Australian Journal of Basic and Applied Sciences, 10(10) June 2016, Pages: 223-228

AUSTRALIAN JOURNAL OF BASIC AND APPLIED SCIENCES

ISSN:1991-8178 EISSN: 2309-8414
Journal home page: www.ajbasweb.com

Dijkstra Based Resilient Braided Disjoint Multipath Routing for Wireless Sensor Network

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ARTICLE INFO

Article history:
Received 13 April 2016
Accepted 21 June 2016
Published 28 June 2016

Keywords:
Braided multipath routing, Dijkstra's algorithm, NCCC, OHMR, Shortest path routing.

ABSTRACT

Designing of network routing and intelligent analysis provides an edge in this exponentially increasingly fast era. In a multihop wireless network environment, routing is a challenging issues which has a significant impact on the performance and Quality of Service of a network. Hence, an ideal routing algorithm should find an optimum as well as shortest path for packet transmission with the time constraint. Generating edge or node disjoint multipath and load balanced distribution between the nodes to balance the communication is computationally hard problem faced in a wireless sensor network. We address this problem through our proposed work, Dijkstra based Resilience Braided Multipath Routing(DRBMR). The potential use of Dijkstra algorithm is explored and utilized along with the property of braided multipath to arrive at the shortest braided disjoint multipath within the stipulate time. Braided multipath is generated and selection of path for routing is based on Dijkstra algorithmic rule. Hence optimal utilization of resource nodes is achieved through this method which significantly saves the energy utilization of the nodes and increases the lifetime.

INTRODUCTION

In a wireless sensor network, energy efficiency is the most critical and essential factor to be addressed. Hence routing algorithms implemented must be robust to failures against the malicious and compromised nodes to ensure successful data delivery. In (Abdullah, M. and A. Ehsan, 2014), a Network Coding based on a Co-operative Communication scheme (NCCC) is proposed. It improves the packet loss resistant of the network and communication fail resistance is improved through the proposed co0operative communication. (Moghadam, M.N. and H. Taheri, 2014) Introduces a heuristic Load Distribution algorithm [HeLD] based on a Braided Multipath which maximizes the throughput and the balanced traffic load of a static network environment. A mathematical optimization model for the wireless sensor network's energy minimization and resilience maximization is discussed in (Velasquez-Villada, C. and Y. Donoso, 2013). The nodes in the network will try to create multiple paths from the beginning trying to reach at least one Base Station thereby increasing the network's resilience. A heuristic algorithm based on the nearest neighbor and minimum hop concept is used to solve the network model. In paper (Sue, C.C. and R.J. Chiou, 2006), on-demand hybrid multipath routing (OHMR) is proposed with distinct features namely establishing braided multiple node disjoint paths between the source and destination node and end-to-end transmission is maintained until a successful transmission is made.

II. Braids:

Due to the high dense deployment of the nodes in the network area, compact form factor of the sensor nodes and high SNR with cheap sensors has made the entry of multipath routing for a sustainability of a wireless

To Cite This Article: Elamathy S and Dr. Ravi S., Dijkstra Based Resilient Braided Disjoint Multipath Routing for Wireless Sensor Network. ***Aust. J. Basic & Appl. Sci.,*** *10(10): 223-228, 2016*

Australian Journal of Basic and Applied Sciences, 10(10) June 2016, Pages: 223-228

sensor network. Multipath routing exploits the network resources by utilizing multiple source- destination paths, bandwidth aggregation, minimized end-to-end delay, increased fault-tolerance, enhanced reliability, load balancing. The definition of a braid can be given as,

2.1. Definition:

Let 'D' be the unit cube in the positive octant of Euclidian 3D-space, with one vertex of the origin. Hence D = {x,y,z ϵ R : 0 ≤ x, y,z ≤ 1} and 'n' can be defined as points $A_1,A_2,\ldots..,A_n$ on the top face of D by

$$\mathbf{A_i = (1/2,\ i/(n+1),1),\ where\ 1 \leq i \leq n} \qquad (1)$$

Hence, 'n' points can be defined as B_1, $B_2,\ldots..,B_n$ on the bottom face of D by

$$\mathbf{B_i = (1/2,\ i/(n+1),0),\ where\ 1 \leq i \leq n} \qquad (2)$$

By adding 'n' polygonal arcs the existing strands, d_1 to d_n to the unit cube 'D' satisfying the following conditions

i. the arcs $d_1,d_2,\ldots\ldots\ldots d_n$ are to be mutually orthogonal.
ii. the conditions $0 \leq S \leq 1$ and $1 \leq i \leq n$, $E_s \cap d_i$ is 1 point.
iii. each strand has the same starting point A_j and end point B_k.

