

Aware-Routing Protocol using Best First Search Algorithm In Wireless Sensor Networks

Ghassan Samara
Internet Technology Department
Zarqa University, Jordan

Abstract—Wireless Sensor Networks (WSNs), sometimes called Wireless Sensor-Actuator Networks (WSANs) are increasingly important because of their practical use in different aspects of our life; this led to proliferation wireless sensor networks at everywhere. Despite the rapid spreading of the WSNs, but energy issue is one of the most significant problems and challenges in this field. Recent developments and widespread in wireless sensor network have led to many routing protocols that try to mitigate this issue. WSNs consist of low-power sensor nodes and a few base stations (sink nodes), all these devices have to be adaptive and efficient in data transmission. This paper proposes an aware-routing protocol based on Best First Search Algorithm (AR-BFS), this protocol aims to focus on the energy efficiency, by reducing the powerconsumption of each sensor node, increase network lifetime, and ensure system reliability.

Keywords—Best First Search (BFS), Heuristic Function, Wireless Sensor Networks (WSNs), Wireless Sensor Actuator Network (WSANs)

I. INTRODUCTION

Wireless Sensor Networks (WSNs) are rapidly emanating as an important and influential factor in mobile computing, wireless systems, and vehicular-ad hoc networks [1],[2]. Which consists of a vast number of sensor nodes collaborate with each other to accomplish a common task, and therefore report the collected data to a center node (sink node).

Wireless Sensor Networks (WSNs) may have a significant number of sensor nodes, which have been deployed over a particular sensing area. These Nodes broadcast their link quality, which is depending on radio frequency environment [3]. The primary purposes of WSNs are to monitor, analyze, combine, and respond to the data which has been gathered by hundreds or thousands of nodes. There are many practical examples of WSNs applications, such as

habitat monitoring, civil structure monitoring, Healthcare monitoring, inhospitable terrain, military use, and factory maintenance, etc. [4 and 5].

The power of WSNs lies in the capability of deploying significant numbers of tiny nodes that have been configured by themselves, each of these sensing node contains a processing unit, sensing unit, external memory, power unit, and transceiver, sometimes it has a power generator. Figure (1) shows the sensor node architecture [6]:

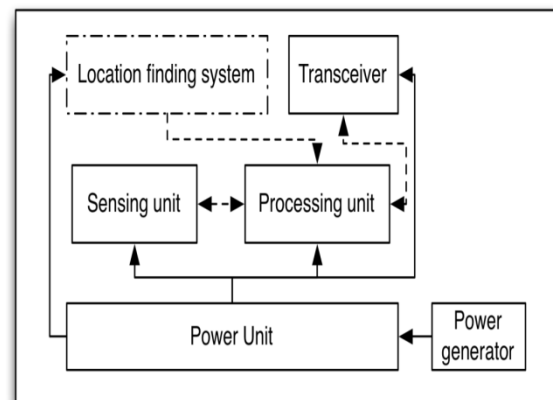


Figure 1: Sensor Node Architecture

Wireless sensor networks suffer from different resource constraints, such as energy and memory size.

Energy consumption of each sensor node during the routing process in wireless sensor network considered as the most common problem in this type of systems, Because of its effect on the WSNs lifetime, and reliability, so that, find a solution for this problem is a big challenge [7],[6], and [8].

Energy consumption in wireless sensor networks can be categorized into two types: power consumption

in communications (Data transmission), and power consumption in computations [9]. Data transmission consumes more energy if it is compared with the energy consumption in computations. Therefore, minimizing data transmission cost will lead to minimize the energy consumption in WSN which in turn will extend the network lifetime, so that many of researchers proposed different approaches of routing techniques to achieve this goal [6 and 9].

The proposed protocol (AR-BFS) takes into consideration the effect of this problem on the reliability and network lifetimeso that it was built to mitigate the impact of this issue on WSNs.

AR-BFS will be used to minimize the power consumption rate at each sensor node in wireless sensor network, and ensure the reliability of the system,extend the network lifetime, and also increase the average of packet delivery rate,all these objectives will be achieved by finding the optimal path during the routing process.

The practical procedureto find this routein this paperis based on selectingmulti-variable heuristic function with Best First Search (BFS) algorithm which means that any sensor node wants to pass data to next node must take into consideration this heuristic which is; straight line distance (SLD) from any sensor node to the sink node, the residual energy for this node, and also the minimum amount of the energy that must be held by this node to be in the path, this technique will save the energy for all sensor nodes in the network, which in turn will increase the WSN lifetime and reliability.

