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Amassment of Data Using Energy Efficient Guide Path and Mobile Relay in Wireless Sensor Networks

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ABSTRACT: There are a large number of reactive routing protocols in an Ad hoc network. The most commonly used one is Ad hoc On demand Distance Vector (AODV) routing algorithm. Establishing reliable and effective communication under the harsh environments of Industrial Wireless Sensor Networks (IWSNs) is a concerning problem that needs to be tackled efficiently. The existing system that is, Reliable Reactive Routing Enhancement (R3E) which is a modification to the existing AODV, involves a biased back-off scheme which is used during the route discovery phase to find a robust guide path. A Wireless Sensor Network may fail due to various reasons. The most concerning problem includes the node failure due to energy depletion which creates bottleneck in the network. Data gathered at the destination may not be reliable if the sensor nodes fail due to battery depletion. This project mainly deals with the concept of finding Energy Efficient Guide Path (EEGP) to provide reliable data delivery from source to destination. Failure of guide path is compensated using mobile relay which uses location based strategy to collect data from the active node and deliver it to the destination. This providesenough time for the deployment of new nodes within the network. Simulation results show that the proposed work has high packet delivery ratio and high throughput while maintaining low end-to-end delay and low packet drop.

KEYWORDS: IWSNs, R3E, EEGP, Mobile Relay, LEF.

I. INTRODUCTION

Wireless Sensor Networks (WSNs) have become an established technology for large number of applications ranging from monitoring, to event detection and target tracking. In industries too, the traditional wired communication has been replaced by WSNssince the Industrial Wireless SensorNetworks(IWSNs) offer several advantages including easyandfast installation and low-cost maintenance. In IWSNs, transmission failures can result in missing or delaying of process or control data, and missing a process or control deadline is normally intolerable for industrial applications, as it may chaos in industrial automation or possibly terminate the automation, ultimately resulting in economic losses.

In [1] Reliable Reactive Routing Enhancement (R3E) is proposed, which increases the resilience to link dynamics for WSNs/IWSNs. Its design inherits the advantages of Opportunistic Routing, which involves multiple neighbors of the sender into local forwarding. R3E is designed to augment the existing reactive routing protocols to combat the channel variation by utilizing the local path diversity in the link layer.Wireless Sensor Networks may fail due to lack of energy of the forwarding nodes. Hence, it is imperative to find the nodes that will provide services for longer duration. For IWSNs, due to harsh and dynamic nature of the links it is necessary to ensure reliable data delivery from source to destination. The major contributionsof the work are as follows:

-To find Energy Efficient Guide Path (EEGP) for data packet forwarding.

-To compensate for the failure of guide path by using mobile relay.

-To reliably deliver packet from source todestination.

The rest of the paper is organized as follows. Section II elaborates the architecture of existing system i.e., R3E. Section III includes problem formulation followed by section IV which provides details about the proposed work. Section

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Vshows the simulationresults of the proposed system. Section VI concludes the paper.

II. RELATED WORK

2.1Reliable Guide Path Discovery

1) RouteRequest(RREQ) Propagation: If a node has data packets to send to a destination, it initiates a route discovery by flooding an RREQ message. When a node receives a non-duplicate RREQ, it stores the upstream node id and RREQs sequence number for reverse route learning. Instead of rebroadcasting the RREQ, a biased back-off scheme at the current RREQ forwarding node is introduced. The aim of this operation is to intentionally amplify the differences of RREQs traversing delays along different paths. This operation enables the RREQ to travel faster along the preferred path according to a certain defined metric. Let t_{ij} denote the back-off delay at the current forwarding node v_j , which receives an RREQ from v_i. t_{ij} is calculated as defined in

$$t_{ij} = \frac{HopCount * \tau}{\sum_k P_{ik} P_{kj} + 1} \qquad (1)$$

where τis a time slot unit; the HopCount is the RREQs hop distance from the source node thus far;P_{ik}, P_{kj} are the PRR of node k from node i and node j from node k respectively, where v_k is a neighbor of v_i and v_j . The rationale is that, the neighbor with shorter hop-count will have a shorter back-off delay to rebroadcast the RREQ [1].

