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Performance Analysis of Routing Protocol for WSN Using Data Centric Approach

A. H. Azni, Madihah Mohd Saudi, Azreen Azman, and Ariff Syah Johari

***Abstract*—**Sensor Network are emerging as a new tool for important application in diverse fields like military surveillance, habitat monitoring, weather, home electrical appliances and others. Technically, sensor network nodes are limited in respect to energy supply, computational capacity and communication bandwidth. In order to prolong the lifetime of the sensor nodes, designing efficient routing protocol is very critical. In this paper, we illustrate the existing routing protocol for wireless sensor network using data centric approach and present performance analysis of these protocols. The paper focuses in the performance analysis of specific protocol namely Directed Diffusion and SPIN. This analysis reveals that the energy usage is important features which need to be taken into consideration while designing routing protocol for wireless sensor network.

***Keywords*—**Data Centric Approach, Directed Diffusion, SPIN WSN Routing Protocol.

I. Introduction

DUE to the recent technology advances, the manufacturing of small and low-cost sensors has become technically and economically feasible. The sensors measure ambient conditions in the environment surrounding and then transfer measurements into signals that can be processes to reveal some characteristic about phenomena located in the area around sensors. A large number of sensors can be networked in many applications that require unattended operations, hence producing a wireless sensor network (WSN). Although sensor maybe mobile, they can be considered to be unchanging after deployment. A typical network configuration consists of sensors working unattended and transmitting their observation values to some processing or control center, the so called sink node which serve as user interface. Most application scenarios for sensor network involve battery-powered nodes with limited energy resources [1][3]. Recharging or replacing the sensor battery may be inconvenient, or even impossible in harsh working environments [4]. Thus, when a node exhausted its energy, it cannot help but cease sensing and routing data, possibly degrading the coverage and connectivity level of the entire network. This implies that making good use of energy resources is a must in sensor networks. This paper aims to show analysis performance of routing protocol in wireless sensor network using data centric approach. Two routing protocols will be analyzed by simulating them using Wireless Sensor Network simulator version 1.0. Both of the routing protocols are selected from data centric routing. The result of the analysis for each protocol is compared and the best routing protocol using data centric approach is proposed for WSN. This paper examines the performance of each of routing protocols which improve the network efficiency and maximize the network lifetime.

Authors are with Universiti Sains Islam Malaysia, Malaysia (e-mail: ahazni@usim.edu.my, madihah@usim.edu.my, azreen@usim.edu.my, ariff@usim.edu.my).

II. WSN Routing Protocols

Routing protocol is created to compromise many aspects such as collision prevention, faster time transmission and energy saving [2]. There are several types of routing protocol in wireless sensor network. However, this paper only discusses two types of routing protocol which are Directed Diffusion and SPIN routing protocol. These protocols are from data centric routing.

SPIN [7] is a negotiation-based information dissemination protocol suitable for WSN. It is based on the concept of metadata. Meta-data is a description of data which in database, it can be used to describe table. In SPIN sensors use metadata to concisely and completely describe the data collected. For SPIN to be beneficial, if x is the metadata descriptor for sensor X, then the size of z in bytes must be shorter than the size of X. If two pieces of actual data are distinguishable, then their corresponding meta-data should be distinguishable [5]. Likewise, two pieces of indistinguishable data should share the same metadata representation.

SPIN uses the following messages to communicate between nodes. Refer to Table I.

TABLE I
SPIN Communication Messages

ADV	This message is used by a node to execute other nodes which contain data to be sent. Note that actual data is sent only when acknowledged and requested by a node.
REQ	This is send by recipient to the sender node, if the recipient is interested in the actual data
DATA	This is the actual data with the metadata header.

However, there are three lack of this simple approach cause to be lacking as a protocol for sensor network:

- Implosion: because in classic flooding, a node always sends the data to its neighbors, without aware of whether or not the neighbor already receive the data from another source.

- Overlap: This lack occur when the nodes often gather overlapping pieces of sensor data.
- Resource Blindness: This is another lack problem; a network of embedded sensors can be “resource aware” and adapt its communication and computation to the states of its energy resources.