Figure (2) shows Pseudocode of the Best First Search Algorithm (BFS):

```
function BEST-FIRST-SEARCH([problem]) returns a solution
OPEN <- an empty set // P1
CLOSED <- an empty set // P2
OPEN<-INSERT(MAKE-NODE(INITIAL-STATE[problem]),OPEN) //P3
repeat
  if EMPTY?(OPEN) then return failure //P4
  best <- the lowest f-valued node on OPEN // P5
  remove best from OPEN // P6
  if GOAL-TEST[problem](STATE[best])
    then return SOLUTION(best) // P7
  for all successors M of best
    if STATE[M] is not in CLOSED then // P8
      OPEN <-INSERT(successor,OPEN) // P9
    add STATE[best] to CLOSED // P10
```

Figure 2: Best First Search Pseudocode

This algorithm operates by finding the optimal route of the data transmission on the wireless sensor network during the routing process, the factor that determines finding path mechanism is the heuristic function that is applied on the Best First Search. Figure (3) below shows an example of finding an optimal path using BFS algorithm based on the heuristic function that has been determined before:

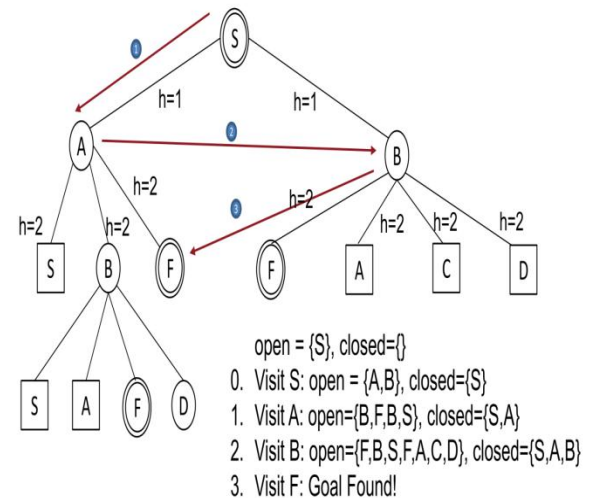


Figure 3: Finding Optimal Path Using BFS with Heuristic

The rest of the paper is arranged as follows: Section 2 describes the Literature Review. Proposed System is discussed in section 3. Finally, the conclusion is listed in section 4.

II. LITERATURE REVIEW

All routing protocols can be categorized into three approaches [9], as shown in figure (4):

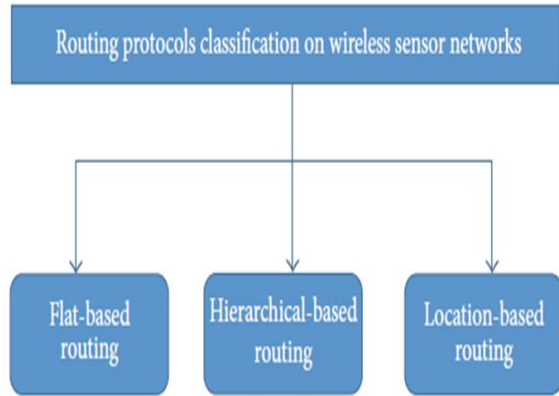


FIGURE 4: Routing protocols classification for WSNs

Many of current routing protocols and algorithms try to mitigate the impact of the energy problem in the WSNs lifetime and reliability, but all of these protocols face different types of challenges because of the poor resources of the sensor nodes, this problem has received a considerable interest from WSNs researchers [6], who proposed many protocols and mechanisms to overcome this issue, here are some of these protocols:

The new hybrid routing protocol in [10] which is called State Aware Link Maintenance Approach that is abbreviated by (SALMA) is proposed, this protocol based on two protocols the first one is Dynamic-Source Routing DSR and the second one is Optimized Link State Routing (OLSR). This protocol focuses on the activeness of sensor nodes in the WSN operations, and it is defined three states of sensor nodes, that is, black, white, and grey. The conclusion of this work proposed protocol gives enhancements in some QoS metrics such as lesser routing overhead than OLSR, smaller delay than DSR, and low-energy-consumption for all sensor nodes in the network. But the improvements of this protocol was at the activeness side of nodes in the network, but it does not achieve enhancements on the power efficiency for WSN.

