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Lifetime Maximization in Wireless Sensor Networks Using Dstar-Lite Algorithm

I.S. Alshawi¹ and I.O. Alalewi²

¹⁻ *Computer Science Dept., College of Computer Science and Information Technology, Basra University, Basra, IRAQ.*

emadalshawi@gmail.com

²⁻ *Computer Science Dept., College of Science, Basra University, Basra, IRAQ.*

ismaielomar@gmail.com

Abstract:

Wireless Sensor Networks (WSNs) are energized by inexpensive batteries with limited power. A remarkable amount of energy is consumed by wireless data transmission. Therefore, energy efficient routing protocols can conserve battery power and gives the network longer lifetime. Using complex protocols to plan data routing can efficiently reduce energy consumption but it can produce delay processing. This paper proposes a new routing method that incorporates Dstar-Lite to find the optimal path from the source to the destination. The proposed method reuses the path until a specific amount of energy consumed in such a way that keeps energy consumption fairly distributed over the nodes of a WSN while reducing the delay of calculating the routing path from scratch. Simulation results demonstrate the effectiveness of the proposed method in terms of reducing energy consumption and decreasing end-to-end delay as compared with Fuzzy logic and A-star algorithm. The results also show that the network lifetime achieved by Dstar-Lite could be increased by nearly 20% and 24% more than that obtained by Fuzzy logic and A-star algorithm, respectively.

Keywords: Dstar-Lite algorithm, Network lifetime, Routing, Wireless sensor networks.

1. Introduction

Wireless sensor network (WSN) is a number of sensor devices (nodes) deployed in an area of interest to monitor one or more physical phenomena such as temperature, light, humidity, movement, etc. Besides sensing, sensor nodes have the capability of wireless communication. Sensor nodes communicate wirelessly with each other and with data collecting unit called base station (sink) to cooperatively perform sensing, data routing and network management tasks. The sink connects the WSN to an existing network infrastructure or to the internet and can be fixed or

mobile. One or more sinks can be used in a WSN [1].

The importance of WSNs comes from its various applications including remote habitat monitoring, battlefield monitoring, and environmental data collection (e.g. temperature, humidity, light, vibration, etc.). In such applications, hundreds or even thousands of low-cost sensor nodes are distributed over the area to be sensed, with nodes organized into a wireless network in an intelligent way, in which each sensor node periodically reports its sensed data to the sink [2, 3].

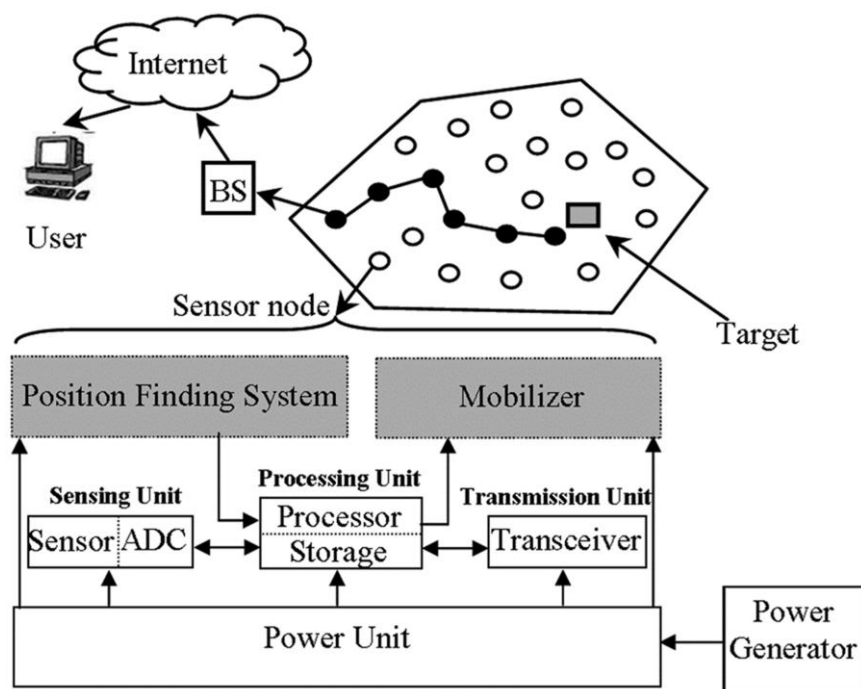


Fig. 1. Components of a sensor node

Sensor nodes in the large-scale data-gathering networks are generally powered by small and inexpensive batteries that produce limited energy with the expectation of surviving for a long period [4]. Fig. 1 shows the schematic diagram of components inside a typical sensor node that comprises of sensing, processing, transmission, mobilizing, position finding system and power units. It also shows the communication architecture of a WSN. Each sensor node makes its decisions based on its mission, the information it currently

has, knowledge of its computing, communication, and energy resources.

The limited transmission range and energy resource make it more feasible if sensor nodes transmit their sensed data through short-distance multiple hops. Hence, the sensor can send its own data or act as a relay to forward other sensor's data. Energy is therefore of utmost importance in power-constrained data-gathering sensor networks. Energy consumption should be carefully managed to maximize the network lifetime [3, 5].

Uneven energy consumption is an inherent problem in WSNs characterized by the multi-hop routing and many-to-one traffic pattern. This uneven energy dissipation can significantly reduce network lifetime. Generally in routing methods, the best path is selected for data transmission from source to destination [4].

