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Efficient Smart Routing Protocol for Faithful Transmission Of Packet and Traffic Balancing (ESFTB)

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ABSTRACT

As nowadays the Wireless networks have become more popular in real world environments. Wireless sensor networks have large benefits in terms of flexibility, easy and fast installation and low cost. WSNs can be used in any environments for example Industrial wireless sensor a network (IWiSNs) which may have harsh environmental conditions, thus providing faithful and efficient communication is a big challenge. Lot of research work has happened to provide efficient mechanism for reliable packet transmission. In the traditional approach, when the node has data to be sent to sink, it first establish the path and then forwards the data, even though there are multiple paths, it uses shortest path. The energy level of nodes across this path drains which may lead to node failures, in turn failure of communication network. This work proposes reliable transmission and load balancing approach to improve network lifetime. Through extensive simulations, comparing with other routing protocols, [ESFTB] increases packet delivery ratio, with high energy efficiency.

Keywords: - WiSNs, IWiSNs (Industrial Wireless Sensor Networks), Faithful Transmission, Traffic balancing.

I. INTRODUCTION

A Wireless sensor networks can be defined as the network of devices, denoted by nodes which can sense the environment and also communicate each other and exchange the information gathered from the monitored area through the wireless links in the network. WiSNs are adapted in industries due to their several benefits over wired system like easy and fast installation and also low cost of maintenance. In IWiSNs[1] , the sensor nodes are scattered and are deployed to sense the surrounding and transmit the sensed information over the distances that depends on the application of these sensor nodes.

The wireless channel conditions in industries is considered to be harsh due to varying temperature, high vibrations , interference issues and many other constraints. So, when sensor nodes deployed in such harsh environment the vulnerability of the wireless signals leads to transmission failure and also missing or delaying of process or control data which can be a loss in terms of money, time, and man power. However for industries, missing of process or control deadline is normally intolerable, which possibly terminate the industrial automation and finally resulting in loss. The traditional routing protocols like AODV [2], AOMDV [3] and DSR [4] have their limitations in industrial installations. The sensed information should be reliably and timely delivered to the sink node. It also requires that these networks operate for many years without replacing the batteries. Therefore, reliability, timeliness and also energy efficiency is important for proper functioning of IWiSNs.

II. RELATED WORK

There are many routing mechanisms in WSNs to transmit the data packets to the sink node. Before transmission of data the path must be established from source, which uses source routing protocols. Due to varying environmental conditions and energy levels of sensor nodes results in path breaks or node failure. So new path needs to be established which may consume more time and energy. To overcome these reactive routing protocols were introduced.

Charles Perkins and Elizabth proposed AODV [2] reactive routing protocol. While repairing the broken links in the network AODV provides a quick response and also loop few routes. AODV does not store any routing information, but it discovers new path when necessary and from point of failure. Mahsk K. M. and Samir .R. Das proposed Ad-Hoc on Demand Multipath Distance vector reactive routing [3] for dynamic Ad-Hoc networks. It discovers multiple paths form source to sink node, which helps to find alternate new route in case of route failures, although it discovers multiple paths it uses only one path. Dynamic source routing[4] is also a reactive routing protocol, During transmission of data if any path failure occurs, then every node updates the path to the source node using route discovery mechanism, so that here there is heavy burden on source node. J.A. Sanchez , R.M Perez and P.M .Reriz proposed the Beacon- less On Demand Routing [5] in WiSNs, Here the design concentrates on collisions and losses occur in radio communication systems. And also determines the impact of the size of packet on Packet Reception Ratio. For Industrial wireless sensor networks an efficient route selection algorithm was proposed. It mainly aims to provide reliable and energy efficient network. It concentrates on link weight, traffic congestion and interferences issues to obtain route in order to transmit data to the intended node. Energy efficient opportunistic routing [6] in WiSNs has been proposed to address how to select and assigning priorities to the list of forwarders in order to minimize cost of the energy needed to forward data to the sink node. Here the challenge is to compute expected cost. When the sensor node needs additional overhead. It is also interesting in designing opportunistic routing protocols to deliver that data reliably and timely. To overcome the problems of reliability and energy consumptions, opportunistic routing has been proposed which improves robustness also consumes very less energy to forward data to the sink node. On WiSNs each node has many neighbor nodes, during data transmission opportunistic routing selects multiple nodes to overhear the forwarding candidate. Although reliability is one of the main challenge that needs to be met in any routing protocols in WSNs. Concentrating on this may lead to some problems. By considering some other aspects such as network life time, energy efficiency can obtain better transmission. Load balancing is also important approach that needs to be considered to ensure network lifetime. Although there is a lot of work done to balance load across the network. When the sensor node has data to be sent to sink it discovers paths to the sink, even though there are multiple paths, it uses the shortest path. When the energy level of node decreases, this may lead to failure of nodes which in turn leads network failure. Energy consumption of sensor node is due to sensing of data, receiving and forwarding of data.

