ISSN: 2454-9940

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

E-Mail :
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INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940www.ijsem.org

Vol 11, Issuse3,July 2020

Optimisation and Computing (ICMOC 2012) International Conference on Modeling Energy Efficient Node Disjoint Multipath Routing in Wireless Sensor Networks: A Reliability Analysis of the Route Redundancy Model

PANNEERU DEVI[1] , THATIPAMULA APOORVA[2] , BAPANAPALLI NAGALAKSHMI [3]
PONUGOTI AKHILA[4]
SUPERVISOR , M SHAILAJA

Abstract

Every node in a sensor network works toward a common goal: relaying the phenomenon data it has observed to the sink node. Optimal route selection is a common feature of many routing algorithms designed for sensor networks. Nodes following this ideal route have high consumption, leading to their premature demise. Reliability of paths is crucial in multi-path routing.is high since there are many routes outside the best ones. This paper presents a theoretical framework for investigating the route redundancy model for node-disjoint multipath networks in wireless sensor networks, with the aim of improving the network's dependability. Probability values and the dependability of route redundancy in single and multiple pathways with varying numbers of nodes are explored.

Keywords: *Route Maintenance, RouteReliability, NodeDisjoint, MultipathRouting, WirelessSensor Networks*.

Introduction

Development of networks of low-cost, low-power, multipurpose sensors has attracted increased interest in recent years due to advancements in wireless communications and electronics. Wireless sensor networks (WSN) study draws from several fields. It helps solve problems in many different areas, including the application domain, hardware, and software. efficient system requires robust network and communication infrastructure. Sensor node design was aided by recent developments in low-power, short-range transceiver, processor-unit, and power-unit technologies [1]. Wireless sensor networks (WSNs) are a kind of MANET in which a certain number of exceedingly small, self-sufficient devices known as wireless sensor nodes are networked together. An event or phenomenon may be detected, data collected, and sent to a sink node using a sensor network. Sensor networks arecharacterized by their limited energy, transmission power, memory, and computational resources as well as their dense deployment, self-organizing capabilities, short range broadcast communication, cooperative effort of sensor nodes, multi hop routing, and frequently changing topology due to fading and node failures.

Associate Professor[1,2,3,4]
ANURAG ENGINEERING COLLEGE
AUTONOMOUS
(Affiliated to JNTU-Hyderabad,Aprroved by AICTE-New Delhi)
ANANTHAGIRI (V) (M), SURYAPETA (D), TELANGANA-508206

ISSN2454-9940www.ijsem.org

Vol 11, Issuse3,July 2020

Many small sensor nodes work together to form a WSN. These sensor nodes may talk to one another and relay data to the sink node in a single hop or over numerous hops. All the sensor nodes in the network eventually make their way to the sink node. Sink nodes link sensor networks to either pre-existing communication infrastructure or the internet, from which users may get the collected data [2]. Sensing units, processors, transceivers, mobilizers, a positioning system, and power units are the basic components of a sensor node. In a low-resource setting, it is still difficult to get the sensed data from the source to the sink node. The best route between the source and the sink is determined using metrics like the information gradient, the shortest possible hop, the lowest possible transmission cost, the highest possible residual energy, etc. [3]-[6]. To extend the life of their networks, several routing protocols aim to decrease node energy consumption [7]. This creates the best possible route between the starting point and the ending point. The network's lifespan may not be improved by choosing the shortest way between the source and the destination and transmitting the data through that route. When compared to multi-path routing strategies, such a method wastes more energy. The possible numerous pathways between the source and sink node are selected by the multi-path routing protocols [8]. Multi-path routing has a higher overhead than single path routing due to route finding. However, multi-path routing reduces the need to constantly find new routes since it allows the network to continue functioning even if some of the pathways between a source and destination become unavailable [9]. While a primary link is down, the data may still be sent over the backup way thanks to the route maintenance mechanism. In this research, we offer an analytical model for enforcing routes in a disjoint multipath routing protocol that conserves energy on the nodes. (EENDMRP). There are three types of route redundancy covered: single-node redundancy over a single path, multi-node redundancy over a single path, and multi-node redundancy over a single path. This paper's remaining sections are structured as follows. In Part 2, we analyse the secondary sources. Section 3 provides an overview of the EENDMRP. We offer a node-disjoint multipath routing reliability study for WSN in Section 4. The findings are described in Section 5. In the last part, we make some conclusions.

