An “Energy Aware” routing protocol for pre-detection and its prevention of Fault Tolerance for WSN

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Abstract

Energy has been a major concern in almost all networks, especially the consumption and optimized utilization of energy. Lots of work has been experimented and proposed in the past with relevant evidences for fault detection too. However, researchers have yet to find the absolute solution to routing protocol for pre- “fault tolerance and prevention” using energy efficient awareness. In this paper, we have designed a protocol, if in case of failure which selects succeeding node in energy efficient manner; and if in case of its failure, sensitively restores the connectivity of the neighbors of a cluster around that node.

Keywords: Wireless Sensor Networks; Fault tolerance; Network lifetime; Wireless Sensor and Actuator Networks (WSANs), Routing; Kautz graph; Real-time; Energy-Efficiency;

1. Introduction

The objective of this paper in brief is explained with the definition of importance of energy efficient pre-fault detection in WSNs. We propose a disseminated important productive steering calculation for WSNs that takes mind adaptation to internal failure of the network. At that point, we propose a circulated steering calculation called DBTR (Dispersed blame tolerant directing calculation) that considers important utilization of the CHs yet additionally their adaptation to non-critical failure.

The commitments of this work include:
1) A hypothetical investigation of the Kautz diagram for its relevance in WSANs to meet the important proficiency and ongoing correspondence necessities in overlay support and steering.
2) A Kautz diagram installing convention that uses Kautz charts to the physical topology of a WSAN and interfaces the diagrams utilizing disseminated hash table (DHT) [13] for high versatility and ongoing correspondence, and an important productive topology upkeep system.
3) A hypothetical investigation of directing ways in the Kautz chart and an effective detection of the fault tolerant steering convention is analyzed to help detection of fault tolerance, continuous and important productive information transmission.

Apart from these, numerous analysts have proposed the utilization of some uncommon hubs called portals/transfer. Our commitment in this paper is to present a novel protocol and resulting with numerical definition for energy efficient fault mitigation, monitoring and possibly the removal of the fault. Accordingly, keeping in mind the end goal to proceed with usefulness of the WSNs, the directing calculations should adapt to fault tolerant perspective, particularly when some CHs give negative acknowledgement. The calculation empowers a transfer hub to rapidly and productively recognize the following best path from itself to the destination after steering failure.
without information transmission. Each group has a pioneer called cluster head (CH) which gathers information from its part sensor hubs totals them and send it to the BS. The sensor hubs sense the nearby information and forward it to a remote base station (BS) called sink. Because of hub versatility and resultant directing packet transmission failures, adaptation to non-critical failure is urgent to guarantee dependable hub correspondence. A remote sensor arrange (WSN) ordinarily comprises of hundreds or thousands of sensor hubs, which are conveyed physically or arbitrarily, finished an objective milestone. A WSAN comprises of sensor hubs equipped for estimating jolts in the earth and actuator hubs fit for influencing their nearby condition.

Contribution: It enables a relay node to quickly and efficiently identify the fault tolerance, assign the sensed data through actuator to the alternatively best path (algorithm), rather than relying on retransmission from the source thus saving the additional energy consumption.

Motivation: Energy conservation and fault tolerance are the most two important challenging issues for the development of large-scale wireless sensor networks (WSNs).

Objective: All the real nodes are carefully sensed through an actuator. Our protocol is advantageous over previous Kautz graph based works in that it does not need an energy-consuming protocol to find the possible path; instead, detects the fault at succeeding node and diverts into the other possible path following suitable routing path algorithm. We also theoretically study various fault detection and prevention technique in all the possible routing paths, based on which we develop an efficient fault-tolerant routing protocol by optimizing energy efficiency. We all are aware that in real-time, energy aware fault-pre detection has become one of the critical factor in WSNs to enable sensed data to reach actuators reliably and quickly. Therefore, a routing algorithm in WSNs should be energy aware as well as fault tolerant. The paper provides extensive experimental results from OMNET++ of our protocol and compares the same with most recent WSN systems in terms of real-time communication, energy-efficiency, fault-tolerance and scalability. The paper proposes the protocol by multi-path based routing and energy-efficient, respectively.