Sequential Assignment Routing (SAR) was proposed as new routing protocol that is a concern in routing protocols that support some quality of

service. Sequential Assignment Routing is working as multiple paths routing protocol that assists in routing decisions; it is based on three phases: quality of service on each path, energy resources, and the priority level of the packet. This protocol suffers from the overhead of routing tables and quality of service metrics at each sensor node [11].

EDAL is the data collection protocol proposed by the authors in the paper [7], which stands for Energy Efficient Delay Aware Lifetime balancing data collection. The authors of this paper proposed both a centralized heuristic to reduce the computational overhead and also distributed heuristic to make the protocol compatible with large scale networks. The drawback of this approach is the less remaining energy because of the extended period of time that EDAL was running.

In paper [12] a new routing protocol was proposed to achieve energy efficiency in wireless sensor networks by reducing energy consumption on each sensor node, extending WSN lifetime, ensuring reliability for the system, increasing WSN load balancing, and minimizing packets delay. This protocol considered as an intelligent routing algorithm, which is based on reinforcement learning approaches. This protocol suffers from the complicated way of finding CH for each cluster in the network.

Authors in [13] presented a new routing protocol which is perfect for little energy and low-bit rate networks. The idea of this protocol is not complicated, the author of the paper supposed that using the least energy path cost is not always necessarily to be the best for the long term health of wireless sensor network. This protocol assumed that using different routes during routing will make using the resources more equitably, the drawback of this protocol that it focuses on the resources utilization more the energy.

An Energy Efficient Routing (EEHR) protocol using the A-star search algorithm was proposed to find the optimal path from the source node to the sink node in the network. Simulation results with MatLab show that the proposed protocol (EEHR) is efficient in terms of the total of energy consumption and network lifetime if it is compared with the fuzzy

approach, EEHR suffers from the memory consumption at each sensor node participated in the route [14].

The Multihop-LEACH protocol was proposed in the paper [15], this protocol working to improve the mode of communication from single-hop to multi-hop between the selected cluster head and sink node (base station). The results of simulation show that the energy consumption of Multihop-LEACH protocol has better performance than LEACH protocols, but this protocol still suffers from the problem of selecting Cluster Head (CH) for each cluster in the network.

Authors in [16] proposed a new routing protocol, which is called Neighbour coverage based probabilistic rebroadcast (NCPR) protocol, NCPR reduces the packet duplication. Due to the contention and collision is decreased. Moreover, it maximizes the delivery ratio of the packet and minimizes end to end delay. However, the delay that results from total broadcasting is increased.

In [17], authors have proposed a Multi-Constrained QoS Multiple Path Routing (MCMP) protocol, the objective of this proposed protocol is to utilize the multi-path to increase the performance of the network with least cost of energy, but MCMP did not achieve a breakthrough with respect to reduce the consumption rate of energy in the network.

ELCEA protocol was proposed in [11], this protocol can be considered as new and updated version for (DIJKSTRA) algorithm. ELCEA working as routing protocol aims to find a list of the minimum cost paths, then select a path from the list that meets end to end delay requirement. This mechanism led to reducing the energy of the network, also maximize the throughput of WSNs.

Geographical and Energy Aware Routing protocol abbreviated as (GEAR), which is a new routing protocol that is presented by the authors of paper [18], the method of this protocol based on selecting the next hop of the path according to the geographical location closeness or cost,

Control and improve the undesirable behavior of the Evolutionary Algorithm (EA) when used with the clustered-routing problem in WSN is the core idea of

paper [19], the concept of this paper stands on suggesting a new fitness function that merges two clustering sides, namely separation and cohesion error. The results of Simulation over 20 random heterogeneous wireless sensor networks indicates that the author's evolutionary based-clustered routing protocol (ERP) always extend the WSN lifetime, minimize more energy as compared with the results obtained from other protocols, such as SEP, HCR, and LEACH.

