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BACKUP SELECTION FOR CUT-VERTEX AND CONNECTIVITY RESTORATION IN MRSN

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ABSTRACT

Firm communication establishment between sensors is very important in mobile robotic sensor networks (MRSNs), to avoid disintegration of network, in mission critical applications. The cut-vertex is the one which causes network disintegration, due to a sensor node failure or any obstacles appearance in communication path. If a non cut-vertex sensor fails, we can determine alternate path for communication, but if a cut-vertex sensor fails, backup sensor is determined and replaced in place of cut-vertex node, to restore the connectivity in MRSN. Thus we have proposed a connectivity restoration backup selection (CRBS) strategy, which considers all the sensors in the network are connected as polygon, the backup sensors are selected for cut-vertices and the sensor displacements are done using motion controller, to avoid inter-sensor collision within the network.

Key words- Backup sensor, Cut-vertex, MRSN, Connectivity restoration, Sensor displacement, Collision avoidance, etc.,.

1. INTRODUCTION

The MRSN has its wide range of importance in environments, where human interaction is difficult, in mission critical applications such as military surveillance, weather forecasting, etc.,. The communication establishment and transfer of information without any loss, within sensors is very important.

The cut-vertex is the one, where sensor failure cause disjunction of communication link between sensor nodes and converts network into two or more disconnected networks, unable to establish communication path between sensor nodes.

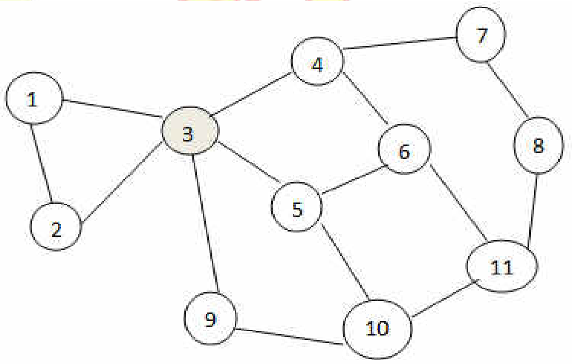


Fig 1.1- Cut-vertex in MRSN

In Fig 1.1, the sensor node 3 is a cut-vertex, because the failure of node 3 splits the MRSN into two separate parts, which cannot establish communication between each other. The other nodes are non cut-vertices, because the failure of these nodes does not disconnect the network and have alternative path for communicating with other nodes in MRSN.

The failure of non cut-vertex sensor does not affect the MRSN, because an alternative path can be determined using other sensors within the network. But if a cut-vertex sensor fails, it creates severe issue in MRSN.

Thus the possible cut-vertices in the network and backup sensors determination with sensor displacement are done for connectivity restoration within MRSN.

Thus we have proposed a new connectivity restoration backup selection (CRBS) strategy for determining cut-vertex and connectivity restoration in MRSN.

Thus section 2, describes about the previous related works in this field. Then section 3 describes briefly about our new CRBS strategy. And, section 4 containing information about simulated results and graphs. Thereby section 5 concludes the paper, followed by references in section 6.

2. COMPREHENDED WORKS

In the MRSN, the communication establishment between sensor nodes for information exchange is very important. But the main issue is the sensor node failure in cut-vertex and any obstacles present in communication path. Thus to avoid this problem there are many solutions provided early. Since this is mobile network the sensor nodes moves randomly, which may replace the failure node and restore the network connectivity.

The distributed connectivity restoration with respect to the failure of single cut-vertex has been extensively investigated. Both direct movement and potential force based movement are implemented. The direct movement can be further divided into block movement and cascaded movement methods according to their different patterns. Several algorithms were proposed for achieving a 2-hop connectivity fault-tolerant configuration in multi-robot networks by moving a subset (block) of mobile robots. Block movement can maintain the topology within the subset, but requires a significantly large movement distance. To overcome this drawback and reduce the number of sensor moved, the cascaded movement method that only moves a set of necessary node for restoration is developed.

The Distributed Actor Recovery Algorithm (DARA) is proposed to address the 1- and 2-connectivity restoration in wireless sensor and actor network (WSAN) with 2-hop neighboring information, DARA selects the backup candidate according to their node degree and distances, then the selected nodes are move to substitute the failed nodes in sequence. Since only 1-hop neighbors are considered in DARA, it can increase the total movement distances in the sensor restoration process, which includes multiple sensor displacement frequently within the network.

A Least-Disruptive topology Repair algorithm (LeDiR) was proposed, by considering the impact of topology change on network performance. In LeDiR selecting a candidate node is done for restoration based on the partial view of network topology via a routing table.

A k-hop neighboring information based connectivity restoration framework, named Hybrid connectivity restoration framework (HERO) was presented, the proposed method includes a potential function to drive the backup sensor to its destination while avoiding inter-sensor collisions. HERO does not assign any backup sensors before the failure of cut-vertices. As a pure reactive approach, the connectivity restoration process with HERO will normally consume more time and involve more sensors, which make it less effective.

