ROUTING PROTOCOL DEVELOPMENT USING COOPERATIVE POWER & ENERGY EFFICIENT CONCEPT IN WIRELESS SENSOR NETWORKS-COPE

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Abstract

This paper is related to the development of Cooperative Power and Energy-efficient RoutingProtocol named as COPER for the Wireless Sensor Networks and its performance is compared with the Low Energy Adaptive Cluster (LEACH) and Power Efficient Gathering in Sensor Information Systems (PEGASIS) routing the rejuvenated & improvised routing protocol schemes. NS2 is used as the simulation tool. The comparison of the work done isbased on the performance metrics of the WSNs such as the packet delivery ratio energy efficiency and thethroughputs and the effectivity of the protocols proposed is seen here. From the results, it can be inferred that after each round, the number of dead nodes is relatively very less, but the number of alive nodes increases after every round because of energyefficiency, thus providing a better throughput. The entire WSN will be able to transmit more number of data packets from the nodes to the destination, henceincreasing the throughput of the proposed system. The simulation results shows the effectivity of the methodology that is being proposed by us.

Keywords: WSN, Static, Dynamic, Packets, Authentication, Sensor, Node, Distribution, Network, Key, Message Authentication Code Protocol, Security,Routing, Management, Sink, Cryptography, Source,Energy, Router, Attacker, Base Station, Machine condition monitoring, Industrial wireless sensor networks, Cooperative communication, Medium access control, Indoor industrial monitoring.

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1. Introduction

A **wireless sensor network** (*briefly abbreviated as WSN*) is a dedicated sensor monitoring system for recording the state or condition of a network, which consists of a number of parameters called as nodes (*source, sink, base station, attackers*), the recorded data being maintained at a central location. As there are 2types of WSNs, viz., *static WSN* & mobile WSN, each
one has got advantage over the others & the latter has been used in our research work. Transmission of data packets in WSNs in the recent digital era plays a very important role in the progress of a nation that too with minimized energy [1]-[5].

2. Proposed Methodology

In the work considered, we have proposed one novel methodology for the energy efficient distributed cooperative routing protocols for wireless sensor networks. In all the proposed work, theobjective have been achieved using the NS-2 platform, simulations are performed & the simulated results shows the efficiency of the methodology developed, at the same time comparisons being done with the work done by others so that the efficency of the methodology proposed by us is seen. Data has been efficiently transferred from the source to the sink through the cluster heads even in presence of attacker nodes with minimized energy & using the concept of cooperative nodes. The proposed work is being titled as, "***Design & development of Cooperative***

Power and
Energy-efficient Routing Protocol". Finally, the performance is compared with the Low Energy Adaptive Cluster (LEACH) and Power Efficient Gathering in Sensor Information Systems (PEGASIS) routing the rejuvenated & improvised routing protocol schemes [6]-[10].

3. Review of literature / survey

Coming to the literature review, a large number of researchers have worked on the topic chosen by us [1]-[40]. A brief review of the work done by various authors was being presented with their advantages & drawbacks in the thesis report. To start with, 1000's of research papers were collected from various sources, studied @ length & breadth and its aftermaths were studied. As in our research work, we have concentrated on the cooperative methods, relay based
methods & the underwater cloud methods. Some of the above mentioned drawbacks which were existing in the works done by the earlier researchers were considered in our research work & new algorithms were developed in order to overcome some of the deficiencies of the existing algos and also sincere effort is made to develop some high efficient algorithms for reducing the energy consumed by the nodes during the data transmission in the networks from the source to the sink was considered herewith. The research work was verified through effective simulation results done in the Network Simulator (NS-2) environment, thus substantiating the research problem undertaken [1]-[40].

4. Tools used in the research work

Tool used in the research work are - The hardware system specifications that are used for the simulation purposes are Hardware Specifications : Mainprocessor - Dual Core, Hard disk capacity - 1 TB (min), Cache memory - 4 GB, RAM - 8 GB, Monitor - Flat screen LCD, Mouse - Logitech 3 button & the Software Specifications - Operating system - Linux (Ubuntu 13.01v), Platform NS-2, Backend – VMWare, Software
- Network Simulator 2.35, Programming languages - Tool Command Language, AWK, C++ [11]-[15].