Related Works

Ad hoc On demand Multipath Distance Vector (AOMDV) is a technique that Marina et al. It is a technique for discontinuous multipath routing that is begun at the source and is reactive at the node/link level. To find numerous routes between the source and the destination during each route discovery, AOMDV expands upon the Ad hoc On demand Distance Vector (AODV) protocol. The network's disjoint Ness and lack of loops are ensured by computing several pathways across it. The primary motivation behind AOMDV's design was to provide rapid and reliable route restoration in the event of a route breakdown. In AOMDV, Route Error (RERR) packets are used for route management. An RERR packet is sent by an intermediate node when it learns of a link failure (through link-layer feedback). All sources of traffic that rely on the failing connection will have their broken routes removed once the RERR packet makes its way to them. After getting the RERR, a source will perform a fresh route discovery if it is still in need of the route. AOMDV additionally has a timer-based approach to automatically remove obsolete routes. Small timeout settings are used by AOMDV to prevent routes from becoming obsolete. This may reduce the efficiency gain from using alternative routes. When removing outdated routes, AOMDV uses a reasonable timeout value and control messages to do so proactively. To boost QoS in event-based wireless sensor networks, Marjan Radi et al. [11] presented a Low-Interference Energy-Efficient Multipath Routing Protocol (LIEMRO). By finding numerous pathways between the source and sink nodes that minimize interference, this protocol aims to improve packet delivery ratio, lifespan, and latency. An error is sent to the sending node if the receiving node on an active link fails to receive a Clear to Send (CTS) packet or an Acknowledgement (ACK) packet from the next hop node within k tries. (Through the reverse path). When an error message is received, the sending node will switch off the path it came from and reroute traffic via other channels. A Node Disjoint Multipath taking Link and Node stability Routing (NDMLNR) protocol was suggested by Upadhyayaet al. [12]. The purpose of NDMLNR is to improve the network's quality of service. A node will notify its predecessor node through a message that it is unable to take part in routing if its connection stability drops below the link stability threshold. Disable that route, the predecessor sends

ISSN2454-9940www.ijsem.org

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a signal to its source node. After that, the sending node takes the data packets along the secondary route. If there is no other available route, the node that initiated the search must begin the process again.

Overview of the EENDMRP

The EENDMRP protocol is an active, sink-initiated, node-disjoint multipath routing method. Based on the number of hops between the source and the destination, EENDMRP assumes that a WSN has a certain number of stages Sti, I = 1, 2, l. The drain is a St0 node, or stage zero. In St1, all the nodes may talk to the same "sink" node. A Sti is assumed to be anEach node can talk to other nodes on the same stage (Stage I) and the following level up (level i+1). However, it is not possible for it to talk to Sti1 nodes. This eliminates the possibility of circular routes developing. Except for the sink node, every other node in the network has an extremely high hop count number in the outset. At the outset, the residual energy of every node is greater than the threshold energy. During the route creation phase, many routes are produced from each node to the sink. Route Construction (RCON) packets are sent back and forth between the nodes during this time. Every sensor node has its own routing table and will only transmit the RCON packet once. The node that receives the RCON packet checks its routing tables and handles the packet if there is a path to the sink. The hop count is checked to see whether the route to sink from that node is already in the node's routing database. The packet is processed by RCON if its hop count is less than the node's hop value and its residual energy is more than the threshold energy value. The receiving node will make changes to the RCON packet. Whenever the RCON is updated, the hop count is increased by one, the forward node id is changed, and the node id is appended to the path. When a node gets an RCON packet, it modifies its routing database to reflect the added information. The RCON packet is broadcast to all network nodes, who in turn update their routing table. When all potential pathways between a source and a destination have been produced, the node-disjoint multipaths are found. When sending the sensed data to the destination, the source node divides the traffic across the node's discontinuous multipaths, considering the node's residual energy and the length of the queue that has already been filled. When a routing failure occurs due to a node's death or relocation, the source node is notified through the RERR packet.

