International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com

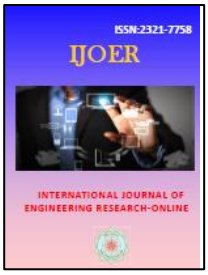
Vol.5., Issue.1., 2017
January-February

REVIEW ARTICLE

ISSN: 2321-7758

REVIEW OF CUTS IN WIRELESS SENSOR NETWORK

MANI SHARMA[1], NAVIN KUMAR TRIVEDI[2]
[1]M.Tech Student, MGM COET, Noida
[2]HOD, Department Of Computer Science & Engineering
Mahatama Gandhi Mission's Engineering College, Noida, India



ABSTRACT
Large companies and organizations are deploying sensor nodes due to their small size and low cost. Unsuitable environmental conditions where sensor nodes are being deployed and limited battery life of sensor nodes are the major causes of failure of sensor nodes which divides the network into multiple components. This results in network cut. This review paper describes the network cut problem faced by wireless sensor network.

1. INTRODUCTION

Wireless Sensor Network

Wireless sensor network is the network of devices called sensors. Each sensor has a capability to sense the environment and communicate the data gathered from the monitored area by the wireless link. Sensor nodes have various connected components such as RF Transceiver, sensors, etc. Wireless Sensor Network is composed of powerful Base Station and small sensor nodes. Base Station is also known as source node which acts as an interface between users and network.

Sensor nodes have small size and they consume low power. This is main reason of deploying sensor nodes by large companies and organizations. Limited power consumption of sensor and the environment where they are deployed leads to the node failure which results in cuts in wireless sensor network. This network cut partitions the sensor network into multiple connected components.

Now-a-days wireless sensor network is facing a big problem of node failure. The problem of cut is common in wireless sensor network. Various cut detection schemes have been proposed by researchers for identifying cuts and their recovery in wireless sensor network. But no efficient scheme has been implemented which can tracks the existence of cuts correctly in wireless sensor network.

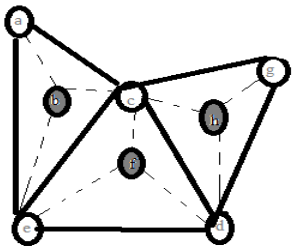
In this paper, we address the challenges faced by sensor network due to node failure which has not received adequate attention. This problem must be solved to improve operational reliability of network.

2. CUTS in Wireless Sensor Network

Cut in wireless sensor network is defined as the disconnection of nodes which results in division of wireless sensor network into multiple connected components. Network Cut is also known as Network partitioning or network disconnection. According to graph theory, cut vertex is defined as the node in network whose failure separates the sensor network into disjoint components. Network cut leads in reduction in number of multi hope path in the network. Two nodes are said to be disconnected if there exists no path between them.

Graphical Representation of Cuts: The following figure shows the graphical representation of cuts in wireless sensor network S (V, E). Let a be the source vertex and d be the destination vertex. Vertices a, e, d, g, c are active vertices. Bold edges show the connection between active vertices. Vertices which are in gray color have failed due to certain reasons

such as harsh environment, limited battery life, etc. Gray color vertices are disconnected from active vertices. Hence, their connectivity has been lost and these disconnections are shown by the dashed edges. Due to failure, these gray color vertices are the disconnected from active vertices. Hence, gray color vertices are cut vertices. Hence, b, f, h are the cut vertices of the graph S (V, E). Due to cut vertices, wireless sensor network is partitioned into multiple connected components. Hence, data transmission will be difficult due to the presence of these cut vertices as they block data transmission.



The above figure showing cut vertices in wireless sensor network

3. Problem due to Cuts

Network Cut results in:

1. Data loss as it prevents the data from reaching to its destination.

2.Reduction of number of paths between the nodes. This results in loss of connectivity between the nodes which is very disastrous for sensor network. Hence, loss of connectivity leads to the breakdown of entire sensor network.

3.Wastage of energy of precious nodes when there is no news of node failure in the network during data transmission.

4.Loss of operational efficiency of the network.

5.Loss of operational reliability of sensor network.

4. Cut Detection in Wireless Sensor Network:

Cut Detection is the process of searching the presence of disconnected sensors in wireless sensor network.

Hence, by cut detection we mean:

1.Detection of DOS event by each node when it occurs.

If a node x is disconnected from source, then we say that Disconnected from Source (DOS) event has occurred for node x.

2.Detection of CCOS events by those nodes which are near to a cut.

If a node x is connected to the source, but gets disconnected from node y, then we say that Connected but Cut Occur from Somewhere (CCOS) event has occurred for node x.

3. Approximate location of cut.

By approximate location, we mean that the region or space where active nodes lies at the boundary of cut and connected to the base station.