5. Design of the routing protocol

Our strategy is to develop a mechanism by using an enhanced cooperative power & energy efficient called as the (COPER). Here, our main aim is to propose the formation of a clustering group each headed by a cooperative relay node which will get linked to the other cluster's cooperative nodes & all of them jointly helping in the transmission of the data to the sink so that no data packets are lost & some of the parametric values are increased, i.e., enhance thenature of cooperativeness b/w the clusters groups with the cooperative relay nodes in the data transfer [16]-[20].

VII. Main objective

The main objective of the research work being to reduce not only the energy & power consumption, but also the delay in the data transfer between the nodes, thus serving the cooperative routing protocol as a potential scheme for lowering the effects of channel fading and increasing the transmission energy efficiency in Wireless Sensor Networks (WSNs). Another major objective being the comparison done on the basis of the performance metrics of energy efficiency, packet delivery ratio and throughput &
thus works on the concepts of minimized energy and power of the nodes [21]-[25].

VI. Energy model

The energy model of the source & the sink nodesin the cooperative WSN is considered here in this context [25]. Energy is the important criterion for a decentralized network. By the cooperative physical layer network coding scheme, the requirement ofenergy transmission can be reduced. The first-order radio mathematical model for WSNs is considered. The energy model of the source & the sink nodes in the cooperative WSN is being presented in a nutshell. Energy is the important criterion for a decentralized network. By the cooperative physical layer network coding scheme, the requirement ofenergy transmission can be reduced. The first-order radio model that is considered for WSNs is given as follows. The system performance is evaluated in 2 cases, viz., $d \leq d_0$ & $d \geq d_0$. Note that [25]
if $d \leq d_0$, then,

$$E_{Tx}(l,d) = lE_{elec} + l\varepsilon_{fs}d^n$$

Again if $d \geq d_0$, the energy model would be

$$E_{Tx}(l,d) = lE_{elec} + l\varepsilon_{amp}d^n$$

Simplifying, we get

E k, d E EDA D e D d^4 whereas, equation for the reception energy would become as

$E_{rx}(L) = E_{elec} \times L$

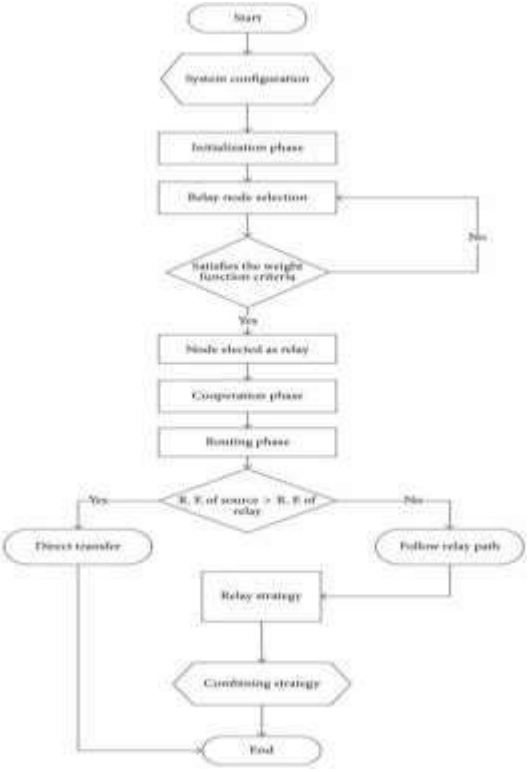
VII. Flow chart of proposed algorithm

The flow chart for the development of the COPERP & for the efficient transfer of the data from the source to the sink is best shown in the form of a generalized data flow diagram as shown in the Fig. 1. Once the main file, main.tcl is run, few files are generated in which the datas will be stored starting from the node deployment until the data is being transferred to the end point. The files that are developed during the process of writing the script & during the execution of the program are large in numbers [26]-[30].

Once the developed program is being run (main.tcl), the following files are generated which will help us to study the various characteristic features of the WSN. The coding (script writing) for the efficient data transfer using minimum energy concept avoiding the void nodes using the Energy Based

Cooperating Routing Protocol is developed in the NS2 tool by writing *.tcl scripts and once it is completed, itis tested for its effectiveness as per the algo steps.