3. CRBS STRATEGY

The connectivity restoration backup selection (CRBS) strategy, have been proposed in this paper to overcome the drawbacks of previously presented solutions.

Since the previous solutions have less efficiency due to selecting backup sensors only after failure at cut-vertex, it is time consuming process for restoring connectivity in MRSN. Thus the possible cut-vertices and backup sensors for cut-vertices are predetermined in CRBS strategy.

And many previous solutions deals with only single sensor failure. Thus, the CRBS strategy deals with multiple sensor failure simultaneously and obstacle free path recovery within MRSN.

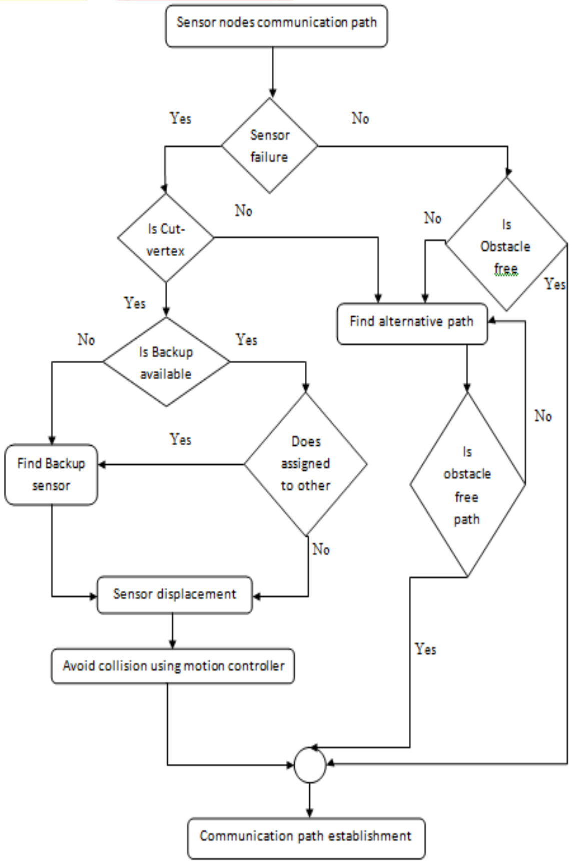


Fig 3.1- Flowchart for execution of CRBS

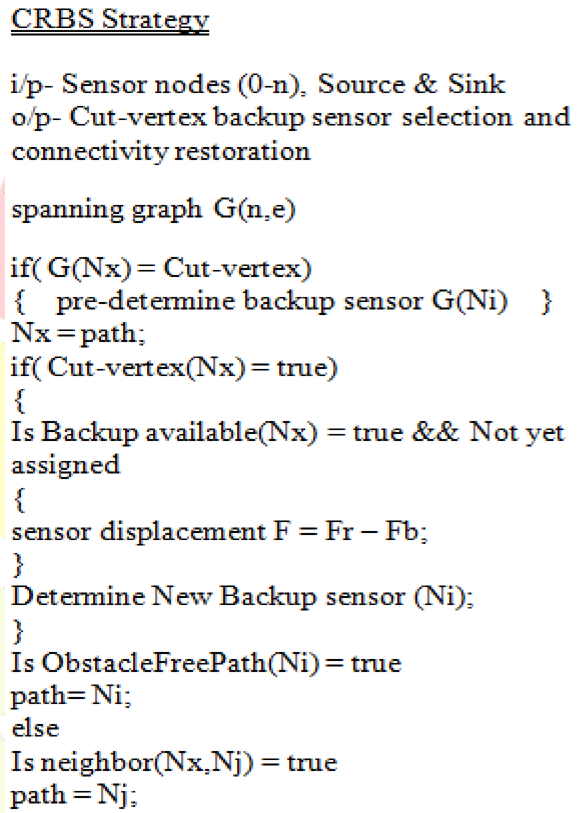
In Fig 3.1, the execution process flow of CRBS strategy is shown. In this first all the possible cut-vertices in MRSN is determined and backup sensors are pre-determined before starting the communication process within MRSN.

Thus during communication establishment in MRSN, it checks for failure of sensor node. And checks weather the failed sensor is a cut-vertex. If sensor is not a cut-vertex, then alternate path is determined and it checks for obstacle free path and communication path is established within MRSN.

But, if the failed sensor is a cut-vertex, then it checks for availability of pre-determined backup sensor. And it also checks weather the pre-determined backup sensor is assigned for other cut-vertex, since CRBS deals with multiple sensor failure simultaneously. If not assigned, sensor displacement is done.

Else if backup is unavailable, new backup sensor is found for cut-vertex and then sensor displacement is done. Sensor displacement is done with the help of motion controller, to avoid inter-sensor collision within MRSN.

