SPAR: Shortest Path Adaptive Routing for Wireless Sensor and Actor Networks

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Abstract

Wireless sensor and actor networks (WSANs) consist of three components which are sensor nodes, actor nodes and central controller (sink). The act of sensors is gathering data from the physical environment and sending them to the actor or the sink. The actors react according to received data from the sensor or the sink. After detection of an event, this data must be sent to the sink or actor immediately. To send this data to the sink, there exist several paths in which finding a suitable path can improve the performance of the network. In this paper a protocol on routing has been proposed, in which protocol sensors cache the identity of neighboring nodes, and by first sending a group of the identity of intermediate nodes will be named as the selected path till arriving the first actor, during which the next sending will only be carried out through that path.

Key words: WSANs, Routing, Coordination, Sensor, Actor.

1.0 Introduction

After an event is detected by sensors, it must be reported on time to carry out appropriate reaction [1]. According to the network, sending the report is done in two ways. If network is semi-automated architecture, then the routing protocol will be similar to sensor-actor routing in wireless sensor network [2, 3, 4]. But if network is automated architecture, in other words, sensors communicate with actors without sink and sending self reports to actors directly, the powerful routing algorithms must be implemented in order to have optimal performance of these networks. In these networks, upon detecting the event, the data is processed immediately, and sending them to actors without sink's interference. Actor does the right reaction to the event without receiving any command from sink. Therefore, since such systems were designed for real-time applications usually making suitable decision, sending data on time and optimal routing can be very important. Hence methods of data sending, sensor-actor communication, methods of routings and suitable actor selection face many challenges [2].

2.0 Related works

Akyildiz et al. [3] deployed a routing method entitled flooding, that broadcast its data to all neighbors in every step. In this method, for a large message that is communicated in the network, traffic will increase and network life time will reduce, and data will be delivered to destination at high delay. But this routing method has an advantage, which is data delivery is carried out at a very high reliability.

In [5, 6, 7, 8], direct diffusion routing was introduced, that is a data-centric method. It means, initial step sink sends the request to all neighbors and after that, sensor will send the data by only one path. In this method, lots of time elapses between sending request and answering it. But in [9] an Energy-Efficient Layered Routing Scheme for wireless sensor and actor networks have been proposed entitled ELRS, whereby the network is divided into two layers that communicate together, that is, actor communicate with actors and sink and sensors communicate with sensors and actors as hop-to-hop. At first according to the number of actors and their positions, sensor/actor area is divided into several actors' area. All sensors must be covered at the actor's area. In every actor area, actor is network's center and sensors transmit data to actors.

In [10], actor is a cluster head for routing establishment, sending a message to all nodes for establishing path, and sensors also has a memory for routing. Once the data is gathered, every sensor can send its data to actor. Times of routing's establishment is shown in this message. Upon reset routing, routing parameter increases by 1 unit, sensors by this increment detects that routing has been carried so its data must have been sent.

Another parameter is considered as an actor's identification, which is attached to establishment of routing message. After a sensor received the message, it must be registered to that actor area. Sensors have identification too which is sent in answer to an actor's call. There exists a hop counter whenever a message is sent by sensor, this parameter increases one unit. Establishment routing message has a life time parameter that is equivalent to the maximum number of hops and shows the maximum movement of this message to actor area. This life time parameter can be estimated based on an initial range of actor area. We can limit the actor area by the parameter in order to save system energy. Sensor's memory has a field with neighbors' identification [9]. Upon a sensor sending a data to actor, it randomly selects a neighbor in its routing memory. In this method data can be delivered to actor and then the sensor can send data to the sink too.

In wireless sensor and actor networks, actors are always mobile in networks [10]. Hence, if actor is able to move, it will update the routing. For this purpose, actors must be coordinated together, actor area divided then the act of routing must be reorganized. Therefore at any time when routing has reorganized, this routing message must be reacted. On the other hand, removable actors can improve the power consumption. When the actor finds sensors in its area with the least energy consumption, it can move to areas that the neighbors are sensors with high energy [11].

3.0 Proposed protocol

In proposed protocol, actor and sensor nodes broadcast their identification to the neighbor nodes; it means after configuring the network, every node knows all neighbors. The sensor nodes triggers and resends the identification to the neighbors upon the event. Each node sends only its identification to all other nodes, and receives identification of its neighbors, cached to its memory. Naturally, in some sensor memory, there exists identification of actors. Most of sensor memory only contains one type of identification, which is sensor identification. Only little sensors have both the actor and sensor identification in the memory. Sensor with two types of identification, that is, sensor and actor in its memory connects the sensor as a source and the actor as the destination.

Therefore, there are two types of identification: actor identification and sensor identification. Every node can receive two types of identification. The node that receives both these identifications are called interface node (IN). Upon receiving the two types of identifications, the task of IN is to send its identification to actor. On other hand, actor identification attaches its identification sent to previous node. In this order every node receives identifications of other nodes, and knows that all data will be sent and received along this path. According to Fig. 1, order of actor identification will be fixed while passing through intermediate nodes, but sensor's identification modifies frequently by the first packet that is sent to the source.