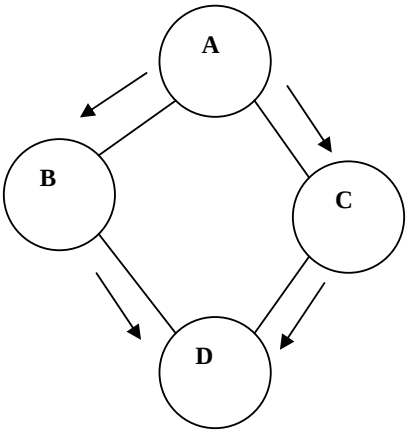

Fig. 1 The implosion problem

Fig. 1 is the example on implosion problem. Here, node A start send the data to both of its neighbor, B and C. Then, B store the data received from A and send the copy of it to their neighbor D, the protocol therefore wastes resource by sending two copies of data to D.

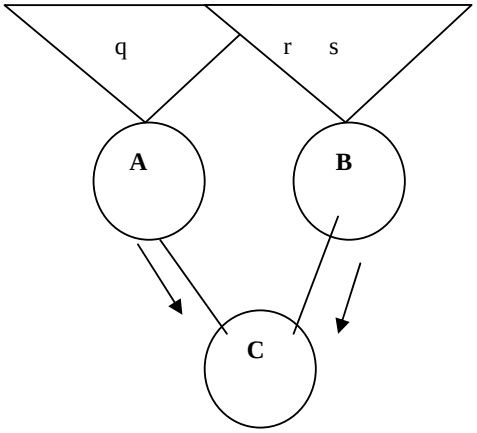

Fig. 2 Overlap problem

Fig. 2 shows the problem can cause wastes energy and bandwidth sending two copies of a pieces of data to the same node. Two sensors cover an overlapping geographic region and C gets same copy of data from this sensor which marked as r [1].

Directed Diffusion [6] [7], is a data-centric routing and use attribute-value pairs scheme for data queries. In order to create a query, an interest is defined using a list of attribute-value pair such as objects, interval, duration, geographical area, etc. The interest is broadcast by a sink through its neighbors. As the interest propagated throughout the network, gradients are setup to draw data satisfying the query towards the requesting node. Each sensor receives the interest, setup a gradient toward the sensor nodes from which it receives the interest. This process continues until gradients are setup from the source back to the base station. Interest initially specify a low rate of data flow, but once a base station starts receiving events, it will reinforce one (or more) neighbor in order to request higher data rate events. Fig. 3 shows an example of Directed Diffusion sending interest, building gradients and data dissemination [6].

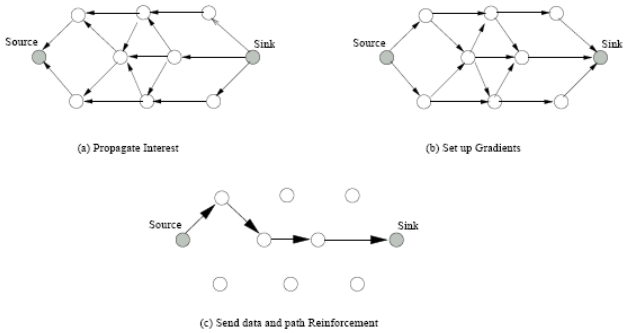

Fig. 3 Interest Directed Diffusion in WSN.

III. Performance Testing

This section discusses simulation on energy performance using WSN Simulator 1.0. The simulation primarily study on data centric routing energy usage in SPIN and Directed Diffusion. SPIN is negotiation based data dissemination protocol suitable for wireless sensor networks. Thus, it assumes that all sensor nodes can be sinks potentially. Every node uses meta-data to name their data. By using this meta-data, each node can negotiate whether to deliver data or not to eliminate the redundant data transmission throughout the network. In other words, every node can make its communication decisions based on negotiations with neighbor nodes about application-specific knowledge of the data and the resource available to it. This negotiation enables sensors to distribute data efficiently with limited energy.

