

Hybrid Scalable and Efficient Routing Method for WSN Based on Fuzzy and A-Star Algorithm

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ABSTRACT-*Energy constrained wireless sensor network (WSN) has attained considerable research attention in recent years and requires robust and energy efficient routing protocols for communication in fading environments to minimise the energy consumption. Energy conservation is a critical problem in wireless sensor networks (WSNs) so that the energy consumption must be minimized while satisfying application requirements. A wireless sensor network (WSN) consists of hundreds or thousands of energy limited sensors. Distributing energy dissipation evenly throughout the sensors and saving energy are important goals in designing of WSN protocol. Resource limitations have to be taken into account when designing a WSN infrastructure. Unbalanced energy consumption is an inherent problem in WSNs, characterized by multihop routing and a many-to-one traffic pattern. This uneven energy dissipation can significantly reduce network lifetime. This paper approaches some methodology to improve lifetime. While approaching we must consider some criteria like remaining battery power of each node, minimum number of nodes in routing path, minimum traffic load.*

KEYWORDS-Wireless sensor Network, network lifetime.

1. INTRODUCTION

A wireless sensor network is a network of distributed autonomous devices that can sense or monitor physical or environmental conditions cooperatively [1]. WSNs are used in numerous applications such as environmental monitoring, habitat monitoring, prediction and detection of natural calamities, medical monitoring and structural health monitoring [2]. WSNs consist of a large number of small, inexpensive, disposable and autonomous sensor nodes that are generally deployed in an ad hoc manner in vast geographical areas for remote

operations. Sensor nodes are severely constrained in terms of storage resources, computational self organizing nodes self organize into a wireless network, termed data-gathering sensor network, in which each sensor node must periodically report its sensed data to the sink(s). Sensor nodes in such large-scale data-gathering sensor networks are generally powered by small inexpensive batteries in expectation of surviving for a long period. Therefore, energy is of utmost importance in power-constrained data-gathering sensor networks, and energy consumption should be well managed to maximize the post deployment network lifetime. Processing and Coordination and management of sensing Activities were conducted. In most applications, sensor nodes are constrained in energy supply and communication bandwidth. Thus, innovative techniques to eliminate energy inefficiencies that shorten the lifetime of the network and efficient use of the limited bandwidth are highly required. Such constraints combined with a typical deployment of large number of sensor nodes pose many challenges to the design and management of WSNs and necessitate energy-awareness at all layers of the networking protocol stack. For example, at the network layer, it is highly desirable to find methods for energy efficient route discovery and relaying of data from the sensor nodes to the BS so that the lifetime of the network is maximized. Routing in WSNs is very challenging due to the inherent characteristics that distinguish these networks from other wireless networks like mobile ad hoc networks or cellular networks. First, due to the relatively large number of sensor nodes, it is not possible to build a global addressing scheme for the deployment of a large number of sensor nodes. Before proceeding further, let us explain three main reasons that can cause an imbalance in energy distribution.

1.1 Topology: The topology of the initial deployment limits the number of paths along which the data packets can flow. For example, if there is only a single path to the sink, nodes along this path would

deplete their energy rather quickly. In this extreme case, there are no ways to reach an overall energy balance.

1.2 Application: The applications themselves will determine the location and the rate at which the nodes generate data. The area generating more data and the path forwarding more packets may suffer faster energy depletion.

1.3 Routing: Most energy-efficient routing protocols always choose a static optimal path to minimize energy consumption, which readily results in energy imbalance since the energy at the nodes on the optimal path is quickly depleted. In view of the above causes, there are five possible solutions to balance energy consumption:

a) Deployment optimization: The original node distribution is to maximize network lifetime according to the traffic pattern in applications, which can solve the problem of mismatch between topology and application. For example, we need to deploy more nodes in the heavy-loaded areas and paths. In addition, the areas closer to the sink should be covered with higher energy density (ED), since the closer to the sink a node is, the more packets does it have to relay. Solutions based on this principle are proposed in [5] and [6].

b) Topology control: The basic idea is that, instead of transmitting at maximum power, nodes collaboratively adjust their transmission power and form a proper network topology to balance energy consumption. The investigations in [7], [8], and [9] fall into this category.

c) Mobile sink/relay nodes: Mobile sink and relay nodes can achieve balanced energy consumption by relieving heavily loaded areas or paths in a way dual to the optimization deployment. However, additional mechanisms need to be devised to support node mobility. The solutions following this paradigm can be found in [10], [11], and [12].