1. The coding is done in the .tcl scriptingincorporating the developed hybrid protocol & the developed code is saved in a folder in the Ubuntu environment.
2. Ubuntu is started & at the terminal, commands like sudo –s is being used to enter the kernel afterwhich the password is being set.
3. The source code in which the directory / folder is present is changed using cd command andentered & the code is run using ns filename.tcl.
4. The command window of the NS-2 simulator (NAM window) appears with the simulator start button along with the network animator.
5. Once the simulation is started, the sensor node deployment within the ‘n’ number of cluster heads along with the base station, sink, source, etc…. & the ‘m’ attacker nodes appear on the NS-2 animator screen) and the full randomdeployment of the nodes is done.
6. Data transfer starts from the source (normally the cooperative relay node R-N & ends with d), nodes starts sending & receiving the data packets as per the algorithm developed …. Seen in the form ofconcentric circles.
7. Simulation takes couple of minutes, passes different stages of data packets sending, verification, encryption, decryption from thesource to the sink, simulation speed can be increased by increasing the steps provided at the right-hand upper corner of the NAM window.
8. Data transfer takes place using the clustered group’s cooperative relay nodes.
9. Results are observed at the command prompt (terminal) by using the results visualizations chmod 777 results.sh & ./results.sh or sometimesthe result observation command can be directly embedded into the code at the end of the program.
10. Output graphs showing all the parameters such as transmitted data packets, received data packets & the average energy are observed & discussions are made length & breadth w.r.t. to developed COPE’s significance.
11. Comparison is done with the existing protocols, thus showing the effectivity of the proposedmethodology that our work is more energyefficient compared to the others.



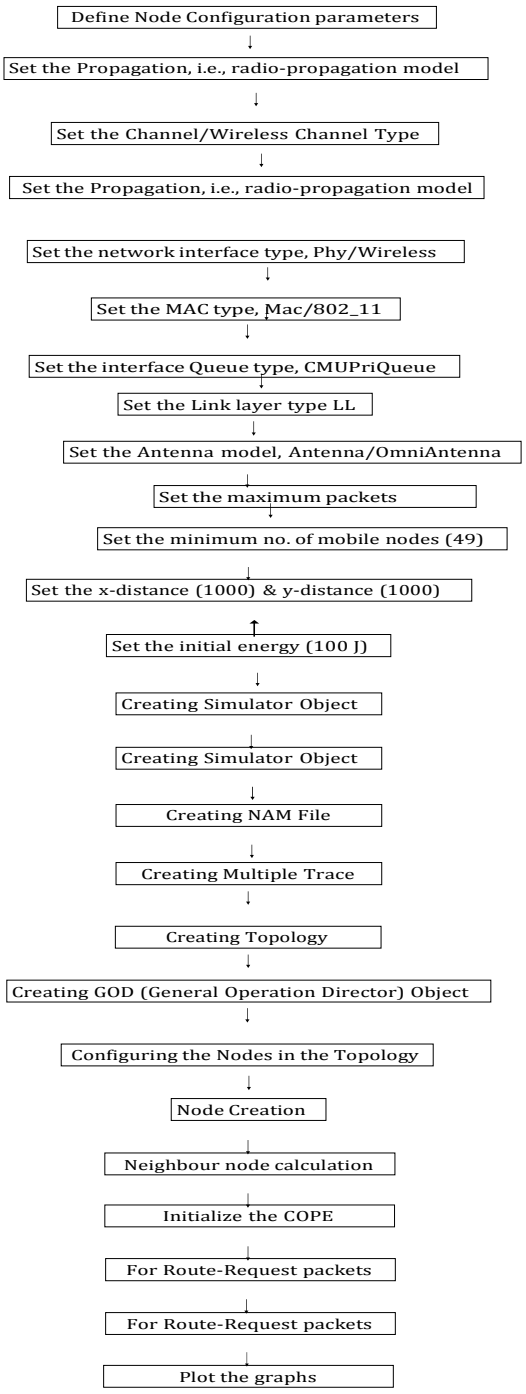


Fig. 1 : Flow chart of the sub-parts developed in thecoding process

4. Simulation results

The performance of the power and energy awareprotocol COPER is evaluated with the help of simulations done in the NS-2 environment, in which it is compared with LEACH, PEGASIS & 802_llD protocols. A network size of (1000 m × 1000 m) is considered here, where 48 nodes are deployed randomly in the field and sink node is placed at the coordinate's location of (500 m, 550 m) of the network. 80 rounds were taken and nodes with initial energy of nodes 0.75 Joules and radio range of 12 m was selected. Assuming that the channel is collision free, the radio parameters used in simulation are taken from the specification sheet [35]-[40].

