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REVIEW ON VARIOUS ROUTE OPTIMIZATION TECHNIQUES FOR WSN

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Abstract: *Wireless sensor networks (WSNs) have important applications in remote environmental monitoring and target tracking. The development of WSNs in recent years has been facilitated by the availability of sensors that are smaller, less expensive, and more intelligent. Each sensor node is battery powered and it is not convenient to recharge or replace the batteries in most of the cases, especially in remote and hostile environments. The design of a WSN depends significantly on its desired applications and must take into account factors such as the environment, the design objectives of the application, the associated costs, the necessary hardware, and any applicable system constraints. Due to the limited capabilities of sensor nodes, it is generally desirable that a WSN should be deployed with high density and thus redundancy can be exploited to increase the network's lifetime. Now my objective is to study and analysis various route optimization techniques for WSN and how to minimize the power consumption, maximize the network lifetime by using various optimization techniques.*

Keywords: *WSN, PSO, ACO, GA, Linear/ Nonlinear Programming (LP/NLP).*

1. INTRODUCTION

A Wireless Sensor Network (WSN) is a network comprising large number of wirelessly connected heterogeneous sensors which are spatially distributed across an interested field. It has been applied in many fields such as military investigation, medical treatment, environmental monitor and industry management. However, WSNs differ from other networks, in which sensor nodes have limited energy supply, constrained computation and communication abilities. Therefore, how to prolong the network lifetime is an important and challenging issue, which is also the focus of designing the routing protocols for WSNs. A great many routing protocols have been specifically designed for WSNs classified as data centric, hierarchical and location based. In recent years, with the development of computational intelligence (CI), routing protocols which are based on such intelligent algorithms as reinforcement learning (RL), fuzzy logic (FL), genetic algorithm (GA), ant colony optimization (ACO) and neural networks (NNs) have been introduced to improve the performance of WSNs. [6]

WSN nodes can sense the environment, communicate with neighboring nodes, & in many cases perform basic computations on the data being collected and the environment can be the physical world, biological system, or an information technology (IT) framework. WSN is used in many applications such as radiation and nuclear-threat detection systems, weapon sensors for ships, toxins and to trace the source of the contamination in public-assembly locations, structural faults in ships, volcanic eruptions, earthquake detection, aircraft, and buildings, biomedical applications, and seismic monitoring.. For example, a chemical plant could be easily detected for leaks by hundreds of sensors that automatically form a wireless interconnection network and immediately report the detection of any chemical leaks. In addition to reducing the installation cost, wireless sensor networks also have the ability to adapt dynamically to changing environment. These can respond to changes in network topologies. A WSN node consists of four major parts such as:

1. Sensor unit.
2. Processing unit.
3. Energy source unit.
4. Transceiver.

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The main function of wireless sensor nodes is to sense and collect data from a target area, process, and transmit the data via a radio transmitter back to a command center where the underlying application resides (sink). In order to achieve this task efficiently, an efficient routing protocol is needed to set up paths of communication between the sensor nodes (sources), and the command center (sink). The path selection must be such that the lifetime of the network is maximized [3].

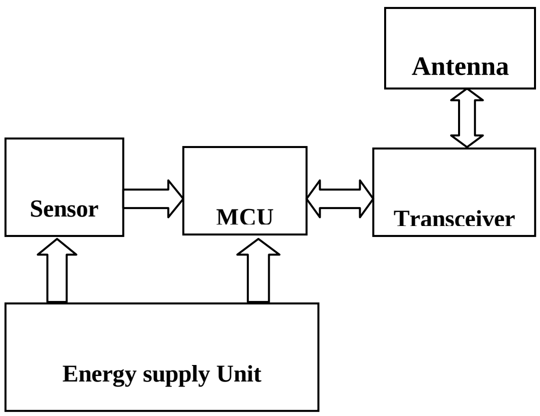

Fig 1.1: WSN node architecture

WSNs design and routing factors

The design of routing protocols in WSNs is affected by many challenging factors to be addressed which are outlined and discussed below.