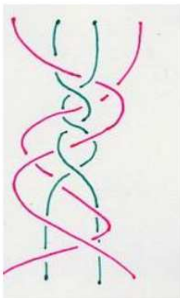

Fig. 1: Braid

2.2. Significant features of a braided multipath:

Some of the significant features of the braided multipath which has made it an important method

- end-to-end reliability
- enhanced security by the elimination of the malicious or compromised nodes
- using multiple paths to forward the same event, the probability of the event reaching sink is increased and this also ensures to avoid packets being forwarded to the same broken link
- energy-efficient data dissemination paths between sources and sinks

III. Network model building:

A wireless sensor network consists of dense nodes. There is a single Base station also called as SINK. A link is established between the nodes for communication. Any two concurrent transmissions causes congestion in the network resulting in the failure of transmission. A wireless senor network topology is considered as an undirected graph G = (N,I) where 'N' represents the set of deployed nodes nodes deployed in the network area and 'L' represent the set of interference links caused between the nodes. A node cans either send\receive data at a time. Every sender node is assigned a unique channel for communication.

IV. Construction of disjoint braided multipath:

While constructing a braided path, the network is assumed to be dense enough for sufficient multiplicity of paths between sources and destination. The network is considered as a static network. There is only one SINK and flow of message is from nodes to SINK and not the other way around. Every node keeps the neighborhood information as its level and parent list.

4.1. Algorithm:

Step1 Identify the primary path P between source and SINK

Step2 Find the first braided disjoint alternate path P_1 which is the best alternate path node-disjoint with the primary path P

Step3 Find the second braided disjoint alternate path P2 which is the first best node-disjoint with the first alternate path and the second best alternate path to the primary path and so on.

4.2. Alternate braided multipath analysis:

When alternate path reinforcement is not received by a node in the primary path, path reinforcement message is propagated to its most preferred neighbor. The shortest path is set as the criteria for selecting the preference node. Conversely, when a node already in the primary path receives the path reinforcement message, it does not propagate it further and is discarded. Since the construction of braided path involves global knowledge of deployed network topology, this algorithm is called idealized algorithm and the corresponding braided multipath is called idealized k-disjoint braided multipath. In Figure 2, node n_{k+1} send an alternate path reinforcement message to find the route around the node n_k that passes through a_{i-1} and a_i before it rejoins the primary path at node n_{k-2}. An alternate path reinforcement message sent out by n_{k+1} can follow any sequence of nodes in constructing the path that can be completely disjoint from the primary path and join the primary path at node n_k.