Many routing algorithms share the problem of that they attempt to minimize the total energy consumption in the network at the expense of non-uniform energy drainage in the networks. Such approaches lead network to partition because some nodes that join two or more network parts are drained from their battery quicker energy. In many cases, the lifetime of a sensor network is over as soon as the battery power in critical nodes that are common in many routing paths is depleted. A perfect routing method would slowly and fairly distribute energy consumption among nodes, leading all the nodes to die nearly at the same time [2].

Therefore, in this paper, the proposed method attempts to investigate the problems

2. Related Works

In traditional routing methods over WSNs, each node selects specific nodes inside its transmission diameter to relay data based on specific criteria in order to extend network lifetime. Therefore, a good routing scheme in WSNs involves finding the optimal transmission path from the sender through one or more relay node(s) toward the destination aiming on network lifetime enhancement. Having this idea, the lifetime problem in WSNs has gained significant attention in the recent past.

The work in [6] is proposed to lessen the hop stretch of a routing path (defined as the ratio between the hop distance of the shortest path and that of a given path) in order to reduce the energy consumed by end-to-end transmission. The approaches in [7] and [8] have a different way for maximizing the network-lifetime. They tried to distribute the traffic load to the nodes with much residual energy for

of balancing energy consumption, lessening of end-to-end delay caused by path planning and maximization of network lifetime for WSNs. The new method is utilizing Dstar-Lite algorithm to select an optimal routing path from the source to the destination by preferring the highest remaining battery power and minimum traffic loads then reuse the path smartly to minimize the delay produced by path planning each time while keeping energy consumption balanced between discovered paths.

The rest of this paper is organized as follows. Related work (prior arts) and related concepts of the routing algorithm to maximize the lifetime of WSN is presented in section 2. Research problem is given in section 3. In section 4, the paper briefly describes Dstar-Lite algorithm. The implementation for the proposed routing method is presented in section 5. Simulation results are described in section 6. Finally, conclusion is presented in section 7.

conserving the availability of the sensors that have less energy. All of the previously mentioned works use fixed paths for better energy-efficiency; nonetheless, without path variety, those nodes engaged in fixed routing paths may deplete their energy earlier.

Opportunistic routing introduced in [9] has two natural advantages, i.e. path diversity and improved transmission reliability; these advantages were exploited to develop a distributed routing method for extending the network lifetime of a WSN. In this work each sensor is assisted to determine a suitable set of relay nodes with the priorities defined for them, thus, enabling effort to maximize the network-lifetime. In [10], a shortest cost path routing algorithm is proposed by Chang and Tassiulas in which link costs that reflect both the communication energy consumption rates and the residual energy

levels are taken into account for maximizing network lifetime. The authors in [11] presented a uniform balancing energy routing method that chooses the nodes whose remaining energies were greater than a given threshold as forwarders for other nodes in every transmission round, and distributes the energy consumption to many sensors to increase the lifetime of the whole network.

Lu et al. in [12] proposed an Energy-Efficient Multi-path Routing Protocol (EEMRP). It utilizes a load balancing method to assign the traffic over each selected path after searching multiple node-disjoint paths. In this protocol, link costs are calculated based on both the remaining energy level of nodes and the number of hops. The level of load balancing over different multi-paths is evaluated using a fairness index. Furthermore, the reliability of successful paths is sometimes limited since EEMRP only considers data transfer delay. In [13], a novel energy-aware geographic routing protocol (EAGR) in WSNs is proposed by Huang et al. The protocol attempts to reduce the energy consumption of end-to-end transmission. With EAGR, an existing geographic routing protocol is used adaptively to find an anchor list depending on the projection distance of nodes to control the direction of packet forwarding. Each node holding the message makes use of geographic information, the characteristics of energy consumption, and the metric of advanced energy cost to decide forwarding upon and dynamically adjusts its transmission power to the minimum level required to reach the selected node. The authors of [14] proposed an efficient scheme called data-driven routing protocol to investigate the mobility problems in WSNs with mobile sinks. Data-

3. Problem Statement

Commonly in WSNs applications, large number of sensor nodes are deployed in large areas and in dense form. These sensor nodes are powered by small and inexpensive batteries that cannot be

driven routing protocol attempts to reduce the overheads for the path planning caused by sink mobility and keep well performing the packet delivery.

Investing the advantages of Computational Intelligence (CI), a high weight genetic algorithm is used by the protocol presented in [15]. In this protocol, the sensor nodes have taken into account the data traffic rate to monitor the network congestion. Wang et al. [16] used the Biogeography-Based Optimization (BBO) algorithm to handle the dynamic deployment problem in both static and mobile sensor nodes in WSNs based on a binary detection model. Fuzzy logic is also utilized in the novel methods presented by [17], [18] and [19] for routing packets in WSNs where each node selects the best node from a set of candidate nodes in the forwarding paths to maximize the lifetime of the sensor networks. Keyur et al. in [20] used A-star algorithm to search optimal path from the source to destination in such a way that prevents sensor nodes from being engaged in a routing path when their energies is lower than a specific minimum energy level. In [21], Alshawi proposed a routing protocol that incorporates Artificial Bee Colony optimization algorithm (ABC) and Fuzzy logic, in this protocol, fuzzy logic is used alongside with ABC to calculate the optimal path starting from the source node toward the sink considering the traffic load, residual energy and distance to sink to decide which node is the next to be part of the optimal path until the sink is reached. ABC is also exploited by the authors in [22] and [23] to propose a hierarchical clustering scheme for WSNs to maintain least possible energy consumption in the network.

replaced or recharged due to the harsh conditions and inaccessibility of deployment area in most of the applications. After their energy is depleted, nodes will stop working and turn to die.