Thus connectivity restoration is achieved at cut-vertex and communication path reestablishment is done in MRSN.



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CRBS Strategy

i/p- Sensor nodes (0-n), Source & Sink
o/p- Cut-vertex backup sensor selection and
connectivity restoration

spanning graph G(n,e)

if( G(Nx) = Cut-vertex)
{    pre-determine backup sensor G(Ni)    }
Nx = path;
if( Cut-vertex(Nx) = true)
{
Is Backup available(Nx) = true && Not yet
assigned
{
sensor displacement F = Fr – Fb;
}
Determine New Backup sensor (Ni);
}
Is ObstacleFreePath(Ni) = true
path= Ni;
else
Is neighbor(Nx,Nj) = true
path = Nj;
```

Algorithm – Connectivity Restoration & Backup Selection Algorithm

The Algorithm, describes the CRBS strategy. In this, all the sensor nodes connected as polygon in MRSN is considered as spanning graph representation, for easy determination of cut-vertex and backup sensors.

Using the graph, all the cut-vertices(Nx) is found and backup sensor(Ni) is pre-determined. Then during transition the nodes Nx in the path is checked for cut-vertex when it fails.

And if(Cut-vertex(Nx) = true) then it checks for backup, Is Backup available (Nx) = true && Not yet assigned. Then sensor displacement F = Fr – Fb is done. Where, F is the total motion controlled force to drive the backup sensor to cut-vertex, Fr is random motion force and Fb is force break applied to avoid inter-sensor collision within MRSN.

Else if backup sensor is unavailable, new backup sensor (Ni) is determined. And Is ObstacleFreePath(Ni) = true, then path is assigned. Otherwise new obstacle free path is determined using Is neighbor(Nx,Nj). Thus connectivity restoration is succeeded in MRSN.

Thus the proposed CRBS strategy will performs backup selection for cut-vertex and connectivity restoration in MRSN with high efficiency.

4. SIMULATED RESULTS

The proposed CRBS Strategy is implemented using simulation tool and the output result efficiency are compared with previously proposed solution for connectivity restoration with obstacle avoidance problem in the network.

The following graphs are the results obtained by simulating the CRBS strategy. Whereas the colours in the graph indicates,

- 🟦 CRBS
- 🟥 HERO

Where,

CRBS- Connectivity restoration backup selection (CRBS) strategy

HERO- Hybrid connectivity restoration framework

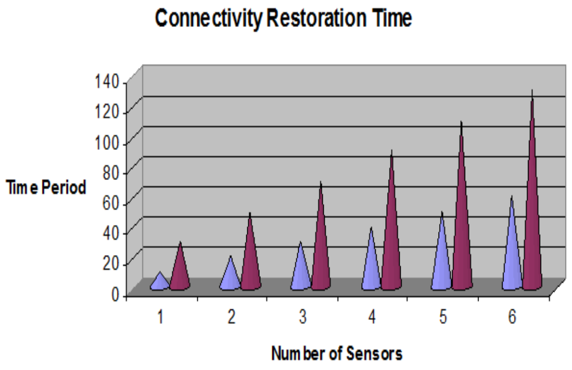

Fig 4.1- Connectivity restoration time period

In Fig 4.1, The graph indicates the results obtained by simulating the previously proposed HERO and the proposed CRBS strategy with respect to time required for connectivity restoration process in MRSN. Thus the time required is comparatively reduced by implementing CRBS strategy. Since, we are pre-determining backup sensors for all possible cut-vertices in MRSN.

In Fig 4.2, The graph represents the total travelling distance of backup sensors during connectivity restoration process in MRSN. Thus it indicates the improved performance of CRBS by reducing the travelling distance of sensors.

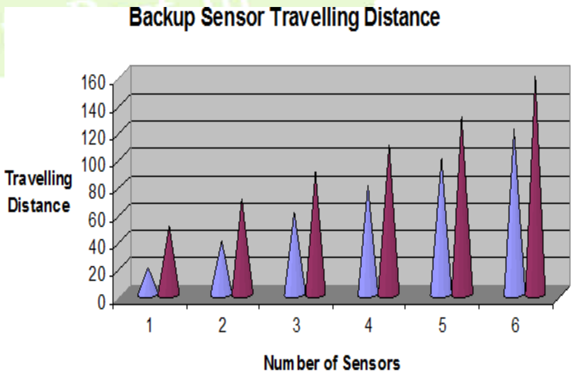

Fig 4.2- Total travelling distance

Thus the performance and efficiency of sensor nodes is considerably improved by implementing CRBS strategy in MRSN.

5. CONCLUSION

The major problem cut-vertex determination, backup selection and sensor displacement without collision can be effectively solved using proposed CRBS strategy. Thus the future enhancement of this paper can be done related to various forms of obstacles appearing within the transmission path of MRSN.

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