Evaluation of SVR: AWireless Sensor Network Routing Protocol

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ABSTRACT

The advancement in technology has made it possible to create small in size, low cost sensor nodes. However, the small size and low cost of such nodes comesat a price that is, reduced processing power, low memory and significantly small battery energy storage. WSNs (Wireless Sensor Networks) are inherently ad hoc in nature and are assumed to work in the toughest terrain. The network life time plays a pivotal role in a wireless sensor network. A long network lifetime, could be achieved by either making significant changes in these low cost devices, which is not a feasible solution or by improving the means of communication throughout the network. The communication in such networks could be improved by employing energy efficient routing protocols, to route the data throughout the network. In this paper the SVR (Spatial Vector Routing) protocol is compared against the most common WSN routing protocols, and from the results it could be inferred that the SVR protocol out performs its counterparts. The protocol provides an energy efficient means of communication in the network.

Key Words: **Wireless Sensor Network, Spatial Vector Routing, Sensor Protocols for Information via Negotiation, Low-Energy Adaptive Clustering Hierarchy, Routing Protocols.**

1. INTRODUCTION

WSNs [1-2] differ from the classical wired and wireless systems. WSNs are normally classified as ad hoc networks. With advancements in technology it is now possible to design sensor nodes of miniature size. The reduced size of sensor nodes introduces many new challenges such as reduced memory, processing capabilities and battery energy, which have to be addressed. To address these challenges there is a need of energy efficient schemes, which reduce the communication costs. Routing protocols could be designed to reduce the overall energy consumption of such systems and smart operations could be carried out to extend the lifetime of the network. Sensor nodes even possess the ability to go into sleep mode while not functioning to further reduce their energy consumption.

Introducing an energy efficient routing protocol could reduce the communication costs of the network and increase the network life time. An energy efficient routing protocol could serve as the back bone of a smart spatially aware system to carry out smart operations within the network [3-4].

In the paper the introduction is followed by Section 2, WSNs routing protocols. This section provides a brief idea of WSN protocols. The section is further divided in

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three sub sections, the SVR, the SPIN (Sensor Protocols for Information via Negotiation) and the LEACH (Low-Energy Adaptive Clustering Hierarchy). In each section the core concepts of these three protocols are explained. The description of SVR, SPIN and LEACH protocol is followed by the simulation setup in Section 3, which describes the simulation environment. Section 4 includes the results obtained through the simulation trials and the discussions. Finally, the paper is concluded in Section 5 and future work is discussed.

2. WIRELESS SENSOR NETWORKS ROUTING PROTOCOLS

Various routing protocols have been proposed [5-10] for routing in sensor networks and could be employed in WSNs. Some of the existing geographic routing protocols [11-12] have already been compared with the SVR protocol, in this paper the SVR protocol is compared with two of the most popular routing protocols for wireless sensor networks.

2.1 Spatial Vector Routing Protocol

The SVR protocol [11-12] routes the packets throughout the network, based on the bearing angle, which a node creates with all its proximate nodes and the destination node. In the setup phase the protocol initially computes the proximate nodes P_n, for the source node S_n. Once the proximate nodes are known the bearing angles are computed, from S_n to the destination node D_n and from the S_n to the P_n. The node that has the shortest distance from the source node and is in the direction of the D_n is selected as the next hop.

The protocol routes the data packet from one node to another, employing the described mechanism until the data packet reaches the destination node. The protocol may be implemented for a mobile wireless sensor network with slight modifications. The working of the SVR protocol is demonstrated in the Fig. 1.

2.2 Sensor Protocols for Information via Negotiation

SPIN [13] is a data-centric protocol for WSNs which uses meta-data information to route packets throughout the network. SPIN uses a three way hand shake to reduce data redundancy, eliminate flooding, to overcome the situation of overlapping (when nodes get same information from different sources) and make sure the node only responds if it has enough energy to carry out the task. SPIN uses meta-data which is information about the data packet, which should be ideally smaller in size as compared to the packet it self and should be unique. SPIN involves three steps to forward the data, which are mentioned below.