Since a network will be unable to accomplish its assigned mission or not work in full potentials when nodes died. The lifetime parameter of WSNs is indispensable when evaluating performance of routing protocols [3]. When the same path founded by a routing protocol is chosen for all next communications as with many routing algorithms in order to achieve battery performance in terms of low transmission delay, the nodes of this path will drain their energy in fast manner [3, 4,

5]. While these routing algorithms minimize the total energy drainage in the network, they produce uneven energy consumption in the networks. Such algorithms cause network partition problem which deteriorates or even nullifies the usefulness and effectiveness of the whole network [3]. Fig. 2 shows how the network partitioned (a set of nodes may become unreachable) caused the death of some sensor nodes that are the only connector of a part of the network to the destination.

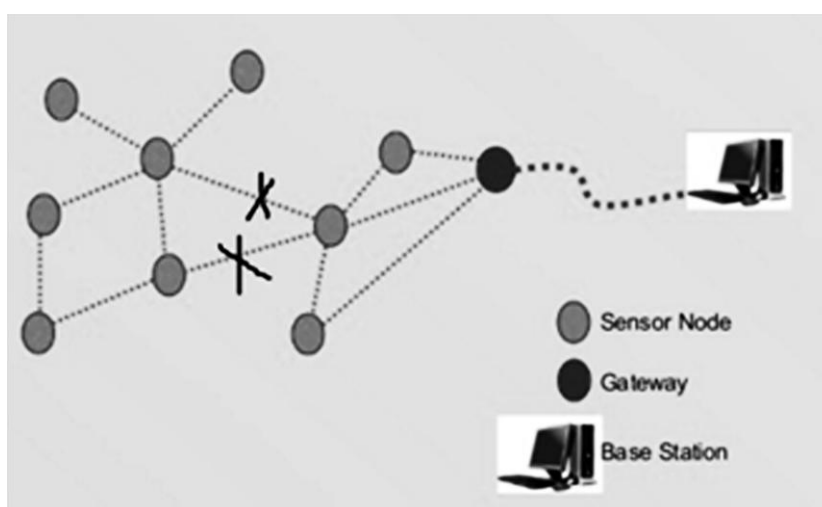


Fig. 2. Network partition due to the death of certain nodes.

The lifetime of a WSN is over once the battery power of critical nodes that act as a relay for a part of the network is depleted. The problem then is to determine a set of routes for each node to forward data through according to some routing parameters (i.e., the routing configuration) that increase network lifetime. Prolonging the lifetime of WSN can be dealt with as optimization problem. The variables of this optimization problem are routing parameters at nodes. A sensor node can send its own sensed data or act as a relay to forward data of other nodes. In both cases, each node is required to send this data packet to the sink. When the sink is within the node's transmission range, the packet is sent directly in single-hop fashion. Otherwise, the packet sent toward the sink through one or more intermediate nodes (hops). However, the nodes select one of its

neighbouring nodes as next hop, that will lead nodes selected as next hop to be incorporated in routing the data of other nodes. This case will impact the energy depletion of the network and the lifetime as well.

The aforementioned literatures present a number of different metrics that have been considered to maximize the lifetime of the sensor networks. These metrics are as follows:

1) Remaining Energy (RE)

To keep the network functioning for longest possible time, an efficient routing method is needed. Hence, the most important aspect of routing in WSNs is the energy efficiency. Under this criterion, the focus is on the residual energy (i.e. the current battery power status) of the nodes. A routing method that uses this metric would then attempt to find routes that have

the largest total remaining energy from source to sink. In other words, nodes having more remaining energy would participate more than the ones with less power [4, 12, 24]. An example is shown on Fig. 3 where a small sensor network in which, a source node tries to send a packet to a sink node.

The numbers inside the nodes refer to the remaining energy of the nodes. In this example, a routing protocol would choose A–D–G as the optimal path because it traverses the nodes with the largest total remaining energy (i.e. 10).

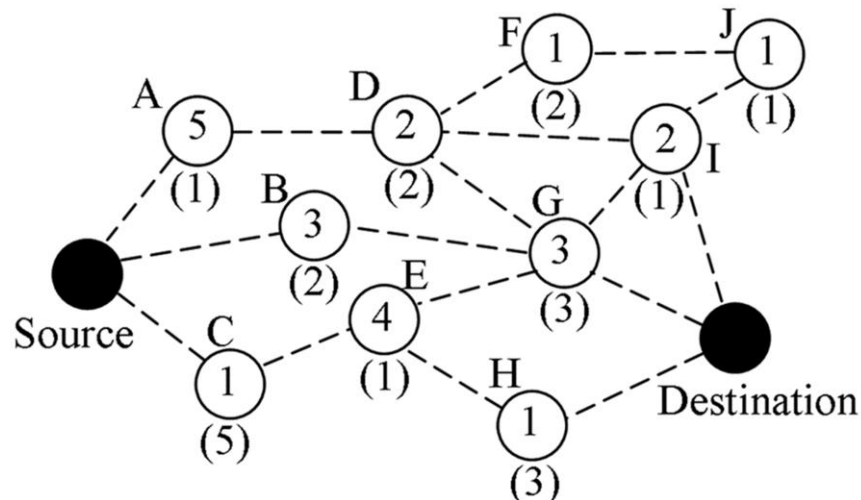


Fig. 3. Routing options in a small WSN using different metrics (Remaining Energy is the number inside nodes, and Traffic Load is the number in parentheses below nodes)

2) Minimum hop(MH)

Minimum hop (or shortest hop) is the most common criterion used in routing protocols. Under this criterion, the path from the sender (i.e. source) to the sink that traverses the smallest number of intermediate nodes (hops) will be selected as the optimal one. The shortest path will reduce end-to-end delays and resource consumptions by involving the smallest possible number of hops [12, 19, 24]. In Fig. 3, a routing protocol built on this criterion, could find the path B-G which comprises the minimum hop (i.e. 3).