2)RouteReply(RREP) Propagation: When a node receives an RREP, it checks if it is the upstream guide node of the RREP. If that is the case, the node realizes that it is on the guide path to the source, thus it marks itself as a guide node. Then, the node records its upstream guide node ID for this RREP and forwards it. In this way, the RREP is propagated by each guide node until it reaches the source via the reverse route of the corresponding RREQ. Finally, this process finds a guide path from the source to the destination [1].

III. PROPOSED WORK

Typically, in multi-hop communication scenario, the sensors closed to the sink are the first to run out of energy. This is due to the fact that these sensors are required to forward all other nodes data. Once these nodes are disconnected, the operational lifetime of the networks ends. The capacity of the battery for each sensor node is considered limited in terms of energy. When energy depletion of sensor node results in a dead node that is unable to communicate with the other nodes, this creates bottleneck in an IWSN. This may cause the sink to receive only a part of the sensed data. For effective and reliable communication in IWSN, this problem has to be alleviated.

3.1 Network Model

A sensor network consists of a number of sensors and a number of base stations. Two sensors are neighbors if they can directly communicate with each other. The sensors share the same wireless media and each packet is transmitted as a local broadcast in the neighborhood. Assuming the existence of a MAC protocol, which ensures that, among the neighbors in the local broadcast range, only the intended receiver keeps the packet and the other neighbors discard the packet. The sensors are statically located after deployment. The mobile sensors that form a dynamic ad hoc network are not considered here. A data packet may be sent from any source to any destination. The network is considered to be homogeneous and all the sensor nodes have the same initial energy. The different phases which are involved in a reliable data packet delivery include:
- Route discovery
- Selection of Energy Efficient Guide Path(EEGP)
- Deploying a mobile relay to compensate failure of EEGP

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3.2 System Working

Whenever a source node has data packets to be sent tothe destination node, it initiates the route discovery by sending the RouteRequest (RREQ) packet throughout the network. This causes destination to send RouteReply (RREP) packet towards the source through the path from which the RREQ is first received. This is the usual path which is selected using the routing protocol.

Algorithm 1 RREQ and RREP propagation

1: **if** Non-duplicate RREQ **then**

2: **if** v_j is the destination node **then**

3: send out RREP

4: **else**

5: Forward RREQ to othernodes

6: return to step 1

3.3 Energy Efficient Guide Path

After a considerable amount of time, the obtained pathmay fail when the sensor nodes along the routing path lack energy or are affected by some industrial conditions. This results in failure of the entire process within the industries. In order to avoid such catastrophic results, an alternate Energy Efficient Guide Path (EEGP) is found. The alternate path is found based on the fact that nodes within this path have more packet reception ratio and energy. The forwarding candidates within the EEGP are selected at the time when the usual path is found. The Link Expiration Factor (LEF) determines the neighboring nodes with high packet reception ratio and high energy. The LEF is obtained by the following equation:

$$LEF = -(ab + cd) + \frac{Q}{a^2 + c^2} \qquad (2)$$

$$Q = \sqrt{(a^2 + c^2)r^2 - (ad - bc)^2} \qquad (3)$$

$$a = ef_i \cos\theta_i - ef_j \cos\theta_j \qquad (4)$$

$$b = x_i - x_j \qquad (5)$$

$$c = ef_i \sin\theta_i - ef_j \sin\theta_j \qquad (6)$$

$$d = y_i - y_j \qquad (7)$$

In the above equation, x and y represents the coordinates of nodes i and j, θ represents the direction coordinatesof nodes i and j and ef is the product of packet reception ratio and energy of nodes i and j. In this way, the EEGP can be found efficiently.

