Efficient Routing In Wireless Sensor Networks

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Abstract- Wireless Sensor Networks (WSNs) consist of thousands of tiny nodes. A sensor network is composed of a large number of sensor nodes; having the capability of sensing, computation and wireless communications; which are densely deployed either inside the phenomenon (something known by sense perception) or very close to it. Many routing, power management and data dissemination protocols have been specifically designed for WSNs where energy consumption is an essential design issues. Application specific wireless sensor networks have various routing protocols depending on application and network architecture. The study of various routing protocols presents a classification, as data-centric, hierarchical and location-based protocols. In this paper, we present a survey of the state-of-the-art routing techniques in WSNs. A comparison has been made between two routing protocols, Flooding and Directed Diffusion, on the basis of throughput and lifetime of the network. Simulation of AODV is also carried over two topologies with same source and destination node.

Keywords – Wireless Sensor Networks, Routing, AODV, Directed Diffusion, Flooding.

I. INTRODUCTION

"A sensor network is a deployment of massive numbers of small, inexpensive, self-powered devices that can sense, compute, and communicate with other devices for the purpose of gathering local information to make global decisions about a physical environment." WSNs are resource limited, they are deployed densely, they are prone to failures, the number of nodes in WSNs is several orders higher than that of ad hoc networks, WSN network topology is constantly changing, WSNs use broadcast communication mediums and finally sensor nodes don't have a global identification tags. The major components of a typical sensor network are: Sensor Field, Sensor Nodes, Sink, and Task Manager.

A sensor is a small device that has a micro-sensor technology, low power signal processing, low power computation and a short-range communications capability. The protocol stack used by the base station and sensor nodes combines power and routing awareness, integrates data with networking protocols, communicates power efficiently through the wireless medium, and promotes cooperative efforts of sensor nodes. The protocol stack consists of the physical layer, data link layer, network layer, transport layer, application layer, power management plane, mobility management plane and task management plane.

The rest of the paper is organized as follows. Proposed RCP is explained in section II. Experimental results are presented in section III. Concluding remarks are given in section IV.

II. PROPOSED ALGORITHM

Proposed Reliable Communications Protocol (RCP)

The major application of a wireless sensor network is to monitor a remote environment. Data of individual nodes are usually not very important. Since the data of sensor nodes are correlated with their neighbor nodes, data aggregation can increase reliability of the measured parameter and decrease the amount of traffic to the base station. RCP uses this observation to increase the efficiency of the network.

To develop the RCP, some assumptions are made about sensor nodes and the underlying network model. For sensor nodes, it is assumed that all nodes are able to transmit with enough power to reach the remote server if needed, that the nodes can adjust the amount of transmit power, and that each node can support different Medium Access Control (MAC) protocols and perform signal processing functions. These assumptions are reasonable due to the technological advances in radio hardware and low-power computing. For the network, it is assumed that nodes have always data to send to the end user and the nodes located close to each other have correlated data.

In RCP, clusters are formed only once during the setup phase before the network starts to run. Some nodes are elected as Cluster Heads at the beginning of the setup phase. Each Cluster Head sends an invitation message to its neighbor nodes to setup its own cluster. When a cluster is established, the cluster-head collects the data of sensor nodes of that cluster, perform local data aggregation, and communicate with the remote server. The detailed description of the Reliable Communication Protocol is given in the following sections.

2.1 Hausdorff Clustering Algorithm

Consider a WSN with a single Remote server and N nodes. Let V = {vi = (xi, yi), i = 1. . . N} be the set of node coordinates.

Hausdorff Distance: Let the set of sensor nodes S be partitioned into M clusters {G1, G2, ..., GM}. Let the Euclidean distance between node m and node n be denoted as

$$d(v_m, v_n) = ||v_m - v_n|| = \sqrt{((x_m - x_n)^2 + (y_m - y_n)^2} \quad \text{………. (1)}$$

In Hausdorff Clustering Algorithm the nodes make autonomous decisions. At the beginning, each node broadcasts a topology discovery message with the lowest power level to find all its neighbors. Then, the BS appoints an initiator for starting the clustering operation. The initiator broadcasts a clustering message and awaits join requests from neighboring nodes. It then admits cluster members according to the clustering conditions.

