A Survey on Fault Tolerant Multipath Routing Protocols in Wireless Sensor Networks

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Received: 10 April 2015 Accepted: 2 May 2015 Published: 15 May 2015

Abstract

Wireless Sensor Networks (WSNs) consists of large number of energy constrained sensor nodes that are randomly deployed. Sensor nodes have the ability to sense and send data towards the base station (BS). Sensor nodes require large amount of energy for data transmission. So while transmission, some nodes die because of energy depletion. In this case, chance of data loss increases. In order to reduce the data loss fault tolerance technique are used. To provide fault tolerance some Multipath Routing Protocol (MRP) are proposed, which can be classified in two ways i.e. alternative path routing or retransmission and concurrent routing protocol or replication. In MRP, multiple paths are used to send data from source to destination, where if one node fails during data transmission, another node can be used to transmit the same data to the destination by following other optimal path. In this paper we survey various multipath routing protocols along with their fault tolerance schemes and compare each protocol with various parameters.

Index terms— WSN, fault tolerance, multipath routing protocol, retransmission, replication

1 Introduction

ireless sensor networks have currently research attention due to its large area of significance that are not under the human control. It is a wireless network comprising of huge amount of static or mobile sensors. Inside a WSN, the sensors autonomously associate to sense, collect, process data and transmit those sensed data to some specific data processing centers. These characteristics along with self-organization and self-configuration capabilities of sensor nodes make WSNs very promising for applications in many different fields. WSNs are interesting from an engineer perspective, because they present serious key design challenges. Sensor nodes are battery driven and hence operate with a limited energy resource. In large and dense sensor networks it is not feasible to replace batteries when a sensor node is down. In practice, it will be necessary in many applications to provide guarantee that a network with unattended wireless sensors can remain operational without any replacements for several years. For instance, in forest and unreachable areas, such as the Antarctica or the deepest zones of the Atlantic Ocean, sensors can be easily deployed in order to form a large-Author: Department of Computer Science and Engineering Punjab Institute of Technology Kapurthala, PTU Main Campus Kapurthala (Punjab), India. e-mail: dhir.balwinder@gmail.com dense sensor network and sense seismic waves, temperature or other parameters as well. In these scenarios, the replacement of the battery of a sensor node would be highly expensive.

Nodes in a wireless sensor network has to be able to configure their own network topology; localize, synchronize, and calibrate themselves; coordinate internode communication; and determine other important operating parameters. They also must be able to adapt themselves to the environmental conditions and unexpected situations in order to keep the performance negotiated and have a robust network. After deployment it is common in wireless sensor networks having topological changes due to changes in position of sensor nodes, ability to reach, available energy, and device failure or energy depletion.

The routing protocol cannot be directly applied due to existing design challenges in WSN like energy consumption, node deployment, Quality of services (QoS) data aggregation and node mobility in the ad hoc network or cellular network. For example if we want to deployed the large number of sensor nodes in WSN, then it will not possible to build a global addressing scheme as the overhead of ID maintenance is high. We have already discussed about the sensor nodes that sensor nodes depends upon energy for its activities, thus if one node fails or link breaks due to its limited battery lifetime, then it will affect the entire network, hence a careful resource management is required. To provide fault tolerance the routing protocol should be designed. Due to fault tolerance mechanism the data loss should be reduced, and it will also increase the reliability of the network which is most important. It is essential to specify the contrast between faults, errors, and failures. Various definitions are used about these terms. From survey "A fault is any kind of imperfection that leads to an error." "An error refers to mistaken (undefined) system state. Such a state may lead to a failure". "A failure is the disclosure of an error, which occurs when the system drifts from its statement and cannot deliver its purposive functionality".

In this paper also focused on the metrics to enhance the reliability of WSN by using multipath routing. Here in this paper the existing technique of fault recovery also classified in to retransmission and replication. In our survey we also describe the Year ( ) G advantages of using multipath routing protocol along with their fault tolerant mechanism to increase the WSN reliability issues. The rest of the paper is organized as follows. Section II. Focus on different mechanisms to provide fault tolerance. Further, section III provides the work related to fault tolerant routing techniques. Finally section IV concludes this paper.