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III. PROPOSED WORK

Now here we consider dense network of wireless sensor nodes with many neighbors. Before finding path nodes checks its transmission range, once this process is completed it comes to know its surrounding neighbors and transmission Range. The figure1 illustrates the functional architecture of ESFTB. This approach is a middleware design between the MAC layer and network layer to improve the reliability in network. The design involves the following tasks.

- Reliable path identification
- Selecting support nodes
- Forwarding decision and Prioritization
- Load Balancing
- Data Transmission

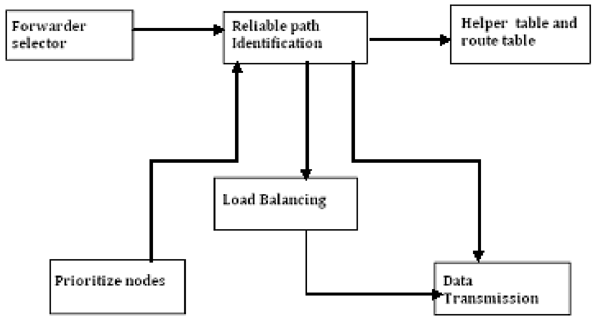

Fig1. Functional architecture overview of ESFTB

a) Faithful path identification

In wireless sensor network before forwarding the data packets to the intended node, path must be established. Here the source node broadcasts route request packets till it reaches the sink, and sink will reply to this request through the same or different routes. This route should be reliable and efficient to forward the data packets. This phase mainly has two modules

I. RRQ [Route Request Propagation]
II. RRP [Route Reply Propagation]

Route Request Propagation

This is the initial task needs to be done by any node in the network when it has data to be sent to destination. When some node has sensed data and knows the intended node to which data needs to be sent, it broadcasts the route request packets to all neighbours. Each packet consists of source node id, destination to be reached, RRQ sequence number and also the nodes covered so far. Biased Back-off delay scheme is also introduced to avoid multiple rebroadcasting of data at RRQ forwarding nodes. The node which has highest priority will broadcasts data packets and acknowledges the other nodes to stop timer. if timer expires and if neighbour nodes did not receive any acknowledgement, then the node with next high priority will broadcast RRQ. So that this enables RRQ packet to traverse faster across network to reach destination. Let X_j is current forwarding node, the back–off Delay time is denoted by T_{ij} ,

X_j receives the route request packets from X_i. T_{ij} is denoted using $T_{ij} = (((\text{Hop-Count}) / (\sum p_{ik}\, p_{kj} + 1)\ ((\text{Maximum energy}/ \text{available energy})/ \text{Number of } CN_j)$, v_k € $F(I,j)$

Where

T is time slot, CNj is common neighbors of node j, Hop-Count is nodes distance from source to current node, P_{ik} is packet delivery ratio from i to node k,

P_{kJ} is packet delivery ratio from k to j, Maximum energy is the energy given to the node when it is deployed and available energy of energy remained in a node.