Basically, SPIN uses resource-adaptive negotiation mechanism. Before any data is really transmitted, a sensor node performs negotiations by using its meta-data. These negotiations are done by exchanging a new data advertisement message (ADV) and a request for data message (REQ) between the sender and the receiver. After the negotiation, the sender transmits its data to the receiver (DATA).SPIN assures that there is no redundant data sent throughout the sensor network. In addition, SPIN checks the current energy level of each sensor node and adapts the protocol depending on how much energy remains. In SPIN simulation testing, there is some limitation. The nodes is being designed and linked in shortest path. The negotiations are done by exchanging a new data advertisement message (ADV) will display in blue color links and a request for data message (REQ) between the sender and the receiver will display in green color links. After the negotiation, the sender transmits its data to the receiver (DATA) where will be displayed in red color links. The event

will be the packets that being transmits along the gradient path. Every transmitting packet to nodes, the links will be displayed in red color. In short, SPIN simulation tests differentiate those message elements with colors. Each colors presenting different element of message in SPIN routing scheme.

In directed diffusion, communication primitives are expressed in terms of named data rather than node addresses. Attributes of the sensed event are used to name data in directed diffusion. Directed diffusion consists of several elements: interests, data messages, gradients, and reinforcements. An interest message is query or an interrogation which specifies what a user wants. Each interest's message contains a description of data interested by a user. Typically, data in sensor networks is collected or processed information of a phenomena which matches an interest or a request of a user. Such data can be an event which is a short description of the sensed phenomenon. In directed diffusion, data is named using attribute-value-pairs. The interest is disseminated throughout the sensor networks to "draw" named data toward the user. Interest propagation establishes gradients within the network for data propagation. Specifically, a gradient is a direction state created inside each node which receives an interest. The gradient direction is set toward the neighboring node from which the interest is received. Events are propagated toward the interest originators along multiple gradient paths. The sensor network reinforces one or a small number of these paths.

For directed diffusion simulating testing, there is some limitation. The node is being designed and linked in shortest path. The gradient for each node is being set which display the blue color link in network map while the others links will display in black color. The even will be the packets that being transmit along the gradient path. Every transmitting packet to nodes, the links will be display red color. In short, these simulation tests skip the interest operation and directly implement the basic links for each node, shortest path for gradient links and event for transmitting packet for selected nodes.

IV. Simulation Results

This section discusses simulation result performed on SPIN and Directed Diffusion. Wireless sensor nodes are arranged according to the figure below. There are ten nodes being tested.

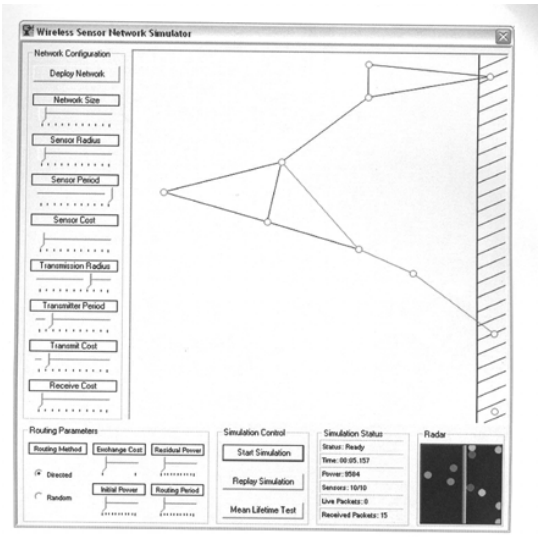

Fig. 4 WSN – 10 Topology Nodes

These protocols are tested on a number of factors. The main experiment is actually measure the energy of the network. When a node receives and transmit a data packet, the total energy will decrease gradually. Fig. 4 shows the simulation test network ran using 10 nodes for 2 minutes for both Directed Diffusion and SPIN. In Directed Diffusion as seen from the Fig. 5, the energy of the network decreases rapidly and goes down approximately to zero in 2 minutes. This is because the effective of transmitting and receiving data in the network and the sensor will find the shortest path, and then later it is set the appropriate gradient for the path which enables the node to transmit and receive the appropriate packet or data. The rapid uses of the gradient path also contribute to decrease of energy. This is due to the node only transmitting and receiving data packet with gradient path which is the main basic operation for this routing protocol. This also to make sure that the transmitting and receiving duplicate data or packet can be eliminated. Deploying the small size of network to the directed diffusion protocol dramatically reduce the total system energy usage. Thus, will prolong the life of network it self.