- *ADV (Advertisement)*: On sensing information a node will broadcast an advertisement ADV throughout the network, the message will consist of the meta-data, not the data itself.
- *REQ (Request)*: The second phase of the three way negotiation is request REQ, on receiving the ADV message a node checks whether it has received data with the meta-data identifier. If it has already received it would simply not respond to ADV message, but if the node has not received a data packet with the given identifier it will send a request message to the node.
- *Data*: The final step is when the source node (the node that initiated the process) receives a request message; it will then send the actual data and the meta-data header.

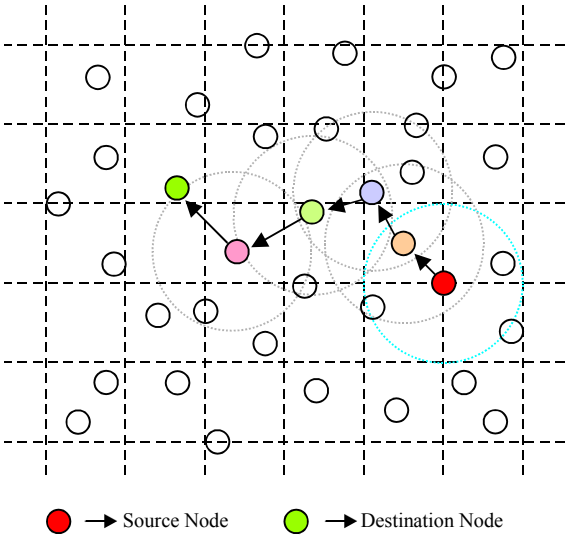

FIG 1. SVR PROTOCOL

SPIN's three way negotiation is shown in Fig. 2. The negotiation technique assures that each node will only receive data with the same meta-data header once, which will reduce data redundancy and only if the node has enough energy left to carry out all three steps it will participate in the negotiation. SPIN performs well for broadcasting as each node receives a single copy of the data packet. However, the protocol fails to send a packet between any two specified nodes, without forwarding the packet to all the nodes in the network.

2.3 Low-Energy Adaptive Clustering Hierarchy

LEACH [14] is a clustering based protocol. LEACH differs from other clustering protocols where the cluster heads are pre determined and fixed. In the case of LEACH the cluster heads are randomly selected for a round and the number of rounds depends on the simulation time. However, the number of cluster heads is decided in advance considering different parameters

