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Energy efficient routing based on Restricted Braided Multipath Routing in wireless sensor network

S. Elamathy[1] and S. Ravi[2]

ABSTRACT

The measures of Quality of service of a Wireless Sensor Network are end-to-end delay, energy efficiency, packet delivery ratio. Multipath routing especially Braided multipath routing serves as an efficient mechanism to serve the traffic distribution, balancing network load, energy efficient transmission. By exploiting the properties of braids and the broadcast nature of the wireless sensor network, a new idea of Restricted Braided Multipath Routing(RBMR) is proposed in this paper. The construction of braided multipath for routing is restricted near the primary path by significantly reducing the discovery of alternate paths in the network area. In terms of transmission overhead and delay, the performance and efficiency of RBMR is analyzed which proves the better performance of the proposed method of routing than the existing methods.

Keywords: braided multipath, alternate path, energy efficiency, wireless sensor network

1. INTRODUCTION

Extensive usage of wireless sensor network (WSN) coins the main reason for the development of numerous routing protocols.Braided multipath routing resolves the problem of routing and helps in maintaining the redundancy of the wireless sensor network. Since most of the resource nodes are involved in the primary path, energy efficiency is achieved by maintaining the braided paths as close as possible to the primary path[7].

A Network Coding based Co-operative Communication scheme(NCCC) is proposed in [8]. The packet loss-resistant capability of the network is improved through network coding. Communication fail-resistant capability is improved through co-operative communications. A heuristic Load Distribution algorithm [HeLD] based on a Braided Multipath is introduced in [9], trying to achieve maximization of throughput and a well balanced traffic load and of bandwidth to convey this information to a Base Station. Every element in the network is static. In [10], provides a mathematical optimization model for the wireless sensor network's energy minimization and resilience maximization. The devices within the network will try to create multiple paths from the beginning trying to reach at least one Base Station to increase network's resilience. The model is solved through a heuristic algorithm based on the nearest neighbor and minimum hop concepts. [11] explores the network redundancy through multipath routing. This paper proposes on-demand hybrid multipath routing (OHMR) with two distinct features two novel characteristics; it establishes braided multiple node disjoint paths between the source node and destination node and end-to-end transmission is maintained for a significant period of time.

[1] Electronics and Communication Engineering Dr. M.G.R. Educational and Research Institute University Chennai, India, *Email: elamathy.j@gmail.com*

[2] Prof. & Head, Electronics and Communication Engineering Dr. M.G.R. Educational and Research Institute University Chennai, India, *Email: ravi_mls@yahoo.com*

2. MULTIPATH

Multipath routing as drawn an intensive attention in wireless sensor network. The dense deployment of nodes in the network area has made the multipath routing a promising technique to face the frequent topological changes in the network communication. It also enhances the robustness of the packet delivery thereby balancing the traffic load and reducing the end-to-end delay.

3. BRAIDS

The geometrical definition of a braid can be stated as,

3.1. Definition

An n-braid can be defined as a collection of n disjoint strings where the endpoints are fixed.

Mathematically a braid can be defined as follows,

3.2. Definition

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

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

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

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

By the addition of "n" polygonal arcs d_1 to d_n to the unit cube "D" such that the following conditions are satisfied.

(i) The arcs $d_1, d_2, \ldots\ldots d_n$ are mutually orthogonal.

(ii) for the conditions $0 \leq S \leq 1$ and $1 \leq i \leq n$, $E_s \cap d_i$ is found to be exactly one point.

(iii) each strand d_i begins at the same starting point A_j and ends at same end point B_k.

The resulting collection of "n" arcs $d_1, d_2, \ldots\ldots, d_n$ is called nbraid. The first relation ($ac = ca$) is valid for any two letters distant of atleast 2 in the alphabet. The relation ($aba = bab$) is found to be valid only for two consecutive letters in the alphabet.While construction of braided paths, the inverse property is considered. The "n" strings corresponding to "n" descending strings without crossing is termed as identity braids. improved the overall Quality of Servce(QoS) of the wireless sensor network.

3.3. Significant features of a Braided Multipath

Some of the major advantages of a braided multipath which has made it a predominant feature of a energy efficient wireless network are as follows,

- End To End Delay: while using single path on-demand routing protocol, the failure of a route means the initiation of discovery of a new path for the continuation of the commenced transmission.

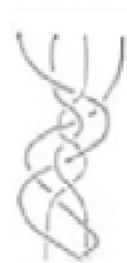

Figure 1: Braids

This route discovery greatly increases the transmission time as it includes the route discovery time and retransmission time through the newly discovered path. Braided multipath utilization significantly reduces the end-to-end transmission delay with high throughput.