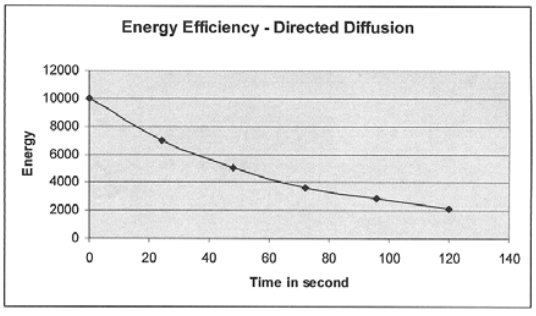

Fig. 5 Energy efficient-Directed diffusion

On the other hand, SPIN as shown is in Fig. 6, with the same parameters, the energy decreases at a much slower rate and even after 20 seconds, the network still had almost one

third of energy. This proves that having meta-data actually increase the energy efficiency of a network drastically because SPIN will start with advertise its interest, then waiting a request from any node before start transmitting data again. From the result, it proves that meta-data negotiation keeps SPIN nodes from sending out even a single redundant data packet in a network.

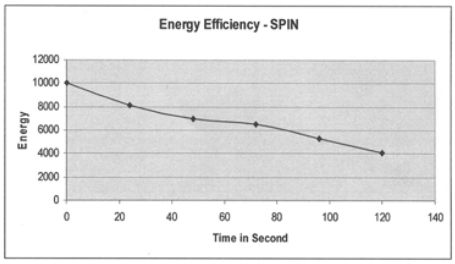

Fig. 6 Energy efficient-SPIN

Another result is based on average packet received by nodes. From Fig. 7, the packet received by nodes dramatically decrease receiving packet from the first 20 seconds. This is because nodes that links to the shortest path nodes and the gradient links uses a lot of energy for transmitting and receiving packet. Thus, they generate overhead and reduce the life time of the nodes in the network. When this occurs, the topology and links for every node will change. The distance for transmitting and receiving packet will be a bit larger and will consume a lot of energy.

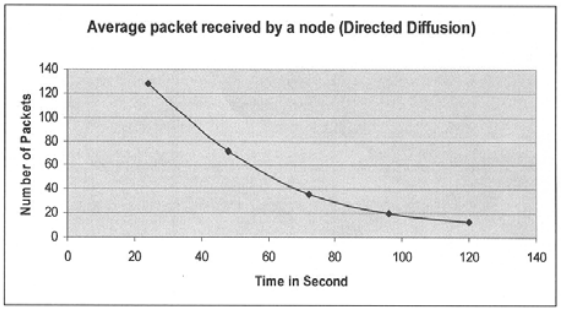

Fig. 7 Average packet received -Directed diffusion

As shown from the Fig. 8, the original data packets received by nodes actually less than the directed diffusion because the simulation is stopped in the middle when some packet are still being transmitted or scheduled. SPIN operation will transmit almost zero redundant data packet and decrease the operation of sending wasted data packets.

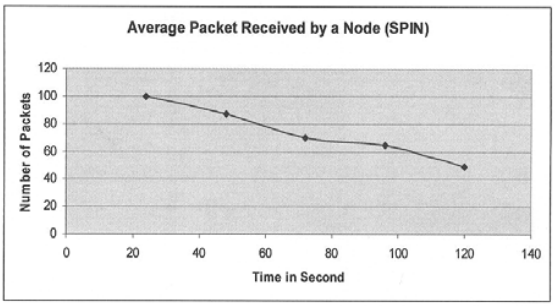

Fig. 8 Average packet received by a node- SPIN

V. Conclusion

Based on the study of these routing algorithms, it shows that some of the desirable features of a good energy efficient routing protocol for sensor network are:

- Random path selection. If a routing algorithm can support multiple paths to a destination with low overhead, it could help in balancing the network load
- Data fusion. If nodes could classify and aggregate data, it helps in efficient query processing, and decrease network overhead dramatically.

In conclusion, as referring to data centric routing, SPIN having slower rate in decreasing energy which is much better rather than directed diffusion. This proves the fact that having meta-data negotiation increases the energy efficiency of a network.

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