3) Traffic Load (TL)

The current amount of traffic still present in a node's queue is called traffic load (or intensity) of a node. A data queue overflow problem in the sensor nodes is resulted by high traffic load and could lead to the loss of valuable information. Also, since the limited battery energy of the sensor nodes is quickly consumed when having high traffic load, the lifetime of the

whole network would become shorter [4, 19, 24]. Therefore, it's preferred when avoiding more traffic from being sent to the nodes of high traffic load in order to keep the WSN performing for longer time. In Fig. 3, the parenthesized numbers below each node represents the traffic load of that node. Considering this criterion, the path A-D-I is preferred as it totally has the lowest traffic load (i.e. 4).

To extend the network lifetime and reduce the path finding time in each transmission round, this paper proposes a new routing method using Dstar-Lite algorithm. The proposed routing method is used to find the optimal routing path from source toward destination, that has taken into account the above metrics (Remaining Energy, Minimum hop and Traffic Load) and balancing among them. Also, the proposed method is reusing the path repeatedly for later transmissions until a specific change occurs in the cost of any node of that path. Then, another path will

be searched starting from the changed node position in order to lengthen the lifetime of the sensor network as much as possible and

avoid uneven energy consumption while minimizing the delay caused by path finding process.

4. Dstar-Lite Algorithm

Dstar-Lite is an incremental heuristic graph search algorithm. An incremental search tends to recalculate only those start distances (that is, distances from the start vertex to a vertex) that have changed or have not been calculated before. A heuristic search tends to recalculate only those start distances that are relevant for recalculating a shortest path from the start vertex to the goal vertex [25].

The search is done in backward manner (starting from the goal node and ending on the start node) evaluating (or expanding) each encountered node based on the sorted priority queue until the start node is reached. The flowchart in Fig. 4 illustrates the general idea of Dstar-Lite algorithm.

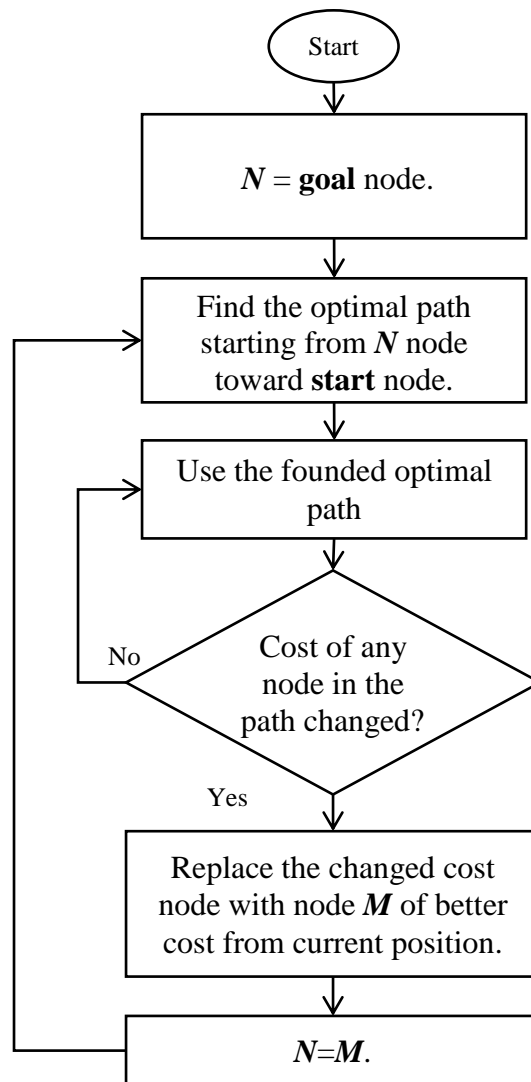


Fig. 4. Dstar-Lite (general algorithm)

Each node has a *Key* value (evaluation function) depends on the two values that are, *g* value refers to the start

$$rhs(s) = \begin{cases} 0 \\ \min_{u \in succ(s)} (g(u) + c(u, s)) \end{cases}$$

Where $succ(s)$ is the set of nodes that are successors to s and $c(u, s)$ is the cost of moving from u to s .

$$key = [\min(g(s), rhs(s)) + h(s, S_{start}); \min(g(s), rhs(s))] \quad (2)$$

Where $h(s, S_{start})$ is an estimate of the distance from node s to the start node (S_{start}).

One advantage of Dstar-Lite is that it uses knowledge from previous searches to perform later searches much faster than is possible by solving each search task from scratch. Dstar-Lite efficiently recalculates a shortest path from its current node to the

distance of a node (node cost) and rhs (right-hand side) value which is calculated as the following:

$$s = \begin{cases} S_{goal} \\ otherwise \end{cases} \quad (1)$$

The priority queue is sorted based on *Key* values and *Key* of a node (s) is a vector of two components calculated as the following:

goal node by recalculating only those goal distances that have changed (or have not been calculated yet) and it is relevant for recalculating the shortest path. The challenge is to identify these cells efficiently [25], thus we applied a specific mechanism in this regard explained in the next section.

5. Implementation of Dstar algorithm in WSNs

This section will describe how Dstar-Lite algorithm is exploited to be applied in WSNs routing. It uses to conserve total network energy for longer time while performs search tasks faster by using knowledge from previous searches to bypass the overheads of initiating path finding process from scratch, therefore, reduces delay of data transmission.