Hence, cut detection is important for finding out failed nodes in wireless sensor network for maintaining its reliability so that wireless sensor network can provide fault free service to the companies, organizations and users. Fault tolerant scheme must be developed to track the inactive nodes as well as help to recover the network. Restoration of network connectivity is the main issue in sensor network.

5. LITERATURE SURVEY

N. Srivastava proposed a scheme to detect e- cuts [1] in sensor network. e- cut is a linear cut that divides the wireless sensor network into two planes one plane consists of the fraction of e-deactivated nodes and other plane consists of active nodes including base station. They assumed that the source must lie in the safe side of plane. Their scheme selected a small subset of nodes, which act as sentinels. At regular interval, there is a communication between the sentinels and source. If there exists any failure in communication from sentinel, it means that sentinel has been cut off. They proved that a 0(1/e) sentinels are needed to detect e-cut where e<1. They developed two algorithms one algorithm is deterministic for making minimum sentinel set and second algorithm is randomized for computing 0(1/e) sized sentinel set. Their algorithm is centralized, as the entire process is performed at source.

The limitations of algorithms are:

1. They focused on linear cuts, other cuts such as circular cut, polygonal cut were not considered.'
2. Their algorithm is centralized, there is need of global topology information.
3. They didn't address the issue of noise or inherent instability of single sensor node. If

one of the node in sentinel set naturally dies, it can mislead the algorithm.

Prabir Barooah proposed a distributed algorithm named Distributed Cut Detection (DCD) algorithm [2]. The algorithm allows every sensor to detect DOS events and a subset of sensors to detect CCOS events. The algorithm is distributed and asynchronous. It is robust to temporary failure of communication between pairs of sensors. A main component of this algorithm is an iterative computational step. With the help of this step, nodes compute their electrical potentials. The convergence computation rate is independent of network size and structure. DCD suffers the limitation when failure of node takes place in malicious mode, then there will be insecure cut detection.

M.Won and R.Stoleru focused on problem of destination based cut detection [3] where cuts are identified and detected with respect to the target destination and introduced a reactive solution of cut detection named Point-to-Point Cut Detection (P2PCD). In this, source is able to determine that whether destination is reachable or not. They also proposed proactive solution RE-CDM, that efficiently identify the presence of cuts between base station and small set of destinations. RE-CDM allows each node to check connectivity to multiple sink nodes. But P2P-CD protocol depends on node's position. So, routing is performed on the basis of position, other types of routing are not allowed.

Shuguang Xiong and Jianzhong Li proposed a distributed algorithm Cut Vertex Detection (CVD) algorithm [4] to detect cut vertices. The algorithm consists of three phases: tree building phase, Tree Coding phase, Cut Finding phase. In tree building phase, a spanning tree T(s)is produced from a graph G (v, e) from a given wireless sensor network. In tree coding phase, the spanning tree T(s) produced from the tree generating phase is used. Each node of T(s) is assigned an interval code. Cut Finding phase identifies the cut vertices by using edge coloring mechanism. CVD only identifies the cut vertices so recovery of network must be given priority which is not provided by CVD algorithm. Modification must be performed for network connectivity restoration by informing the base station about the failure of node.

Izzet F. Senturk, Kemal Akkaya, Sabri Yilmaz presented a distributed relay node positioning [5] in order to return back the network connectivity in partitioned wireless sensor network by using Game theory with relay nodes and disconnections. Initially, the deployment of relay nodes at certain locations in a breakage area and they relocate themselves to ensure network recovery from breakage. An estimated Nash Equilibrium is assigned to each partition. On the basis of estimated equilibrium, pdf is defined for each partition. Relay nodes recover that partition first whose pdf is highest. This process continues until all the partitions are recovered and same equilibrium is reached.

Barooah et al. described the challenges of previous cut detecting schemes. The Distributed Source Separation Detection (DSSD) algorithm [6] is completely distributed and identifies arbitrarily shaped cuts. Each node maintains a positive scalar value called state. The modification of state of each node is determined by states of its immediate neighbors. If a node is connected to the sink node, then its state has positive value. If not, then the value will be zero. DSSD algorithm suffers from the problem of control message overhead as iterations of algorithms depends of network's degree.

The artificial routing protocol [7] is proposed to detect cut vertices in wireless sensor network by Ms. Rini Mathew and Mrs. Annadevi. E. In this method, neighbor node gets message from the cut vertex that it is deactivating. the neighbor node informs the source node and destination node about this event of node failure. Then source node initiates by using alternate path to send data packets to its destination. This method takes less time to be implemented. Less iterations are performed as compared to the previous implemented algorithms. For time management and to improve efficiency, this algorithm can be optimized. The only drawback it suffers is that it can only be applied to the immobile nodes.