1. **Limited energy capacity**: the process of setting up routes in a network is greatly affected by energy considerations. Since sensor nodes are battery powered and they have limited energy capacity. Energy poses a great challenge in many applications of sensor networks. In the case of directed and multi-hop routing, directed routing would perform good enough if all sensor nodes are close to the sink, whereas multi-hop routing consumes less power than directed routing due to the fact that, sensors are usually randomly scattered in the area of deployment, though it may introduce important overheads for topology management and MAC protocols. Routing protocols design for sensor networks should be as energy efficient as possible to extend their lifetime, and hence, extended the network lifetime without performance degradation.

2. **Node deployment**: sensor nodes deployment in WSNs is application dependent and affects the performance of the routing protocol. If nodes are randomly deployed, they required to create an infrastructure in an ad-hoc manner and organize themselves to establish paths to route the events using route discovery so as to allow connectivity and energy efficient network operation.

3. **Sensor location**: sensor location at the early stage of route discovery is a great challenge in the design of routing protocols. As most of the already proposed protocols assume that the sensor nodes either are equipped with global positioning system (GPS) receivers or other forms of sensing the destination or sink, to learn about their locations, other challenge which has to be managed is the location of the sensors.

4. **Dynamic network**: sensor networks consist of three main components; sensor nodes, event, and sink. Since sensor node and sink are always supposed to be fixed or mobile, even though, nodes are fixed in most of the applications, this have to support the mobility of sinks or gateways in the networks. Hence, the stability of the routing data is an important design issue in addition to energy consumptions and bandwidth utilization.

5. **Hardware resource constraints**: sensor nodes also have limited storage and processing capacities, and hence, low computational capabilities. The hardware constraints offer many challenges in the network and software protocol design for sensor networks, which have to be reviewed alongside with the limited energy.

6. **Data aggregation and gathering**: data gathering or reporting is concerned with any physical event of the sensor network. This could be event driven, query driven, automated time driven, or both combined. Data gathering methods are highly important with respect to sensor network routing, as after receiving signals or data, the node has to transfer, route the data or information to the sink. Also, since sensor nodes may generate significant ambiguous data, similar packets from multiple nodes can be aggregated so that the number of transmissions is reduced, which will help in energy minimization.

7. **Latency**: latency or end-to-end delay in WSNs is how much it takes for a data packet to get from one node to the sink or vice versa. This is the measure of either one-way (the time it takes for the source to send a packet to the sink), or round-trip (the one-way latency from source to sink and from sink back to the source). Data aggregation and multi-hop relays can affect latency.

8. **Scalability**: since sensor applications may have many sensor nodes, it implies that, since the no. of sensor nodes deployed in the sensing area may be in the order of hundreds or thousands and

it then means that routing algorithms must be scalable enough to handle and respond to the events. Abstraction & simplicity mechanism is a demanding factor, since a large amount of data is expected to be decreased to manageable size.

9. **Fault tolerance**: the failure of a particular sensor node due to power, physical damage, or environmental interference in a network, should not in any way influence the overall network performance or task handling. In case of the failures, routing protocols should be able to generate new routes to the data collection point or sink [3].

2. OVERVIEW OF PARTICLE SWARM OPTIMIZATION

Particle swarm optimization (PSO) is inspired by natural life, like bird flocking, fish schooling and random search methods of evolutionary algorithm. It can be observed from the nature that animals, especially birds, fishes, etc. always travel in a group without colliding. This is because each member follows the group by adjusting its position and velocity using the group information. Thus it minimizes individual's effort for searching of food, shelter etc. PSO consists of a swarm of a predefined size (say N_P) of particles. Each particle gives a complete solution to the multidimensional optimization problem. The dimension D of all the particles is equal. A particle P_i, 1rirNP has position X_{id}, $1 \le d \le D$ and velocity V_{id} in the *d*th dimension of the hyper space. We adopt the notation for representing the *i*th particle P_i of the population as follows:

$$P_i = [X_{i,1}, X_{i,2}, X_{i,3}, \ldots, X_{i,D}] \quad \textbf{(2.1)}$$

Each particle is evaluated by a fitness function to judge the quality of the solution to the problem. To reach up to the global best position, the particle Pi follows its own best, i.e., personal best called $Pbest_i$ and global best called *G*best to update its own velocity and position. In each iteration, its velocity V_{id} and position X_{id} in the *d*th dimension is updated using the following equations respectively:

$$V_{i,d}(t) = w * V_{i,d}(t-1) + c1 * r1 *(Xpbest_{i,d} - X_{i,d}(t-1)) + c2 * r2 * (Xgbest_d - X_{i,d}(t-1) \quad \textbf{(2.2)}$$

$$X_{i,d}(t) = X_{i,d}(t-1) + V_{i,d}(t) \quad \textbf{(2.3)}$$

Where *w* is the inertial weight, *c1* and *c2* are two non-negative constants called acceleration factor and *r1* and *r2* are two different uniformly distributed random numbers in the range [0, 1]. The update process is iteratively repeated until either an acceptable *Gbest* is achieved or a fixed number of iterations t_{max} is reached [8].

3. LITERATURE REVIEW

3.1 Span of Research Work

A number of journals and research papers published during the above span 2010-2014 have been studied. The various aspects of the problem were studied.

Jalel Ben-Othman et.al (2010), In this paper, author propose an Energy Efficient and QoS aware multipath routing protocol (abbreviated shortly as EQSR) that maximizes the network lifetime through balancing energy consumption across multiple nodes and uses the concept of service differentiation to allow delay sensitive traffic to reach the sink node within an acceptable delay. It also helps to minimize the end to end delay through spreading out the traffic across multiple paths, and expand the throughput through introducing data redundancy. EQSR protocol uses the residual energy, nodes available buffer size, and Signal-to-Noise Ratio (SNR) to predict the best next hop through the paths construction phases. Based on the concept of service differentiation, EQSR protocol uses a queuing model to handle both real-time and non-real-time traffic. By means of simulations, we estimate and compare the performance of our routing protocol with the MCMP (Multi-Constraint Multi-Path) routing protocol. Simulation results have reported that our protocol achieves lower average delays, more energy savings, and higher packet delivery ratio than the MCMP protocol [1].

Ahmed E.A.A. Abdulla et.al (2011) In this paper author propose a solution to address this issue through a hybrid approach that combines two routing strategies i.e. flat multi-hop routing and hierarchical multi hop routing. The former aims to reduce the total power consumption in the network, and the latter attempts to reduce the amount of traffic by utilizing data compression. We mathematically examine the power consumption of our proposed algorithm, and then we demonstrate through extensive simulations that the proposed scheme is able to extend the network lifetime by alleviating((((the hotspot problem [2].

Adamu Murtala Zungeru et.al (2012) this paper presents a comprehensive survey and comparison of routing protocols in WSN. The

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first part of the paper surveys state-of-the-art routing protocols in WSNs from classical routing protocols to swarm intelligence based protocols. The routing protocols are classified based on their computational complexity, energy efficiency, path establishment and network structure. The second part of the paper shows a comparison of a representative number of classical and swarm based protocols. Comparing routing protocols in WSNs is presently a very challenging task for protocol designers. Often, much time is needed to re-create and re-simulate algorithms from descriptions in published papers to perform the comparison. Compounding the problem is that some simulation parameters and performance metrics may not be mentioned. Author sees a need in the research community to have standard simulation and performance metrics for comparing different protocols. At the end, the final part of the paper re-simulates different protocols using a Matlab based simulator: routing modeling application simulation environment (RMASE), and gives simulation results for standard simulation and performance metrics which we hope will serve as a benchmark for future comparisons for the research community [3].

Jeong-Hun Lee et.al (2013), in this study, author proposes mathematical models for a routing protocol (network design) under particular resource restrictions within a wireless sensor network. We consider two types of constraints: the distance between the linking sensors and the energy used by the sensors. The proposed models aim to identify energy-efficient paths that minimize the energy consumption of the network from the source sensor to the base station. The computational results show that the presented models can be used efficiently and applied to other network design contexts with resource restrictions (e.g., to multi-level supply chain networks) [4].

Jacques Bahi et.al (2013), In this paper, author introduce an efficient lifetime optimization and self-stabilizing algorithm to enhance the lifetime of wireless sensor networks especially when the reliabilities of sensor nodes are expected to decrease due to use and wear-out effects. Our algorithm finds to build resiliency by maintaining a necessary set of working nodes and replacing failed ones when required. We provide some theoretical and simulation results, that completely demonstrate the usefulness of the proposed algorithm [5].