For Remote Server:

Assign one of the nodes as the Cluster head.

For Cluster heads:

Form a cluster using the Hausdroff distance measure.

For all other nodes:

Receive a message from Cluster head.

Request for Joining the cluster.

Declare itself an cluster head if rejected by all neighboring clusters.

Figure 1. Summary of procedures for RS, cluster head and Ordinary nodes.

Set-up Phase

In the set-up phase (Figure 2) ONs are associated with their own CH, by properly defining the cluster size and then making the network infrastructure ready to deliver data. The first procedure to form clusters is the Cluster Head node selection.

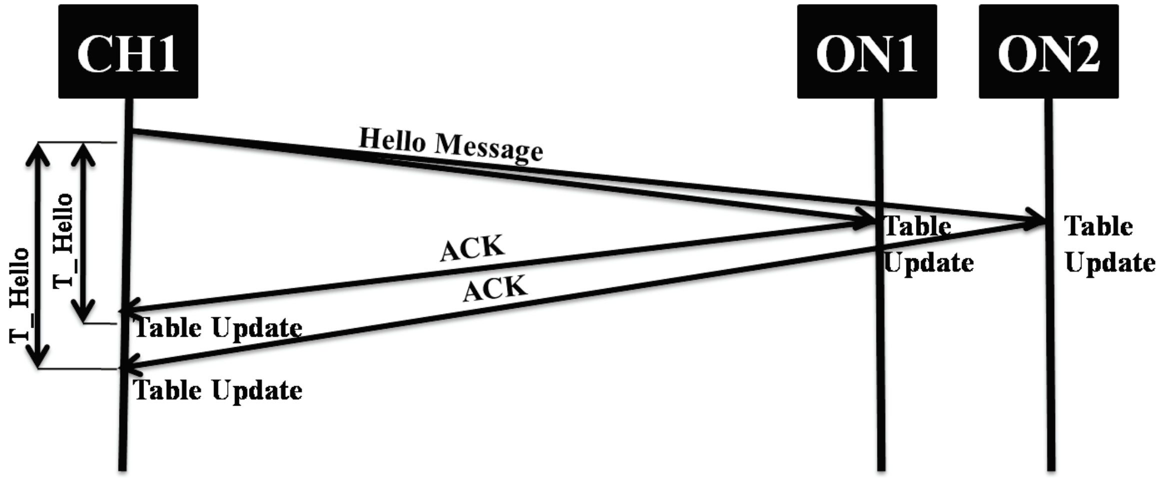

Figure 2. Time diagram of setup phase.

At the beginning of the setup phase, CH starts broadcasting HELLO packets with a time period THELLO. The overall setup phase duration TSetUp depends upon the number of nodes, network topology and size. The HELLO packet's header comprises at least two fields: the sender identifier ID(S) and sequence number SN. Upon the reception of this message, an ON replies to the CH with an acknowledgment message (ACK) in unicasting modality. At the end of this phase, every CH knows of its neighbor ONs, while each ON is aware of its own CH; this information is locally stored by each node in its neighbors' table. If an ON receives more than one HELLO packet from different CHs, it is associated with first CH, while keeping trace of other backup CHs.

HELLO Packet contains the desired geographical locations of the cluster head. These desired locations are chosen so that the average number of sensor nodes in different clusters is the same and the average distance between sensor nodes in each cluster becomes minimized. Such criteria decrease the overall power consumption and share energy load among all of the nodes in the network. Thus, the network lifetime becomes longer and all of the nodes die almost at the same time. Hence, we do not lose the chance of sensing every piece of underlying area during the network lifetime.

2.2 Steady State Phase

Once the set-up phase is completed, Steady State Phase begins (Figure.3). ONs are able to transmit data (Data-Message) to their CHs. Addition packets are also sent to monitor the status of the bidirectional link between CH and ON (Control-Message) and to notify an abnormal behavior (Alarm). In this case the remote server generates an alarm.

