SOFT COMPUTING APPROACH TO DESIGN ENERGY EFFICIENT PROTOCOL IN WIRELESS SENSOR NETWORK

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Abstract. The major limitation of Wireless Sensor Network (WSN) is the efficient utilization of energy resources. Maximum energy is lost during communication in terms of transmission power. The minimum and maximum value of transmission power depends on the node density for any particular network. In this research work the transmission power which is generally considered to be fixed for any node is subjected to be changed by taking random values between minimum and maximum transmission power as directed by the proposed neural network model. The idea cab be used in any simulation technique to enhance the lifetime of WSN. It proves that the network can save the energy considerably.

Keywords. Wireless sensor network (WSN), Routing Protocol, Energy Efficient, Neural Network (NN), AODV

1. INTRODUCTION

WSN is a network in which nodes are distributed randomly to monitor the environmental parameters. In this nodes are capable to sense for the targeted parameters, process it and send to the sink through wirelessly via neighbor nodes. Sensor nodes in WSN having several major constraints in the terms of memory, computing and energy. Because each and every sensor nodes works on the limited power supply given by battery so nodes should be properly and effectively use for the communication. Else it will be degrade the lifetime of WSN and it will come to one point that WSN will be not do any communications. So energy is the major research challenges. Every nodes in WSN is tiny in nature so memory and processing capability is minimal. But WSN having the redundant nodes which can help to give the alternate path for communication. Nodes receives and transmit the information to the neighbor nodes according to the transmission range. In general if the neighbor nodes in high distance nodes require more transmission power, if less than its requires less transmission power. But according to the survey and existing work done, each and every nodes having fix transmission power for minimum and maximum distance of neighbor nodes. Which is not appropriate in the terms of saving energy and enhancing the lifetime of WSN.

So there is a need of system which make nodes to set the transmission range dynamically or randomly according to the distance of neighbor nodes. So if nodes in less distance than it will help to achieve the energy target. This can be done with the help of routing protocols, in the below section survey is done on various algorithm, mechanism and routing protocols. In all, neural network is the best suitable for the dynamic or random transmission range according to the neighbor nodes.

2. Literature Survey

In this work [1], authors proposed distributed algorithms to reduce energy consumption during the communication in WSNs by minimizing the total transmission power of sensors without affecting the connectivity of the network. DTRNG algorithm is used based on the Relative Neighborhood Graph (RNG) in graph theory. With the help of this algorithm a node can dynamically adjust its transmission power if it is involved in a topological change. DTCYC algorithm is used in this work to determine the Transmission power by removing the largest edge in Cycles which minimize total transmission power. Therefore, the DTCYC algorithm is
efficient in saving energy and can thus increase’s the lifetime of the network. This work having various advantages such as
1. Distributed algorithms which will reduce communication energy consumption in WSNs.
2. Cycles will increase the lifespan of the network.
3. Smaller range will consume more energy

Limitation of work: there is no clearly analyses the algorithm and choosing the network range need to be done properly, large range consume more energy.

In this work [2], authors have used the smart antenna system to decrease the energy consumption. In this energy consumption of the home or office is compared using smart antenna system (SAS) and omnidirectional systems (OAS) statistically. The wireless sensor network allows multiple access which increases the overall transmission capacity providing better service quality. Due to the problems in wireless systems and reducing the deployment costs of wireless access, technologies such as ZigBee, MTM, HSPA etc. will become a remote access Trojan. So smart antenna system can increase the capacity of wireless network, as the SAS allows energy to be transmitted or received in one direction rather than disseminated in all directions. There are several features of this work
1. Potentialities of integration of smart antenna system in wireless sensor networks.
2. Performance is traced by comparison of WSN using SAS and OAS.
3. SAS is more energy efficient.