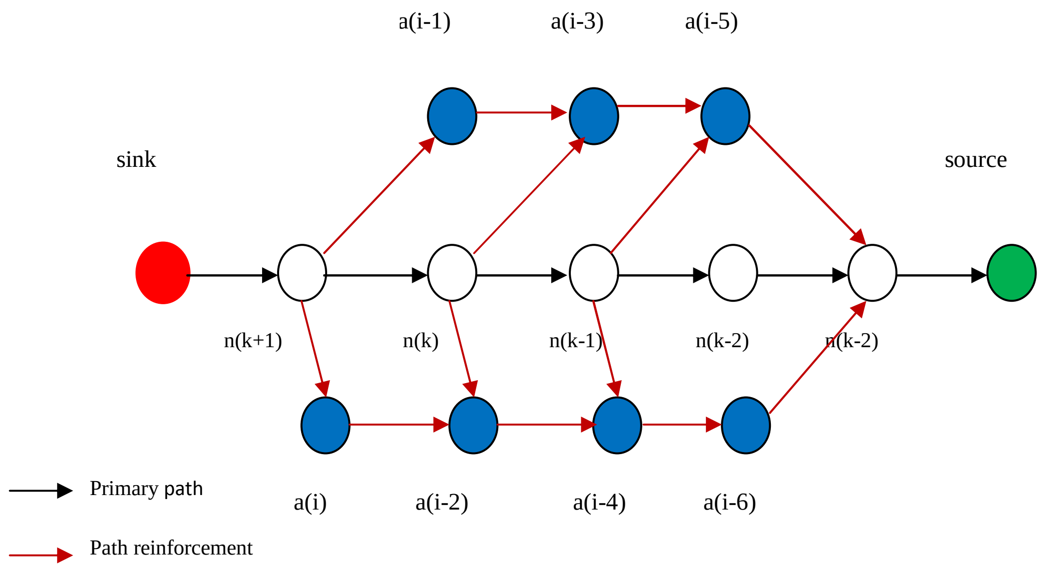

Fig. 2: Alternate path reinforcement

V. Dijkstra's algorithm:

It is considered as the most efficient method which is based on the Bellman optimization method. The working principle of Dijkstra's algorithm is by searching the network uniformly but the nodes with less probability to fall into the constructing path are also visited unnecessarily. It calculates the shortest path between any two nodes on a network using a graph consisting of nodes and edges. A cost value is assigned to each node and it is set as zero for source node and infinity for all other nodes. The deployed nodes are divided into two sets, as tentative and permanent. The nodes are chosen and are set as tentative. All the constructed paths are analyzed to find out the most feasible path. It is found to be time consuming since the arrival of the shortest path involves the entire network path analysis.

VI. Dijkstra resilient braided multipath routing (DRBMR):

In the existing braided routing protocols, the constructed paths are not shortlisted based on the distance between the current node and source. To make the routing more efficient and to reduce the transmission time, Dijkstra algorithm is used to find the shortest braided disjoint multipath between the SINK and the source node. The identified shortest paths are assigned priority numbers based on its length. A cutoff path length is set and on reaching it, the rest of the constructed braided alternate paths between the SINK and the source nodes are discarded. The second parent node nearer to the SINK is chosen and the primary path and its braided alternate paths are constructed. Dijkstra algorithm is applied to the second set of paths. All the selected paths are maintained in a table at each parent node.

6.1. DRBMA algorithm:

Step1 Given initial graph G=(V, E). All nodes have infinite weight except the source node s, which has 0 weight.
Step2 First we choose the node, which is closest to the source node, s. We initialize d[s] to 0.
Step3 The primary path is constructed between the SINK and the source node.
Step4 The alternate braided path is constructed according to the braided routing algorithm.

paths are added in the braid set.

Step5 The length of the alternate paths are computed and the shortest path is identified using the Dijkstra algorithm.

Step6 The shortest path is identified and priority is assigned in ascending order.

Step7 Is the cutoff path is reached, the rest of the constructed braided paths are discarded.

Step8 The second nearest node to SINK is chosen for path construction and the steps 3 to 7 is repeated.

DIJKSTRA (G, w, s)
INITIALIZE FIRST PARENT (G, s)

1. B ← { } // B contains all the constructed alternate braided multipath
2. Initialize priority queue S ;S ← V[G]
3. while priority queue S is not empty do
4. m ← EXTRACT_MIN(S) // Pull out new path
5. S ← S È {u}
6. for each node n in Adj[u] do
7. Relax (u, n, w)