1.4 Data aggregation: Data from different sources are aggregated by exploiting redundancy with the objective of minimizing energy consumption in transmissions. The work in [13], [14], and [15] explores the possibility of avoiding energy holes in data-gathering sensor networks through traffic compression and data aggregation.

1.5 Energy-balanced routing: Under a designated topology, employing an energy-balanced routing protocol (EBRP) may be a feasible approach to prolong the network lifetime, yet maintaining the

network connectivity. To the best of our knowledge, only little work takes energy consumption balance into account while designing routing algorithms.

Although numerous energy-aware routing protocols have been proposed in the literature, most of them focus only on energy efficiency, namely finding the optimal path to minimize energy consumption. In our opinion, an energy-aware routing protocol should not only aim for energy efficiency, but also for balancing energy consumption.

2. BACKGROUND

Wireless Sensor networks have recently become a premier research topic and have opened up new challenges for researchers. They have generated lot of interest from both industrial and research perspectives. They have a great potential for long term applications and also have the ability to transform human lives in various aspects. A Wireless Sensor Network can be generally described as a collection of sensor nodes organized into a cooperatively network that can sense and control the environment enabling interaction between persons or embedded computers and the surrounding. In traditional optimal path routing schemes over WSNs, each node selects specific nodes to relay data according to some criteria in order to maximizing network lifetime. Therefore, a good routing method in WSNs involves finding the optimal transmission path from the sender through relay nodes to the destination in order to prolong the network lifetime. Due to this conception, the lifetime problem in WSNs has received significant attention in the recent past.

2.1 Energy Balanced Data Gathering Protocol

Basically there is a problem of maximizing network lifetime through balancing energy consumption [3] for uniformly deployed data-gathering sensor networks. Author formulated the energy consumption balancing problem as an optimal transmitting data distribution problem by combining the ideas of corona-based network division and mixed-routing strategy together with data aggregation. They first proposed a localized zone-based routing scheme that guarantees balanced energy consumption among nodes within each corona. The approach for computing the optimal number of coronas in terms of maximizing network lifetime is also presented. Based on the mathematical model, an energy-balanced data gathering (EBDG) protocol is designed and the solution for extending EBDG to large-scale data-gathering sensor networks is also presented. Simulation results demonstrate that EBDG significantly outperforms conventional multi hop

transmission schemes, direct transmission schemes, and cluster-head rotation schemes in terms of network lifetime demonstrate that EBDG significantly outperforms conventional multi hop transmission schemes, direct transmission schemes, and cluster-head rotation schemes in terms of network lifetime. Compare performance of EBDG in terms of energy consumption balancing and network lifetime extension with multi hop routing and direct transmission schemes. Again with Cluster-Head Rotation Scheme and Maximum Lifetime Data Gathering Scheme. Comparison shows that there is better achievement with EBDG protocol in lifetime enhancement.

2.2 Energy-Balanced Routing Protocol (EBRP)

Energy-Balanced Routing Protocol (EBRP) [7] by constructing a mixed virtual potential field in terms of depth, energy density, and residual energy. Basic approach is to force packets to move toward the sink through the dense energy area so as to protect the nodes with relatively low residual energy. To address the routing loop problem emerging in this basic algorithm, enhanced mechanisms are proposed to detect and eliminate loops. The basic algorithm and loop elimination mechanism are first validated through extensive simulation experiments. Finally, the integrated performance of the full potential-based energy-balanced routing algorithm is evaluated through numerous simulations in a random deployed network running event-driven applications, the impact of the parameters on the performance is examined and guidelines for parameter settings are summarized. Experimental results show that there are significant improvements in energy balance, network lifetime, coverage ratio, and throughput as compared to the commonly used energy-efficient routing algorithm.

2.3 Energy-Efficient Multi-path Routing Protocol (EEMRP)

Energy-Efficient Multi-path Routing Protocol (EEMRP) [15] has the capability of searching multiple node-disjoint paths and utilizes a load balancing method to assign the traffic over each selected path. Both the residual energy level of nodes and the number of hops are considered to be incorporated into the link cost function. It uses a fairness index to evaluate the level of load balancing over different multi-paths. Furthermore, since EEMRP only takes care of data transfer delay, the reliability of successful paths sometimes is limited.