Both a short and long term periodical channel evaluations are delivered to the remote server together with a list of the network clusters. Moreover, each CH could allow a remote interaction with WSN by sending either a QUERY or a PING message to ONs in order to read the node's battery level or the network status. For the sake of reliability each message is acknowledged with a proper ACK packet.

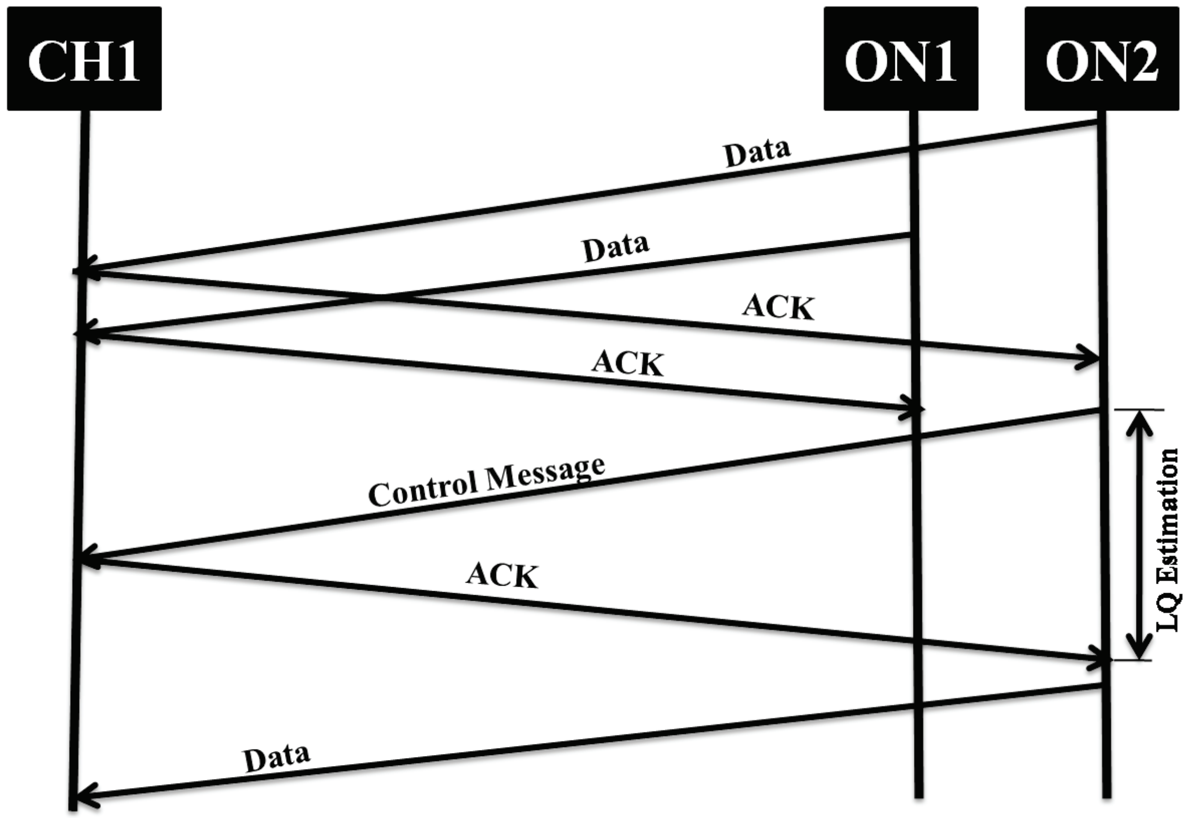

Figure 3. Time diagram of steady state phase.

2.3 Recovery Phase

To provide fault tolerant communications, a recovery phase (Figure .4) is introduced, managing situations in which a CH has been damaged. In this case, orphan ONs are associated with another CH in a direct or indirect way. if a CH presents an improper functioning or it is under attack, the ONs belonging to its cluster are not capable of sending data to the remote server. To become aware of this, an ON looks through the link quality (LQ) defined as:

$$LQ = \frac{N_{Rx-CH}}{N_{Tx-ON}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(2)}$$

Where NRx-CH represents the estimated number of packets successfully received by CH and NTx-ON is the number of packets sent by ON.