A typical algorithm described is DFS [8]. DFS performs a DFS traversal to search the cut vertices in the graph, at that time it searches the back edges

connecting a vertex and its ancestor. The algorithm uses the decision condition to identify the cut vertices is that x is not a cut vertex if there exists a back edge connecting a vertex in subtree Tsub(v). v is a root vertex of Tsub(v).

DDFS (Distributed Depth First Search) [9] is implemented to find cut vertices in graph. This algorithm is implemented by passing a message from the sink vertex s. the message performs a depth- first search visit of graph and there is a proper classification of edges into the tree edges, back edges and cross edges. A counter is incremented each time when message visits a vertex. Each vertex p gets an index x(p). this index x(p) is counter of first visit message. Each leaf vertex u, sends smallest index x(v) to its parent w. From all the indexes received from its children, parent w keeps the smallest index. W is a cut vertex if the smallest index received to W from its children is smaller than x(w). This index is known as y(w). min(y(p)) is sent by w to its parent. This process continues and then each vertex can locally identify whether it is a cut vertex. Causes that show its limitations are:

1. Time delay of DDFS is large and much higher than other algorithms. It also grows much faster than other algorithms in large networks because DDFS has to traverse each edge in serial order in network.
2. DDFS is more sensitive to vertex failure than other algorithms. Hence, its robustness is relatively low.

BFS [10] algorithm is implemented for the detection of cut edge. The issue of cut edge detection is different from the problem of the cut vertex detection. If a node is a cut vertex, then no edge will be incident on it. On the other hand, if an edge is a cut edge, then it is not necessary that the nodes connecting that edge be the cut vertices.

CAM algorithm [11]is implemented for cut detection. It uses the local flood scheme with TTL threshold. Every neighbor has a TTL that tells the time of expiry of message. Every candidate sends a component probe message to every neighbor. When node receive message, it modifies local information and decides whether to forward message or to return an arrival message. The candidate is a cut node when graph of CAM has multiple components. CAM takes communication cost which is very large.

RE-CD [12] is implemented by M.Won, M.George and R.stoleru to identify cuts. RE-CD is a cluster based and proactive algorithm. It improves the energy efficiency of DSSD by reducing its convergence rate. This algorithm also suffers the limitation that cut detection takes place with respect to sink node. This limitation is overcome by RE-CDM which is an modified version of RE-CD. It detects the cut with respect to more than one sink node.

The summary of implemented algorithms by researchers including features, advantages and limitations are mentioned in the table given below Table:

S.no	Proposed Algorithms	Implemented By	Features	Advantages	Limitation
1.	Linear Cut Detection	N.Srivastava, Subhash Suri and Csaba D.Toth	Centralized, identifies linear cut.	Minimize message overhead.	1.Can't identify other shaped cuts such as polygonal cuts, circular cuts, rectangular cuts, etc. 2.Needs global topology information. 3. Issues of noise or inherent instability has not been addressed.

2.	DSSD	Baroaah et.al	Distributed, involves only nearest neighbour communication.	Cuts of any shape can be detected.	Faces the problem of control message overhead.
3.	RE-CD	M.Won, M.George, R.Stoleru	Proactive, Cluster based	Improves the energy efficiency of DSSD.	Detection takes place with respect to a single sink node.
4.	RE-CDM	M.Won, R.Stoleru	Extension of RE-CD ,Proactive, distributed, Lightweight solution, detection takes place with respect to multiple sink nodes.	Robust method, No need of node position information, doesn't depends on space and implementation overhead.	Less energy efficient than P2P-CD.
5.	P2P-CD	M.Won, R.Stoleru	Reactive solution, Uses peer-to-peer cut detection, needs node position information.	More energy efficient than RE-CDM.	Incurs communication overhead.
6.	DCD	Prabir Baroaah, Harshvardhan Chenji, Radu Stoleru, Tamas Kalmar-Nagy	Distributed, Asynchronous, Fast Convergence rate	DCD doesn't depends upon network's structure and size. Hence, cut detection is fast, robust solution.	Cut detection is insecure when node failure occurs in malicious mode.
7.	DFS	T.H.Coremen, C.E.Leiserson, R.L.Rivest, C.Stein	Centralized, searches all the back edge connecting a node and its ancestor.	Lowest communication cost in case of low network size.	Increase in time delay with increase in network size, low robustness.
8.	DDFS	D.B.West	Extension of DFS, implements DFS by passinging a message from sink node	Low communication cost and low time delay in case of low network size.	Low robustness, Increase in time delay and communication cost with increase in network size.
9.	CAM	X.Liu, L.Xiao, A.Kreling and Y.Liu	Employs local flood scheme.	Efficient scheme.	Large communication cost, High time delay.