Jacques Bahiet. et.al (2013) this paper surveys intelligent routing protocols which contribute to the optimization of network lifetime in wireless sensor networks (WSNs).Different from other surveys on routing protocols for WSNs, this paper first gives new ideas on the definition of network lifetime. Then, with a view to prolonging network lifetime, it analyses the routing protocols based on such intelligent algorithms as reinforcement learning, ant colony optimization, fuzzy logic, neural networks and genetic algorithm. Intelligent algorithms provide adaptive mechanisms that exhibit intelligent behavior in complex and dynamic environments like WSN. Inspired by such an idea, some intelligent routing protocols have recently been designed for WSNs. Under each category, it describes the representative routing algorithms and further analyzes the performance of network lifetime defined in three aspects. This paper plans to give assistance in the optimization of network lifetime in WSNs, simultaneously offering a guide for the collaboration between WSNs and computational intelligence (CI) [6].

Xuxun Liu et.al (Aug 2013) in this paper, author consider the problem of grid-based coverage with low-cost and connectivity-guarantee (GCLC), and propose a novel deployment approach, ACO-Greedy, to solve this question. This approach is based on the ACO with greedy migration mechanism, which can rapidly complete the full coverage, and markedly minimize the deployment cost. Besides this, ACO-Greedy can dynamically adjust the sensing/communication radius to alleviate the energy whole problem and prolong the network lifetime. The simulation results show that our developed approach can not only decrease the deployment cost, but also effectively balance power consumption among sensor nodes and prolong the network lifetime in grid-based WSNs [7].

Pratyay Kuila et.al (2014) This paper presents Linear/ Nonlinear Programming(LP/NLP) formulations of the problems followed by two proposed algorithms for the same based on particles warm optimization. The routing algorithm is developed with an efficient particle encoding scheme and multi-objective fitness function. The clustering algorithm is showed by considering energy conservation of the nodes through load balancing. The proposed algorithms are investigated extensively and the results are compared with the existing algorithms to demonstrate their superiority in terms of network

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life, dead sensor nodes, energy consumption, and delivery of total data packets to the base station [8].

Table1: Comparison of Various Optimization Techniques Used In WSN.

Techniques	ACO	GA	PSO
Proposed by	Marco Dorigo	John Holland	Dr. Eberhart And Dr kennedy
Year	In 1992	In1970's	In 1995
Inspired By	Ants to forage food source.	Law of biological reproducti-on.	Social behavior of bird flocking or fish schooling.
Strength	Positive Feedback accounts for rapid discovery of good Solutions	Support for multi-objective optimization, useful and efficient when search space is large and complex.	Simple in concept, easy to implement, computationally efficient, find better, globally optimal solution.
Limitations	Stuck into local optimal solution	May converge towards local optima.	PSO do not guarantee an optimal solution is ever found
Applications	Schedulin g, travelling salesman problem	Vehicle routing problem, travelling salesman problem	Scheduling ,image recognition

M. Emre Keskin et.al (Jan 2014) In this study, author first provide a mathematical model which integrates WSN design decisions on activity schedules, data routes, sensor places, trajectory of the mobile sink(s) and then present two heuristic methods for the solution of the model. We show how the efficiency and accuracy of the heuristics on several randomly generated problem instances on the basis of extensive numerical experiments [9].

Salim EL KHEDIRI et.al (2014) in this context, the main point in such topology is to select a cluster. One of solutions is to choose a cluster alternately. On the other hand, this choice does not consider the energy as important criteria in actual papers. In order to reduce energy consumption, our new method is introduced in this paper to optimization Low Energy Adaptive Clustering Hierarchy (OLEACH) to improve existing LEACH and LEACH-C by selecting cluster according to the residual energy of nodes dynamically. The simulation results display that proposed algorithm achieves longer stability by comparison to original LEACH and LEACH-C [10].

4. CONCLUSION

Power-aware routing in wireless sensor networks (WSNs) focuses on the crucial problem of extending the network lifetime of WSNs, which are reduced by low-capacity batteries. GA has very high processing demands and is usually centralized solutions. They are slightly better suited for clustering when the clustering schemes can be pre- deployed. ACO is very flexible, but generates a lot of additional traffic because of the forward and backward ants. PSO is simple in concept, easy to implement, computationally efficient, find better, globally optimal solution.

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