2 II.

3 Mechanism to Provide Fault Tolerance

Fault tolerance ensures that a system must be work in the presence of fault without any interruption. Fault tolerance increases the availability, reliability and consequent dependability of the system. Here are many approaches for fault tolerance is there but the most popular approach is multipath routing. In multipath routing there are multipath between source nodes and the sink have the highest energy to consume and traffic generation. There are some additional benefits of multipath routing i.e. bandwidth aggregation and load balancing.

We can classify the routing protocol for WSN [1,2] in to groups on the basis of find the path, proactive routing where computing and maintenance of path should be done in advance and store in the routing table, reactive routing where path paths are created and demanded.. There are two mechanisms [6] used to create multiple paths:? Disjoint multipath ? Braided multipath

In Disjoint multipath a number of additional multipaths are created which are joined to primary path by node/link disjoint and with other additional path. Thus if failure arise at any instant of time that does not affect he additional path. The additional path consumes more energy than primary path because they have longer latency. So if this multipath scheme is used in the network with K node/link disjoint routes from node to sink that can tolerate at least K-1 network failure.

In Braided multipath an additional path is created for each node, in primary path that doesn't include that node. This additional path are not much more expensive then the primary path, In case of latency and overhead. Here if all of the nodes on primary path fails then additional path can e used.

4 Multipath Routing in WSN

Due to the high potent of wireless links and limited capacity of a multi-hop path [5] and the [3,9], single-path routing approach is impossible to provide remarkable high data rate transmission in WSN. At present, the multipath routing approach is employ at high level as one of the possible solution with limited sources.

Multipath routing can be divided in two ways:

? Alternate path routing or Retransmission ? Concurrent path routing or Replication

5 a) Alternate path routing or Retransmission

Alternate path routing or Retransmission is one of the most popular mechanism, if the data packet is not transmit to sink successfully, then the source node retransmit the data packet on multiple path by using the minimum hope count and minimum energy consumption depending upon the requirement of network. In the process a source node send data packet to sink and if the data packet successfully received by the sink then the sink send the acknowledgement back to source node as reply. If sink node does not send the acknowledgement and sender does not receive the acknowledgement before time out, it means that data packet is not reached at the sink, and sender retransmit the data packet. In WSN packet loss rate is high then other networks. So the retransmission is very popular mechanism.

But there are some drawbacks of this method i.e. It increases the traffic on network. Delivery delay is due to acknowledgement message. Large memory space is needed to buffer the data packet until the sensor does not receive the acknowledgement. Objectives: 1. To provide fault tolerant routing. 2. To reduce the frequency of route rediscovery process.

6 b) Concurrent path routing or Replication

Concurrent path routing or Replication means the redundancy. To introduce the redundancy into delivery of the data packet [8] is another mechanism that s used in fault tolerance routing protocol in WSN. By this mechanism to ensure the delivery of original data packet to sink, transmit multiple copies of the original data packet at the multiple path in order to recover from the path failure this mechanism have major drawbacks, i.e. it introduce

7 Related Works

The main idea of this paper is to study about the current state of fault tolerant routing techniques.

8 a) Alternate path routing or Retransmission based schemes

In this section, retransmission based routing protocols are described and culminate the key ideas. Directed Diffusion (DD) [4] is supposed to be as one of the important routing protocol. There are many other routing protocol that that are act as directed diffusion protocol or use the same concept. The main idea of this protocol is that interest message is broadcast by sink that cyclically refresh along the network, a query is contained in this packet called information that the sink wants to request from the sensor nodes. When interest packet is received by the nodes, all nodes existing in the network catch the packet and store it to the memory then flood to their neighbor nodes to ensure that they get the packet or not. Each node in the network generates the Gradient which includes the direction in which the data will be send and the values of data rate. When a node found data then it compared with the information that it store in the cache, if it matches the node is supposed to be the source node and it cyclically broadcast a message at low rate to ensure sense the data. When the sink receive many detection events, which means there are multiple paths that are going to source, it broadcast a reinforcement message to one path which have the least delay by enhance the data rate in the interest packet.

Fault tolerance: if the reinforced path fails then the sink will not sense or detect any data. For rerouting the lost data it reinitiates the reinforcement message. Here to provide a fast recovery from the path failure the sink must be cyclically broadcast the reinforcement message to hurriedly found the additional path that created on the demand of this case. Since this protocol is based upon the query driven data delivery concept, so it can works for such application that are based upon environment monitoring and requiring the continuous data delivery to the sink. This protocol is not be supposed as the energy efficient protocol. Sensor nodes may also introduce the overhead by the matching data and queries.

Informer homed routing protocol (IHR) [21] for WSN. This protocol is to prevent from the data loss, and to increase the data reliability. There are two cluster heads are choose based upon the energy called primary cluster head and the backup cluster head. The backup cluster head is used when the failure occur and have less energy than the primary cluster head. Sensor nodes send the data to the primary cluster head then primary cluster head send it to the sink. Backup cluster head receive the beacon message it means that the primary cluster head is alive. If beacon messages stops received to backup cluster head it means that primary cluster head is fail.

9 Highly Resilient, Energy Efficient Multipath

Routing Protocol (HREEMRP) [7] for is based upon he directed diffusion concept. There are some multipath routing schemes that finds several moderately disjoint paths, these are not the disjoint path, alternatively they are braided multipath for maintain the multipath to keep the low cost, and to rapidly recover from the path failure. The periodic flooding avoided by this protocol. Fault tolerance: When a path failure occur, the beacon message stop received that are send by the primary cluster head to backup cluster head. Backup cluster head wait for particular time period after then it again retransmit the data packet which are interrupted due to the failure. Finally the traffic move to the backup cluster head. If the service path set up again, then the traffic back move on it.

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Fault tolerance: Multipath between source node and sink set up by network, one path is known as the primary b) Concurrent path routing or Replication based schemes Now a days the research provide us such protocols by which we can send the data packet over multipath to get reliability. In this section, retransmission based routing protocols are described and culminate the key ideas. [20,10]. In the functioning of this protocol the sink cyclically broadcast a routing update packet in the network by this each node become to know its neighbor node and the hop count to the sink. When the source node wants to send the data, it generates a packet with dynamic packet state (DSP) fields in the header that have the network condition (local channel error, hop distance to the sink, desired reliability).Multiple copies of the data packet are created to be sent on multipath to the sink (the number of these multipath is therefore a function of the reliability) depending on the desired reliability identified by the source node. To forward the packet each intermediate node uses the information in the DSP and decides how much number of copies of the data packet is sent over the multipath. Mostly, the intermediate nodes take decision of which neighbors to forward the packet to (usually the node which is closer to the sink are chosen, otherwise random nodes are chosen). This process continues until the data packet reaches the sink.

N to 1 multipath routing protocol [11] is proposed to converge cast the traffic at different path. The main purpose of these protocols finds multiple node disjoint path from all sensor nodes to sink simultaneously. Here it improves the data transmission reliability. N to 1 multipath routing protocol performed by a single flooding strategy in two phases called branch aware flooding and multipath extension flooding.

In branch aware flooding the all source nodes find the several paths to the single sink and update a route table. In addition, if an intermediate node overhears a route update message then this path will also add to routing table. In multipath extension flooding more paths are discover from source to sink. path from where the data route from source to sink and the additional path is maintained by the sending keepalive data continuously. Thus if primary path failed then nodes can recover quickly by reinforcing the other path to retransmit the data packets. In this case energy is consumed because all the paths from source to sink are created in advance and additional path maintained by sending the keep-alive data continuously. Fault Tolerance: Fault tolerance provided in the Rein Form by sending multiple copies of the same packet to the sink over randomly chosen paths. This duplication occurs at the source node or at every intermediate node in the network. Thus in this scheme a higher delivery ratio or overhead is reached. But the advantage is that if some data packet is lost by any reason then original packet can still be recovered from the other duplicated packets.

Fault tolerance: here the traffic can be introduced by data transmission from single path. To avoid this N to 1 discover an additional approach. By this each link between two individual nodes that belongs to different branches of spanning tree also establish an additional path. Hence the traffic split in to several segments.

H-SPREAD multipath routing protocol [12] is a combination of N to 1 multipath routing protocol and hybrid data transmission technique. H-SPREAD improves the reliability and secures the data transmission in WSN. It uses the threshold secret sharing scheme, and path discovery. H-SPREAD only improves the reliability and secure data delivery but it cannot secure individual nodes. [13] is based upon cross layer design between Mac layer and network to provide timeliness and reliability. From Here the reliability demand also be achieved. The delay requirements are satisfied through various applications. MMSPEED provides the different speed layer over a single network. The data packets are assigned to different speed layer and placed in the suitable queue by the speed category. The FCFS policy is applied here. This technique also ensures that data serviced according to their priority i.e. high priority packet are serviced before low priority packets. Because it is cross layer design between Mac layer and network so contention based Mac protocol utilize the CSMA/CA mechanism [18,19] to perform channel access, that employee the local priority data transmission at network layer not at the link layer.

11 Multipath multispeed protocol (MMSPEED)

Geographic progress when we send data packet through node B

12 Multi

constrained QoS multipath routing(MCMP) [14] is mainly designed to provide QoS in terms of reliability and delay. MCMP develop according to linear programming approach which defined end to end soft QoS problem by deterministic approximation. Using following equation MCMP maps the delay and reliability along different path to the sink node. (1)? ? ? = ?? ? ? ?**(2)**

Here L i d and ?????? represent delay and reliability requirements at node i. ?? ?? is delay by packet at node i.

?? ?? is fraction of reliability requirements assigned to path passing by node i. ? ?? is hop count from node I to sink. MCMP utilize the two strategies i.e. delay and reliability. The delay requirement of the intended application fulfilled when all intermediate node used equation 1. To choose the neighbor node during route discovery. To achieve reliability each node selects one or set of neighbor nodes which provide reliability toward the sink. Therefore, at route discovery each source node discovered the set of partially disjoint path that satisfy the delay and reliability demands. Energy constrained multipath routing protocol (ECMP) [15] is the enhanced version of MCMP. It provides energy efficient communication. As MCMP it also satisfies the QOS in terms of delay and reliability requirements of intended application. Fault tolerance: It clearly seen that node A have two neighbor node B and node E and distance between node A and node B is shorter then node A to node E [16]. So energy consumed by data transmission from link A to B is lower than link A to E. so node B is selected as the intermediate nose to send the data. In MCMP, node randomly chooses their next-hop neighbor node without checking its energy consumption. But in the ECMP it refines the set of next hop nodes, and chooses that node which considers the energy efficiency of the link toward the neighbor node.

IV.

13 Conclusion

There are various routing protocols that have been proposed in the literature to support fault tolerance in WSNs. This paper focuses on the various multipath routing protocols, in which the technique of the protocol is described along with their fault tolerant mechanisms. Table **??** and II are the summery tables which are drawn on the

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Figure 1: Figure 1 :

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Figure 2: Table 1 :

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Figure 3: Table 2 :

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Reliable Information Forwarding (ReInForm)
using Multiple Paths in Sensor Networks

Figure 4: Table 3 :

Fault tolerance:
Fault tolerance: As mentioned above MMSPEED provide different QoS guarantee in two domains by combine the geographic forwarding technique with a multipath routing approach. The results show that it provide us the successful data transmission over low power wireless link that highly depend upon the interference power of receiver distance but it cannot support long life application because it required extra energy for data transmission.

Figure 5:

213 basis of some important parameters like reliability mechanism, route maintenance, path chooser and performance
214 parameter. [1] [2]

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