They proposed a distributed, scalable and localized multipath search protocol to discover multiple node-disjoint paths between the sink and source nodes. They also propose a load balancing algorithm to distribute the traffic over the multiple paths discovered. They compare their proposed scheme with the directed diffusion, directed transmission, and the energy-aware routing protocols. Simulation results shown that proposed scheme has a higher node energy efficiency, lower average delay and control overhead than those protocols.

2.4 Online multipath routing algorithm

Author analyzed the maximum lifetime routing problem in wireless sensor networks, and presents an online multipath routing algorithm. The proposed algorithm [17] strives to maximize the network lifetime metric by distributing the source-to-sink traffic for a given routing request along a set of paths. Fuzzy membership function is used for designing the edge weight function. Simulation results obtained under a variety of network scenarios show that the proposed multipath scheme is able to achieve better lifetime results than those obtained by its predecessor single-path fuzzy routing scheme as well as by another well-known online routing scheme, namely the Online Maximum Lifetime heuristic. It uses an edge-weight function in the path search process.

2.5 Optimal Forwarding by Fuzzy Inference Systems (OFFIS)

The authors presented Optimal Forwarding by Fuzzy Inference Systems (OFFIS) [18] for flat sensor networks. The OFFIS protocol selected the best node from candidate nodes in the forwarding paths by favoring the minimum number of hops, shortest path and maximum remaining battery power, etc. They compare OFFIS with the minimum transmit energy (MTE) technique and show that the lifetime can be improved.

2.6 Fuzzy reasoning method

A fuzzy reasoning method [23] is proposed that employs an explicit feedback mechanism to improve the robustness of fuzzy reasoning. The fuzzy rule base, the fuzzy reasoning method, and the corresponding reasoning goals/constraints define the three distinct ingredients of fuzzy reasoning. While various existing fuzzy reasoning methods are essentially a static mapping from the universe of single fuzzy premises to the universe of single fuzzy consequences, the new fuzzy reasoning method maps sequences of fuzzy

premises to sequences of fuzzy consequences and is a function of the underlying reasoning goals.

Simulation shows that the new fuzzy reasoning method is much more robust than the optimal fuzzy reasoning method proposed in our previous work. The explicit feedback mechanism embedded in the fuzzy reasoning method does significantly improve the robustness of fuzzy reasoning, which is concerned with the effects of perturbations associated with given fuzzy rule bases and/or fuzzy premises on fuzzy consequences. The work presented in this paper sets a new starting point for various principles of feedback control and optimization to be applied in fuzzy reasoning or logical inference and to explore new forms of reasoning including robust reasoning and adaptive reasoning.

2.7 Defuzzification method

Some of the most important defuzzification methods [24] and investigates their properties. With three application examples, it illustrates how to select appropriate defuzzification methods using application specific properties. Defuzzification is used to transform fuzzy inference results into crisp output. The standard defuzzification methods fail in some applications. It is, therefore, important to select appropriate defuzzification methods depending on the application.

2.8 A-Star Algorithm

Modified traditional A* algorithm [27] by weighted processing of evaluation function, which made the searching steps reduced from 200 to 80 and searching time reduced from 4.359s to 2.823s in the feasible path planning. The artificial searching marker, which can escape from the barrier trap effectively and quickly, is also introduced to avoid searching the invalid region repeatedly, making the algorithm more effective and accurate in finding the feasible path in unknown environments. They solved the issue of virtual human's obstacle avoidance and navigation through optimizing the feasible path to get the shortest path.

From above literature survey, we should consider some metrics so that we can prolong network lifetime and different parameters related to network like Energy (Residual and Average), Throughput, PDR, End to End Delay, Routing load. These metrics can be traffic load, minimum hopes and remaining energy in each node.

