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Fault Tolerant, Energy Saving Method for Reliable Information Propagation in Sensor Network

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Abstract **-** The reliability of wireless sensor networks (WSN) is affected by faults that may occur due to various reasons such as malfunctioning hardware, software glitches, dislocation, or environmental hazards, e.g. fire or flood. Due to inherent nature of these networks a sensor node may fail and hence the route may also fail. A WSN that is not prepared to deal with such situations may suffer a reduction in overall lifetime, or lead to hazardous consequences in critical application contexts. One of the major fault recovery techniques is the exploitation of redundancy, which is often a default condition in WSNs. Another major approach is the involvement of base stations or other resourceful nodes to maintain operations after failures. In this paper we proposed a fault tolerant method for fast, robust and guaranteed prorogation in sensor networks. The proposed multi path routing approach offer better bandwidth utilization, energy saving and guaranteed delivery of information. This approach also includes error reporting features. Before sending an event source node check the remaining Energy level and highest Data rate among all its gradients and select the path on the basis of route score which consider above factors.

Keywords *- Wireless sensor network, fault tolerant protocol, Source, Sink, Multipath Routing.*

I. INTRODUCTION

Nodes in WSNs are prone to failure due to energy depletion, hardware failure, communication link errors, malicious attack, and so on. Unlike the cellular networks and ad hoc networks where energy has no limits in base stations or batteries can be replaced as needed, nodes in sensor networks have very limited energy and their batteries cannot usually be recharged or replaced due to hostile or hazardous environments. So, one important characteristic of sensor networks is the stringent power budget of wireless sensor nodes. Energy dissipation at sensor node is a major concern, as in many applications sensors have to be deployed in inaccessible environments.

Sensing alone is not an energy consuming activity, but networking and programming certainly are. Prolonging battery life in sensor nodes and, by extension, the overall network lifetime is therefore a foremost task in the design of practical WSNs [4], [5], [6]. The development of network of low cost, low power, multifunctional sensors have received increasing attention[7].Two components of a sensor node, sensing unit and wireless transceiver, usually directly interact with the environment, which is subject to variety of physical, chemical, and biological factors. It results in low reliability of performance of sensor nodes. Even if condition of the hardware is good, the communication between sensor nodes is affected by many factors, such as signal Strength, antenna angle, obstacles, weather conditions, and interference. Fault tolerance is the ability of a system to deliver a desired level of functionality in the presence of faults. Since the sensor nodes are prone to failure, fault tolerance should be seriously considered in many sensor network applications.

II. RELATED WORK

Sensor network introduce new challenges that need to be dealt with as a result of their special characteristics. In [9] author has proposed an algorithm which will route data through a path whose nodes have largest residual energy. The path changed whenever a better path is discovered. The primary path will be used until its energy falls below the energy of the backup path after which the backup path is used. Hence node may achieve the longer life. In [8]Author proposed a multilevel routing Protocol to maintain network connectivity even if a node runs out of energy, thus prolong the network lifetime and provide reliable data delivery. It performs Level Implementation and Path Establishment, which models the sensor network into levels according to the hop distance from the sink node. Once Level and Path establishment is over, It performs Data Transmission operation in which when an event occurs at the source node the data is forwarded from source node to parent node (which is one level up from the node.).Source node also store copy of it until it gets the ACK from the parent node. According to [1] routing in WSNs can be divided into Flat-based routing, Hierarchical-based routing and Location-based routing depending on the network structure. In flat-based routing, all nodes are typically assigned equal roles or functionality. In hierarchical-based routing, however, nodes will play different roles in the network. In location-based routing, sensor nodes' positions are exploited to route data in the network. In [2] author address the reliability issue by designing a general energy-efficient, load balanced, fault-tolerant and scalable routing protocol. A novel general routing protocol called WEAR is then proposed to fill the gap by taking into consideration four factors that affect the routing policy, namely the distance to the destination, the energy level of the sensor, the global location information and the local hole information. The routing decision is based on a heuristic named weight, which is a combination of the four factors including the distance to the destination, the energy level of the neighbor sensors, the global location information and the local hole information. Hole is defined as a large space without active sensors, resulting from dead and/or fault sensors.