ALGORITHM: Route Request

```
void RecvRRQ (Packet *p)
{
if New RRQ then
{
If j is the destination node then
 Send back RRP;
Else
CN(i,j) = N(i)∩N(j);
}
S(i,j) = {cn1}, CN(i,j) = CN(i,j)-{cn1};
While CN(i,j) ? do
{
if CheckConnectivity(S(i,j), cn1) then
S(i,j) = S(i,j) U {cn1};
Exit(0);
CN(i,j) = CN(i,j)- cn1;
Exit(0);
}
Calculate ti,j and call Backoff(ti,j,p);
Exit(0);
}
else
Drop p;
Exit(0);
}
```

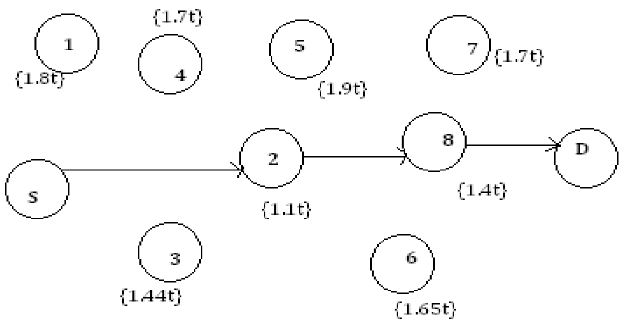

Fig 2. Example of forwarding RRQ packet.

As shown in figure2. Any node that receives the route request will calculate the back-off time considering itself as guide node previous nodes as upstream nodes. For example, the nodes 1, 2, 3, 4 receives RRQ from the source node S. the node 2 calculates the back-off delay time, it assumes itself as guide node and S as upstream node. Each node will have local neighbor table, for this table the node 2, identifies 1, 3 and 4 as support nodes, then it can calculate back-off delay value. In figure the label {1.8 t} by the side of node 1 shows that back-off time it needs to wait. And the node 2 has {1.1 t} the delay time according to formula specified in 1. Comparing with the other support nodes 1, 3 and 4, node 2 has high priority and low delay time. Node 2 s timer expires soon compared to other support nodes; hence it rebroadcasts the route request to next nodes. Similarly the node 8 forwards the packet before the surrounding neighbors, hence RRQ traverses along the path source-> 2 -> 8-> sink. Once it reaches sink it informs source about path. Duplicate RREQ packets will be discarded, only RREQ which receives first will be considered and replied to it by sink.

Route reply propagation

Once the RRQ packet reaches the intended node then it has to reply back to source by RRP packets. When destination sends route reply the nodes that receive packets, checks whether it is intended to receive, if yes, then marks itself as guide node. This guide node records its upstream guide node and forwards RRP. This process continues until it reaches source and once it reaches the path becomes guide path from source to sink for transmission of data.

ALGORITHM: Route Reply

```
void RecvRRP (Packet *p)
{
if New RRP then
if vj==vi-1 then // vj is the selected next-hop &
guide node
vi -1;
Mark myself as a guide node and Record vi and
H(i-1, i);
Get RRPs next-hop node id vi-2;
Attach vi, S(i-1, i), vi-1 and S(i-2, i-1) to RRP;
forwardRRP p;
else if vj, S(i-1, i) then // vj is a helper in S(i-1, i);
Record vi+1, H(i, i+1), vj and H(i-1, i);
Drop p;
else
Drop p;
Exit(0);
else
Drop p;
Exit(0);
                    }
```

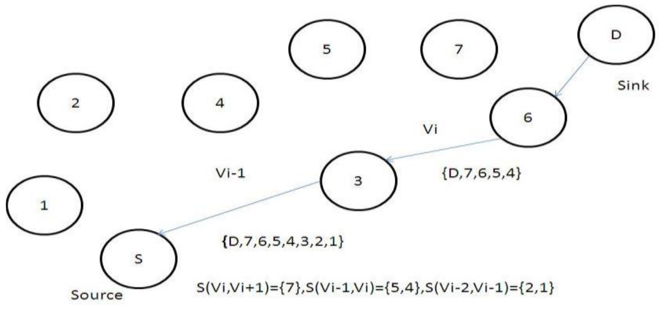

Fig 3. Example of RRP propagation

As shown in figure3 Route reply propagation. Suppose if 6 is current guide node, its helper node H (6, D) will be attached in the packet. When 6 forwards the data to next node 3 , the helper node 4 overhears this RRP and record the piggy backed information {D,7,6,5,4} .the one-hop neighbors of node 4 is {2,3,4,5,6}.

b) Selecting Support Nodes

Support nodes are the one hop neighbors, selection of support nodes among the available list of supporters is important to avoid delay in identifying new path from the point where node fails. Whenever the guide node fails the support node with next high priority is selected as guide for transmitting data without finding new path. It also avoids collision during transmission of data.