1) Traffic load: The traffic load (or intensity) of a node is defined as the pending amount of traffic in a node's queue. This includes the application traffic and also the traffic that a node has already committed to forwarding. In the case that concentration of events in

some particular sub-areas is more than that of areas, using shortest path will cause implosion along the path. The high traffic load causes a data queue overflow in the sensor nodes, resulting in loss of important information. In addition, since the battery energy of the sensor nodes is quickly exhausted, the entire lifetime of wireless sensor networks would be shortened [3], [16].

2) Minimum Hop (MH): The most common criterion used in routing protocols is minimum hop (or shortest hop), that is, the routing protocol attempts to find the path from the sender (i.e. source) to the destination that requires the smallest number of relay nodes (hops). The basic idea behind this metric is that using the shortest path will result in low end-to-end delays and low resource consumptions, since the smallest number of forwarding nodes will be involved [15], [18].

3) Remaining Energy (RE): Undoubtedly the most crucial aspect of routing in WSNs is the energy efficiency. Under this criterion, the focus is on the energy capacity (i.e. the current battery charge level) of the nodes. A routing protocol that uses this metric would then favour routes that have the largest total energy capacity from source to destination. In other words, nodes having greater remaining energy participate more than the nodes with limited power [3], [15].

To avoid network partitioning and to extend the network lifetime, Energy(Residual and Average), Throughput, PDR, End to End Delay, Routing load this paper proposes a new routing method using a combination of Fuzzy approach and A-star algorithm. The proposed routing method is used to select the optimal routing path from source to destination by considering the above criteria (Remaining Energy, Minimum Hop, and Traffic Load) and balancing between them to lengthen the lifetime and different parameter mentioned above of the sensor network as much as possible.

3. FUZZY APPROACH AND A-STAR ALGORITHM

A. Fuzzy Approach

Fuzzy logic was first introduced in the mid-1960s by Lotfi-Zadeh in [22]. Since then, its applications have rapidly expanded in adaptive control systems and system identification. It has the advantages of easy implementation, robustness, and ability to approximate to any nonlinear mapping [1]. Fuzzy logic analyzes information using fuzzy sets, each of which is represented by a linguistic term such as "small," "medium," or "large." Fuzzy sets allow an object to be a partial member of a set. In Fig. 4, if X suggests a collection of objects denoted by x, usually X

is referred to as the “universe of discourse,” and then a fuzzy set A_n in X is defined by a set of ordered pairs:

$$A = \{(x, \mu_A(x) / x \in X)\} \dots \dots \dots (1)$$

Where the function $\mu_A(x)$ is called membership function of the object x in A . This membership function represents a “degree of belongingness” for each object to a fuzzy set, and provides a mapping of objects to a continuous membership value in the interval $[0..1]$. When a membership value is close to the value 1 ($\mu_A(x) \rightarrow 1$), it means that input x belongs to the set A with a high degree, while small membership values ($\mu_A(x) \rightarrow 0$), indicate that set A does not suit input x very well [23]. In fuzzy systems, the dynamic behavior of a system is characterized by a set of linguistic fuzzy rules based on the knowledge of a human expert. These rules are of the general form IF antecedent(s) THEN consequent(s), where antecedents and consequents are propositions containing linguistic variables. Antecedents of a fuzzy rule form a combination of fuzzy sets through the use of logic operations. Thus, fuzzy sets and fuzzy rules together form the knowledge base of a rule-based inference system. Rules are the heart of a fuzzy system and may be provided by experts or can be extracted from numerical data. In either case, the rules that we are interested in can be expressed as a collection of IF-THEN statements.

The processes of making crisp inputs are mapped to their fuzzy representation in the process called fuzzification. This involves application of membership functions such as triangular, trapezoidal, Gaussian etc. The inference engine process maps fuzzified inputs to the rule base to produce a fuzzy output. A consequent of the rule and its membership to the output sets are determined here. The defuzzification process converts the output of a fuzzy rule into crisp outputs by one of defuzzification strategies [24].

