Energy Enhancement by Selecting Optimal Routing Path from Source to sink Nodes: Survey

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Abstract

*WS*Ns are used for collecting information required by smart environments where resource limitations have to be taken into account when designing its infrastructure. The unbalanced energy dissipation significantly reduces the network lifetime. In this paper the routing methods namely A- star algorithm and fuzzy approach for WSN to determine an optimal routing path from the source to the destination, by considering the battery power, number of hops, and traffic load for extending network lifetime of WSNs. Results show that network lifetime improves by employing the optimized routing protocols and enhances the network lifetime.

Keywords: WSN, lifetime enhancement, multipath routing, fuzzy membership functions, A* algorithm

Introduction

Wireless sensor network (WSN) is composed of cheap and tiny unreliable sensors with limited resources, where the sensors possess sensing, computing and communicating capabilities [1]. Each node in a sensor network is composed of a radio-transducer, a small microcontroller and a battery. Sensor nodes in the large-scale data-gathering networks are generally powered by small and inexpensive batteries in expectation of surviving for a long period [3].Primarily these sensors are used for data acquisition and are required to disseminate the acquired parameters to special nodes called sinks or base-stations over the wireless link as shown in fig 1.

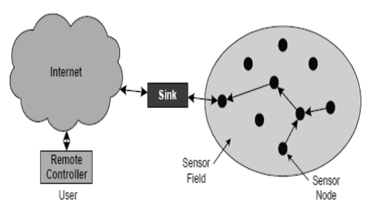

Fig.1. Sensor Network Architecture

Components inside a typical sensor node comprises of sensing, processing, transmission, mobilizes, position finding system and power unitsas shown in fig 2.Each sensor node makes its decisions based on its mission, the information it currently has, knowledge of its computing,communication, and energy resources. The node must have capability to collect and route data either to other nodes or back to an external base station or stations that may be a fixed or a mobile node capable of connecting the sensor network to an existing communication infrastructure or to the internet [4].

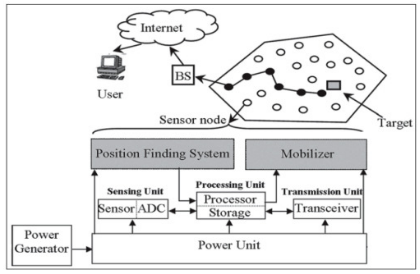

Fig.2. Components of a sensor node

Due to limitations in the communication range, sensor nodes transmit their sensed data through multiple hops. Energy consumption should be well managed to maximize the network lifetime [5]. The uneven energy dissipation can significantly reduce network lifetime. Over a period of time, if the same path is chosen for all communications in order to achieve battery performance in terms of quick transmission time, then those nodes on this path will get drained fast [3], [5], [7]. In many cases, the lifetime of a sensor network is over as soon as the battery power in critical nodes is depleted. Therefore, in this paper, the various methods are analyzed to investigate the problems of balancing energy consumption and maximization of network lifetime for WSNs.

RELATED WORK

In traditional optimal path routing schemes over WSNs, each node selects specific nodes to relay data according to some criteria in order to maximize network lifetime. Therefore, a good routing method in WSNs involves finding the optimal transmission path form 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.

Following are the salient features of the routing algorithms proposed in the past:

A. Energy-Efficient Multi-path Routing Protocol (EEMRP):

This protocol has a capability of searching multiple node-disjoint paths and utilizes a load balancing method to assign the traffic over each selected path. In this both the residual energy level of nodes and the number of hops are considered to be incorporated into the link cost function. Furthermore, since EEMRP only takes care of data transfer delay, the reliability of successful paths sometimes is limited.

B. Optimal Forwarding by Fuzzy Inference Systems (OFFIS*):*

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.

C. Fuzzy logic systems*:*

This present a novel algorithm for routing analysis in WSNs utilizing a fuzzy logic at each node to determine its capability to transfer data based on its relative energy levels, distance and traffic load to maximize the lifetime of the sensor networks.

D. A-Star algorithm based Energy Efficient Routing (ASEER):

This approach is mainly used to extend lifetime of Wireless Sensor Network. In ASEER, using A-Star algorithm the relay schedule is computed by some centralized entity, with an assumption that the average amount of data generated by each cluster is known.

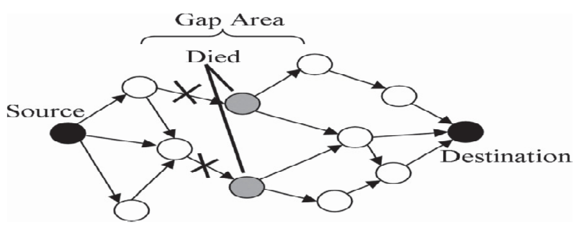

Fig. 3 Network partition due to the death of certain nodes

Fig.3 shows the network partition (one part of the network may become disconnected from the destination) due to the death of some sensor nodes. From the aforementioned literatures, we note that a number of different metrics have been used to prolong the lifetime of the sensor networks. These metrics are as follows:

1) **Remaining Energy (RE):** 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.

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.

3) **Traffic Load (TL):** 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.