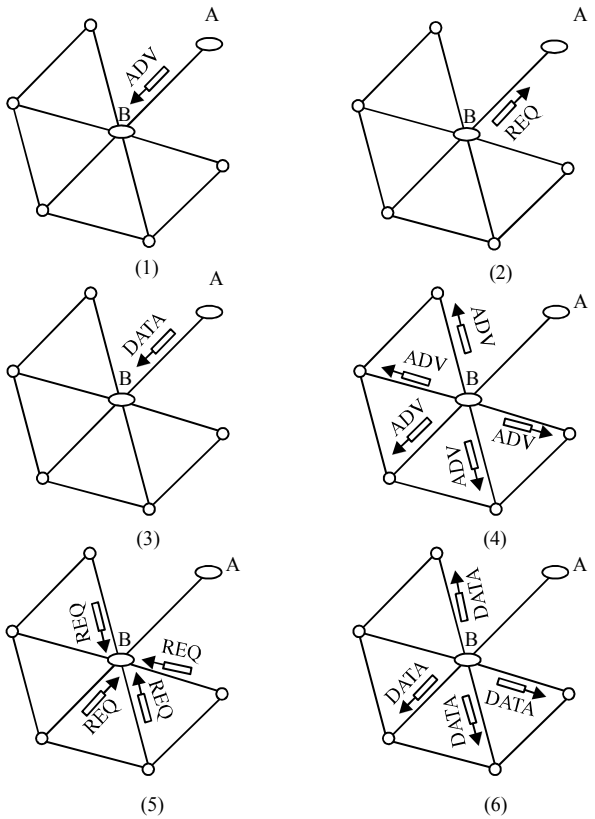

FIG. 2. SPIN PROTOCOL

like the network topology, the communication cost, etc. The sensor nodes elect themselves as cluster heads for a round depending on the energy left and whether they have served as the cluster head or not. Serving as the cluster head is a much more energy consuming task as compared to being the member of a cluster, as the cluster heads perform the task of communicating with the base station. Once a node has elected itself as the cluster head it will broadcast the message throughout the network and the non-cluster nodes will decide whether to join the cluster head or not on the basis of the communication cost (energy consumed to communicate with the cluster over the others). This process is known as the set-up phase, which is followed by the steady state phase in which the cluster heads aggregates the messages arriving from the cluster members and sends them to the base station. Ideally the cluster nodes transmitter is only turned on when it needs to communicate with the base station once the set-up phase is complete.

LEACH suffers from the choice of randomly electing cluster heads as a node elected could be very near to the base station and another could be far. Similarly a node, by chance could be near the cluster head in most of the rounds, which could significantly reduce its communication over heads while others could be more far off. As a result, the nodes could start to die randomly (certain number of nodes from a certain area) which would create an imbalance in the existing system.

The SVR protocol is a flat data centric protocol, which has an ability to route data packets throughout the network in an efficient way. The protocol employs the directional approach to route packets, ensuring the packet is routed to the closest neighboring node in the direction of the destination node. The SPIN protocol is also a flat data centric routing protocol that further extends the concepts of flooding with an exception, negotiations which are carried out before routing the packets. This approach eliminates the chances, of a node to receive several copies of the same packet, which occurs in flooding. The cluster based protocol LEACH differs from SVR and SPIN significantly. The protocol routes the packet within clusters and then the

cluster heads forward the packet on behalf of the cluster members. The protocol outperforms other cluster based protocols as it employs an effective cluster head selection, however, this cluster head selection scheme is not optimal yet.

3. SIMULATION SETUP

The simulation trials were carried out on NS-2 (Network Simulator-2) [15]. To support the architecture of a Sensor node the simulator was patched with the Mannasim Framework [16]. The simulation parameters and the NS-2 Network parameters are shown in Tables 1-2.

TABLE 1. SIMULATION PARAMETERS

Parameter	Value
Sensor Nodes	100
Network Size	400 x 400 m
Duration	200s
Initial Energy	10J
Packet Sending	0.034W
Packet Receiving	0.026W

TABLE 2. NETWORK SIMULATOR-2 NETWORK PARAMETERS

Parameter	Type used
Channel	Wireless Channel
Radios Propagation Model	Two Ray Ground
Network's Interface type	Wireless Physical
Medium Access Control	802_11
IQ	Priority Queue
Link Layer's type	LL
Antennas model	Omni Antenna
Maximum packet in IFQ	200
Sense power	0.015W
Process power	0.026W
Instruction in seconds	8000000

4. RESULTS AND DISCUSSIONS

The simulation trials were carried out on two networks, a regular distribution of sensor nodes and an irregular distribution of sensor nodes, with different source and destination nodes for three different scenarios. In all the three scenarios communication takes place between twenty, source and destination nodes. In the first scenario the destination node is the same for the entire source nodes. While the remaining source nodes were selected by increasing the initial source node number by a factor of 1. In the second scenario the initial selected source and destination node are node 1 and 4 respectively and the remaining 19 nodes were selected by an increment of 5 to the initial set. The source and destination nodes selected in the second scenario vary, from a range of node 1-99. In the third scenario there is an increment of 2 is made to the initial source and destination node, node 5 and node 9 respectively to select the twenty, source and destination nodes.

The results for each scenario were based on thirty iterations. The results of the first scenario from the simulation trials are shown in Figs. 3-4. These results were obtained from two constant source and destination nodes. From the results it is clear that the SPIN routing protocol is more energy greedy as compared to LEACH for both node distributions. SVR is slightly better than LEACH in terms of energy consumption in the regular distribution but it performs much better than LEACH in the irregular distribution of the first scenario. However, there are a few nodes in the regular distribution where the sensor nodes have consumed more energy with the SVR protocol as compared to LEACH. The nodes simulated with SVR protocol exhibit a more balanced energy consumption pattern as compared to LEACH and SPIN. The nodes tend to consume energy in a regular pattern. In the first scenario the SVR protocol in both distributions exhibits a balanced energy consumption among all the nodes, which results in an increased network life time.