10.	CVD	Shuguang Xiong, Jianzhong Li	Distributed, scans each node in parallel way, makes use of edge color mechanism to detect cut vertices.	Outperforms DFS,DDFS,CAM in communication cost and time delay, high performance than DFS,DDFS,CAM.	Only cut vertices can be detected, network connectivity can't be restored by this algorithm.
11.	BFS	B.Milik and M.Malek	Detects cut edge, begans from sink node and search continues in a breadth first way.	Energy efficient, BFS can extented to track bridges where routing and bridge detection can performed at similar time.	Unable to identify cut vertices because it tracks cut edges and tracking cut edges is different from tracking cut vertices.
12.	Distributed Relay Node Positioning	Izzet F.Senturk, Kemal Akkaya, Sabri Yilmaz	Self deployment strategy, Uses Game Theory to detect cuts.	Restore network connectivity, reduce movement overhead on relay nodes.	Connectivity can be restored without using this strategy if the sensor nodes have the capability of moving.
13.	Energy based Cut Detection	Miss Rini Mathew,Mrs Annadevi.E	Uses dynamic source routing to find cut vertices.	Reduces time delay	This method can be applied to only immobile nodes.

FUTURE WORK

Developing fault tolerant scheme which will identify the cut vertices as well as restore the network connectivity by connecting partitions in network. So, tracking the cut vertices and recovering the network connectivity is a part of our future work.

CONCLUSION

In this paper, we focused on the problem of cuts in wireless sensor network which results in loss of connectivity among nodes. Data transmission is not possible due to presence of cut vertices in a network as there are chances of data loss in sensor network. Hence, we concluded that Cuts in wireless sensor network are a big problem and needed to be detected and removed as soon as possible**.** If detection of cuts will not be taken in time, then wireless sensor network will be partitioned into various disjoint sets. Therefore, it is necessary to identify cut vertices in sensor network. We discussed various cut detection techniques implemented by researchers in this paper**.** On the basis of our studies, no efficient method has been implemented so far to detect network cut completely.

ACKNOWLEDGEMENT

We are expressing our pleasure and thanks to all teachers of computer science department who have cooperated us in this project. We are happy to express thanks to those people who have directly or indirectly helped us to complete this research paper.

REFERENCES

[1]. N. Shrivastava, S. Suri, and C. Toth, "Detecting cuts in sensor networks," *ACM Transactions on Sensor Networks*, vol. 4, no. 2, pp. 1–25, 2008.

[2]. P. Barooah, H. Chenji, R. Stoleru, and T. Kalmar-Nagy, "Cut detection in wireless sensor networks," *IEEE Transactions on*

Parallel and Distributed Systems, vol. 99, no. PrePrints, 2011.

[3]. M. Won and R. Stoleru, "Destination-based cut detection in wireless sensor networks," in *Proceedings of IEEE/IFIP International Conference on Embedded and Ubiquitous Computing (EUC)*, 2011

[4]. Shuguang Xiong and Jianzhong, "An Efficient Algorithm for Cut Vertex Detection in Wireless Sensor Network", *International Conference on Distributed Computing* system, 2010

[5]. Izzet F.Senturk, Kemal Akkaya and Sabri Yilmaz, "Distributed Relay Node Positioning for Connectivity Restoration in Partitioned Wireless Sensor Network" ,2012

[6]. P. Barooah, "Distributed cut detection in sensor networks," in *Proceedings of IEEE Conference on Decision and Control and European Control Conference (CDC)*, 2008.

[7]. Ms. Rini Mathew and Mrs. Annadevi. E "Artificial Routing Protocol for Cut Detection of Cut Vertices" vol. 9, 2012

[8]. T. H. Cormen, C. E. Leiserson, R. L. Rivest and C. Stein, "Introduction to Algorithms (Second Edition)", The MIT Press, 2002

[9]. D. B. West, "Introduction to Graph Theory (Second Edition)", Prentice Hall, 2001.

[10]. B. Milic and M. Malek, "Adaptation of the Breadth First Search Algorithm for Cut-edge Detection in Wireless Multihop Networks", in ACM International Workshop on Modeling Analysis and Simulation of Wireless and Mobile Systems (MSWiM), 2007.

[11]. X. Liu, L. Xiao, A. Kreling and Y. Liu, "Optimizing Overlay Topology by Reducing Cut Vertices", in ACM Workshop on Network and Operating System Support for Digital Audio and Video (NOSSDAV), 2006.

[12]. M. Won, M. George, and R. Stoleru, "Towards robustness and energy efficiency of cut detection in wireless sensor networks," *Elsevier Ad Hoc Networks*, vol. 9, no. 3, pp. 249–264, 2011.