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2. Literature Review

Hubs, which are provisioned with additional important and bigger correspondence, extend than the ordinary sensor hubs. Second, Allude can rapidly and productively
distinguish the elective ways and their lengths essentially in light of hub IDs upon a directing disappointment; past technique [18] needs to rely upon a important expending steering age calculation. We perform broad investigations on the proposed calculation by recreation and contrast the outcomes and the dispersed important adjusted steering (DVAS) calculation [15], the fault tolerant bunching calculation as proposed by Gupta et al [13]. Further, a multi-way directing calculation and an important effective multicasting calculation are proposed for intra-and between Kautz cell correspondences. In this paper, we will likely outline an important effective steering calculation for WSNs by taking consideration of adaptation to internal failure of the CHs. Especially, the disappointment of a CH upsets the correspondence with its part sensor hubs as well as with different CHs as they are associated with steering collected information to the sink through different CHs [10]. The outcomes demonstrate that our proposed protocol and subsequent calculation performs superior to the previous calculations regarding the quantity of dead CHs, add up to important utilization of the system, the quantity of information bundle transmitted to the BS and standard deviation of residual important of the entryways amid the system lifetime. Likewise, the two techniques utilize either geological directing [7] or topological steering [8], [9], which expend a lot of important by depending on position data created by GPS or a virtual coordination strategy [10], [11], [12] or flooding to find and refresh directing ways. Along these lines, the overlay isn't steady with the hidden physical topology and multi-jump directing must be utilized for the correspondence between two neighboring Kautz hubs in MANETs. In numerous uses of WSN, CHs are picked among the typical sensor hubs, which may attack the succeeding node because of quick exhaustion for such additional node. The greater part of the directing conventions for versatile improper systems (MANETs) and WSNs treat each hub similarly and neglect to use the abilities of asset rich gadgets to diminish the correspondence trouble on low-asset sensors. The calculation depends on

1) Cost work
2) The packets that are acknowledged negatively, and
3) the separation of next-node from the BS.

3. Survey of Kautz Graph Methodology

3.1 About Kautz Graph

The Kautz graph is a directed graph. The directed graph here refers to the movement of the path with the knowledge of behavior of succeeding node while the resource is at the present node. We define this with an assumption that let the degree J and dimension I+1, which has (J+1)\(^I\) vertices labeled by all possible strings \(s_0, s_1, s_2, s_3, s_4, s_5, s_6, s_7, \ldots \ldots \ s_J\). Now, this \(s_0, s_1, s_2, s_3, s_4, s_5, s_6, s_7, \ldots \ldots \ s_J\) are supposed to be composed of nodes \(s_j\), chosen from an alphabet \(A\) containing \(J+1\) nodes. \(J+1\) nodes are subjected to the condition that adjacent nodes in the entire traversing path cannot be equal

\[
i.e. \ s_j \neq s_{j+1}
\]

Referring to the figure below, the Kautz graph has \((I+1)J^{J+1}\) edges

\[
i.e. \ \{(s_0 s_1, \ldots s_i, s_{i+1}) \mid s_i \in A \ s_j \neq s_{j+1}\}
\]

It is natural to label each such edge of as \(s_0, s_1, \ldots \ s_i, s_{i+1}\), giving a one-to-one correspondence between edges of the Kautz graph and vertices of the Kautz graph.
4. The Proposed Energy Model

Continuing the introduction and related works in section 1. and 2. above, we start with the following parameters before proposing our new model:

1) Action detection using sink node, which will be referred as SN (Actuator)
2) Analyze and Application of Kautz Graph Theory to realize the sensed data to be sent to the actuator
3) Pre-fault detection
4) Fault Tolerance

Let the energy consumption be $E(x; y)$.

**Pre-requisites:**

$E(x; y)$ is used to sense the bit data from $x$ to it’s neighboring node (here in this case we have assumed it as ‘$y$’). As we aware, there are four issues related with the energy consumption.