Firstly, we assume that, the sink has knowledge about the current status of each node in terms of battery energy level, location coordinates and traffic load. Thus, the proposed routing method finds the routing path for sensor node that has data to be sent (source node) or (s) toward the sink for the first time as the following:

$$d = \sqrt{(X_s - X_n)^2 + (Y_s - Y_n)^2} \quad (3)$$

Where (X_s, Y_s) and (X_n, Y_n) are the (x, y) coordinates for nodes n and source node s . The h value for a

1. Starting from the sink as current node to be expanded, detect all neighbouring nodes that can directly communicate with the sink (i.e., their transmission range can reach the sink). When the source node (s) is detected as sink's neighbour, it could send its collected data directly without any intermediate hop, otherwise, calculate the key values for all detected nodes as the following:

- a) As assumed, knowing (x, y) coordinates for each sensor node in the network, distance (d) of each node (n) to the source node (s) can be calculated as the following:

node can be calculated then by distance normalization to $[0...1]$ using feature scaling method:

$$h = \frac{d - \text{minimum distance}}{\text{maximum distance} - \text{minimum distance}} \quad (4)$$

Knowing the maximum possible diagonal length), minimum distance in the sensor area (i.e., distance is 0, and then we have:

$$h = \frac{d}{\text{maximum distance}} \quad (5)$$

- b) After that g value is to be calculated based on the remaining energy e scaled between 0 to 1 using feature scaling. Having minimum and maximum possible battery energy levels are 0 and max_e respectively then:

$$g = \frac{e}{max_e} \quad (6)$$

- c) Using the same concept of a) and b), rhs value is the normalized traffic load of a given node, that is:

$$rhs = \frac{t}{max_t} \quad (7)$$

Where t is the current traffic load of the corresponding node and max_t is the maximum possible traffic load (i.e., queue length).

- d) After g , h and rhs values are calculated, key value is obtained using the following equation:

$$\text{Key} = \alpha * g - \beta * rhs + \gamma * (1/h) \quad (8)$$

Where α , β and γ are integer coefficients specified by the user to control the effectiveness of each variable (metric). For example, to give g more effectiveness than both of rhs and h , then α value should be more than both β and γ values.

2. When a set of nodes detected in the same expansion process, they are successors to the expanded node and substitutes to each other. The pack pointer of each node discovered during the expansion process is set to the expanded node.

3. After each node expansion process, the expanded node will be removed from PQ and the set of detected nodes will be added to the priority queue (PQ) which is then sorted by key values in descending order. The next node to be expanded is the first node in the top of PQ .

4. The process from 1 to 3 is repeated until the source node is detected then the optimal path can be easily traced back by following the back pointers from the source node toward the sink.