B. A-Star Algorithm

A-star search algorithm is a widely used graphic searching algorithm. It is also a highly efficient heuristic algorithm used in finding a variable or low cost path. It is considered as one of the best intelligent search algorithms that combines the Merits of both depth-first search algorithm and breadth-first algorithm. A-star path searching algorithm uses the evaluation function (usually denoted $f(n)$) to guide and determine the order in which the search visits nodes in the tree. The evaluation function is given as:

$$F(n) = g(n) + h(n) \dots \dots \dots (2)$$

where $g(n)$ is the actual cost from the initial node (start node) to node n (i.e. the cost finding of optimal path), $h(n)$ is the estimated cost of the optimal path from node n to the target node (destination node),

which depends on the heuristic information of the problem area [25]. Generally, A-star algorithm maintains two lists, an OPEN list and a CLOSE list. The OPEN list is a priority queue and keeps track of the nodes in it to find out the next node with least evaluation function to pick. The CLOSE list keeps track of nodes that have already been examined. Initially, the OPEN list contains the starting node. When it iterates once, it takes the top of the priority list, and then checks whether it is the goal node (destination node). If so, the algorithm is done. Otherwise, it calculates the evaluation function of all adjacent nodes and adds them to the OPEN list. After the A-star algorithm is completed, it will find a solution if a solution exists. If it doesn't find a solution, then it can guarantee that no such solution exists. A-star algorithms will find a path with the lowest possible cost. This will depend heavily upon the quality of the cost function and estimates provided [26].

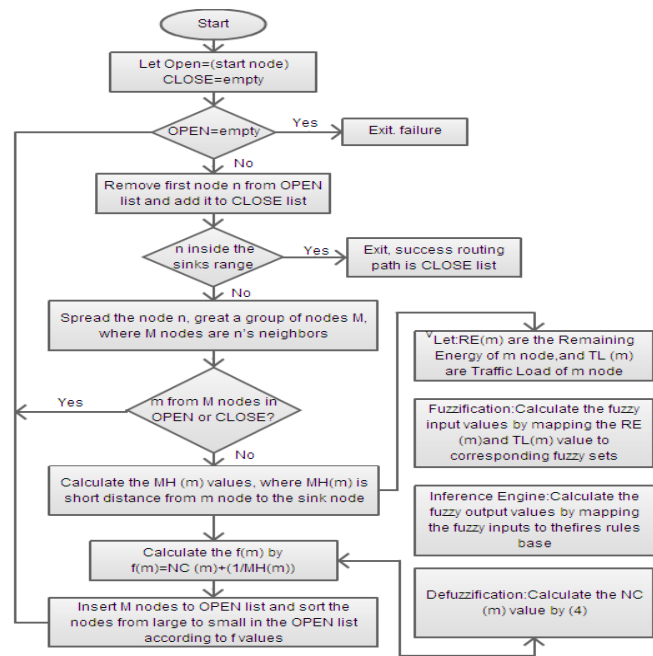


Fig. 1 Proposed Algorithm

4. RESULT AND DISCUSSION

After implementation of fuzzy approach we got some result of network lifetime, Energy (Residual and Average), Throughput, PDR, End to End Delay, Routing load. As compare to previous somemethodology results we are getting are better. Some results after implementation of fuzzy approach as shown in figure. For this we have consider various number of nodes like 20,40,60,80,100. For this we have used Ad-hoc on demand vector routing protocol.

We have used tool like NS-2 to get simulation result. From all these result we are able to analysed effectiveness of proposed method.

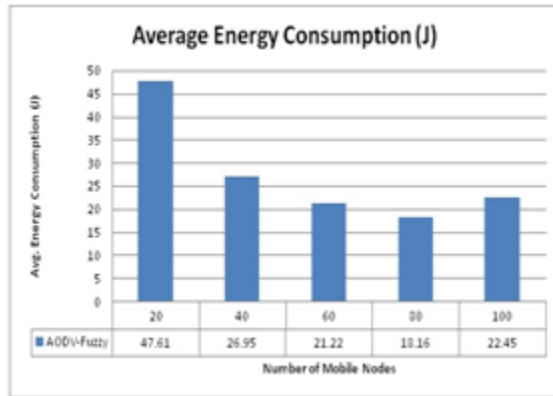


Fig.1 Average Energy Consumption (J)