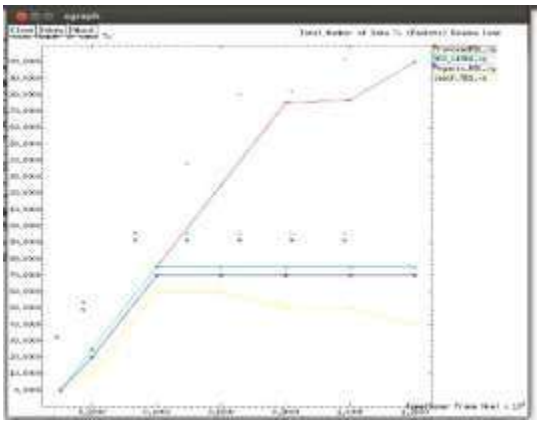


Fig. 2 : Total no. of data packets transmitted for the COPE, 802_llD protocol, Pegasus & Leach for a randomized load

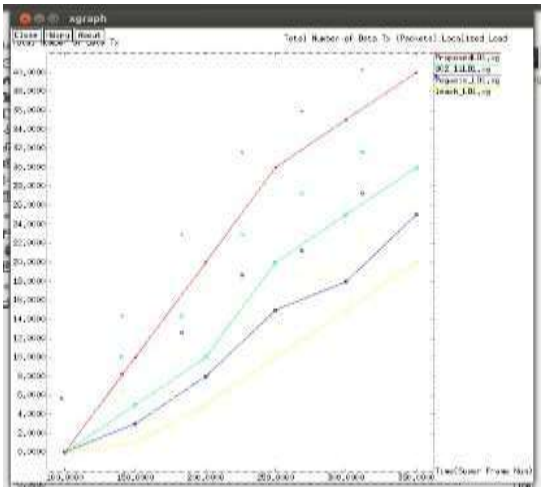


Fig. 3 : Total no. of data packets transmitted for the COPE, 802_llD protocol, Pegasus & Leach for a localized load

The figures displayed from 2-10 shows the packets transmitted Tx from the cooperative relay node station from a particular cluster group (numberof data packets transmitted) of the compared protocols with COPER protocol with 2 types of loads, viz., random & local. In LEACH, the packets transmitted are the minimum comparative to other protocols and COPER presents with the best results as

indicated by the red plot line. PEGASIS is better than LEACH but worse than COPE protocol as ourprotocol is much energy efficient due to consideration of the probability of selecting a cluster head.

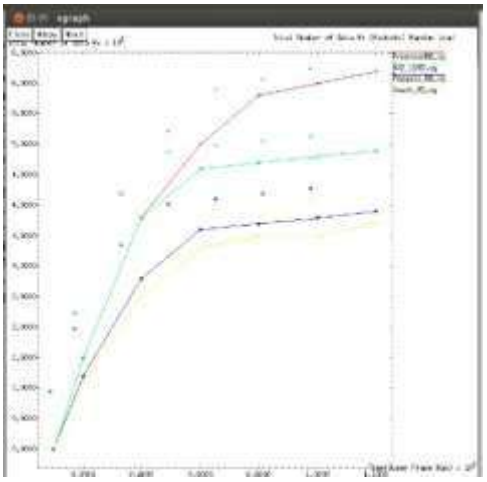


Fig. 4 : Total no. of data packets received for the COPE, 802_llD protocol, Pegasus & Leach for a random load