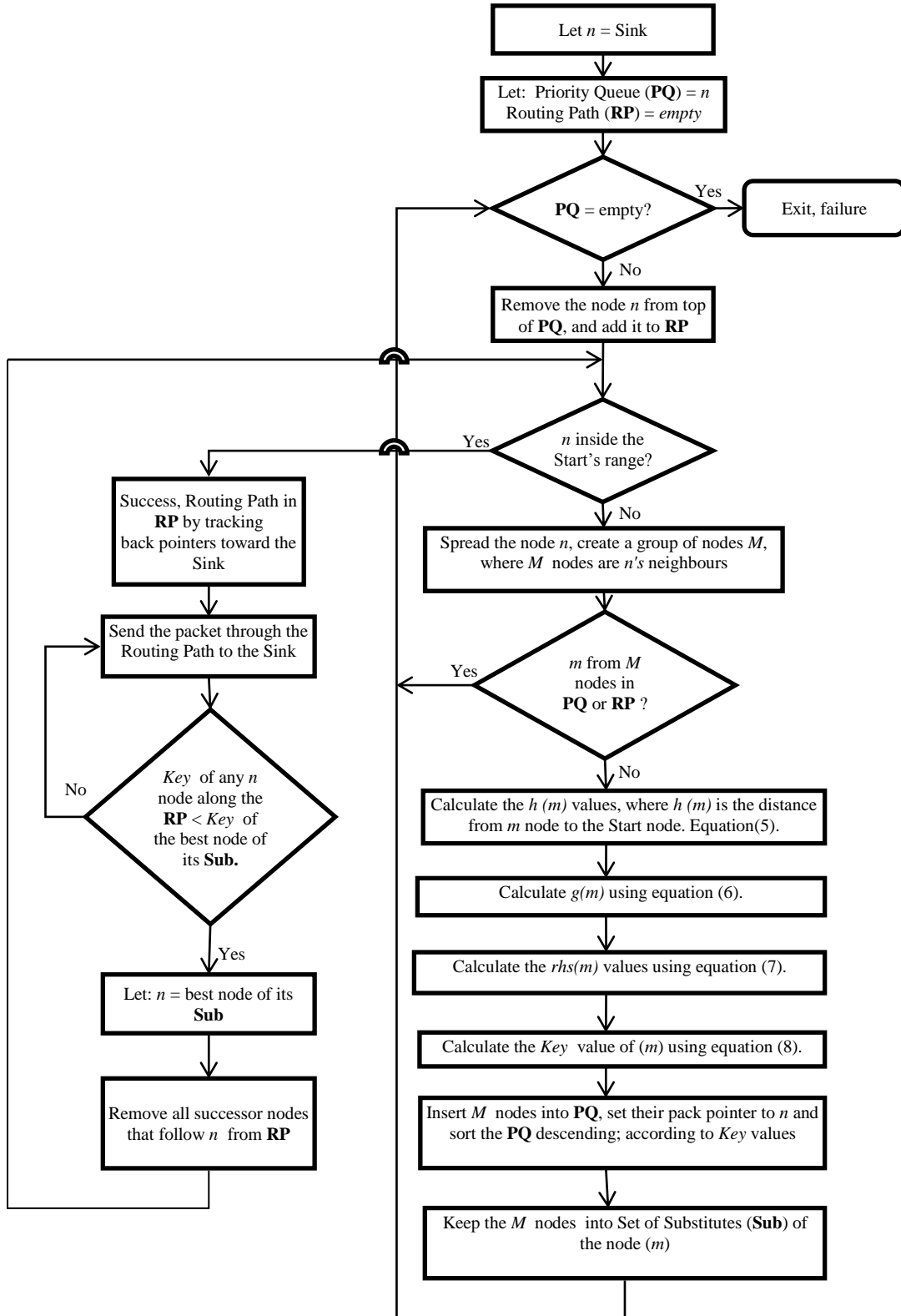


Fig. 5. Implementation of Dstar-Lite algorithm

5. Path finding process is done when the source node is founded or when the PQ becomes empty and the source node is not reached yet. In the latter case, the algorithm is failed to find the optimal path due to network partition.

After the optimal path is founded for a specific source node, it will be used for all later data transmissions of that node until the change in the cost of any node in the path is detected. The change detection process is done after each time the optimal path is used; it can be explained as the following:

6. Simulation Results

To evaluate the effectiveness of the proposed method considering balancing energy consumption and maximizing network lifetime, simulation results of the proposed are compared with those of A-star search algorithm and with those of Fuzzy approach. The three methods involve the same routing metrics; namely, the remaining energy, the shortest hop, and the traffic load during search of the optimal path from the source node to the sink node.

A-star algorithm is shown to obtain better results than existing maximum lifetime routing algorithms in literatures

6.1. Simulation Setup

The simulations are carried out using MATLAB. 100 sensor nodes deployed in a topographical area that has of 100m×100m dimension. Nodes deployments are done in a random manner. The topographical area has the sensed transmission limited to 30m. The performance test of the proposed method is done in this topographical area. The data sink is located at (90m, 90m). The initial energy is 0.5 J for all sensor nodes in the network. The first order radio model that is largely used in the area of routing protocol evaluation in WSNs [27] is also used in the proposed method. According to this model, transmission and receiving costs are characterized by the expressions $E_n T(k) = E_{elec} \bullet k + E_{amp} \bullet k \cdot d^2$ and

1. Each intermediate node in the optimal path is compared with its best substitute node from step 2 in path finding process. If the key of any intermediate node is smaller than the *key* of its best substitute node in the list of substitutes, change is detected.

2. Whenever change is detected, the best substitute node becomes the starting point of the next path finding process. Hence the time of path finding from the sink to the changed node position is saved.

The flowchart of the proposed routing protocol is shown in Fig. 5.

such as Genetic Algorithm, Warshall algorithm [20] and AODVjr algorithm [26]. The fuzzy approach is also shown to produce better performance over existing maximum lifetime routing algorithms in literatures such as Online-Maximum-Lifetime-heuristic (OML) [17] and Minimum Transmit Energy (MTE) [18]. Experimental results obtained under various network scenarios in [17, 18, 20, 26] indicate that both the Fuzzy approach and A-star algorithm give optimal performance in terms of the network lifetime as well as the average energy consumption.

$E_n R(k) = E_{elec} \bullet k$, respectively, where k is the number of bit per packet (packet size), d is the distance from the sender node to the receiver node, E_{elec} and E_{amp} are per bit energy dissipation in transmitting or receiving circuitry and energy required per bit per square meter for the amplifier to yield reasonable signal to noise ratio (SNR) respectively. Simulations are done using the values $50nJ/bit$ and $100pJ/bit/m^2$ for E_{elec} and E_{amp} , respectively. The traffic load, in each node is assumed to be generated randomly having [0...10] range of values. Table 1 illustrates system parameters in details.

Table I Simulation parameters.

Parameter	Value
Topographical area (meters).	100m x 100m
Sink location (meters).	(90,90)
Number of nodes.	100
Transmission range limit (meters)	30m
Initial energy of node	0.5 J
E_{elec}	50 nJ/bit
E_{amp}	100 pJ/bit/m ²
Packet size	2k bit
Number of transmitted packets	20,000
Maximum node's traffic queue	10

6.2. Experimental Results

The number of alive nodes for each transmission round using the three different approaches is shown in Fig. 6. It is obvious that the proposed method conserves more alive nodes than both A-star algorithm and Fuzzy approach after the same number of packet transmitted. When all the 20,000 packets are sent in the area, the network

lifetime achieved by the proposed method is nearly 24% more than that obtained by A-star algorithm and nearly 20% more than that obtained by Fuzzy approach.

Moreover in Fig. 6, one can notice that the proposed method keeps the number of living nodes always higher than that of both A-star algorithm and Fuzzy approach.