III. DIRECTED DIFFUSION PROTOCOL

Directed diffusion [3] is a novel data-centric, data dissemination paradigm for sensor networks. Directed diffusion has some novel features: **data-centric dissemination**, **reinforcement-based adaptation** to the empirically best path, and **in-network data aggregation** and **caching**. Directed diffusion consists of several elements: interests, data messages, gradients, and reinforcements. An *interest* message is a query or an interrogation which specifies what a user wants. Each interest message contains a description of data interested by a user. Typically, *data* in sensor networks is the collected or processed information of a phenomenon which matches an interest or a request of a user. 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 shown in figure 1. 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 shown in figure 2. Events are propagated toward the interest originators along multiple gradient paths. The sensor network *reinforces* one or a small number of these paths shown in Figure 3.

When a node receives an interest, it checks to see if the interest exists in the cache,If no matching, node creates an entry(gradient and data rate) If interest exists but no gradient, adds a gradient and updates the timestamp and duration fields. If interest exists and have gradient, just update the timastamp and duration When gradient expires, it is removed from the interest entry. After receiving an interest, a node may decide to re-send the interest to some subset of its neighbors. To its neighbors, this interest appears to originate from the sending node, although it might have come from a distant sink. This is an example of a *local interaction*. In this manner, interests *diffuse* throughout the network. Not all received interests are re-sent. A node may suppress a received interest if it recently re-sent a matching interest. The interval attribute specifies an event data rate (Hence, the data rate is 100 events per second in that example). However, unlike that example, the interval attribute in this initial interest is much larger. As *exploratory*, the initial interest is intended to determine if there are any sensor nodes that detect the four-legged animal. Hence, the initial exploratory interest specifies a low data rate (*e.g.,* 1 event per second). Since the location of the sources is not precisely known, interests must necessarily be diffused over a broader section of the sensor network than that covered by the potential sources. As a result, if the sink had chosen a higher initial data rate, higher energy consumption might have resulted from the wider dissemination of sensor data.

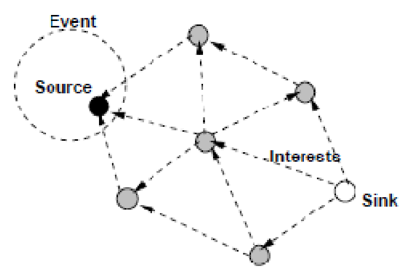

Fig. 1: Intrest Propogation

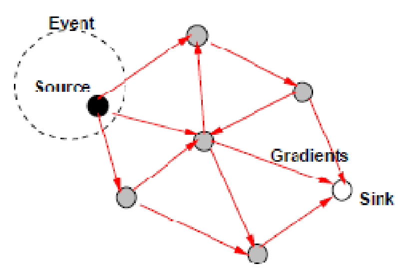

Fig. 2 : Initial gradient Setup

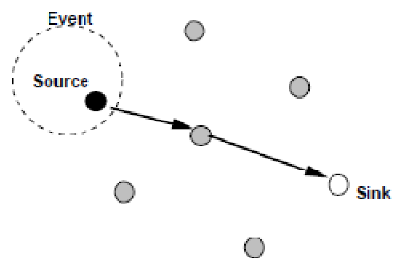

Fig. 3 : Data delivery along Reinforced Path

IV. PROBLEM FORMULATION

In this paper we have proposed a method based upon directed diffusion Protocol, that avoids a node to be overburdened thus prolonging the network lifetime. It uses route score while selecting the best path which consider the energy level of the next sensor node and the higher date rate from current node sensor to sink sensor node. Fault tolerant property of this method ensures robust delivery. Since source node will store there event until it receives the Acknowledgement, it offers guaranteed propagation of information.

V. AN OUTLINE OF THE PROPOSED APPROACH

For proposed Method we have chosen flooding as design choice for diffusion element Interest propagation and multipath delivery for selective quality among different paths for diffusion element as Data propagation. Here selective quality is higher requested data rate requested by sink and residual energy of neighbouring nodes of path.