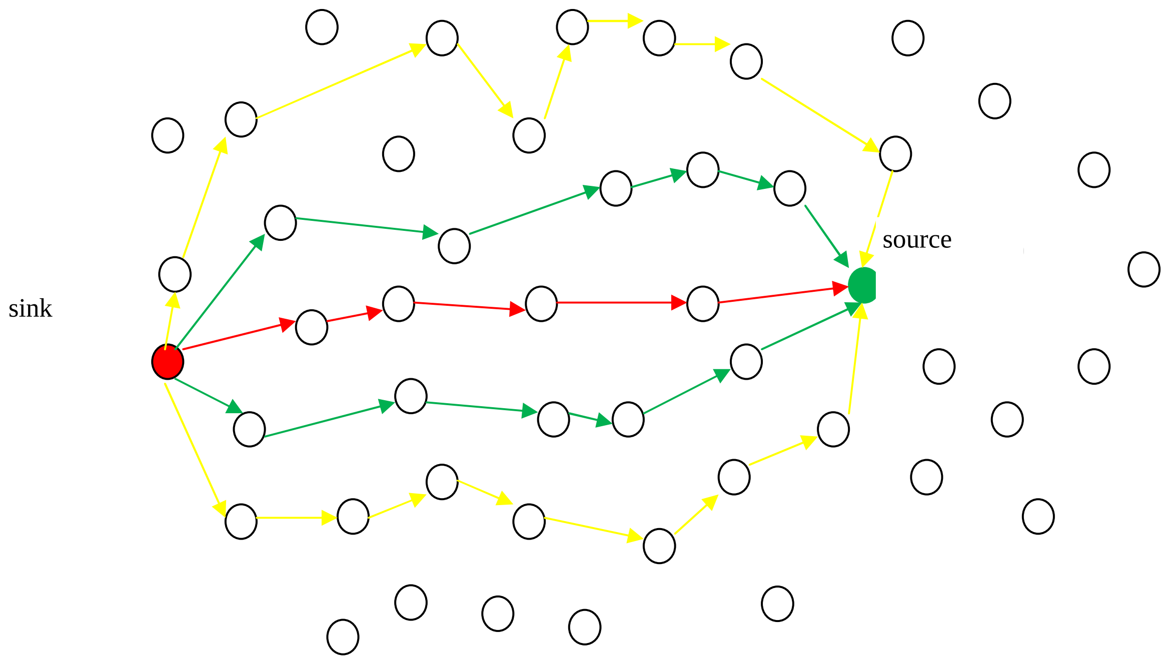

Fig. 3: shortest braided path selection using Dijkstra algorithm

RESULTS AND DISCUSSION

The relative performance of Dijkstra Resilient Braided Multipath is evaluated using two metrics: resilience and overhead maintenance. Parameter resilience is the measure of possibility of availability of the alternate path between he SINk and the source node when the shortest path fails. The maintenance overhead is the measure of amount of energy required to maintain these alternate paths. Always there is a tradeoff between these two parameters, a network to become more resilient tends to consume more energy. But our DRBMR algorithm uses less energy of the nodes, since the irrelevant paths are discarded before the routing path selection decreases the possibility of selecting the faulty path. When there is a total failure of the selected path, the alternate braid set with different parent is computed as a total alternative.

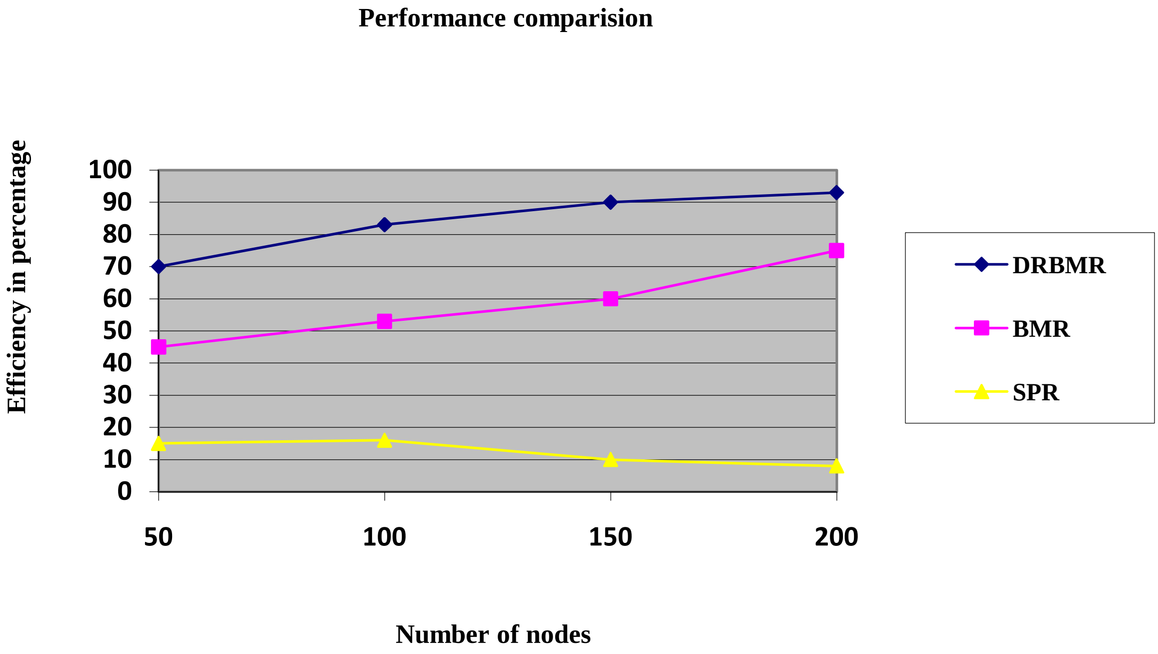

Fig. 4: Efficiency rate of DRBMR algorithm

VIII. Conclusion & future work:

In this work we have used the braided multipath routing for energy-efficient recovery during failure of nodes in wireless sensor network. By selecting the shortest path using Dijkstra method of shortest path selection, the shortest braided path is selected. Paths overriding the cutoff condition are discarded. The energy/resilience tradeoffs is high when compared with the other existing algorithms. As a future work, the energy/resilience tradeoff with varying density of nodes and for a patterned failures occur.

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