- Load Balancing: Load balancing is the optimal use of the available resources in the network to reduce the congestion caused by packet retransmission traffic. Over utilization of the link established causes congestion and braided multipath routing provides alternate paths as a solution for the congested link. The traffic load can be leveled by distributing the traffic on multiple paths. But it may lead to extra propagation delay but holds successful transmission of packets with minimal delay time in choosing the alternate braided path.
- Fault Tolerance improvement: Due to the restricted energy availability in sensor nodes, the probability is high for the failure of nodes. In such cases, reliable and energy efficient delivery of packets is crucial. This problem is addressed by using braided multipath which increases the fault tolerance of the network. All the above said features of a braided multipath routing has

4. NETWORK MODEL BUILDING

A wireless sensor network consists of a set of nodes. The Base station is the SINK of the network. A communication link is established between the two nodes say "L" = (a, b) indicates the packet transmission initiated by node "a" to the node "b". Any two concurrent transmissions occurring on the same channel are found to be conflicting if there exist an interference link from the sender node "a" to the receiver node "b". Topology of a wireless senor network is considered as an undirected graph $G = (N, L)$ where "N" denotes the set of nodes deployed in the network area and "L" represent the set of interference links occurring between the nodes. The routing tree is formed from the set of the communication link used for data collection at the Base station. A node cannot simultaneously send and receive data at a time, also it cannot receive data from multiple sender nodes. Hence, every sender node is assigned a unique channel for communication. The nodes in the network are clustered based on the KenKen approach.

5. BRAIDED MULTIPATH ROUTING

Braided Multipath Construction phase starts after the discovery of neighboring node where every node holds its neighborhood information. The SINK holds the location information of all nodes in the network and with this basic information it proceeds with the route request to the nearest cluster head node. The Restricted Braided Multipath Algorithm determines only two routes for a parent node namely primary path and the first alternate braided path.

The primary path is constructed with the best feasibility neighbor node with the minimum number of hops. The first braided alternate path is constructed with the next feasible neighbor node with the minimum number of hops to the destination node. During the path discovery phase, the important criteria used to search out the alternate path are the path disjointness. Hence the paths can be classified as,

- *Non-disjoint alternate path:* Also referred as joint multipath will have most of the nodes and links in common for the paths.
- *Disjoint alternate Paths:* This method attempts to search out for paths which are disjoint and supporting the uniqueness of every path. Further it is classified as follows:
- *Link-Disjoint Multipath:* It discusses the set of paths that doesn't contain any link in common however could share some intermediate nodes.
- *Node-Disjoint Multipath:* It refers the set of paths where every alternate path doesn't share any node apart from the source and the destination node. Hence the paths are unaffected by failure of other paths.

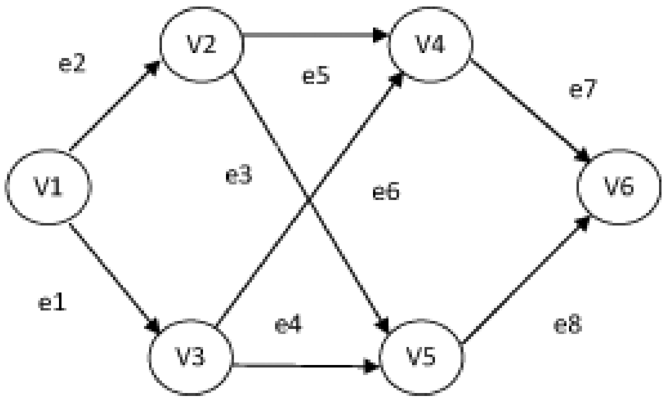

Figure 2 (a): Connectivity graph with nodes and directed links

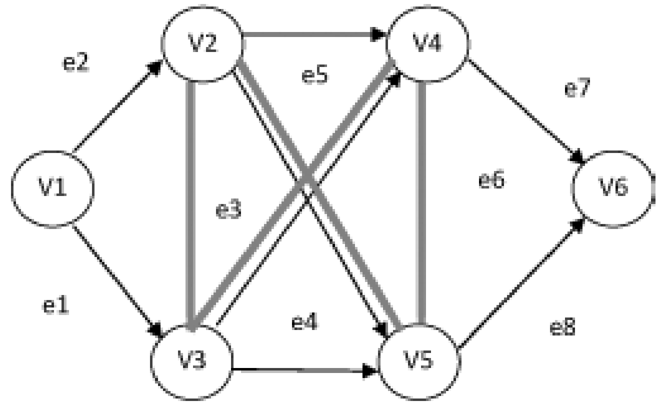

Figure 3 (b): Interference by the neighborhood nodes

A network with 6 nodes and its directed links is shown in Figure 2, where v1 is set source node and v6 is destination node. In Figure 2, the vertices are set as nodes and the edges as links. we put forward the restricted braided multipath algorithm to search minimum delay paths from source to the destination node.