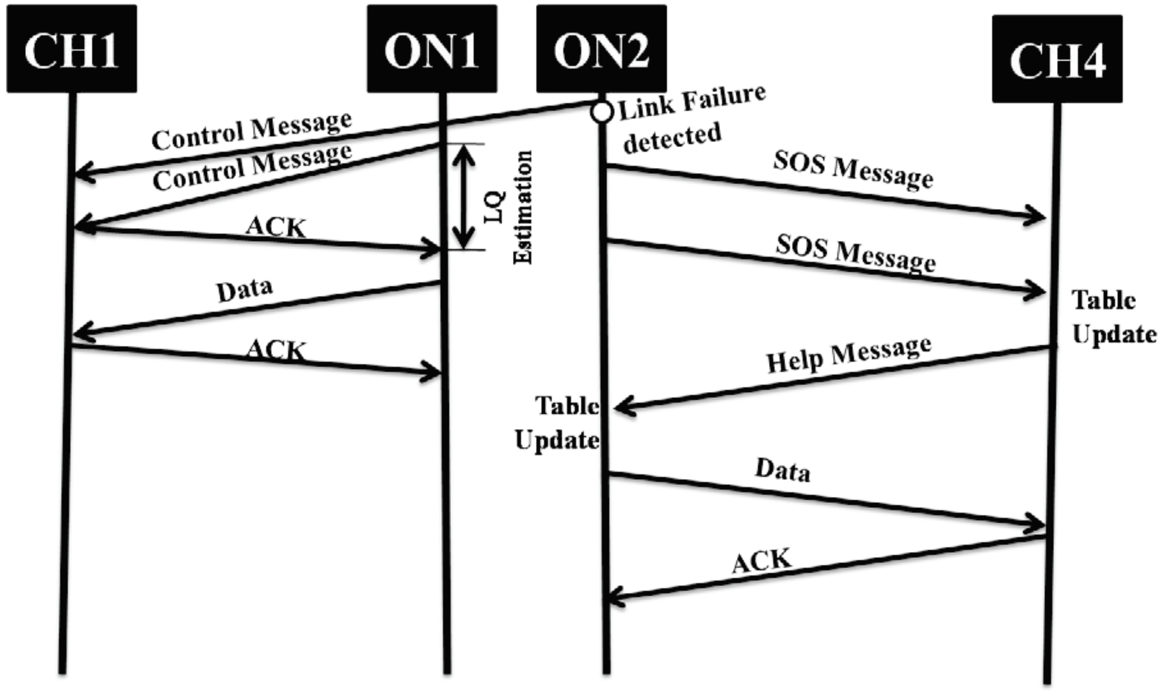

Figure 4. Time diagram of recovery phase.

Link quality can also be calculated as

$$LQ = \frac{\text{Sequence No.of last ACK received from CH}}{\text{No.of data packets transmitted by ON}} \qquad \text{…………………. (3)}$$

The LQ evaluation is performed basing on the sequence number of ACK messages, so that no additional overhead is needed. When the value of this parameter is below a certain threshold, ON sends an SOS message to its CH. If another CH receives this message it associates the orphan node, notifying it with a HELP message. At the end, the respective neighbors' tables are updated, as it is pointed out in Figure 4.

If there are no CHs able to support an orphan ON, i.e., no HELP message is received, then the network tries to reconfigure the end-to-end paths already established to provide adequate connectivity. In particular, that ON sends a SOS message to neighbor ONs, which reply with a HELP message. ON selects the most suited vice-CH among them according to minimum distance. The recursive application of this procedure implies the adoption of a multi-hop routing strategy is adopted, setting up a sort of ad hoc network to reach the remote server.

III. Experiment and Result

The test set for this routing evaluation and implementation are selected with some fix number of nodes. Fedora 12 operating system platform is used to perform the experiment. The PC for experiment is equipped with an Intel Dual Core 1.6 GHz processor Personal laptop and with min 512GB memory.

The proposed algorithm is tested using simulation of network which is wireless sensor network. Initial setup shows number of networks sensors used, cluster formed by nodes and head of cluster.