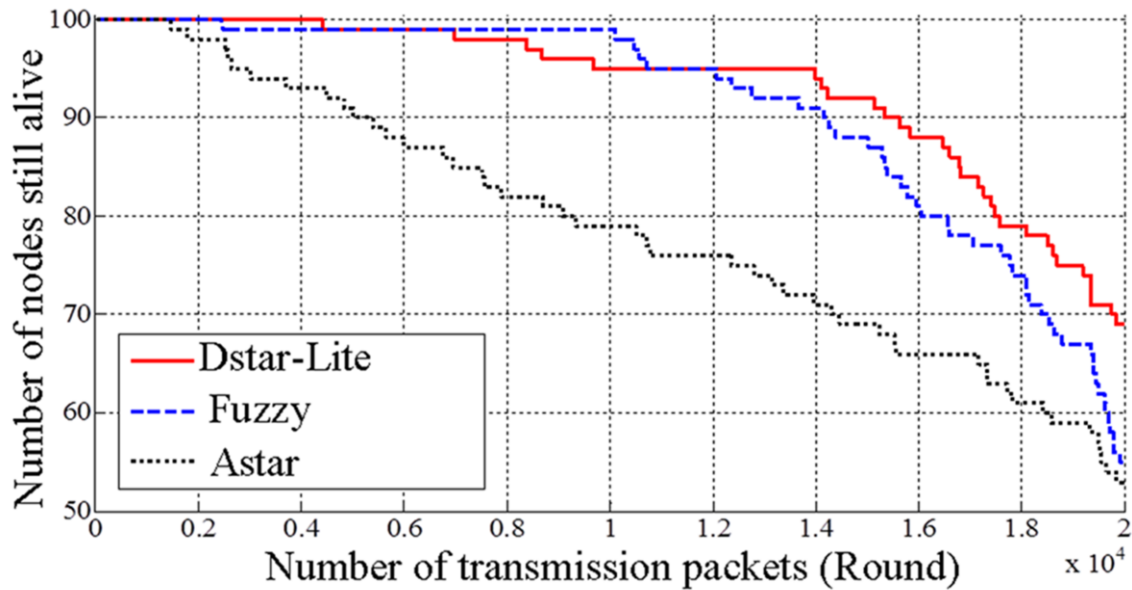


Fig. 6. Number of nodes still alive for each round.

The difference in the duration of time relevant to the first dead node computed using the three different approaches is shown in Table 2. Remarkably, the first node death

occurrence in the proposed method is much later than that of both A-star algorithm and Fuzzy approach.

Table: II Number of Rounds with the First Dead Node.

Approach	A-star	Fuzzy	Proposed method
Number of packet sent causing first node death (lifetime)	1462	2460	4404

Having Fig. 6 and Table 2, one can conclude that, the proposed method is more efficient than both A-star algorithm and Fuzzy approach in balancing energy consumption and prolonging of network lifetime.

The average remaining energy of a WSN decreases with the number of

transmission rounds increment. As the number of delivered packets increases, the proposed method results in higher average remaining energy values than both A-star algorithm and fuzzy approach. Fig.7 shows that the better energy balance in a WSN is achieved by the proposed method.

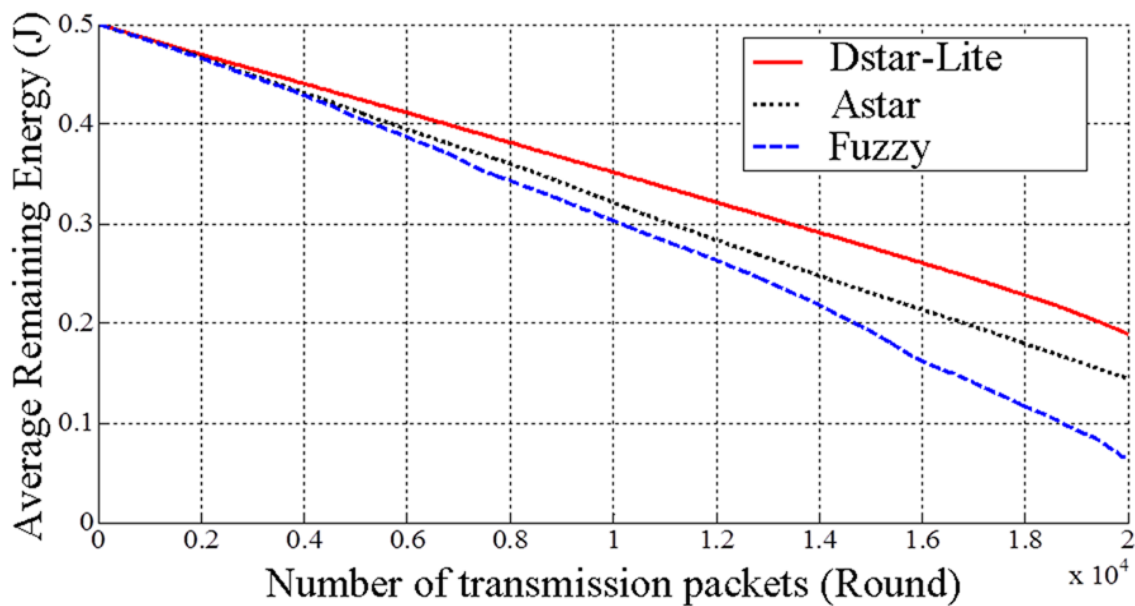


Fig. 7. Average remaining energy for each round

The delay caused by data packets transmission is an important parameter for

certain applications where the sensed data is needed to be collected shortly. The three different approaches are compared as shown in Fig. 8. The proposed method has clearly shortest delay than A-star algorithm

and fuzzy approach. Shorter delay implicitly indicates energy saving and efficient transmission (especially for secure and important information). Particularly, data packets are sent through different node-disjoint routing paths with multipath routing to eschew network congestion and expand the network lifetime.

