In digital transmission, the number of error bits has been given as the number of received bits of a data stream in a communication channel that have been altered due to various factors such as noise, interference, distortion or bit synchronization errors. The bit error rate (BER) is the number of errors bits per unit time. The bit error ratio (also BER) is defined as the number of error bits divided by the total number of transferred bits in a particular time interval. Bit error ratio is a unitless performance measure, which can be often expressed as a percentage. For example, in the case of QPSK modulation and AWGN channel, the BER as function of the Eb/N0 is given as:

$$\mathrm{BER} = \tfrac{1}{2}\left(\sqrt{Eb/No}\right) \qquad (15)$$

• LOSS Path loss, or path attenuation, has been defined as the reduction in power density (attenuation) of an electromagnetic wave as it propagates through space. This term has been commonly used in wireless communications and signal propagation. Path loss may be caused due to a number of effects, which include free-space loss, refraction, diffraction, reflection, aperture-medium coupling loss, and absorption. Path loss is also affected by terrain contours, environment (urban or rural, vegetation and foliage), propagation medium (dry or moist air), the distance between the transmitter and the receiver, and the height and location of antennas.

• SNR Signal-to-noise ratio (SNR or S/N) is defined as a measure that compares the level of a desired signal to the level of background noise. SNR can be further explained as the ratio of signal power to the noise power, often expressed in decibels. A ratio higher than 1:1 (greater than 0 dB) indicates more signal than noise.

Signal-to-noise ratio is defined as the ratio of the power of a signal (required input) to the power of background noise (unwanted input):

$$\mathrm{SNR} = \frac{P_{signal}}{P_{noise}} \qquad (16)$$

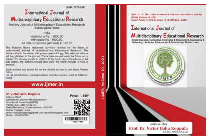
where P is average power. Both signal and noise power must be measured at the same points in a system, and within the same system bandwidth.

Depending on whether the signal is a constant (s) or a random variable (S), the signal-to-noise ratio for random noise N becomes:

$$\mathrm{SNR} = \frac{s}{E(N^2)} \qquad (17)$$

where E refers to the expected value, i.e., in this case the mean square of N and can be expressed as:

$$\mathrm{SNR} = \frac{E(S^2)}{E(N^2)} \qquad (18)$$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• Energy Reduction Duty cycling schemes is the most compatible technique for energy saving and others are the data-driven approaches that can be used to improve energy efficiency. Further communication protocols are also used to save energy for sensor networks.

The properties which have been discussed in methodology section of the file are further discussed below along with their results and also comparing these results with the previous method used to improve the link utilization and hence at the end of this section we came to the conclusion that our method improves the quality much better than the existing one. The properties which we discuss would include bit error rate (BER), Loss of a link, Energy consumption, signal to noise ratio (SNR), which in our case is kept fixed and we analyse other properties based on it. The signal to noise ratio will be given different fixed values and by obtaining the other parameters with respect to it, we then compare the results obtained with the existing method on the same set of values for signal to noise ratio on which the other parameters have been obtained previously. On comparing the results, we came to know that our method shows much better results than the previous existing one as:

Parameter results

Results of Bit Error Rate: Bit error rate (BER) is one of the important parameters in improving the link in wireless communication networks because it shows how much data which have been received at the receiver is error free that means how many bits have been transmitted from the transmitter reaches to the receiver without error, hence affecting the overall performance of the system.

The symbol error rate (SER) for a rectangular M-QAM, here M stands for how many bits are transmitted in QAM like (16-QAM, 64-QAM, 256-QAM etc) with size L = M2 can be calculated by considering two M-PAM on in-phase and quadrature components. The error probability of QAM symbol has been obtained by the error probability of each branch (M-PAM) and is given by:

$$p_s = 1 - \left(1 - \frac{2(\sqrt{M}-1)}{\sqrt{M}} Q\left(\sqrt{\frac{3\bar{\gamma}_s}{M-1}}\right)\right)^2 \quad (21)$$

If the use of a nearest neighbor approximation has been considered for an M-QAM rectangular constellation, then there are 4 nearest neighbors with distance dmin. So, the SER for high SNR can be approximated by

C (22)

And if we had to calculate the mean energy per transmitted symbol, it can be calculated as:

$$\bar{E}_s = \frac{1}{M}\sum_{i=1}^{M} A_i^2 \quad (23)$$

Using the fact that Ai=(ai+bi) andai and bi(2i-1-L) for i = 1,…….,L. After some simple calculations we obtain:

$$\bar{E}_s = \frac{d_{min}^2}{2L}\sum_{i=1}^{L}(2i-1-L)^2 \quad (24)$$

For example, for 16-QAM and dmin= 2 the Es = 10. For 64-QAM and dmin = 2 the Es= 21.