Level 1

Level 2

Level 3

Sink Node *Source Node* Path established

Fig. 4 : Level and Path established

A. Level Implementation

Once the nodes are deployed sink broadcasts ADVT packet to discover the level 1 node and set its parent to sink. After ADVT message is sent by sink node the Level count records how many hops it has travelled from the sink. Sink is at Level 0.The Level Count ((LC) is increased by one each time when a node receives ADVT message. When receiving An ADVT message a node consider itself in level N+1,if the level count received is N. It Smaller level count ADVT message is received the node updates its level according to new level count .the parameters of ADVT message are N_i and LC_i. Thus with help of ADVT message network is modelled into various levels and implement a path from each sensor node to sink.

B. Data Propagation

Once Level Implementation is over, interest is injected by sink node. The sink node creates a task state which will be purged after the time indicated by the duration attribute. For each active task, the sink periodically *broadcasts* an interest to all its neighbors This initial interest also contains the attributes [3] like type, interval, duration and Rect .

type = wheeled vehicle // detect vehicle location

interval = 20 ms // send events every 20 ms

duration = 10 seconds // for the next 10 seconds

rect = [-100, 100, 200, 400] // from sensors within rectangle

The interval attribute specifies an event data rate. As *exploratory*, the initial interest is intended to determine if there are any sensor nodes that detect the event like four-legged animal. Hence, the initial exploratory interest specifies a low data rate (*e.g.,* 1 event per second). Every node maintains an interest cache. Each item in the cache corresponds to a distinct interest. Interests do not contain information about the sink but just about the immediately previous hop. An interest entry in the cache consists of several fields. A timestamp field specifies the timestamp of the last received matching interest. The interest entry also contains several gradient fields (up to one per neighbor). A gradient is composed of a *value* and a direction in which to send events. In our sensor network, the gradient value is the data rate. Gradients are used for data propagation .There are two gradient types: an exploratory gradient and a data gradient. Exploratory gradients are intended for path setup and repair whereas data gradients are for sending real data.When a node receives an interest, it checks if the interest exists in the cache. If no matching interest exists (*i.e.,* the interest is distinct), the node creates an interest entry and determines each field of the interest entry from the received interest. This entry contains a single gradient toward the neighbor from which the interest was received, with the specified event data rate. Node will Propagate Interest to all its children (possibly source node).

When sources detect a matching target, they send exploratory events (possibly along multiple paths) toward the sink. A sensor node that detects a target searches its interest cache for a matching interest entry. In this case, a matching entry is one whose rect encompasses the sensor location, and the type of the entry matches the detected target type. When it finds one, it computes the highest requested event rate among all its outgoing gradients and checks the remaining energy of the immediate node. Whichever node had highest route sCORE node will choose that path to end event to sink node. Considering the remaining energy level of any intermediate node will help in conserving the energy of the node, thus prolonging the network lifetime and conservation of energy.

C. Fault Tolerant Path

In case node runs out of energy, it uses Energy Low Packet to notify its child nodes to change their parents to ensure no disconnection thus maintain network connectivity. The parameter of energy Low message is its node ID (N_j).node that receive this message and have their parent set to the node that sent the message, use Parent Search packet to find out new parent or their neighbours. The neighbours reply this packet using Neighbour Message whose parameter are N_j and LC_j. The nodes that change their level due to Energy Low Message use Level Change message to change their level of their child nodes. Parameters of Level Change message will be N_j and LC_j. Before sending the Neighbour message in reply of Parent Search message, neighbouring node will check whether it is not having more than certain numbers of children. In our example a node should not have more than two children. This maximum limit can be changed as per application requirement. In this way when node changes its parent, it re-establish new path.