Algorithm 2 Routing of data packet

procedure :(Routing(Packetp))
Send data from source to destination through the first path obtained through RREP propagation
Calculate LEF values for each node usingeq.2
Let LEF_x, x=1,2...,k, be the LEF values of the nodes arranged in the descending order in the LEF_{table}
Let LEF_i and LEF_j be the LEF of node v_i and v_j respectively
if ($LEF_i < LEF_j$) **then**
if v_j is geographically closer to destination **then**
Mark v_j as Energy Efficient Guide node
else
Select v_i as Energy Efficient Guide node
Find all Energy Efficient Guide nodes, and hence EEGP

3.4Mobile Relay (MR)

The Energy Efficient Guide Path may also fail after theenergy of these forwarders drain after considerable duration of time or due to any industrial condition. It is imperative to compensate for the EEGP failure. To overcome this, a Mobile Relay (MR) can be used. MR is a special support node which performs only a specific task. They are not sources nor destinations of messages, but exploit mobility to support network operation or data collection. These support nodes which gather messages from sensor nodes, store them, and carry the collected data to sinks or destination nodes. The MR used here is in the sleep state and wakes up only after receiving the requests from the active nodes. It is also assumed that the MR is not affected by the environmental disturbances within the industries.

When the guide path fails, the active nodes along the guide path send request to a MR which is initially in the sleep state. Once the MR receives the request, it wakes up and before approaching the active nodes it calculates the distance from itself to each active node. Based on this measurement it selects the active forwarder which is closer to itself. MR then moves to the closer active node and collects data from it and delivers it to the destination. The location based data collection approach is illustrated in algorithm 3.

Algorithm 3 Location based data collection approach

d_p, p=1,2,…,k, is the distance between MR and
location of nodes stored in M R_{table} in the ascending order of the distances from MR

Let v_i and v_j be the active nodes
d_i and d_j be the distance of v_i and v_j from MR respectively
if($d_i < d_j$) **then**
select v_i
MR moves to the location of v_i
MR collects data from v_i
else
select v_j
MR moves to the location of v_j

MR collects data from v_j
MR moves towards destination and delivers data to the destination

The reliable delivery of data is ensured on the basisof availability of alternate methods that support the delivery of data from source to destination. This is shown with the following algorithm 4.

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Algorithm 4 Selection of different path

1: procedure :(Linkfailure(faultnodes))
2: **if** (normal nodes==fault nodes) **then**
3: Select Energy Efficient Guide Path
4: **else**
5: return to step 2
6: **if** (guide nodes==fault nodes) **then**
7: Send request to Mobile Relay
8: **else**
9: return to step 6

IV. PERFORMANCE EVALUATION

In this section, the performance of data delivery using EEGP and mobile relay is compared against the use of R3E. The simulations are done using NS-2.The total number nodes deployed are taken to be 41. Among these nodes, 40 of them are chosen to be static nodesand one of them is a mobile relay.Thesimulation area is taken to be 1150m × 800m. The nodes are configured with certain parameters like receive power, transmit power, idle power, sleep power etc. The routing protocol used here is Ad hoc On demand Multipath Distance Vector (AOMDV), which is a multi-path extension of AODV. The simulation results of various performance metric with respect to time for both R3E and proposed system is plotted. The simulation plot of the proposed system is represented using red colour and for R3E, it is shown using green colour.

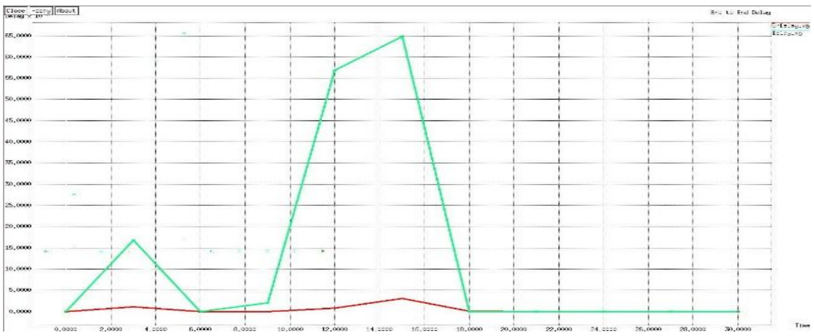

Fig. 1. Comparison of end-to-end delay

Fig. 1. represents the end-to-end delay. It is seen that the given system has less end-to-end delay when compared to R3E. The initial delay is the result of neighbor discovery and RREQ packet broadcasting. The delay seen later is the result of the EEGP failure and the traversing delay of mobile relay.