III. PROPOSED SYSTEM

In wireless sensor network routing protocols classified into three approaches of routing protocols, which are hierarchical-based routing protocol, location-based routing protocol, and flat-based routing protocol. In this paper, flat-based routing protocol using the proposed Aware-Routing protocol based on Best First Search algorithm (AR-BFS) will consider as the approach that will be utilized in the routing process, because it is more suitable than other routing protocols, especially in particular application such as event detection. Data transmission arrives the base station through multi-hop communication paradigm (the final destination will not be reached directly, the number of sensor nodes could be used to route any sensed data to the base station). AR-BFS will control this transmission in the routing process through applying multivariable heuristic function for each hop in the path. Figure (5) below shows the difference between Single-Hop and Multi-Hop communication:

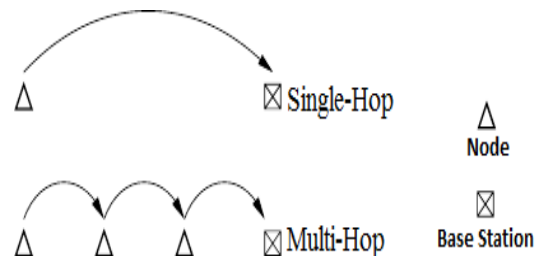


Figure 5: Single and Multi Hop Communication

The multivariable heuristic function (parameters) that will determine the selection process of the sensor

node to participate in the path is composed of three of QoS metrics in the WSN; which are the Straight Line Distance (SLD) from any sensor node to the base station (sink node), amount of energy at each sensor node, and threshold for the minimum amount of energy that must be available for each sensor node to be included in the path.

Taking all these parameters into account will be the only factor to select next node that could participate in the multi-hop process, these parameters will be updatable for each sensor nodes that participated at each path, this done by broadcasting message from base station to all nodes in the network, this will be the indicator in selecting nodes at next path. Figure (6) shows a sample for the multi-hop communication path:

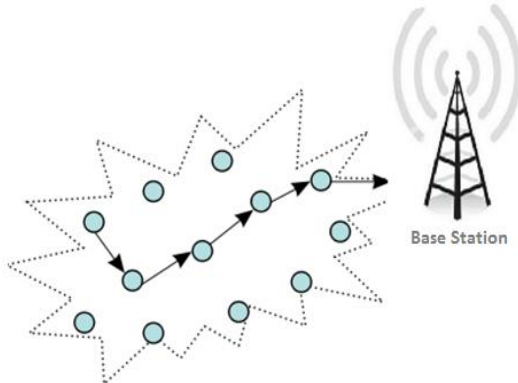


Figure 6: Multi-Hop Communication Path

Figure (7) below shows the flow chart of the proposed protocol (AR-BFS):

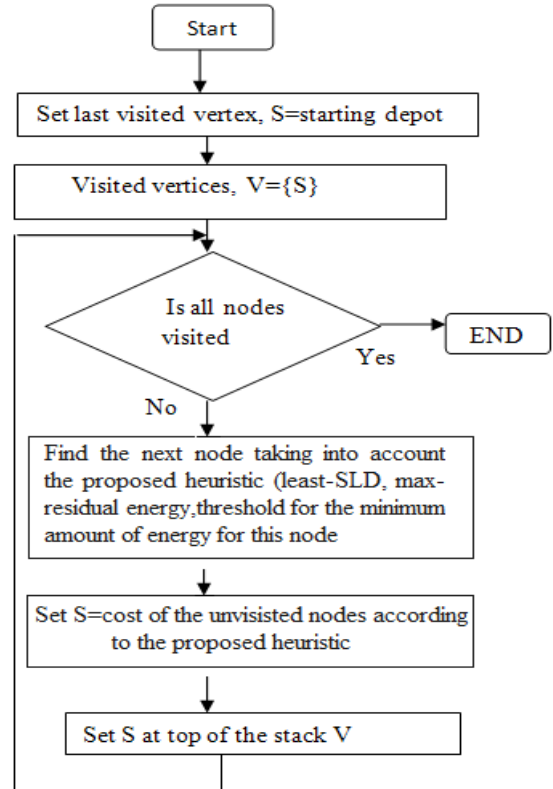


Figure 7: Proposed Protocol Flow Chart

IV. CONCLUSION

This paper proposed an Aware-Routing protocol based on Best First Search algorithm; this protocol used the multivariable heuristic function in the process of selecting the next hop communication path. AR-BFS computes an optimized route to transmit the packets from any sensor node in the network to the base station (sink node).

Since the data are transmitted using an optimal route, the required energy for this transmission will be minimized; thus, the wireless sensor network lifetime is maximized. Also, the reliability of the system and average of packet delivery rate will be increased.

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