A fading channel can also be considered as an AWGN with a variable gain. The gain itself is considered as a RV with a given pdf. So, the average BER can then be calculated by averaging BER for instantaneous SNR over the distribution of SNR:

$$P_b(E) = \int_0^\infty p_b(E/\gamma)P_\gamma(\gamma)d\gamma \quad (25)$$

The BER is expressed by a Q-function as

$$P_b(E) = \int_0^\infty Q(\sqrt{2g\gamma})P_\gamma(\gamma)d\gamma \quad (26)$$

Where g = 1 for the case of coherent BPSK.

The figure below shows the result of Bit error rate (BER) obtained by using the particle swarm optimization (PSO) used in our case and also comparing the result found by us with the existing method in both additive white gaussian noise channel (AWGN) and Rayleigh channel.

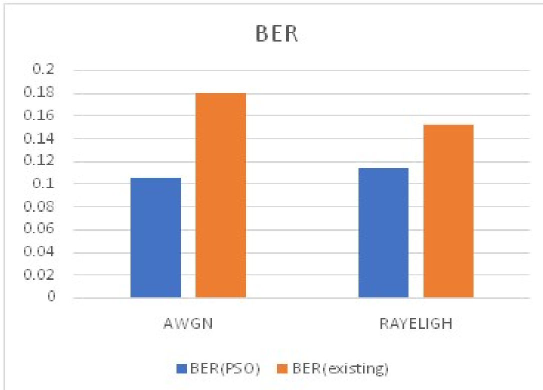

fig 4.1 Comparison of BER

Result of LOSS: Path loss is closely related to the environment where the transmitter and receiver are located. Path loss models have been developed using a combination of numerical methods and empirical approximations of measured data collected in channel sounding experiments. In general, propagation path loss can increase with both frequency and distance:

$$P_l = 10\,log_{10}\left(\frac{16\pi^2 d^n}{\lambda^2}\right) \quad (27)$$

where 'p' is the average propagation path loss, 'd' is the distance between the transmitter and receiver, 'n' is the path loss exponent which can vary between 2 for free space and 6 for obstruction during building propagation and 'λ'is the free space wavelength which can be defined as the ratio of the speed of light in meters per second to the carrier frequency in Hz.

$$\lambda = \frac{c}{f_c} = \frac{2.9979\times10^8 \, meters/second}{f_c HZ} \quad (28)$$

The maximum range between two transceivers can be defined as the distance where the two nodes can communicate with an acceptable BER.

The figure below shows the comparison between the losses in AWGN and Rayleigh channels for both the optimization methods used i, e between particle swarm optimization and existing methods. Here we can see that there is much less loss in PSO method as compared to the existing methods as:

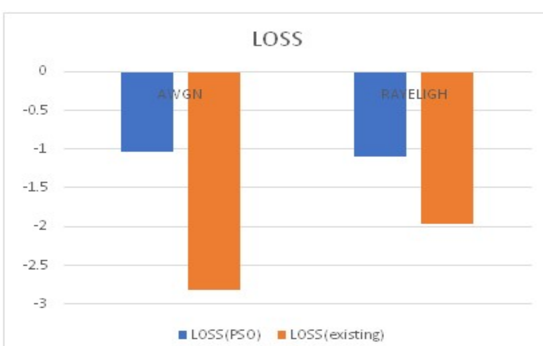

Fig 4.2 Comparison of LOSS

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Result of Energy: A wireless sensor network consisting of a large number of sensor nodes which have been deployed over a vast area to perform local computations which are based on gathering of information from the surroundings. Each node in such a network consists of a battery, but it has been very difficult to change or recharge batteries. Thus, the techniques used for energy conservation in sensor networks are much more important which include duty cycling scheme, data driven approaches, mobility-based schemes, energy efficient MAC protocols and node self-scheduling scheme. These schemes help in improving the energy efficiency of the wireless sensor network so that the network can be used to work with greater efficiency and high battery lifetime.