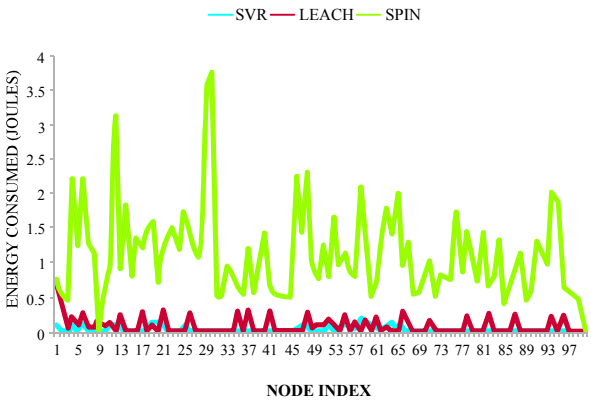

FIG. 3. REGULAR DISTRIBUTION – FIRST SCENARIO

The results from the second scenario of simulation trials are shown in Figs. 5-6. The source and destination nodes for this trial varied between node numbers 1-99. The second scenario results show that the SPIN protocols performance is poor as compared to the other two protocols with most of the nodes consuming more than 0.5J of energy. The performance of the SVR protocol in the second scenario is much better than the first scenario. The SVR protocol manages to conserve much more energy than LEACH with most of the nodes consuming even less than 0.2J. The performance of the LEACH protocol is good. However, there is a performance drop for LEACH as compared to the first set of results.

Finally, the results of the third scenario are shown in Figs. 7-8. The source and destination node for this scenario were very close to each other. The performance of the SVR protocol is similar to the first and second scenario. For the LEACH protocol some nodes have consumed a minimal amount of energy while the others have consumed relatively more energy. The reason behind the varying energy consumption pattern is the random selection of the cluster head. The SVR protocol has been energy efficient.

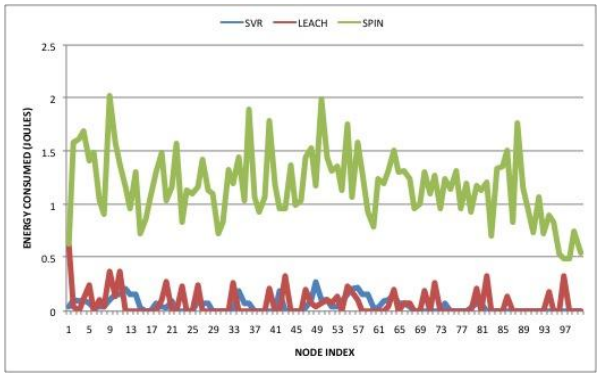

FIG. 4. IRREGULAR DISTRIBUTION – FIRST SCENARIO

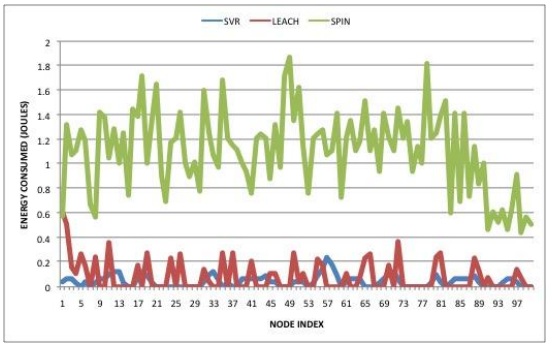

FIG. 5. REGULAR DISTRIBUTION – SECOND SCENARIO

The performance of LEACH is significantly poor in such scenarios because of its design. The protocol is a cluster based hierarchical routing protocol, which uses clusters to communicate rather than nodes performing tasks and communicating individually. The protocol does not cater event driven on demand queries and communication among specified nodes. A smart sensor