Fuzzy Approach And A-Star Algorithm

A.FUZZY APPROACH

Fuzzy systems allow the use of fuzzy sets to draw conclusions and to make decisions. Fuzzy sets differ from classical sets in that they allow an object to be a partial member of a set. For example, a person may be a member of the set *tall* to a degree of 0.8. 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. Fig 4 shows the typical structure of a fuzzy system. It consists of four components namely; fuzzification, rule base, inference engine and defuzzification. 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. The defuzzification process converts the output of a fuzzy rule into crisp outputs by one of defuzzification strategies. Antecedents and consequents of a fuzzy rule form fuzzy *input space* and fuzzy *output* space respectively, which are defined by combinations of fuzzy sets. Non-fuzzy inputs are mapped to their fuzzy representation in the process called fuzzification.

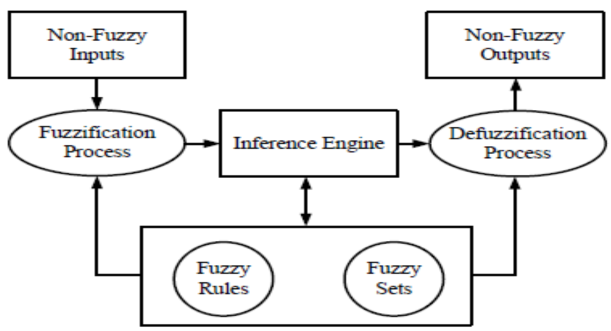

Fig. 4 Block diagram of a fuzzy inference system

B. A STAR ALGORITHM

A-Star algorithm is used to find path and to traverse graph efficiently. It uses heuristics for decision making. The A-Star algorithm is a best-first search algorithm that finds the optimal path from source to destination. It uses a distance and a cost heuristic function (usually denoted f(n)) to determine the order in which the search visits nodes in the tree. The distance-plus-cost heuristic is a sum of following two functions:

i) The path-cost function, which is the cost from the starting node to the current node(usually denoted g(n))
ii) And an admissible "heuristic estimate" of the distance to the goal (usually denoted h(n)).

Generally, the A-Star algorithm creates a tree of nodes and maintains two lists, an OPEN list and a CLOSED list. The OPEN list is a priority queue of nodes, where we can select the next least costly node to explore. Initially, the OPEN list contains the starting node.

These twomethods assume that:

1) All sensor nodes are randomly distributed in the area and every sensor node is assumed to know its own position as well as that of its neighbors and the sink;

2) All sensor nodes have the same maximum transmission range and the same amount of initial energy;

3) Each node has a certain amount of traffic pending in node's queue. The node's queue includes the application traffic and also the traffic that a node has already committed to forward.

PERFORMANCE EVALUATION

A.TROPOLOGICAL SETUP

The simulations are carried out in MATLAB. 100 sensor nodes are randomly deployed in a topographical area A of dimension 100 m × 100 m. Another set of 100 sensor nodes are randomly deployed in a topographical area B of dimension 200 m × 50 m. Both topographical areas A and B have the sensed transmission limit of 30 m. The performance of the proposed method is tested in these two topographical areas. There is only one data sink which located at (90 m, 90 m) for area A and at (180 m, 45 m) for area B. All sensor nodes have the same initial energy 0.5J.

Table I presents the systems parameters in details.

Table I Simulation parameters

Parameter		Value
Tropological Area (metres)	A	100m X 100m
	B	(90, 90)
Sink location (metres)	A	(180,45)
	B	
Number of nodes		100
Limit of transmission distance (metres)		30m
Initial energy of node		0.5J
E_{elec}		50nJ/bit
E_{amp}		100pJ/bit/m^2
Packet data size		
Number of transmission packets		2 X 10^4
Maximum traffic node's queue		10

B.SIMULATION RESULTS

The number of alive nodes as a function of rounds by using the two approaches for both areas *A* and *B* show thatFuzzy approach outperforms than A-star algorithm both areas *A* and *B*. When all packets are sent in area *A*, the network lifetime achieved by Fuzzy approachincreasesnearly by4% than that obtained by A-star algorithm whereas it increasesnearly by5% for area B.Moreover the number of alive nodes is always higher for Fuzzy approach than that of A-star algorithm. The different duration of time corresponding to the first dead node computed using the two different approaches in both areas *A* and *B* is listed in Table II.As the round number increases in the two areas, thefuzzy approach performs better than A-star algorithm.This indicates that, better energy balance in a WSN is achieved by the fuzzy approach in both areas *A* and *B*.

Table II Number of rounds with the First dead node in both areas A and B

Approaches	A-Star	Fuzzy
Lifetime of the first dead node in A area	1462	2460
Lifetime of the first dead node in B area	2110	2263

CONCLUSION

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. To efficiently route data through transmission path from node to node and to prolong the overall lifetime of the network, Fuzzy approach outperforms compared to A-star algorithm. Boththemethodsare capable of selecting optimal routing path from the source node to the sink by favoring the highest remaining energy, minimum number of hops and lowest traffic load. The performance of the both methods evaluated and compared with under the same criteria in two different topographical areas demonstrate the effectiveness of the two approaches with regards to enhancement of the lifetime of wireless sensor networks with randomly scattered nodes.

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