Route Maintenance in EENDMRP

The process of route maintenance is shown operating in Figure 1. Node two and node three are no longer connected. Any connection may fail at any time during the data transmission phase due to factors like physical misplacement of node or node energy being below the threshold energy value. The second node then forwards the RERR message to the information origin. It also transmits to any sources that use that node as a gateway to the sink node. To determine the optimal route to the sink node, node 2 looks up all of the possible routes to the sink node in its routing database. The second node then creates the RERR message and relays it to the first node. If there was a problem with the connection between the source and destination nodes, the RERR message would explain what happened. After receiving the RERR message, the sending node will remove the failed route from its routing database. Information packets leave their original source node and are redistributed to the remaining pathways.

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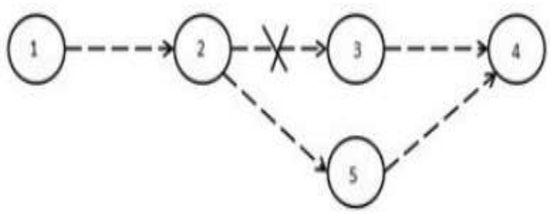

Figure 1: Route Construction Phase in EENDMRP

Reliability analysis of Route Redundancy for Node Disjoint Multipath Routing for WSN

It is critical to enhance the throughput of WSN routing methods. If a node's remaining energy drops to zero or if the received signal intensity is exceptionally low, the connection will be severed. When the residual energy of a node drops below the threshold energy value or the received signal strength of a node is low, the communication connection breaks and the dependability of the channel declines in various WSN applications.

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940www.ijsem.org

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Single node level redundancy over single path

Let us assume that there are M intermediate nodes on the way from the source to the sink. The number of hops between the source and the sink node is M 1. In a route, the reliability Rs is the chance that each node is functioning well or data via the node reaches its destination if the node I and j are not directly connected. on to the node that will receive your data after this one. Given that pm is the likelihood that node m is operational,

$$R_{sl} = 1 - (1 - \bar{p}_m)$$

Multi-node over single-path redundancy at the single-node level

The reliability R small is the likelihood that data via the multi-level node reliably reaches the next hop node, and it is defined as follows: Suppose a single node in a route has multi-level single node redundancy between the nodes I and j.

by,

$$R_{sml} = 1 - \prod_{u=1}^{U}(1 - p_u)$$

Redundancy at the level of a single node through intermediate nodes at many levelsIf there is more than one node with more than one level between nodes I and j along the way from source to sink node, then the dependability of the whole path will increase. Rimmel measures how likely it is that information sent from one node will reach the hop reliably and is bestowed by,

$$R_{mml} = 1 - \prod_{u=1}^{U}(1 - \prod_{v=1}^{V} p_{uv})$$

where V is the total amount of nodes and pub is the likelihood that nodes at the youth level will function as expected. Let us suppose there are M hops in a route so that the analysis is more realistic and meets all the conditions in the node redundancy, including multichip nodes with varying probabilities between the current hop and the next in the path. nodes along the route from the source to the sink. There is the potential for multichip redundancy at every node. The certainty of a road R p is, if the nodes between the hops on any level have different probabilities,

$$R_p = \prod_{u=1}^{U}(1 - \prod_{v=1}^{V}(1 - \prod_{h=1}^{H} p_{uvh})) \prod_{m=1}^{M-uv} p_m$$

where H is the total number of hops in the youth level and punch is the likelihood of all nodes in that level functioning correctly. In a node-disjoint multipath network, the reliability (R) that data received from the source node always reaches the destination node is, if the number of routes between the source and destination is K.

$$R = 1 - \prod_{k=1}^{K}[1 - \prod_{u=1}^{U}(1 - \prod_{v=1}^{V}(1 - \prod_{h=1}^{H} p_{uvh}))] \prod_{m=1}^{M-uv} p_m$$

Results and Discussion

To assess the dependability of the network, simulations are run in MATLAB R2008a. Here we examine how well redundant pathways operate in a fragmented multipath network with nodes. At first, we look at how the redundancy of a route affects its dependability. The work is limited to the first five layers of redundancy in a route for the sake of simplicity. The sum between 2 and 8 nodes along a route. The probabilities of the nodes are chosen to be in the range of 0.5 to 0.9. Using redundant pathways, the dependability of a node-disjoint multipath network may be evaluated. It is assumed that 2, 3, and 4 routes exist between the source and sink nodes. Again, the probabilities at each node are fixed at values between 0.5 and 0.9. The probability of a route Pi when the node probabilities are 0.5, 0.7, and 0.9 are shown in Table 1. Table 1 shows that when the number of levels is large and the number of nodes is small, the route dependability is also large. At redundancy level 1, the route dependability is 0.25 when the probability of a node is 0.5 and the number of nodes is two. The path dependability is 0.7626 as the level rises to five. The route probability rose by 205% while going from two redundancy levels to five. The percentage improvement in route dependability drops from 98.5% to 97.45% while going from 2 to 8 nodes in a path. The dependability of a route is 0.0193 when there are eight nodes in the network and a redundancy level