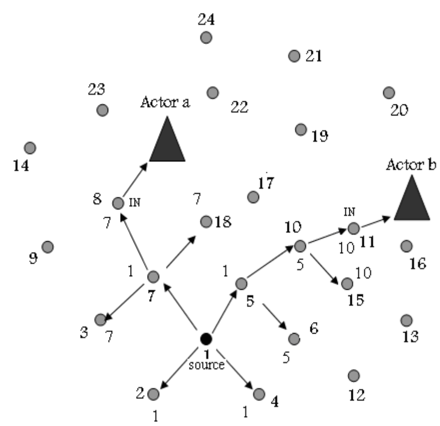


Fig. 1. Routing and actor selection

In this method, every sensor has one identification table (see Table 1), which contains two fields as S-Id and A-Id.

Table 1. Sensor's memory table

A-Id	S-Id
---	xxx
yyy	xxx
---	xxx

S-id field is for sensors identification (sensor receives data from them) and A-id field is for actors (sensor receives messages from them). In total, the data in this table has four statuses:

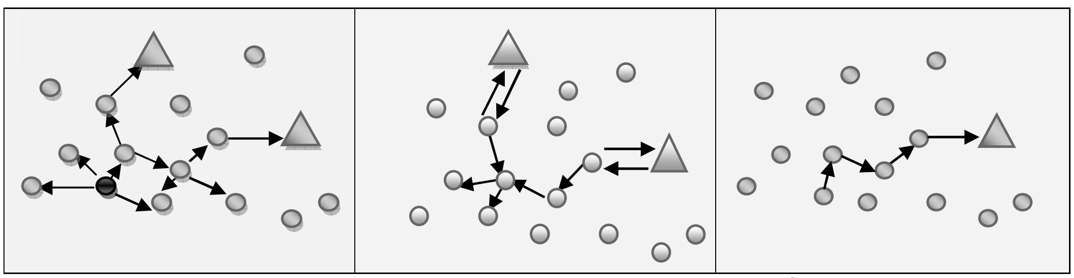
- This table can have no data, it shows this node is out of network and do not have any neighbor; meaning this node has no communication in the network (dead).
- Only S-id field of table contains data, which shows neighbor nodes are only sensor node, therefore this node is considered only passing path for all nodes, and not as an interface node.
- If only A-id column has data, means this node can only send the data to actor and is not able to route every nodes or network.

- If both columns of one table have data, it means the node can communicate with network and it is near an actor. Moreover, it can have an interface node role.

4.0 Mechanism

After network is ready to use, every flooding node sends its Id to neighbors and by this way every node detects the neighbors and saves its Ids to its tables. When an event happens, the sensor that detects the flooding sends its Id to all its neighbors, and every neighbor saves this Id its table. Then column S-id and A-id will be searched for actor's Id. If in this column no actor Id is found, then the sensor will send its Id and data to all neighbors until it arrives at the interfaced sensor. But, if sensor finds an actor's Id in its A-id column, this means this sensor is near an actor, and can act as an interface node. It will activate one of the actor Ids and sends its Id and data randomly.

Actor also after receiving data caches sensor's Id that receives data of it and sends message to interface node that it is available and reacts to the messages which receiving of that sensor. Interface node also sends actor's Id and its Id to sensor that caches it in its table. Previous node carries out this action until actor's id and id of one node are delivered to source sensor. Then, source sensor sends every packet together with its id destination and actor's id to one neighbor randomly. In every sensor, actor's id with data is fixed until data is received at end node, but sensor's id is attached with data, after passing of every node has removed and gives neighbor's id it sensor. This identifiers show selected path, upon first sending from actor to source sensor is fixed. Fig.2 shows group of this ids contain one path that after it source sensor node and every route node knows that data of source node must be sent to what actor.



A) Finding neighbor B) finding active actors C) selecting suitable actor

Fig. 2. Adaptive routing and actor selection

Since every actor is ready to act, this important source sensor registers first actor's id in its memory. This routing has three advantages: first, selecting the nearest path to active actor, second: using other actor as backup, and third: reliability to select optimum actor.

A problem that maybe happens in this routing is because every node sends its id to neighbors. Fig.1 shows sending data in infinitive loop, meaning node 9 sends its data to node 10 and node 10 sends to node 9 and this loop continues. Our solution for this case is every node that receives data from previous node must send data to every neighbor except previous node (except interface node). In this case there exist two challenges: first, in neighbor of interface node maybe exist several actors and interface node must randomly select only one of them. Second, if two actors arrive to source sensor at the same time, how will it be selected by source sensor? The solution is the sensor node must only select one of them randomly and must only send its data of its path.

5.0 Evaluation

We carried out a simulation then we analyze its result.