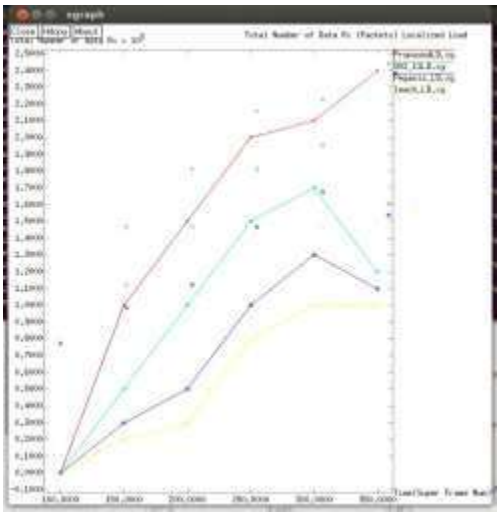


Fig. 5 : Total no. of data packets received for the COPE, 802_llD protocol, Pegasus & Leach for a localized load

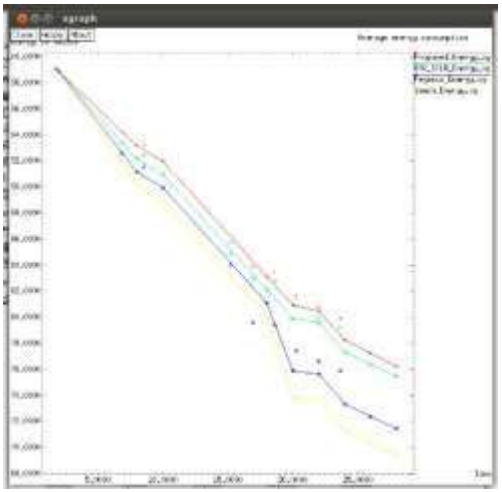


Fig. 6 : Average energy consumption for the COPE, 802_llDprotocol, Pegasus & Leach

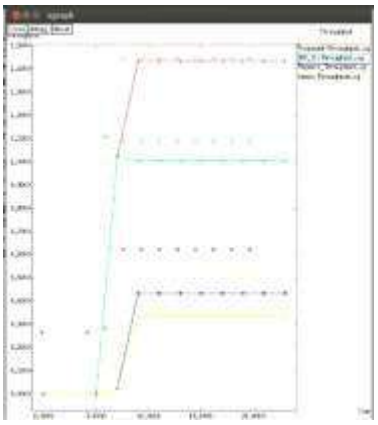


Fig. 7 : Plot of throughput obtained v/s time for the COPE,802_llD protocol, Pegasus & Leach

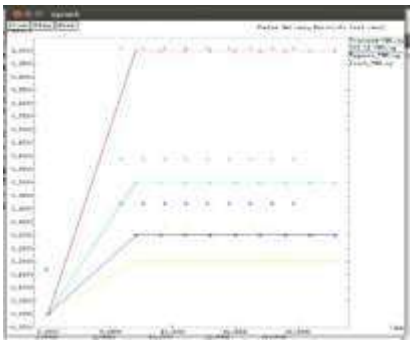


Fig. 8 : Plot of packet delivery ratio or the verificationfailure rate obtained v/s time for the COPE, 802_llD protocol, Pegasus & Leach

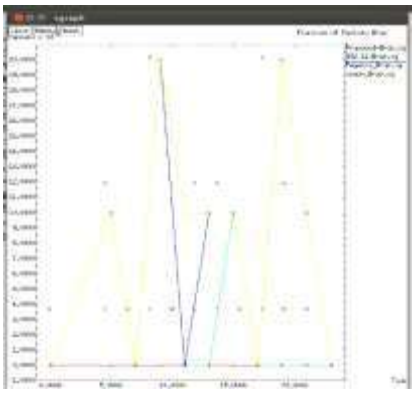


Fig. 9 : Plot of fraction of packets dropped obtained v/stime for the COPE, 802_llD protocol, Pegasus & Leach

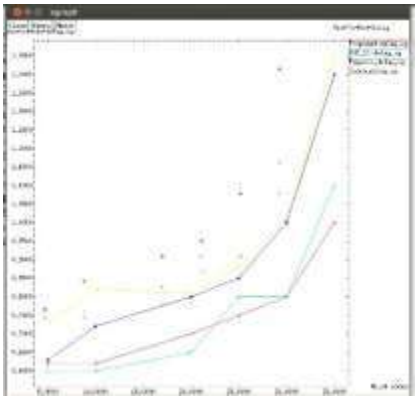


Fig. 10 : Plot of end-end delay obtained v/s the number ofnodes for the COPE, 802_llD protocol, Pegasus & Leach