6. RESTRICTED BRAIDED MULTIPATH CONSTRUCTION

There are two phases in constructing the restricted braided multipath, as

- Establishment of primary path
- Construction of first alternate braided path

6.1. Establishment of primary path

In order to find the primary path both the nearest and alternate nodes are requested for path establishment to find first nearest node towards the source. If it is the nearest node, it will broadcast its number of hop as hop count and node type to the SINK among its neighbor nodes and is called as parent node. Else if it is an alternate node it will broadcasts its node type and number of hops to the alternate routes towards the source. If the node of origin is found to be the parent dominant, then the node type of the found neighbor will be set as parent. If the node is found not as a parent node, then its type is assigned as alternate node. This procedure is repeated until the entire path is established between the source and the destination node. Every established braided path is assigned a unique ID as path ID. In the network, when there is a transmission, every node in the first braided alternate path except the parent node, is put into the sleep mode. To avoid collision only the

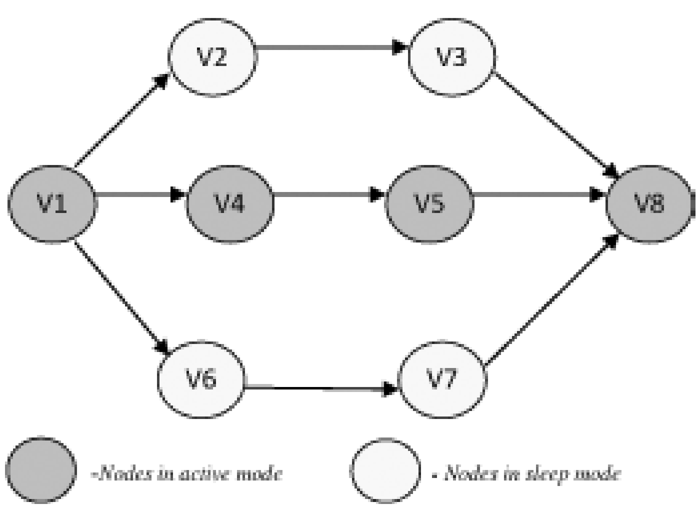

Figure 4: Assignment of modes to the nodes

primary route is made available for transmission between the source and destination. in case of failure of the primary path, the shortest alternate braided path is used for retransmission. This greatly helps in avoiding the interference between the nodes in the primary path of transmission. If all the routes are made available for transmission and there exist no free route between the source and destination, then the process starts from the node discovery phase.

6.2. Algorithm

Step 1: Identify the nearest node to the SINK.

Step 2: Identify the number of hops between the current node to the source.

Step 3: If the number of hops is minimum, then set it as the parent node else set as Alternate node

Step 4: Identify all the nodes available in between the source and destination and mark its status.

Step 5: Construct all the paths between the root node and its neighbor nodes

Step 6: Provide each path a unique ID

Step 7: Put all the nodes except the nodes in the primary path into sleep mode.

6.3. Pseudo code

if *(node == sinknode)* ***then***

Establish Primary Path ();

Establish Alternate Braided Path ();

else if *(node == parent)* ***then***

Establish Primary Path ();

Establish Alternate Braided Route ();

else if *(node == Alternate)* ***then***

Establish Primary Path ();

end if

until *(node == Source)*

procedure *Find Primary Path()*

if *(node == Parent)* ***then***

Broadcast PARENT;

Search for the next best route node accept Parent;

if *(node == Alternate)* ***then***

Broadcast ALTERNATE;

Search for the next best node and prefer Primary;

if *(node _= Parent)* ***then***

node _ Alternate; ***then***

end if

end if

end procedure

if** ((node = Parent)&&(node =Alternate)) **then

node _ Alternate;

end if

end if

if** (node == Alternate) **then

Exit ();

end if

end procedure

7. DATA TRANSMISSION

After the braided multipath construction phase, data transmission takes place between source node and SINK node. Although both the primary and alternate braided routes are available for transmission, only the primary path is preferred. On failure of the primary path only, the alternate braided paths are utilized. The remaining nodes which does not lie in the active transmission path will go to the sleep mode.

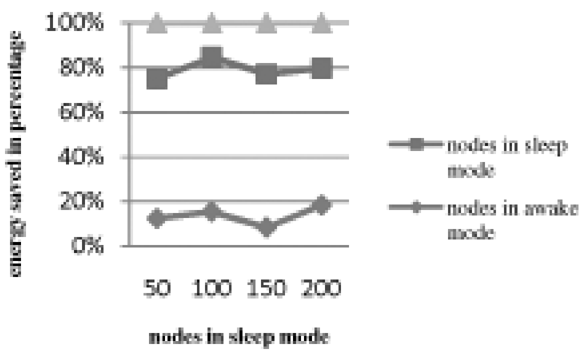

Figure 5: Comparison between the multipath routing and restricted braided multipath routing algorithm

8. CONCLUSION

Only with a little control restriction our restricted braided multipath routing protocol helps in reducing the congestion complexity in wireless sensor network. Moreover, by allowing nodes to choose the primary path dynamically based on the real-time transmission state, RBMR eliminates the effects of network topology modification. Additionally, the performance of the basic RBMR transmission protocol is analyzed in terms of reliability, end-to-end delay and transmission overhead. Thus when compared with the existing multipath routing protocols, RBMR protocol highly saves the energy of the nodes by keeping the non-participative nodes in transmission in sleep mode.

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