Source node runs out of Energy

Child node which changes its Parent and Level

Sink Node

Source Node

Disconnected Path

Re-established Path

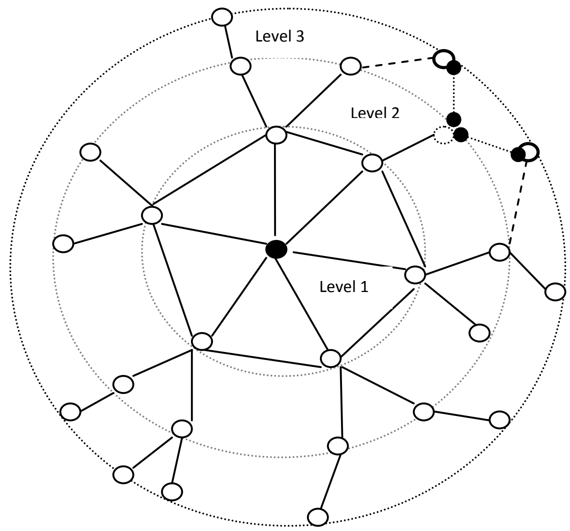

Fig. 5 : Reestablishment of Path When Parent node runs out of energy

D. ROUTE SCORE CALCULATION

Since Route score is a key to make decision during the routing of Events, we need to formally depict the definition of route score. It contains two factors, the highest requesting rate and the remaining energy of among all its outgoing gradients.

Route Score = $\alpha\, ER_j + \beta RE_j$

RE_j is remanning energy of immediate node j.

ER_j is Event rate of immediate node j.

α and β are two parameters denoting the significance of corresponding factors. If we make them any of them be zero, the corresponding component is no more considered .Thus this method can have variant configuration and application.

E. GUARANTEED DELIVERY USING ACKNOWLEDGEMENT

When an even occurs at the source node the data is forwarded from source node to sink node. The source node stores a copy of it. Each receiving intermediate node sends an acknowledgement (ACK Packet) to the node that forwarded the packet to it. On receiving an ACK Packet it deletes the packet for which acknowledgement is received. This continues until the sink receives the packet.

F. RESIDUAL ENERGY CALCULATION

Every node will check the energy level of the next node of the route. Remaining Energy of the j node is

$$R\,E_j = \frac{E0-CEj}{E0}$$

Where E_0 = Initial energy of sensor

CE_j = consumed energy of the sensor

VI. BASIC OPERATION OF METHOD

The objective of this method is to ensure energy conserving and guaranteed delivery of interest and Event and maintain network connectivity even if a node runs out of energy, thus providing reliable data delivery.

When nodes are deployed levels will be implemented .Sink will broadcasts ADVT packet to find Level 1 nodes. Level Count record how many hops node is apart from sink, which will decide the level of node. Thus At first phase Level implementation will be completed. Node which is connected to directly one level down become the parent of those nodes Children nodes had one level more than the level of its parent. For event propagation child node reports to its parent node .Initially Sink broadcasts an interest to all its neighbours. Tasks are described or named using attribute-value pairs. A simplified description of the animal tracking task of can be

type = four-legged animal // detect animal's location

interval = 10 ms // send back events every 10 ms

duration = 10 minutes // for the next 10 minutes

rect = [-100, 100, 200, 400] // from sensor nodes within rectangle

A sensor that detects an animal might generate the following data

type = four-legged animal // detect animal's location

instance = elephant // instance of this type

location = [125, 220] // estimated location

intensity = 0.6 // signal amplitude measure

confidence = 0.85 // confidence in the estimate

timestamp = 01:20:40 // event generated Time

When sources detect a matching target, they send exploratory events (possibly along multiple paths) toward the sink. After the sink receives these exploratory events, it reinforces at least one particular neighbor to "draw down" real *data* (*i.e.,* events at a higher data rate that allow high quality tracking of targets). We call the gradients set up for receiving high quality tracking events *data* gradients. Source node will forward the data to parent node, and storing copy of data, until it gets the ACK .Each parent will send ACK to the node from which I receive the data. On receiving the sensed data sink has send the ACK to last sender, which is Level 1 node. When Node has multipath to send data to sink, which will happen in Fig. 4 at Level 1, node will calculate the Route Score, considering highest data rate and remaining energy of neighbor node from data gradient. Whichever node had largest value of Route Score sender node will select path from that node. In case parent node runs out of energy, it will broadcast energy Low packet. On receiving Energy Low Packet, nodes will find new parent by sending Parent Search Message. Whichever node has less than two children will send neighbor Message to those nodes. Upon receiving many Neighbor Message, node will select parent which has lesser Level, thus will e able to receive interest and propagate Event Faster.

VII . CONCLUSION

Thus have explained a method which has guaranteed Energy conserving and fault tolerant delivery of data packet in sensor network. It is also taking the energy level of a node into consideration thus prolonging the life time and connectivity of the network. It also considers higher requested Data Rate while selecting the Path, thus ensure the faster information propagation.

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