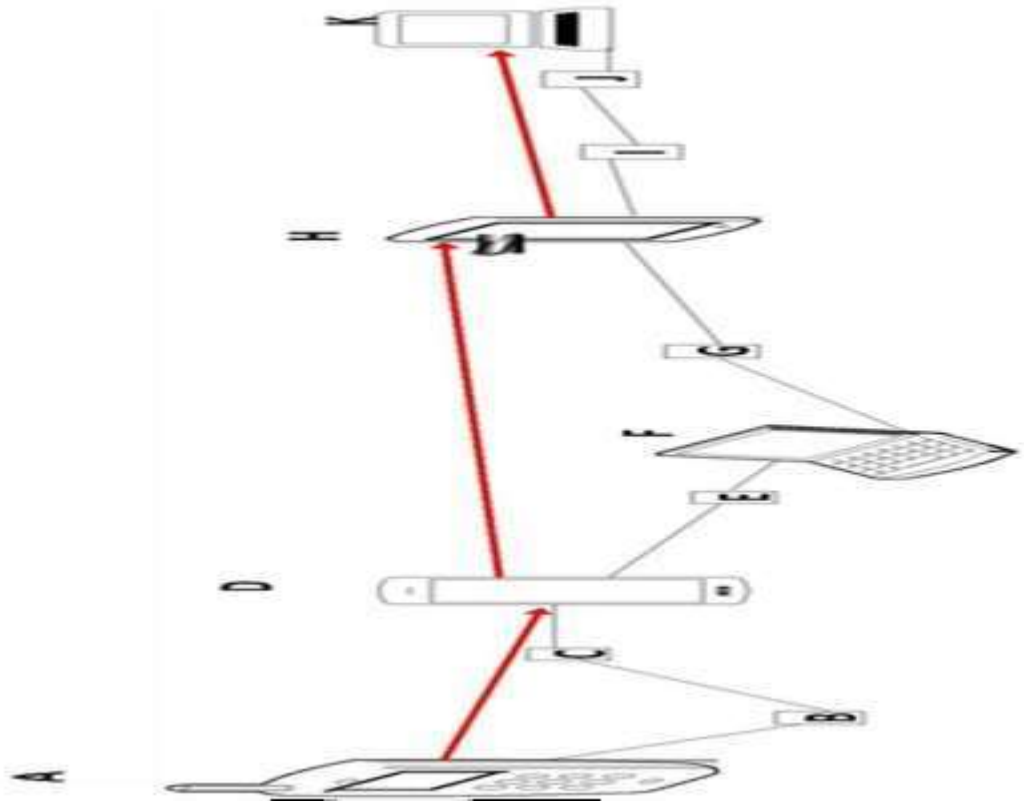


Fig. 11 : Formation of the cluster in a typical WSN

5. Discussion on simulated results

The network model that is taken up for simulation is shown in the Fig. 11. Basically, in this research work, we are concentrating on the main power consumption by the nodes & it should be less. So, thisis what is called as efficient cooperative power & energy protocol & this is going to overcome the problem of LEACH (which is one of the existingsystems) & PEGASIS (which is one of the existing system) & 802_llD protocol (which is one of the existing system). These three existing systems LEACHES, PEGASIS & 802_llD routing protocol have lot of drawbacks, which is overcomed by our proposed algorithm called as COPER [1]-[4].

In this work, we are basically going to concentrate on how the data will be transferred from one place to another place as a result of which in this process we have to save the energy during the data transfer. So, to achieve this, we are going to form a schematic diagram cluster formation like when the nodes are forming in like a group of say 5-8 nodes as shown in the Figs. 2 - 10 w.r.t. the cluster formation of the nodes in a group [5]-[8].

The main intention of this work is nodes formingas cluster group and the residual energy to be consumed be less (one of the parameter of COPE) &we have to make it stable, means it has to be alive fora long time (death time of the node to be lessened or decreased). The next point is network life time to be increased & at the same time, the throughput also and no losses to be there in the designed WSN system.