The Particle Swarm Optimization (PSO) approach can be applied for producing energy-aware clusters having optimal selection of cluster head. The PSO then ultimately reduces the cost of locating optimal positions for the cluster head nodes. The PSO implementation can be performed within the cluster rather than base station, which helps it in making a semi-distributed approach. The selection criteria of the objective function have been based on the residual energy, also on minimum average distance from the member nodes and head count of the probable head nodes.

The figure below shows the comparison of energy utilization in PSO and Existing approach in both AWGN and Rayleigh channels as:

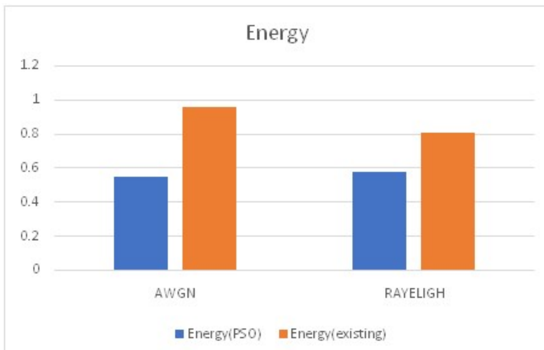

Fig 4.3 Comparison of energy

Result of SNR: All real measurements which take place are disturbed by noise. This can include electronic noise, but can also include external events that mostly affect the measured phenomenon like wind, vibrations, gravitational attraction of the moon, variations of temperature, variations of humidity, etc., depending on what has been measured and due to the sensitivity of the device. It has been regarded as often possible to reduce such noises by controlling the environment. The figure below shows the comparative study of SNR in AWGN and Rayleigh channels using both particle swarm optimization and existing technique as:

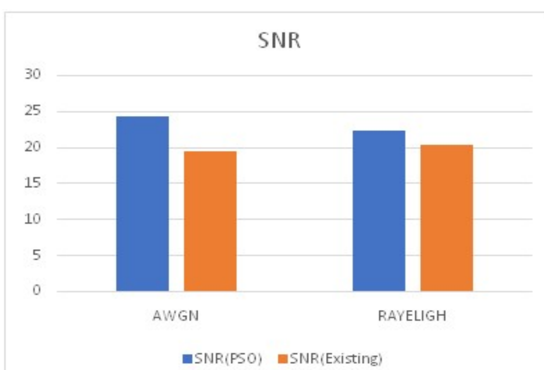

Fig 4.4 Comparison of SNR

Performance Evolution

The table below shows all the parameters in AWGN and Rayleigh channel which further explains the different parameter values side by side

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along with the values of the existing method parameters which enables us to compare and hence come to the conclusion that the PSO optimization method proves to be much more effective and efficient as compared to the previous existing one as shown below

Table 4.1 Table of comparison of BER

Channels	BER (PSO)	BER (Existing)
AWGN	0.1056	0.1792
Rayleigh	0.1138	0.152

Table 4.2 Table of comparison of LOSS

Channels	LOSS (PSO)	LOSS (Existing)
AWGN	-1.0399	-2.819
Rayleigh	-1.094	-1.959

Table 4.2 Table of comparison of LOSS

Channels	LOSS (PSO)	LOSS (Existing)
AWGN	-1.0399	-2.819
Rayleigh	-1.094	-1.959

Table 4.4 Table of comparison of SNR

Channels	SNR (PSO)	SNR (Existing)
AWGN	24.3182	19.3182
Rayleigh	22.3182	20.382

CONCLUSION

As it been seen already in result section that different parameters which have been considered in the topic like BER, LOSS, Energy, SNR in both AWGN and Rayleigh channels have been seen to prove more effective or we can say the values obtained by our method are much better than the values obtained previously. Our method which is based on particle swarm optimization technique have effectively improved the link between trans receiver nodes in wireless sensor networks which is particularly used for internet of things applications in our case.

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