1) path loss between the nodes depending on the transmission environment / impairments
2) energy used by receiving nodes (here ‘$y$’)
3) energy consumed while processing the signal within the channel
4) fault detection at the succeeding node (if any) (here it is ‘$y$’)

We now define the above energy consumption mathematically as below: -

$E(x, y)$ has four parts as per the pre-requisites defined above which can be equated as below: -

$$ [1] $$

where

$d(x, y)$ is the Kautz based nodal distance between $x$ and $y$

– denotes the nodal distance with path loss denoted by $l$
– are the assumed constants that occur due to the issues mentioned in the pre-requisites above i.e. path loss between the nodes depending on the transmission environment / impairments; energy used by receiving nodes (here ‘$y$’); energy consumed while processing the signal within the channel.
– represent the energy used by receiving node where $K_d$ is again a constant which occur while receiving i.e. transmission impairments or electronic dissonancy likely to occur at receiving node.

Most importantly, we assume that for every succeeding nodes i.e. for every neighboring node (here ‘x’ to ‘y’), the sensor nodes have the same $K_b$, $K_c$, and $K_d$.

Definitions: -

With reference to the figure 1 above, we see that the most of the nodes use random mode (any prescribed scheduling algorithms) to transmit the information. But when it senses a neighboring node with some abnormal behavior for e.g. delay in acknowledging the previous node, then it changes to sidestep mode once the information transmits through a directing opening. From the Figure 1, we also see that there is no such a hub closer to the current node (e.g., such an issue exists for hub ‘x’ towards goal ‘y’). Previously, GPSR, Greedy-Face-Greedy (GFG) and Greedy Other Adaptive Face Routing (GOAFR++) were tremendously used for such a kind of fault tolerance; however, they misused in confronting directing plan to opt out the alternative openings, while doing not identify them before information conveyance. Nonetheless, the right-hand lead takes into consideration counter-clockwise sidestep traversal and the left-hand control takes into account clockwise sidestep traversal, implying that them two just stroll along one side of the steering openings for course recuperation.

Figure 1 also depicts the utilizing such two standards. Firstly, the one that bypasses a steering opening by sending the information to the hub that is first crossed by the arriving edge of the packet counterclockwise and secondly clockwise. The fundamental issue is to linearize the system utilizing a calculation like path loss between the nodes depending on the transmission environment / impairments, energy used by receiving nodes (here ‘y’), energy consumed while processing the signal within the channel and fault detection at the succeeding node (if any) (here it is ‘y’).

Relative Neighborhood Graph (RNG), or Gabriel Graph (GG) [4] and after that forward messages to the goals by utilizing the right-hand control or left-hand manage [4], [6] along one or conceivably a succession of adjoining faces which all situate in the one side of the line from the source hub to destination1. To accomplish our plan objective, there are no less than three issues to be tended to for the current geographic directing. Second, how to sidestep directing gaps for stack adjust. To begin with, how to recognize happening in directing will produce long way and henceforth devour extra asset. There are no less than two ways along the opposite sides of the directing opening, i.e., $u$-$w_1$-$w_2$-$w_3$ $v$ in Figure 1.
5. The Methodology

Before defining the proposed protocol, we go through with the following definitions, which are based on the discussion made on the preceding sections:

**Definition 1.**
If \( E(x, y) \) is the energy consumption and \( E(x, y) \leq E_0(x, y) \),

then do

*direct transmission is the most energy-optimal way for data delivery from node \( x \) to node \( y \)*

for \( x \ y \)

else

\( \text{opt } d \)

end do

**Definition 2.** If \( E(x, y) \) is the energy consumption and \( E(x, y) > E_0(x, y) \),

then minimize

till all the hop distances are equal i.e. \( d(x,y) \) must be having equal nodal distance between \( x \) and \( y \)

Check if is occurring

Initialize the actuator

choose the optimal routing hops

**Definition 3.**
If \( d(u; v) > d_{opt} \), \( c(u; v) \) is minimized when all hop distances are equal to \( d(u; v) = d_{opt} \), and the optimal routing hops \( N_{opt} = bd(u; v) = d_{opt}c \) or \( dd(u; v) = d_{opt}e \). Lemmas 1 and 2 show that \( d_{opt} \) is the energy-optimal forwarding distance for minimizing \( c(u; v) \). This observation motivates us to introduce the concept of energy optimal relay region (see Definition 2) for energy conservation.