So, here we are going to construct a network in the form of a clustering group. This is going to work like a linear 3-sensor node model. It will have a sensor node, then we are going to find a relay node & the data is then going to be sent to the destination or a sink node. We have to find a best relay node in the group, which is the main objective of this work. In order to perform this, we have to implement the energy model in this protocol. Based on the energy model the working of the designed WSN system starts & finally compared with the existing algorithm how the energyis minimized, how the throughput is increasing, etc. & finally arrive at the conclusion that our work is better compared to the LEACH, PEAGSIS, 802_llD protocol [9]-[12].

The power saving in the network is beingconcentrated here in this work. Basically, we are going to work with this protocol where we are going to optimize the power & efficiency. So, for this, we are going to take the previous system as leach is one of the existing system which talks about the clustering process. When we want to perform the cooperative process, basically, leach cannot perform the cooperative process, similarly the PEAGSIS also cannot perform the cooperative process operation. Inthis particular protocol, we are implementing the cope & is going to perform the cooperative operation.

Cooperation means, first it will form a network. After forming the network, it is going to suggest or

choose a cooperative node, which is nothing but anefficient node. They should be able to find which the nearest node towards the sink is & that has to be figured out. When we run the developed program, we are going to get a list of nodes which are going to forma group. In that group, we have to find a relay node. This relay node can be found out in such a way that it has to find an efficient node based on their energy and distance also. In this process, it is going to find a relay node. Once the relay node is detected, then it will look for another relay node. Like this, the whole cooperative mechanism is going to perform in an efficient way [13]-[16]
In this COPER protocol, we have to form the network in groups a cluster has to be formed. The node deployment is done to start with, once the nodes are deployed, we have to configure all the nodal network parameters. Once this is done, the nodes willstart to act as a transmitter cum receiver. The networkhas been formed in cluster groups. LEACH, PEGAIS& 802_llD protocol are the existing systems, even they are going to form in clusters, but they don't apply the cooperative mechanisms. Here, in COPER, we are going to apply the cooperative mechanism (which is absent in the existing system) in the cluster format.
So, in clustering mechanism, when the cooperative mechanism is implemented the throughput will increase & efficiency will also be more. To start with the network configuration has tobe done and have to be configured with all the network parameters such as wireless channel, MAC, propagation, physical layer, link layer, mention the sleep power (as when transmission is not there, the nodes can go into the sleep mode, thus saving the energy) [17]-[20].
To start with each node is going to communicate with a neighbouring node & thus going to recruit a cooperative node. First of all, it checks the trace file information. In the trace file, if the energy is having sufficient & it is very close to the sink, then they can be able to recruit it. So, in this process, the nodes are going to communicate with others, when the communication is in progress, we can be able to see the transmission between the nodes, which is called as the data exchange & at the same time, we can try to retrieve their location also, how much is the energy consumed, etc… all these we can be able to get it.
So, when we get this information, our COPERalgorithm is going to predict which node is the best node/relay. This relay node has got sufficient
balancing energy and should not consume much energy & should be able to stay alive for a very long time. In this process, it is going to check for the tracefiles. The trace files will have their energyinformation's (all numerical values will be there).These info's present in the trace file can be used for therelay node selection process. This is new idea where we are implementing the cooperative mechanism on clustering networks [21]-[24].
8 clusters consisting of 6 nodes, one amongst them being the R-N is being formed with the last node being the sink. In the work considered, we have taken 48 nodes. Once the cluster node is formed, those relay nodes are further called as cluster relay nodes (R-N).These relay nodes will help us to transmit the data. The R-N will then have to confirm to their respectiveneighbouring nodes. They have to do this because they have to collect the data from the cooperative nodes. The R-N in a particular cluster group is going to find which the nearest R-N is in the neighbouring cluster nearer to the sink and then it is going to transfer the data to the sink so that we can be able tosave lot of power [25]-[28].
In fact, the sink node is cooperating with the relay nodes (R-N) in each cluster group. It has to get thechannel from one cluster R-N to another cluster R-N and based on these link channels only, it is going to propagate the data, i.e., data transmission starts to take place. Whatever data's are available at the relay nodes (centres of the clusters), they are going to transmit the data's from the R-N to the sink via the R-
N. We never see any drops at the sink. As we have implemented the COPER algorithm, it will make the network more efficient. All the relay nodes of the clusters are going to participate in the transmission process & they keep on sending the data to the sink and the sink can accept all the data's that are comingfrom the relay nodes [29]-[32].
All the nodes are cooperatively participating in the transmission process, hence the name COPER & that's why it is more efficient than the existing systems (cooperative nature not there). Generally, they have to transmit the data in the respective path which is specified. In our proposed system, dynamically all the cooperative nodes are going to participate in the data transfer efficiently. Once, the simulation is run for a specific amount of time, the different x-graphs are obtained & the comments are done as under [33]-[36]. w.r.t. the total number of data transmitted Tx packets from the relay node, the proposed results(shown in red colour), as this has been applied in the clustering technique as a cooperative transmission, the proposed system is going to give better results, i.e., going to transmit maximum data from the source to the sink node compared to the existing system 802_llD protocol, Leach, Pegasus [37]-[40].

- In another graph, when we look into the total number of data packets transmitted randomly from the relay nodes, it is sending more number of packets, even though randomly transmitted, compared to the existing system 802_llD protocol, Leach, Pegasus, it is producing better results.
- When receiving data by the sink node is considered, all the data packets sent by the transmitted node is received, comparatively it is better compared to the existing system 802_llD protocol, Leach, Pegasus w.r.t. the total number of data packets received Rx and as such there is no packet loss [37]-[40].

Considering the total number of transmissions, from this graph, we can infer that the number of data transmissions is very good. Also, the throughput is very good. When the existing system (802_llD protocol, Leach, Pegasus) is considered, the total number of transmissions is going to fall down (green coloured graph) as there is no concept of cooperative mechanism in the existing mechanisms, thus our proposed system is producing better results. But in our case as we are having the cooperative mechanisms, results are very higher and more number of data transmissions are there, no packet loss or end to end delay, etc…. [1]-[10]
Our model has the maximum number of alive nodes left till end of the rounds, hence it is much efficient and gives better results as compared to other protocols. The figures 2 - 10 also reflects the number of alive nodes taken against the

number of rounds ina network, in the sense the number of datatransmissions is more [11]-[20].

In the average energy consumption by the proposed system, again it is giving better results compared to the existing system (802_llD protocol, Leach, Pegasus). In the existing system, the energy consumption is more because of the lack of cooperative mechanisms. But, since in our case as thecooperative mechanism is present, the average energy consumed is very less compared to the existing protocol [21]-[30].

6. Overall Conclusions

Conclusive remarks are presented in this section.Here, the routing protocol development for a cooperative wireless sensor network using the concept of cooperative mechanism & power-energy algorithm is presented. Here, an improvised / enhanced version of the Cooperative Power and Energy-efficient Routing Protocol named as COPERP for the Wireless Sensor Networks and by comparing its performance with the Low Energy Adaptive Cluster (LEACH), Power Efficient Gathering in Sensor Information Systems (PEGASIS) & 802_llD protocol routing by using some rejuvenated & improvised routing protocol schemes is presented. From the results, it can be inferred that after each round, the number of data packets received by the sink increases, thus reducing the power energy consumption, thus providing a better throughput.

The entire WSN will be able to transmit a greater number of data packets from the cooperative relay nodes of the concerned cluster group to the destination (sink node), hence increasing thethroughput of the proposed system. A good performance in terms of SER is achieved as we have developed a rejuvenated scheme from the existing algorithms, which gives rise to a very highly accurate decision at the base station of the WSNs.

A large number of sensor node datas is combinedinto one single data packet & taken care of by the cooperative relay node (R-N), which is used for the transmission purpose of the data packets, thus reducing the overall energy consumption. Quite an amount of energy is being saved, which is very muchfor any typical WSN use for any specific purpose. Thework done could be termed as robust in nature to thefailures in the communication link channels and thus gets adaptable to link conditions which are changingin the wireless scenario & diversity benefit of work done is also verified.

Major advantages of the method presented in this work is reduced power-energy efficiency while moving in the forward selection mode by cooperative mechanism in the WSN, time consumption for the data transfer schemes is lessened, i.e., cooperative paths exists, minimization of the errors, minimization of the holding time for every packet transfer. Algorithms were developed using NS2 tools in the Ubuntu environment. Simulations are observed after running the developed code, thus finally demonstrating the various results obtained for all the test cases along with the necessary observations and explanations in the form of discussions.

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