In this work [3], authors extended the MTUS (modified triple umpiring system), which repair the broken route if the broken node is near to the destination node. Otherwise, if the broken node is far away from the destination node, a Route Error (RRER) message is sent back to the source node, and the source node rebroadcasts RREQ to find a new route. Self-recovery MTUS can repair break route without considering the distance between the broken node and the destination node. Author propose MTUS with optimal Handoff-based self-recover feature, in this MTUS link breakage recovery mechanism is implemented. Source nodes broadcast RREQ message to find new route to destination when there is a link break. MTUS takes intermediate node to detects link breaks which help to repair the break route. But in optimal handoff based self-recovery maintain the route before the complete failure of the link with the help of node’s neighbor power list.

3. Characteristic, Challenges and Design Objectives of WSN

In area of WSN, applications vary and depend on a wide range of technologies, characteristics, design objectives and challenges of WSN. Therefore application requirements on WSNs differ from one application to another. A few explorations that should be taken in consideration is mentioned and discussed below.

3.1 CHARACTERISTICS
WSN is the most effective way of the communication in any industries such as telecommunication. Because it is highly reliable, compatible, feasible and less cost. It is the best suitable for ant task oriented telecommunication or to monitoring purpose in the affordable price such as forest monitoring, sea monitoring communication and border monitoring in defense department. Based on the review and exiting work, WSN characteristics are defined as the follows:

1. **Dense self-deployment:** Dense having the major role while deploying the nodes in WSN. Because nodes are deployed randomly in any particular area with redundant nature. So nodes can configure automatically and communicate with neighbor nodes.
2. **Topological inconstancy:** Nodes are deployed in the place where human cant reach unstructured WSN, so deployment will be done through any machinery devices. Which will be hard, and as it is unstructured topology will be change according to the routing mechanism schedule the path.
3. **Limited transmission range:** Every node can transmit according to the battery power capacity and majorly it is static. So this is the major research challenges to make it dynamic according to the capacity of battery available.
4. **Application centric**: WSN is always designed and deployed for some specific tasks so it is always hard to change or modify.

5. **Less amount of storage and processing**: Nodes having the less memory and processing, due to tiny size.

6. **Limited energy resources**: Sensor nodes in unstructured WSN works on the battery which having the limited power and there is no chance of replacing and charging the battery.

7. **Data redundancy**: Same data can be received from the redundant nodes in WSN.

8. **Broadcast communication**: Flooding technique is used generally in all the existing WSN to send the information to sink or to create the paths.

### 3.2 Objectives of WSN in the Terms of Design

Any proposed WSN will gives the area where to deploy and specify the target application. So according to the requirements design objective of WSN is decided. There are the most common objectives to design any WSN as follows:

1. **Deployment area, available resources and allocated budget**: Deployment area of WSN is mainly depends upon the area geographically. So area is directly proportional to the cost and number of sensor nodes. As number of nodes is directly proportional to the cost of WSN. So all three are linked tightly with each other.

2. **Topology used in WSN**: The size of the network and the area of interest determine the network topology. WSN topology is a dynamic topology that may be simple with single or few numbers in direct communication hops between the nodes or complex with multi-hop complex topological architecture.

3. **Power consumption**: Sensors mainly depend on batteries as power suppliers. It’s not possible to change the battery or recharge.

4. **Coverage range**: In order to preserve the network consumed energy and to increase its productivity and reliability, network coverage range should be selectively determined. Small transmission range between nodes will decrease the amount of needed power for transmission between directly connected nodes. The huge coverage areas usually cases an eavesdropping.

5. **Quality of service**: The frequent changes in the sensed data are highly effected with the time factor. Reliability and usability usually depend on QoS.

6. **Simplicity**: The heterogeneous and autonomous nature of sensors in WSN as well as the complex topological nature requires simple and convenient communication, processing and power consumption models in order to ease and increase the efficient utilization of the network.

7. **Mobility**: Each sensor has the flexibility to change its location based on some environmental factors that strongly affect nodes movements are varies based on the application area. The extent of dynamic in WSN as well as the speed of mobility frequently influences the size, design and protocols of the network.