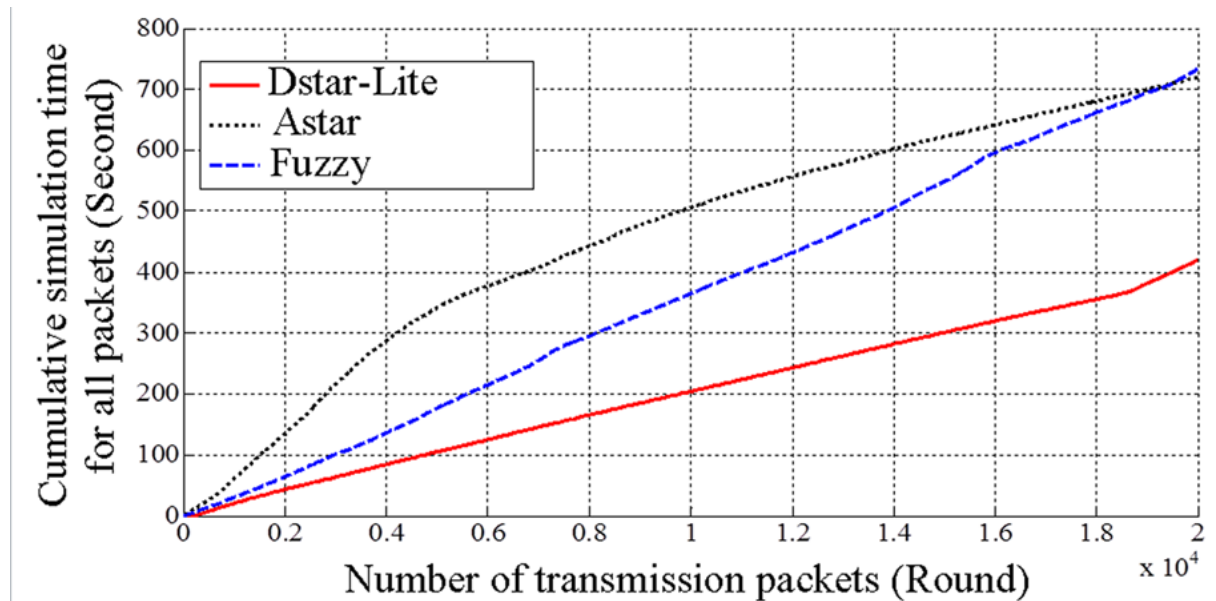


Fig. 8. Cumulative simulation time for all packets.

Note that above simulations are done with the assumption that all the nodes are well maintained (i.e. stable with enough power) until the death of node. In real world, there may be certain factors that lead one or more of the sensors in the critical pathway to perform discontinuously. In

7. Conclusion

In WSNs where nodes powered by limited battery energy, it is important to adopt strategies that efficiently utilize the available energy. Routing path finding methods have a high impact on network lifetime and this is one of the main characteristics of WSNs. Uneven energy drainage is an ingrained problem in a WSN. To achieve efficient data transmission through routing path that is selected to be an optimal path to maximize the overall lifetime of the network with reducing the delay caused by path finding process, we proposed a new method by adopting Dstar-

Lite algorithm. The new method is capable of finding an optimal routing path to be used in data transmission from the source node toward the sink involving intermediate node(s) by preferring nodes with the highest residual energy, minimum hops incorporated and lowest pending traffic. Comparing the proposed method with other two methods, the results demonstrate that the performance of the proposed method, under the same criteria, is much better than that of the two methods in terms of network lifetime and transmission delay.

such case, behaviour performance noise (fluctuations) into the WSN may be added. As there are too many parameters to be considered, future investigations about such topics may be quite interesting and challenging.

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الخلاصة

يتم تزويد شبكات الاستشعار اللاسلكية بالطاقة بواسطة بطاريات منخفضة الثمن ومحدودة الطاقة. يتم استهلاك كميات كبيرة من هذه الطاقة من خلال النقل اللاسلكي للبيانات. لذلك، بروتوكولات التوجيه ذات الكفاءة في استهلاك الطاقة يمكنها ان توفر طاقة البطارية وتعطي الشبكة فترة حياة اطول. استخدام بروتوكولات معقدة لتخطيط عملية توجيه البيانات بشكل كفوء يمكن ان يقلل استهلاك الطاقة لكنه قد ينتج تأخيراً في عملية المعالجة. يقترح هذا البحث طريقة جديدة لتوجيه البيانات والتي تستخدم خوارزمية Dstar-Lite لإيجاد افضل مسار من المستشعر المرسل (المصدر) الى المستلم (الهدف). تعيد الطريقة المقترحة استخدام المسار حتى يتم استهلاك قدر محدد من الطاقة بالشكل الذي يُبقي استهلاك الطاقة موزع بشكل عادل على عقد المستشعرات في شبكة المستشعرات اللاسلكية و يُقوم بتقليل التأخير الناتج عن عملية حساب مسار التوجيه من نقطة الصفر. أظهرت نتائج المحاكات كفاءة الطريقة المقترحة من ناحية تقليل استهلاك الطاقة وكذلك الوقت المستغرق لنقل البيانات بين طرفين (end-to-end delay) عند مقارنتها مع كل من طريقة المنطق المضبب (Fuzzy Logic) وخوارزمية (A-star). كذلك أظهرت النتائج بأن فترة حياة الشبكة التي تم تحقيقها باستخدام الطريقة المقترحة تزيد بما يقارب 20% و 24% عن ما يمكن تحقيقه باستخدام طريقتي المنطق المضبب (Fuzzy Logic) وخوارزمية (A-star) على التوالي.