5.1 Set of simulation

In this case we developed a simulated environment and divided it to various sizes from 50 to 250 nodes by increment step 50. Every node can send radio waves to 40 meters, that one event area with 50 nodes can randomly cover an area by 150 square meters. Other parameter's scales such as average of sensor radio waves are like square meters. These parameters are to compare between our presented method (SPAR) and ELRS, direct diffusion and flooding.
Average Number of Messages (ANM): This parameter shows average number of sending message and returning energy consumption.
Average latency: This parameter shows sending latency from sensor to sink or actor.
Network Life time: This parameter shows time that network is up for event detection.

5.2 Result of simulation

We present result of simulation along with performance analysis of SPAR.

5.2.1 Average numbers of messages for routing establish (ANM)

In this implementation we analyzed ANM with variable size of network with regard to fixed number of actors and following this, we show the number of messages for flooding data to sink.

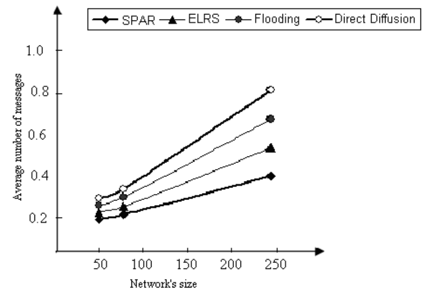


Fig. 3: increment size of network and average number of messages

Fig. 3 shows that the numbers of messages are very much in direct diffusion and in flooding and ELRS are almost larger than SPAR. Because in older methods, sending acknowledgement by sensors cause network's congestion which reduces life time of network. Reason for this congestion in flooding, direct diffusion and ELRS is event area divides to several areas and clusters it. Every cluster sends and receives messages, and this can cause a lot of congestion. Because of Shortest path method in this evaluation does not have clustering, acknowledgement and sink request, hence can cause 20% reduction to send a message. Therefore, in case that size of network is very large, using of SPAR has many advantages.

5.2.2 Latency average

In this implementation focus is on communication message between sensor and sink. Fig. 4 shows flooding method with much latency, meaning increment to network size causes latency to increase very fast. In routing methods comparison of latency parameters are very important. Latency in SPAR is very low, because transfer time between sensor and actor is very low. Changing size of network in direct diffusion, ELRS and our proposed method (SPAR) doesn't have any influences.

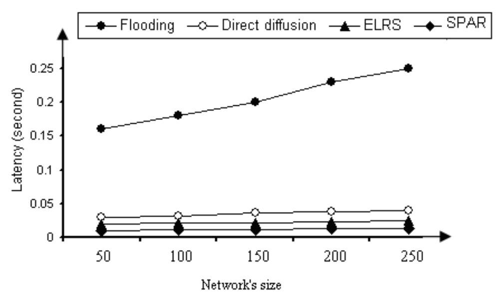


Fig. 4: Latency average

5.2.3 Network's life time

In this implementation we used life time parameter with 1 by 4 frequency.

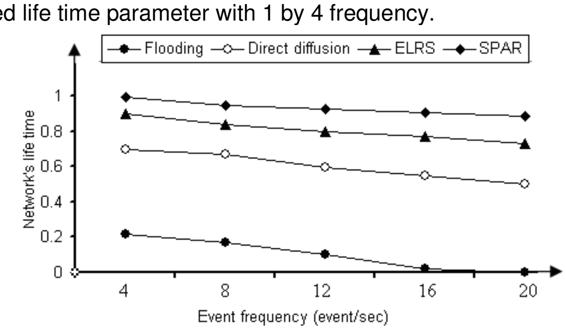


Fig. 5: Network's life time

Fig. 5 shows when the frequency in flooding method is high, life time will reduce rapidly. Because, by sending message and propagating it in all network, every sensor contacts it and this redundancy causes to consume sensors energy. But in other methods, this event is very low. In SPAR, because there is no sink request and node clustering, network life time is improved.

6.0 Conclusion and Future Research

In this paper we tried to optimize speed, life time and number of sent data in wireless sensor and actor networks, in order to send data of physical environment with high speed to actor. This data must be sent at the least time and at high reliability, and also must optimize network's life time. In this paper we have checked and evaluated previous methods to present a routing method that is better than previous methods in latency, speed and network life time. However, parameters such as unanticipated environmental events were not considered in the proposed method. On the other hand some challenges like coordinating 2 actors as if the second actor knows from where it can start the first actor's duty is an important topic which needs further attempts in this respect.

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BIOGRAPHY

Ahmad Najari Alamuti was born at Qazvin, Iran in 1978, and received his B.Sc. degree in Computer Engineering in 2001 from the Tabarestan University of Chalus, Iran. He finished his M.Sc. in Computer Engineering in 2007 and received his degree from Iran University of Science and Technology, Tehran, Iran. His research interests include Wireless Sensor and Actor Networks.