8. **Fault tolerance**: The ability to preserve the network performance and functionality even after individual node failure or congestion in some of parts of the network. The adaptability of WSN can be achieved by using efficient routing protocols, power management approaches and communication establishments.

### 3.3 Challenges

Deployment of WSN face a number of great challenges that urge researches to focus on it in order to reach an optimal performance of WSN, few challenges are listed below [9, 10, 11].

1. **Hardware constraint**: Since WSNs depend on battery based power devices. The less energy consumption devices in WSN are the most efficient and lasting WSN. Because computational capabilities and storage capacity will also affect life time of WSN. Therefore size, processing, cost and the number of the sensors in the applied environment should be considered.

2. **Flexibility**: Flexibility are needed for different network deployment schemes and topologies, routing protocols, power management methods and so on.

3. **Reliability**: The functionality and performance to WSNs should not be affected negatively in the time of any node failure. So there is a need of fault tolerance techniques to ensure reliability.

4. **Connectivity**: Maintain connectivity among all sensor nodes through the network life time is a very challenging issue. Because every node data is important. Some sleep modes can be practiced by some nodes in order to reduce the rate of harvested energy.
5. Power consumption: Sensor works on limited energy so the researchers attentions to power conservation and power management approaches which prolong the WSN lifetime.

6. Deployment: The WSN deployment can be densely by a huge number of sensors in applied area of application or sparse network with a few and limited number of sensors. Communication in WSNs is achieved by single or multi number of hops between sensors. So there is a need of system which should control the deployment cost without affecting the application functionality.

7. Scalability: WSNs should be able to support variety of routing protocols, huge nodes number and wide area of application as well as the frequent increases of network expansion.

8. Lifetime: The longevity and coverage of the WSN should be guaranteed. The main emphasis is to prolong the network lifetime. Some adapting mechanisms such as power management techniques and adaptive routing protocols are used to overcome the limited resources efficiently and to ensure the maximum network lifetime.

4. WIRELESS ROUTING PROTOCOLS

In the WSN energy resources play the vital role because each node in the WSN works having one fixed amount of energy which is provided by the battery. There is no chances of replace the battery and charge it. If energy is properly and effectively utilized then it prolongs the lifetime of WSN.

4.1 ROUTING TECHNIQUE

In general, there are several routing protocols are used in wireless sensor network to improve the quality and make more efficient network. These protocols are designed based on the energy, packet delivery ratio, packet drop ratio, communication links and paths, scheduling and so on. Such protocols are Directed Diffusion routing protocol, sensor protocols for information via negotiation routing protocol, gradient based routing protocol, low energy adaptive clustering hierarchy routing protocol, self-organizing routing protocol, threshold sensitive energy efficient routing protocol, virtual grid architecture routing protocol and so on. But when energy is concerned than routing protocols are designed on the basis of the operation as well as network structure. It classified in the following:

1. Structure base network routing: In this WSN routing is based on the nodes set up and location or position of the nodes. Routing protocols are classified as flat-based routing, location based routing and hierarchical based routing.

2. Operation base network routing: In this protocol is designed for specific targeted operation. These routing protocols are classified as QoS based routing protocol, Negotiation based routing protocol, Query based routing protocol, Coherent based routing protocol and Multipath based routing protocol.

4.2 SOFT COMPUTING PROTOTYPES IN WSN ROUTING:

In the recent work observation, researchers are using the soft computing parameters to optimize the routing of WSN, while considering the enhancement of lifetime, major challenges for design and nodes deployment.

There are several soft computing techniques which may be deployed in WSN to enhance the lifetime such as Neural networks, fuzzy logic, swarm intelligence, reinforcement learning.

1. Reinforcement Learning (RL) Approach: It is an area of machine learning. This approach can be deployed in any software and hardware to find the best possible path for a particular situation. In this there no training is compulsory and it is differ from the supervised learning. If training data is not available than RL can take the decision from experience means past data. If this approach can apply in WSN than it can help to reduce the latency as well as best for traffic load balancing. Its performance can be better than traditional Ad-Hoc Network. It can only help in the scenario of one source to many sink or one sink to many nodes. But not suitable for all the scenario of WSN. According to the result from the existing work, it shows that RL can increase the lifetime of WSN by 50% without learning technique.