**Definition 4.**
The ideal relay location \( f_u \) for node \( u \) is defined as the location on the straight line from node \( u \) to the anchor node or destination \( v \), where \( d(u; f_u) = d_{opt} \).

**Definition 5 (Relay Region).** The relay region \( r(u; v) \) for node \( u \) is defined as the circle area centered at \( f_u \) with radius \( r(u) \), where \( r(u) = d(u; f_u) = d_{opt} \). In order to make Definitions 1 and 2 clear, as shown

6. Proposed Algorithm

**Algorithm 1**: Sensing the fault using Kautz burst packet method through an actuator \( \Phi \).

**Input**: source node \( x \), destination \( y \)

1: \( \text{List}(x; y) = [\text{flag}; \ y] \)

Sensor node and actuation:

2: \( x \) get initializes

3: \( x \) sends a burst packet to \( y \) attached with \( \text{List}(x; y) \)

4: if \( y \) in the succeeding node receives the packet then

5: \( \text{UPDATELIST}(wi; \ \text{List}(x; y)) \)

6: end if
7. Results And Discussions

There are three kinds of packets: beacon packet, burst packet, and data packet in our scheme. The beacon packet is used to exchange location information and residual energy among neighbors, while burst packet is used for finding the anchor lists. Fig. 4 presents the format of the burst packet. Specifically, it includes anchor lists, the locations of source node and destination. The anchor list contains a series of anchor nodes, and a flag field which indicates whether this packet bypasses the routing holes by employing the right-hand rule or left-hand rule. In addition, it includes a temporary void node in each bypass mode but is deleted finally if it violates the determined rules of anchor nodes. Here, the void node is defined as the node that switches to bypass mode from greedy mode, i.e., the node (e.g., node u in Fig. 1) which cannot find a neighbor being closer to the destination than itself, even though there is a path from the source node to destination in the network.

![Figure 4: depicting the comparative analysis](image-url)
8. Comparative Analysis

Table 1: depicting the comparative analysis

<table>
<thead>
<tr>
<th>Metrics</th>
<th>Number of nodes alive over simulation period</th>
<th>Energy consumption over simulation period (J)</th>
<th>Percentage Energy consumption over simulation period</th>
<th>End to end delay (ms)</th>
<th>Message overhead (bytes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ESRP</td>
<td>37</td>
<td>72</td>
<td>36%</td>
<td>2800</td>
<td>450</td>
</tr>
<tr>
<td>LDTS</td>
<td>20</td>
<td>192</td>
<td>96%</td>
<td>3200</td>
<td>600</td>
</tr>
<tr>
<td>SLEACH</td>
<td>30</td>
<td>144</td>
<td>72%</td>
<td>2400</td>
<td>480</td>
</tr>
<tr>
<td>SEDR</td>
<td>26</td>
<td>164</td>
<td>82%</td>
<td>3000</td>
<td>525</td>
</tr>
<tr>
<td>SERP</td>
<td>10</td>
<td>184</td>
<td>92%</td>
<td>3400</td>
<td>630</td>
</tr>
</tbody>
</table>

9. Conclusion

In conclusion, we have discussed about the issues of energy for all networks, especially the consumption and optimized utilization of energy. We have presented our definitions for energy efficient protocol and rigorous simulations have been worked out with relevant evidences for fault detection too. This paper proposes a discrete solution for pre - “fault tolerant prevention” using energy efficient awareness. Finally, in this paper, we have designed a protocol, which selects succeeding node in energy efficient manner; and if in case of its failure, sensitively restores the connectivity of the neighbors of a cluster around that node.

References:


