IMPLEMENTATION OF PREVENTIVE MEASURE FOR NODE FAILURE AND ALGORITHM FOR RECOVERING FROM NODE FAILURE WITH MINIMAL TOPOLOGY CHANGES IN WIRELESS SENSOR NETWORKS

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ABSTRACT
In wireless sensor networks, sensors collect data from their surroundings and forward it to the actor nodes. Actors with collaboration respond so as to achieve predefined mission. Since actors have to carry out their operation with coordination, it is required to have strongly connected network topology at every instance of time. Also the length of path between must be constrained so as to meet the latency requirement of the network. This paper represents the algorithm to curb down topology changes when a network fails and gets disjoined or partitioned. Least-Disruptive topology Repair (LeDiR) algorithm is proposed for this task of minimal topology changes and also changing the cluster head constantly to prevent the failure of the sensor due to overhead is proposed as a preventive measure. LeDiR uses the local view of a node about the network to devise a recovery plan that relocates the least number of nodes and ensures that no path between any pair of nodes is extended.

INTRODUCTION

Interest in the applications of wireless sensor-actor network (WSAN) has been on the top among the researchers. Such applications include applications in remote and harsh areas in which human intervention is risky or impractical. Few examples can be given as space exploration, surveillance of battle fields, search-and research, and protection of coastal and ground borders of a country, etc. A WSAN consists of a set of miniaturized low-cost sensors that are spread in an area of interest to measure ambient conditions in the vicinity. The sensors are the devices which serve as a data collector. Also in case of actor nodes they give the data to the node which processes sensor data and provide the appropriate responses. The examples regarding actors can be given as robots and unnamed vehicles [1]. Given the actors' operation in collaborative manner, a strongly connected inter-actor network topology would be requirement at all the times. Actors usually coordinate their motion so that they stay reachable to each other. But when an actor fails, it may cause the network to partition into disjoint blocks and would thus violate such a connectivity requirement as stated above. The remote setup in which WSANs often serve makes the deployment of additional resources to replace failed actors impractical, and repositioning of nodes becomes the best recovery option [2].
When a node gets failed, the neighbors of that node will individually consult their possibly incomplete routing table to decide on the appropriate course of actions and define their role in the recovery if any. The performance of LeDiR is validated through both analytically and through simulation. The simulation results conclude that LeDiR outperforms or is advantageous over existing schemes in terms of communication and relocation overhead.

SYSTEM MODEL AND PROBLEM STATEMENT

The WSAN involves two types of nodes, one as sensors and another as actors. Out of these two sensors are quite inexpensive and are limited by energy and processing capabilities. In contrast to this actors are having upper hand in capability and energy due to availability of onboard energy supply. They also have higher computation and communication resources. The negative thing about the actors is that they have limited transmission range which is mostly too much less than the deployment area. So it is necessary for actors to rely on contemporary terrestrial radio links for coordination among themselves. An actor adapts to the ranging technologies and

localization techniques to determine its position relative to its neighbour. When a node fails, it may have either limited or significant impact on the network topology depending upon whether it is a leaf node or a cut vertex. A cut vertex is a node, removal of which along with all its edges produces a graph with more connected components than the original. The main focus of this paper is on restoration of strong connectivity when the level of inter-actor topology is considered.
This paper has one assumption as only no simultaneous node failures will occur in the network. Also it is found that most of the other recovery schemes also consider the same as probability of simultaneous node failure is very small and can be neglected. One more assumption is made for simplification of analysis as all nodes have same communication range. But it is the fact that the proposed algorithm do not requires such assumption at all.

RELATED WORK

Different schemes have recently been proposed for the network connectivity restoration in partitioned wireless sensor actor networks. All these schemes have not focused on the length of particular data path. Some schemes recover the network by repositioning of the existing nodes, whereas other schemes place relay nodes very carefully. On the other side some of the schemes regarding sensor relocation concentrate on metrics other than connectivity, e.g., coverage[9]-[15], network longevity[16] and asset safety[17], or to self-spread the nodes after nonuniform deployment[6],[18],[19], which is not our focus in this paper.

LEAST-DISRUPTIVE TOPOLOGY REPAIR

The main goal of the LeDiR is to restore connectivity without extending the length of the shortest path among nodes compared to the prefailure topology. The main idea of LeDiR is to pursue block movement instead of individual nodes in cascade. To limit the recovery overhead, in terms of the distance that nodes collectively travel, this algorithm identifies the smallest among the disjoint blocks. Following are the steps involved in this algorithm:

1) Failure detection: Actor nodes send one type of message, called heartbeat message to their neighbours and ensure that they are functional, and also report changes to the one-hop neighbours. If there is missing heartbeat message then there can be failure, i.e., they can be used to detect the failure.
2) Smallest block identification: LeDiR, so as to reduce the recovery overhead controls the relocation to nodes in the smallest disjoint block. The block which has least number of nodes is smallest block and it will be identified by finding the reachable set of nodes for every direct neighbour of the failed node and then picking the set with the fewest nodes.
3) Replacing faulty node: If node M is the neighbour of the failed node that belongs to the smallest block, M is considered to be replacement of the faulty node. Node M is considered to be "parent". Then a node is considered to be a "child" if it is two hops away from the failed node. A node is said to be "grandchild" if it is three hops away from the failed node and the pattern goes on.
4) Children movement: As considered earlier, node M, which moves to replace the faulty node, some of its children will lose direct links to it. As data paths may be extended, we might not love this to happen.