c) Forwarding Decision

This is runtime forwarding phase, in which it selects potential forwarders and assigns priorities to them. The prioritized node helps in finding new forwarder when current forwarder fails or any link break occurs. When the node in the guide path receives data packet this module checks whether it is intended to receive or not. If yes, then it stores the incoming packets and starts back-off timer in order to return ACK. Suppose if there are no forwarders in the list with high priority to forward ACK before time expires, then the node will broadcast ACK to pervious nodes, so in that any node will take a task of forwarding based on timer.

d) Load Balancing

The idea of load balancing is distributing the data from overloaded node to the neighbor node, which is having less loads. The main challenge is when to balance the load; the load of node is estimated by processing power, which not only includes processing power and buffer capacity or size. As guide path is established during route discovery process, if the path is over loaded or if busy in transferring the data, then according to our approach, we know multiple paths to destination, so it checks for possible alternate path, if yes then it forwards packets through this new alternate path. Or if this new path is busy or heavily loaded then, wait or need to find new path. In this way load across nodes in the network will be balanced.

```
Void loadbalance(packet *p)
{
        Link * L;
        While(path exists)
        {
        If(path 'L' is overloaded or busy)
        {
                If (alternate path 'L' && !busy)
                {
                Send the packets through alternate path
                Else if(alternate path 'L' && busy)
                Wait ();
                }
        Else if (no alternate path)
        Find the path to destination;
        Else send packets;
        }
Else
        Forward packets;
}
}
```

e) Transmission Of Packets

In wireless sensor networks, Co-operation among all the nodes in network is necessary. Since all nodes are not directly connected to destination. The source node having data packets broadcasts all candidates in the forwarding list and their priorities. Each candidate follow the priorities assigned to them in order to forward packets. After receiving the packet the node starts the Back-off delay time. The node with high priority will have less time. So that node whose timer expires will take forwarding task and reply with an ACK to notify sender. The back-off timer value of k'th node in the network is given by t(k) value. And is defined as

$t(k)= (TSIFS + TACK).K$

TSIFS is short inter frame space

TACK is delay for sending ACK.

IV. RESULTS

This work is implemented and demonstrated in network simulator 2, which is combined with the Existing reactive routing protocol AODV and compared results with other reactive routing Protocols. There are lots of metrics to measure the efficient working of any reactive routing Protocol.

A. *Comparison Baselines*

To compare the approach there are some reactive routing protocols, a brief description about
These are:

• AODV-ETX: This is also an extension of AODV protocol. During route discovery phase it uses least expected transmission count [ETX] to find a path from source to intended node. In AODV-ETX, the link layer retransmission of the packets is enabled, i.e. at most three retransmissions at each node in the network. Since other protocols do not adopt this retransmission mechanism.

• REPF: REPF (Reliable and Efficient Packet Forwarding) Protocol is modeled with the intension of improving the performance of AODV by utilizing the local path diversity. During the route discovery phase it identifies the best path along with the alternative paths with same cost by using ETX function. It doesn't utilize the path diversity provided by the nodes in the network. REPF restricts the support nodes to a limited scope, i.e., only the nodes which can connect the two-hop away primary forwarding nodes are considered as helper nodes.

A. *Simulation Setup*

The simulation analysis for the data transmission and to certificate revocation based security is implemented using the Network Simulator NS2. Density Of the nodes is the maximum number of nodes deployed in a given 200m X 200m square area. The nodes are deployed in any sensor environment randomly without any predefined metrics. The range of transmission for each node is set as a radius of 50m. The destination node is placed at the bottom of the sensor area (0m,0m) and the source node is placed at the top of the sensor area (200m,200m). The parameter used T is set to 0.005s in my approach. Guide nodes do not send acknowledgement for each route reply packet in order to avoid the collision. Route reply is acknowledged directly by the receiver, not by each one hop nodes.

The performance metrics are:

1. Packet delivery ratio: It is the ratio of total number of packets received to the total number of Packets sent.
2. End to End delay: Time taken by the node to forward a packet from source node to sink node.
3. Data transmission cost: It is measured as the Total number of data transmissions required to transmit the data from source to destination.
4. Control message cost: It is defined as the Total number of control messages transmitted from source to Destination for transmitting single packet from source to sink.