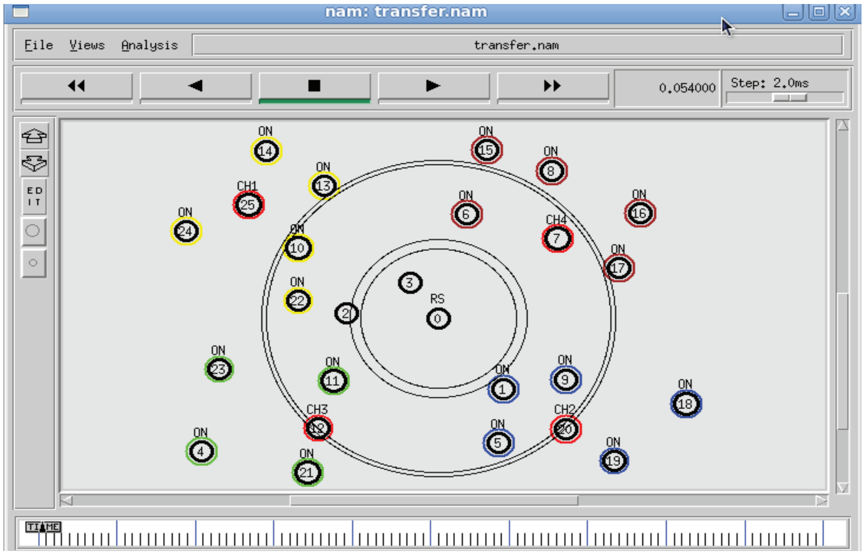

Figure 5. Cluster formed after setup phase

Figure 6 compares the energy consumption for clustering per node of the three protocols. With increasing node density, the energy consumption per node increases because there is more need for the local exchange of messages and for the radio channels to compete. RCP and Hausdorff clustering are seen to be very energy efficient for critical condition applications of WSN.