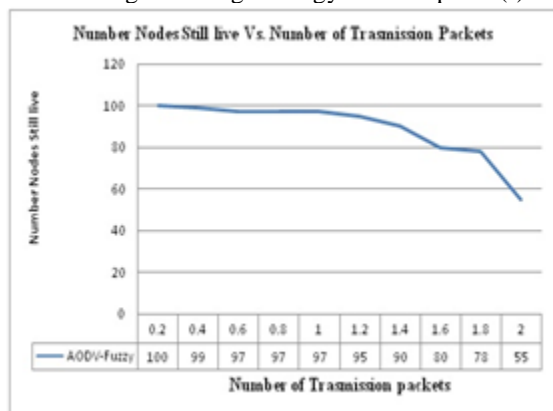


Fig.2 Lifetime in terms of live nodes

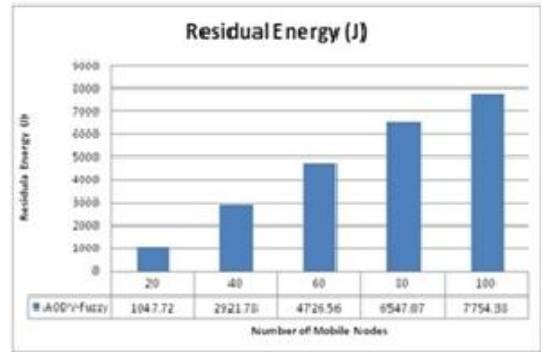
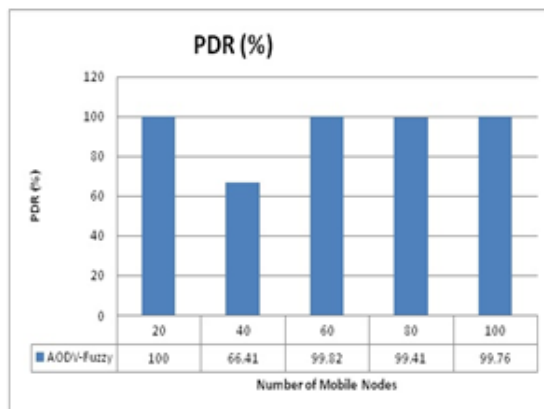


Fig.4 Residual Energy (J)

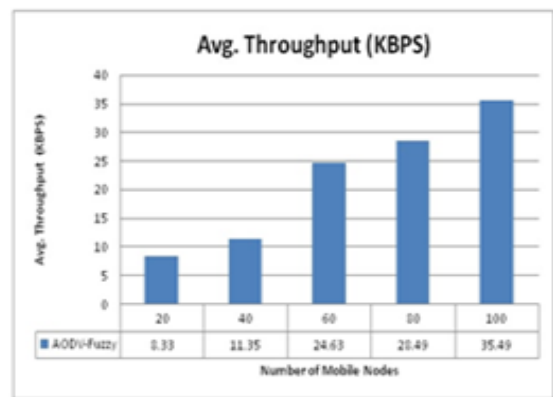


fig5.AverageThroughput

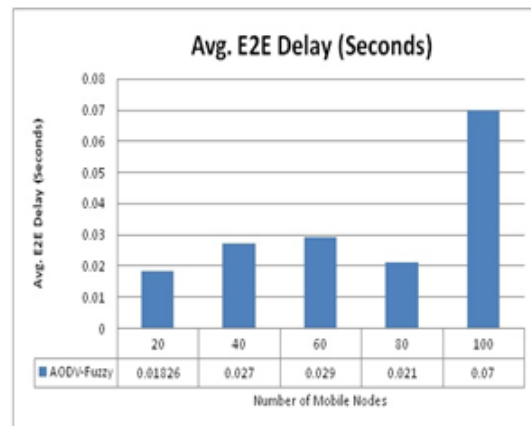


Fig .6Avg End to End Delay

5. CONCLUSION AND FUTURE WORK

In wireless sensor networks where nodes operate on limited battery energy efficient utilization of the energy is very important. One of the main characteristics of these networks is that the network lifetime is highly related to the route selection. Unbalanced energy consumption is an inherent problem in a WSN. To efficiently route data through transmission path from node to node and to prolong the overall lifetime of the network, we proposed a new algorithm by using a combination of both Fuzzy approach and A-star algorithm. After implementation of fuzzy approach we got result of various parameters like energy (average and residual), throughput, PDR, end to end delay, routing load vs. no. of nodes etc. along with these average energy consumption vs. no. of transmission packets, no of nodes still alive vs. no of transmission packet, Average network remaining energy vs. no. of transmission packets.

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