B. *Performance Analysis*

Performances of different protocols are evaluated against different node densities and results are
Shown in figure, a node density varies from 50 to 200. Fig. 4.(a) indicates the packet delivery ratio of different routing protocols under different node densities. The ESFTB routing protocol achieves high end-to-end packet delivery ratio with high node density and involving maximum number of nearest neighbours which are closer to the destination. AODV_ETX best path is discovered based on ETX metric, rather than hop-count metric [3]. At each hop in AODV_ETX three retransmissions of the packets are allowed in link layer, which intern helps to achieve high the packet delivery ratio as shown in figure 4.(a). Since the cooperation among nodes is restricted to limited scope in REPF, hence it achieves less packet delivery ratio. ESFTB achieves 98% packet delivery ratio and increases with node density as shown, which also enables the MAC layer packet retransmissions

Fig. 4.(b) shows the performance comparison of end to end delay against node density. Since AODV-ETX requires more time because it consumes more time for retransmitting a packet than for cooperative forwarding. As it takes several retransmissions to transmit the packet hence end to end delay comparatively higher. End to end delay of REPF and ESFTB is relatively closer since REPF doesn't allow maximum retransmissions and in ESFTB retransmission is done with the knowledge available at MAC layer hence its delay is less compared to AODV-ETX as shown in figure 4.(b).

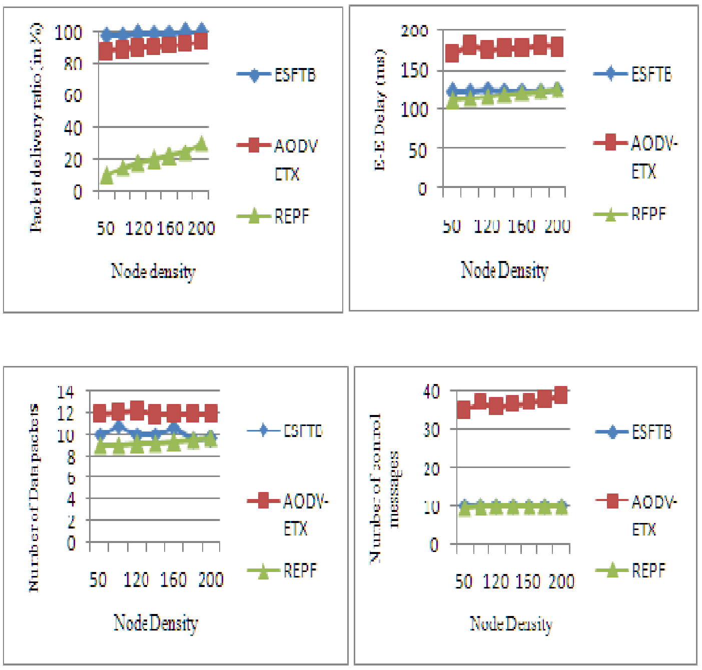

Figure 4.(a) comparison of PDR versus node density
(b) Comparison of end to end delay versus node density
(c) Comparison of data transmission versus node density
(d) Comparison of control message cost versus node density.

Fig. 4.(c) shows the changes of the data transmission costs under different node densities for successful end to end packet transmissions. The cost of data transmission in ESFTB is slightly higher than REPF, since AODV-ETX has higher data transmission cost because of more number of retransmissions carried out while transmitting a packet which is as shown in figure 4.(c). Fig. 4.(d) describes comparison of control message cost against node densities. In ESFTB the cost of control message is slightly equal to REPF since retransmitting packets doesn't require control messages to be transmitted, since path is identified at the beginning of the route establishment phase. The control message cost of AODV-ETX is high compared to other two routing protocols as shown in figure 4.(d).

V. CONCLUSION

The designed ESFTB can be used most with the current reactive routing protocols in WiSN / IWiSNs to increase the reliability, energy efficiency and packet delivery ratio. Here back-off timer scheme is introduced to obtain the best virtual guide path in path discovery phase. Through this virtual path data packets are progressed without using location information. In any of guide node if buffer if full, the data packets are routed through different path, so that it avoids loss of data packets. This concludes that the proposed work can be used with any existing reactive routing protocols to improve energy efficiency and packet delivery ratio.

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