Following figure shows that how LeDiR restores the connectivity after failure of node.

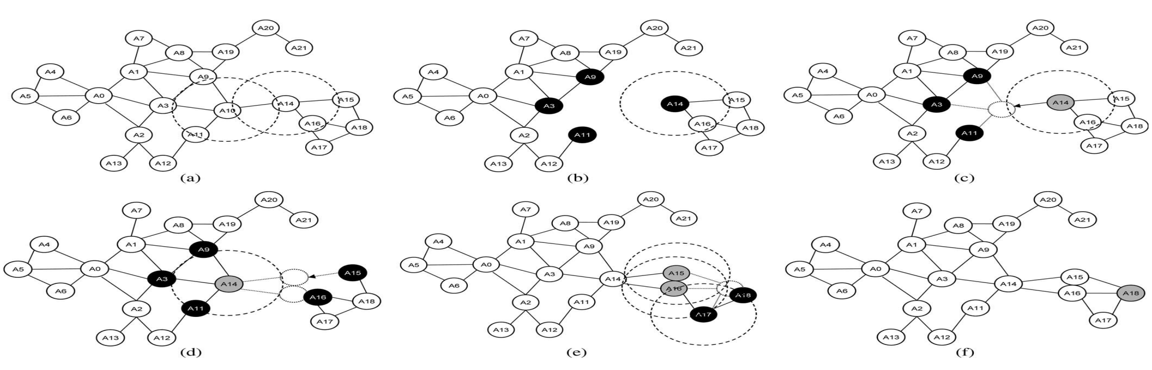

Fig.1: Restoration of connectivity after the failure of node (Here A_{10}) in the connected inter-actor topology. Nodes in black are participating in the recovery process and those in grey are selected to move.

The fig.1 shows how connectivity restoration is carried out in LeDiR, after the failure of one node, here A10. Obviously, node A10 here is an cut vertex and A14 becomes the one-hop neighbour which is the member of smallest block. This is depicted in fig.1(a)-(c). Node A14 notifies its neighbours and moves to position of A10 for the restoration of connectivity and this is shown in fig.1(d). Nodes A15 and A16 are the disconnected children nodes which follow through to maintain communication link with A14,[observe fig.1(e)]. The main objective of the children movement is just to avoid any changes to current routing table. Node A15 notifies its children A17 and A16 would notify A18 before they move. As A18 is having communication links with nodes A15, A16 and A17, it moves to a new location where it can stay connected with these nodes directly. This is shown in fig.1(f). The links which are there between A17 and nodes A16 and A18 are not affected by the process of relocation and hence A17 will not require repositioning. The repaired topology is shown in fig.1(f).

PERFORMANCE ANALYSIS

Table 1. Performance of LeDiR in terms of block selection

Check List	Smallest block selected (% of Cases)	None-Smallest Block Selected (% of Cases)	None of the block selected (% of Cases)
100%	100	-	-
70%	92	08	-
50%	78	22	-
30%	61	39	-
20% or less	07	15	78
Random CL	79	21	-

Table 1 shows the performance of LeDiR in terms of correct block selection under varying CL(confidence level, percentage of entries i.e., routes between actor pair that each node has acquired over time. For example, if 50% entries of the node's A routing table are filled, we say node A has 50% CL.) and presents the percentage of simulated topologies for which the smallest block was selected, a block other than the smallest block was picked, and when the available network state was insufficient to assess the criticality of the failed node and trigger recovery.

PREVENTIVE MEASURE FOR NODE FAILURE

The preventive measure taken for the node failure is of rotation of cluster head which will help in reducing overhead. Cluster head always requires more energy than any other node in the cluster and also it has more load which results in frequent failure of such nodes which are cluster head as compared to other nodes in the network. So if we rotate cluster head which we can do with the help of time allocation methodology. For particular duration we must assign the cluster head position to different nodes in the circuit depending upon the convenience and also taking in consideration of the load on it. This may cause the workload distribution among all the nodes in a cluster and hence the time span for a failure to occur due to such overhead can be increased.
This methodology can be implemented by allowing a particular node say A_i to carry out the task of cluster head for particular time duration say t (units). After this time period gets over another node will be offered this task with the condition that it had not done this earlier as it may cause overload for that particular node and probability of node failure increases due to overload. This way every node will be assigned this task for particular time duration and thus we can prevent a node from getting failed due to such overload. This preventive measure is nothing but a remedy to prevent a node from getting failed, but if node gets failed then the task is much harder and hence this paper has mainly focused on the implementation of LeDiR algorithm.

FUTURE WORK

Partial results (in terms of block selection only) of LeDiR algorithm are included in this paper. Again different parameters like number of nodes considered, energy utilization, etc can be considered to evaluate this algorithm which is the further work to be carried out. There are numerous other parameters which can be considered for evaluation of this algorithm and these evaluation results can be used to compare the performance of this algorithm with other topology repair algorithms. Also the future work includes the results of preventive measures to be included in the paper which will be useful in analyzing the node failure of the network and improvement in its working capability.

CONCLUSION

With the high amount of potential in real-life applications wireless sensor networks (WSANs) are receiving growing attention. In this paper we have tackled an important problem in WSANs that is of re-establishing network connectivity after node failure without extending the length of data paths. We have proposed a LeDiR algorithm for this purpose which restores the connectivity by careful repositioning of nodes and it relies on the local view of network and it does not impose any prefailure overhead also.

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