INTERNATIONAL JOURNAL OF APPLIED SCIENCE ENGINEERING AND MANAGEMENT

ISSN2454-9940www.ijsem.org

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of five. This is much lower than the redundancy levels 1 and 2, and the node count is just four. This finding suggests that a smaller number of nodes in redundant paths with higher redundancy levels are required to achieve good route dependability.

Figures 2 and 3 illustrate this point.

Likewise, Table 1 demonstrates that a path's dependability is greatest with two nodes and five levels. The route reliability is 0.9654 and 0.9997, respectively, where the node reliability is 0.7 and 0.9, the number of nodes in the path is two, and the redundancy levels is five.

Table 1: Path Reliability for differentnode reliability and levels

Node Probability	Number of Nodes	Number of Levels				
		1	2	3	4	5
0.5	2	0.25	0.4375	0.5781	0.6835	0.7626
	4	0.0625	0.1210	0.1760	0.2275	0.2758
	6	0.0156	0.0310	0.0461	0.0610	0.0757
	8	0.0039	0.0077	0.0116	0.0155	0.0193
0.7	2	0.49	0.7399	0.8673	0.9323	0.9654
	4	0.2401	0.4225	0.5611	0.6665	0.7466
	6	0.1176	0.2214	0.3130	0.3938	0.4651
	8	0.0576	0.1119	0.1631	0.2114	0.2568
0.9	2	0.81	0.9639	0.9931	0.9986	0.9997
	4	0.6561	0.8817	0.9593	0.9860	0.9951
	6	0.5314	0.7804	0.8971	0.9517	0.9774
	8	0.4304	0.6756	0.8152	0.8947	0.9400

Table 2: Reliability of nodedisjoint multipath networkwhen, number of levels is two for different node probability

Node Probability	Number of Nodes	Number of Paths		
		2	3	4
0.5	2	0.6835	0.8220	0.8998
	4	0.2275	0.3210	0.4032
	6	0.0610	0.0901	0.1183
	8	0.0155	0.0232	0.0308
0.7	2	0.9323	0.9824	0.9954
	4	0.6665	0.8074	0.8888
	6	0.3938	0.5281	0.6326
	8	0.2114	0.2997	0.3781
0.9	2	0.9986	0.9999	0.9999
	4	0.9860	0.9983	0.9998
	6	0.9517	0.9894	0.9976
	8	0.8947	0.9658	0.9889

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When the probability of a node is 0.5, as illustrated in Figure 4, the network is reliable. It also demonstrates that when there are four pathways in a network and two nodes in each path, the network dependability is 0.8998. The network reliability is 0.0308 when there are four pathways and eight nodes in each path. This is a tiny fraction of what that to situations when there are exactly 2 or 3 pathways and exactly 2 or 4 nodes on each path. This means that the greatest number of disjoint multipaths between the source and sink nodes should be large and that the minimum number of nodes in a path is optimal for good network resilience.Figures 5 and 6 demonstrate the same thing about how dependable a network is with two nodes and four discontinuous pathways between them. Number of nodes in the route is two when node reliability is 0.7 and 0.9 when node reliability is 0.9.

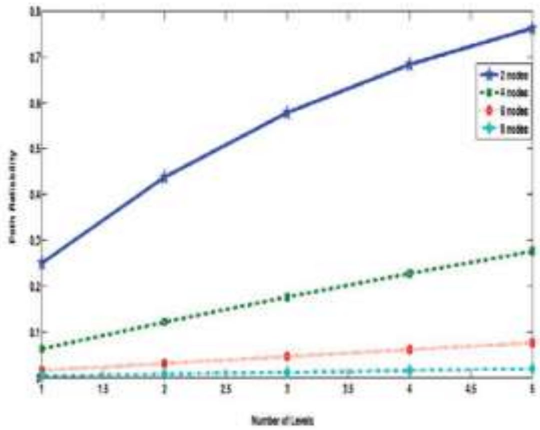

Figure 2: Path Reliability when the node probability is 0.5.