2. Swarm Intelligence (SI) Approach: This approach is based on the Artificial Intelligence system. It can be applied as optimal routing technique in WSN. There are several approaches based on the SI. Such as Ant based routing protocol, sensor driven and cost aware routing protocol, flooded forward ant routing protocol, energy efficient ant based routing approach. SI routing provide better flexibility in routing but it generates heavy traffic in Network. Which makes the
loss of energy and packet loss. So this routing protocol can not be able to deploy if considering the packet delivery ratio and energy because of backward and forward movements in the network.

3. Evolutionary Algorithm for routing in WSN: It is also concept of artificial intelligence to do the optimization for the sensor nodes in the terms of path scheduling. This is similar to VBS(Virtual backbone scheduling) and DAODV(Dijkstra AODV) for the path creation and path selection. But in this optimized path based on the energy of the link nodes which is shortest has to be selected for the communication. Shortest path is a good selection when the node having enough amount of power source but not for fixed power supply.

4. Fuzzy Logic (FL) routing approach: This approach is completely based on mathematical and conceptual model. It can deploy in the WSN where environment of network is undefined. It minimize the energy consumption of node and effectively utilizing the nodes energy in WSN.

5. Neural Network Approach for routing in WSN: This approach is used to enhance the lifetime of WSN using clustering technique. It is based on arithmetic and solve the complex relation in the terms of energy calculation and optimization. It is the best approach for any WSN to solve the energy research challenges. This approach is based on the input provided by the sensor, it can apply to sink to take the decision. Sink will have the nodes details such as power, transmission range, signal strength and data transmission rates, sink will give these details to neural network and final neural network has to provide the optimal path for transmission.

There are several features of Artificial Neural Network model if it can deploy in WSN:
1. Minimal degradation of overall performance of the network
2. Learning of the network is unsupervised continuous process.
3. Network connections (communication paths) can be able to modify according to the experience.
4. Node in WSN can parallel distributed to receive and transmit the information.
5. Sink will be highly and strongly connected with all other nodes in WSN.

Due to the above features of Neural Network which can be deploy in the WSN to enhance the lifetime and make strong and flexible communication in the terms of shifting path from one to another. So below section is proposed method using Neural Network, explained in below section.

5. PROPOSED METHODOLOGY:
Generally in WSN, paths are created by CDS (connected dominant set) and scheduling is done according to protocol, it may be VBS, AODV, DOADV, LEACH etc. But every node having there on fixed radio transmission range which is major drawback in the terms of energy. Because transmission is directly proportional to the power, if node sends the information to more distance it will take more energy and if small distance it will take less energy. So there is a need of dynamic transmission range selection.

In this work, Neural Network methodology is proposed to predict the optimal path according to the distance of the sensor nodes. Below figure 1 shows the neural network deployment in WSN.

Figure 1. Neural network for wireless sensor network
5.1 Proposed algorithm
1. Set up the n number of nodes in WSN with redundant nodes.
2. Sink will keeps the details of each nodes.
3. Nodes parameters such as transmission range, energy of node, distance of neighbor nodes and details of all neighbor nodes.
4. Now sink will may have the details of each node, these parameters will give to the neural network model.
5. Neural network model will decide the path according to the energy level of nodes, range, distance and number of the nodes in the path.
6. Optimal path will be decided by neural network model.
7. This path will have the selection of dynamic transmission range.
8. This path will be enhanced the lifetime of WSN.

6. CONCLUSION
This work is comprehensive study of all the intelligence techniques which is used in WSN to improve the lifetime. This paper is more specific study of neural network, genetic algorithm, artificial intelligence and fuzzy logic. This work brings the neural network in WSN to predict the optimal path for the communication on the basis of transmission range, density, distance and energy level.

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