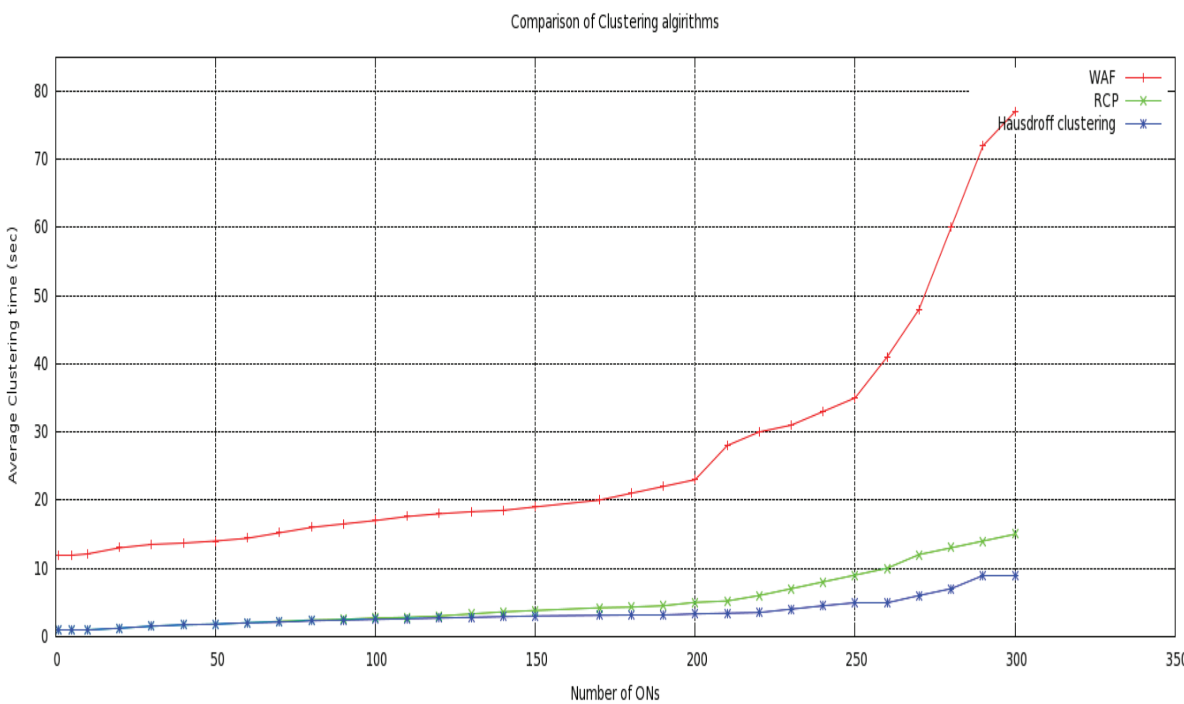

Figure 6. Performance comparison based on average clustering time.

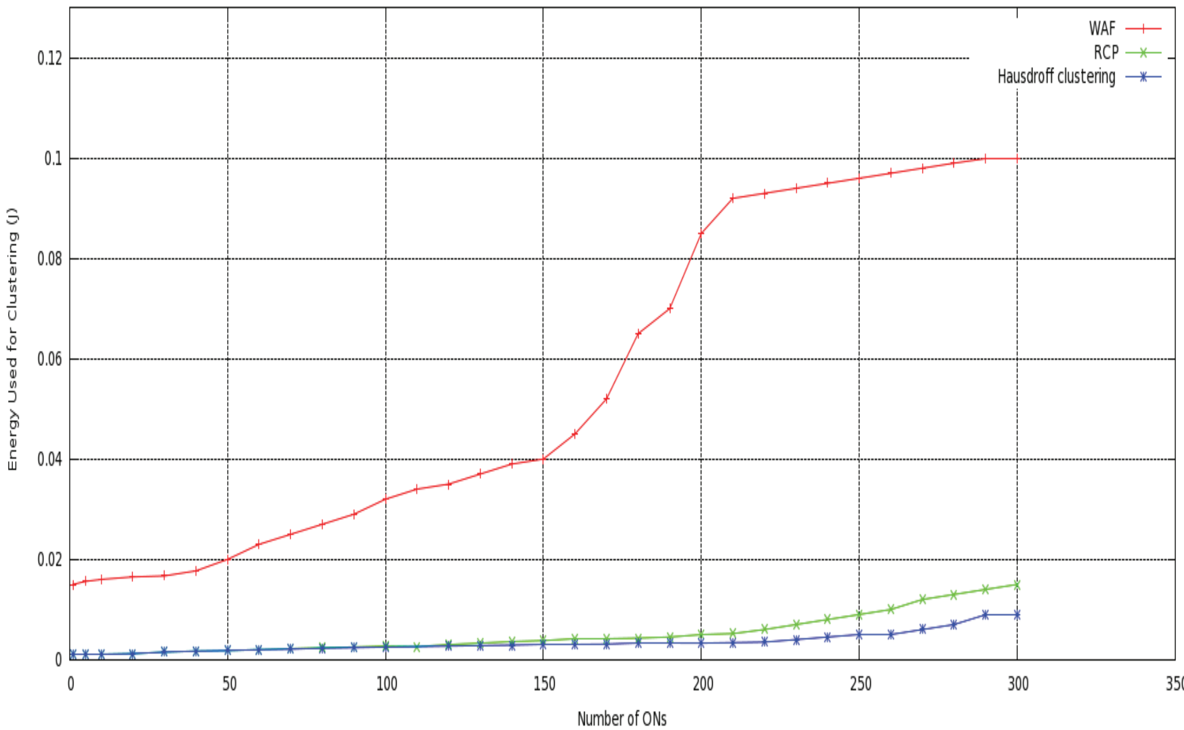

Figure 7. Performance comparison based on energy used for clustering.

IV.CONCLUSION

The WSN application is widely considered as the most promising solution for intelligent environments, provided that effective protocols are designed taking into account specific constraints, as far as the limited resources and the unattended operations. Thus the network has to be tolerant of error and fault.

Our work proposes an effective RCP algorithm for fault management by introducing a recovery phase within the communications framework, aiming at facing fault by autonomously reconfiguring the network topology, without increasing the signaling overhead.

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