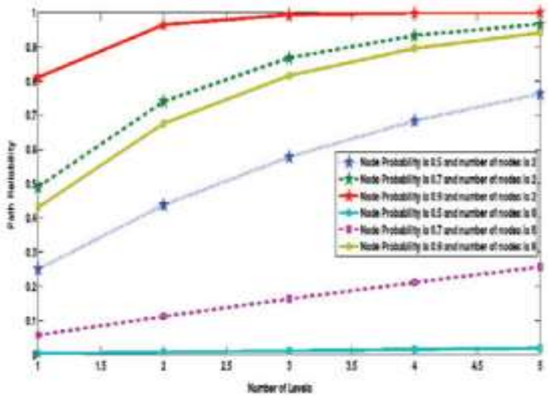

Figure 3: Path Reliability when the node probability is 0.5,07 and 0.9 &number of nodes is 2and 8.

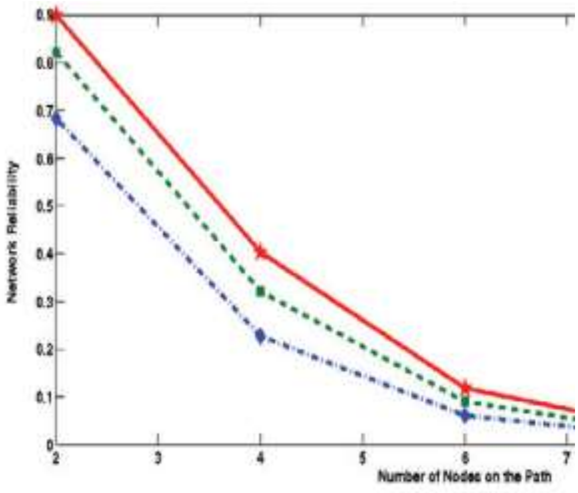

Figure 4: Reliability of node disjoint multipath network when, number of levels is two and node probabilityis 0.5.

Conclusion

It is recommended to have as many pathways as possible between the source and the destination to increase network resilience through redundant paths. Each redundant route must contain at least the required number of nodes.

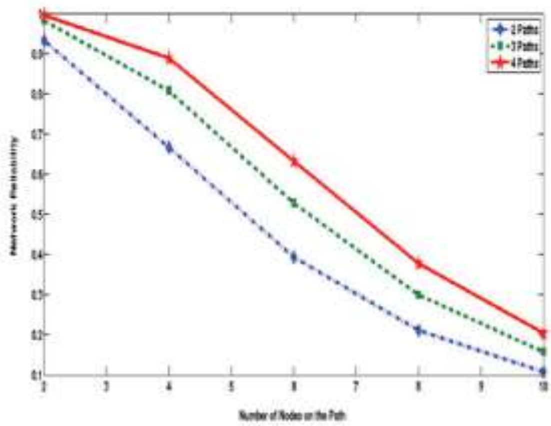

Figure 5: Reliability of node disjoint multipath network when, number of levelsis twoand node probabilityis 0.7.

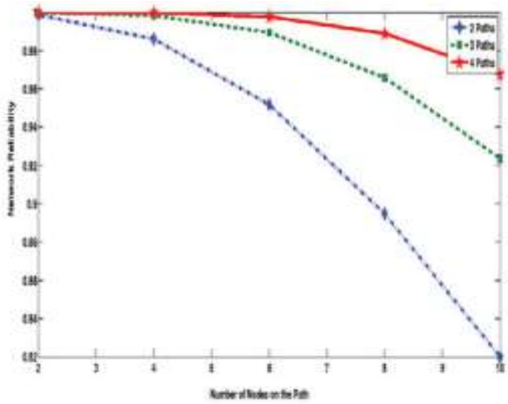

Figure 6: Reliability of node disjoint multipath network when, number of levelsis two andnode probability is 0.9

When each node disjoint route has the largest number of redundant pathways and the least number of nodes in each redundant path, network reliability is maximized in node disjoint multipath networks. With two nodes and four pathways, network reliability in a node-disjoint multipath network is particularly good. Linked system When there are eight nodes and two routes, dependability is poor.

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