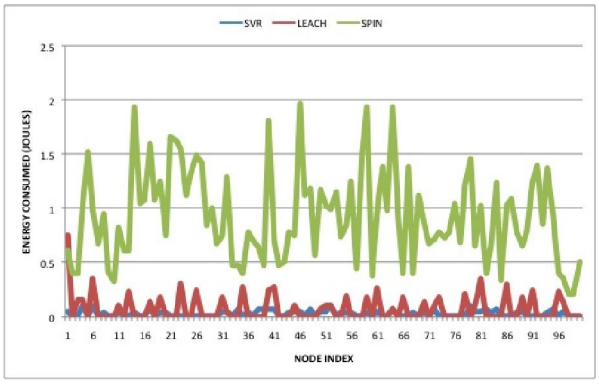

FIG. 6. IRREGULAR DISTRIBUTION – SECOND SCENARIO

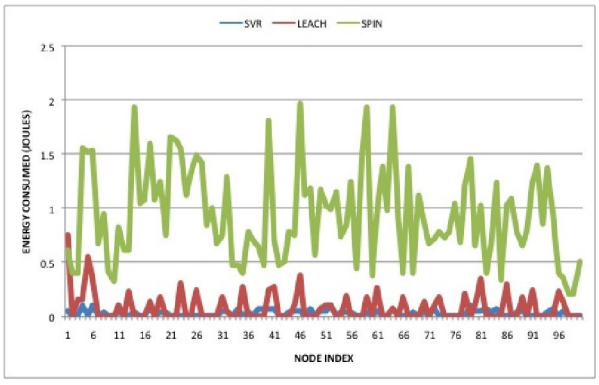

FIG. 7. REGULAR DISTRIBUTION – THIRD SCENARIO

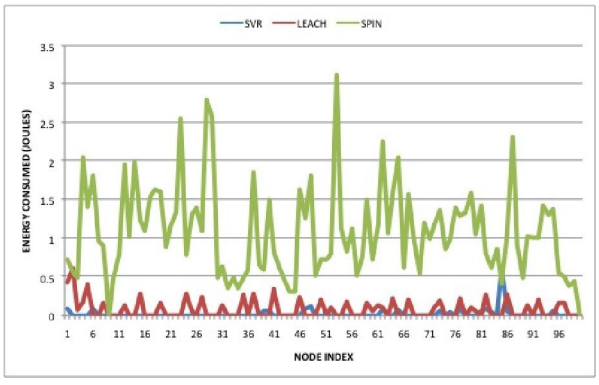

FIG. 8. IRREGULAR DISTRIBUTION – THIRD SCENARIO

network performing smart operations and on demand event driven tasks requires a data centric routing protocol as a driving force. The LEACH protocol does not meet such needs of a smart sensor network.

The SPIN protocols overall performance is considerably poor as compared to the SVR and LEACH protocols. The reason of the poor performance is the mechanism employed by the protocol, which has a prime goal to reduce flooding, which it effectively does. However, the protocol still manages to route a single copy of the data packets to a large number of nodes before it reaches the destination. The transmission of a greater number of packets is the main reason for the huge energy consumption.

From the results of the simulations for all three scenarios it could be inferred that the SVR protocol is much more energy efficient as compared to LEACH and SPIN. The mechanism employed to route packets by SVR is extremely effective. As the protocol computes the proximate nodes and optimal proximate nodes to route packets, these computation tasks consumes less energy as compared to the negotiations carried out by the SPIN protocol. The SVR protocol computes the next hop on the basis of distance and direction to choose the optimal proximate node, while the SPIN protocol does not take direction into account. The performance of SVR is better than LEACH, as the cluster head selection of LEACH at times is unfair for some nodes, depending on their position from the base station.

4. CONCLUSIONS

In this paper the performance of SVR protocol is compared with two WSN protocols, LEACH and SPIN in the context of energy consumption.

The simulation trials were carried out on two networks, a regular distribution of nodes and an irregular distribution of nodes, with different source and destination nodes for three cases. The results for each case were based on thirty iterations. The results show that the SVR protocol outperforms the two protocols.

The SVR protocol could serve as a backbone in the development of smart applications for WSNs in the near future. The protocol could route data in a smart applications, where several attributes of a phenomenon are monitored, and send alerts in troubling situations, for example when a certain attribute reaches a threshold value.

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