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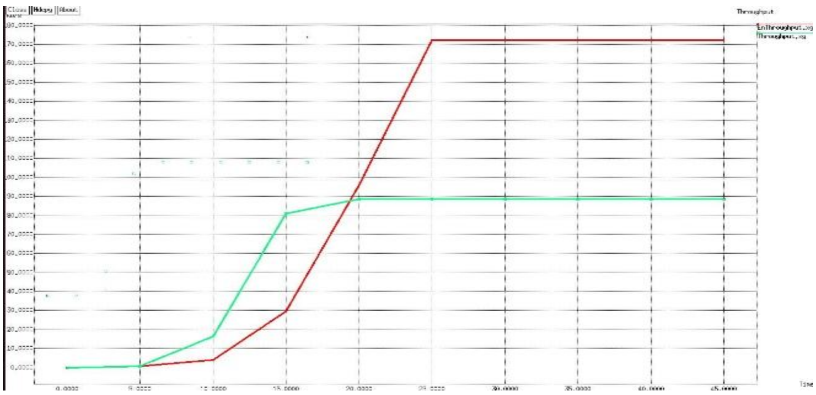

Fig. 2. Comparison of throughput

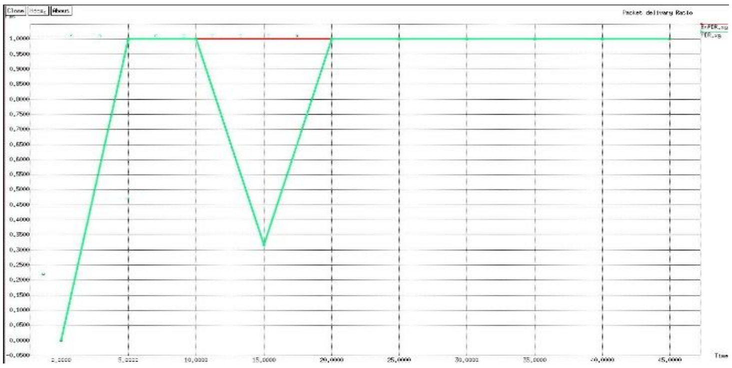

Fig. 3. Comparison of packet delivery ratio

Fig.3. shows that the throughput of the given system is more than that of R3E. This is due to the fact that data always reaches the destination irrespective of the node failure. Fig.4. and Fig.5. shows the ideal simulation results of packet delivery ratio and packet drop.

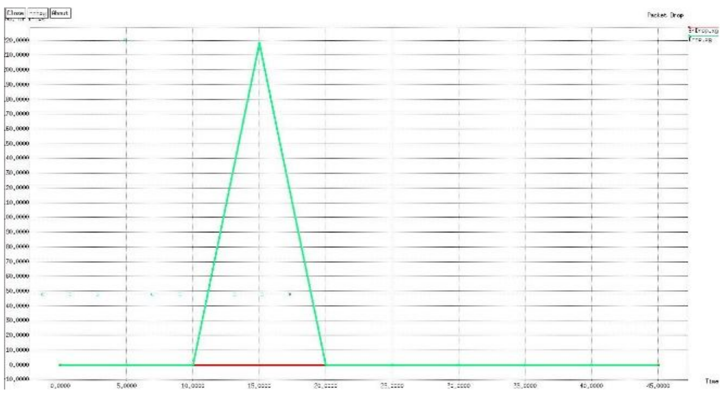

Fig. 4. Comparison of drop

V. CONCLUSION

Most of the wireless sensor networks work with the on-demand or reactive routing protocol. IWSNs demand reliable delivery of data for their efficient working. They may suffer from transmission failures which can badly affect the

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industrial automation process and may cause chaosin the industry.Therefore, the reliability, timeliness, and energy efficiency of the data forwarding are crucial to ensure proper functioning of a IWSNs.

A novel approach is used for providing reliable data deliver from source to destination by using EEGP and mobile relay. Simulation results show that the proposed system has higher throughput and packet delivery ratio while maintaining low end-to-end delay and packet drop.

VI. FUTURE WORK

The proposed work only focusses on the reliable data delivery. But in IWSNs, timeliness of data delivery is also of utmost importance. In order to alleviate this problem synchronizing messages can be sent along with the data packet or a time stamp may be included within the data packet. Also, the integrity of data transfer can be ensured by using secure algorithms like RSA. The energy constraints ofthe mobile relay will also be considered in the future extension of this work.

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