EFFICIENT ROUTE SELECTION ALGORITHM DESIGN FOR INDUSTRIAL SENSOR NETWORKS

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Abstract - ***Improving reliability and energy efficiency is an important consideration in the industrial sensor networks. Due to the limited energy and communication ability of sensor nodes, it seems especially important to design a routing protocol for IWSNs so that sensing data can be transmitted to the receiver effectively. In this paper, an efficient Selection of Route (ESR-LFTI) based on awareness of Link weight and Forward energy density, Traffic congestion, Interference level. In this technique, quantify the link weight, define forward energy density, which constitutes forward-aware factor with link weight, how much traffic congestion is experienced by the nodes and the impact of interference is analyzed. So, based on this the path is to be selected for routing. An analysis result high packet delivery ratio and less delay, less energy consumption and less data transmission cost.***

Keywords: Industrial wireless sensor networks (IWSNs), Forward-aware factor, Reliable guide path discovery, Forward aware factor.

I.INTRODUCTION

Wireless sensor networks (WSNs) are replacing the traditional wired industrial communication systems since the industrial wireless sensor networks (IWSNs) offer several advantages including easy and fast installation and low-cost maintenance [1]. IWSN applications, such as factory automation, industrial process monitoring and control, and plant monitoring, require reliability and timeliness in forwarding messages among nodes. However, the traditional routing protocols, such as AODV, AOMDV, and DSR, may find their limitations in industrial installations due to the harsh environmental conditions, interference issues, and other constraints.

In IWSNs, transmission failures can result in missing or delaying of process or control data, and missing the process or control deadline is normally intolerable[2[for industrial applications, as it may cause chaos in industrial automation or possibly terminate the automation, ultimately resulting in economic losses. The sensed data should be reliably and timely transmitted to the sink node, and the programming or retasking data for sensor node operation, command, and query should be reliably delivered to the target nodes[3]. It is also required that these networks can operate for years without replacing the device batteries. Therefore, the reliability, timeliness, and energy efficiency of data forwarding are crucial to ensure proper functioning of an IWSN

Since the varying wireless channel conditions and sensor node failures may cause network topology and connectivity changes over time, to forward a packet reliably at each hop, it may need multiple retransmissions. This results in undesirable delay as well as additional energy consumption [5]. Opportunistic routing (OR) has been proposed as an effective cross-layering technique to combat fading channels, thus improving the robustness and energy efficiency in wireless networks. Reactive routing protocols are designed to reduce the bandwidth and storage cost consumed in table driven protocols. These protocols apply the on-demand procedures to dynamically build the route between a source and a destination.

Routes are generally created and maintained by two different phases, namely: route discovery and route maintenance [6]. Route discovery usually occurs on-demand by flooding an RREQ (Route Request) through the network, i.e., when a node has data to send, it broadcasts an RREQ. When a route is found [8], the destination returns an RREP (Route Reply), which contains the route information (either the hop-by-hop information or complete addresses from the source to the destination) traversed by the RREQ.

II.RELATED WORK

A) Cluster-Based Forwarding for Reliable End-to-End Delivery in Wireless Sensor Networks

In the cluster-based forwarding (CBF), a general architectural extension to routing protocols that takes inspiration from cooperative communication, and is compatible with most existing routing protocols through carefully defined interfaces [12]. So, it is called as “cluster-based” because, in this approach, groups of nodes cooperate with each other to forward packets. Clusters in CBF are more akin to neighborhoods than to clustering backbones as proposed in ad-hoc networks. Previous clustering methods for ad-hoc networks cannot be used in CBF, because selecting clusters is critical to the performance of CBF[16], and inappropriate clustering will introduce excessive overhead. Therefore, a customized approach is designed in CBF based on an analysis of energy cost.

B) SOAR: Simple Opportunistic Adaptive Routing Protocol for Wireless Mesh Networks

SOAR is a proactive link state routing protocol. Every node periodically measures and disseminates link quality in terms of ETX. Based on this information, a sender selects the default path and a list of (next-hop) forwarding nodes that are eligible for forwarding the data. It then broadcasts a data packet including this information [11]. Upon hearing the transmission, the nodes not on the forwarding list simply discard the packet. Nodes on the forwarding list store the packet and set forwarding timers based on their proximity to the destination. A node closer to the destination uses a smaller timer and forwards the packet earlier [13]. Upon hearing this transmission, other nodes will remove the corresponding packet from their queues to avoid duplicate transmissions. Like all the existing opportunistic routing protocols, SOAR broadcasts data packets at a fixed PHY data rate.

C) EARQ: Energy Aware Routing for Real-Time and Reliable Communication in Wireless Industrial Sensor Networks

EARQ estimates the expected values of the energy cost, delay and reliability of a path to the sink node. These values are computed using only information from neighboring nodes. Based on these values[28], EARQ selects a path that requires low energy, low delay and provides high reliability. For an even distribution of energy expenditure, sometimes EARQ selects a non-optimal path in terms of energy expenditure, but can still deliver a packet in time [15]. This work provides a simple approximation of the minimum delay, given the density of sensor nodes and radio range.

D) Enhancing Real-Time Delivery in Wireless Sensor Networks with Two-Hop Information

Two-hop neighborhood information-based routing protocol is proposed for real-time wireless sensor networks. The approach of mapping packet deadline to a velocity is adopted as that in SPEED [19]; however, the routing decision is made based on the novel two-hop velocity integrated with energy balancing mechanism. The choice of two hops is a tradeoff between performance improvement and the complexity cost [17]. The idea of two-hop routing is straightforward but how to use or integrate the information effectively so as to improve energy and real-time performance is generally nontrivial.

III. PROPOSED METHODOLOGY

A) Forward -aware factor based efficient selection routing method

Based on the detailed analysis of the data transmission mechanism of WSN, quantify the forward transmission area, define forward energy density, which constitutes forward-aware factor with link weight, how much traffic congestion is experienced by the nodes and the impact of interference is analyzed. So, based on this the path is to be selected for routing.

To extend the network lifetime an innovative technique is proposed which is called Efficient Selection of Route based on awareness of **L**ink weight and **F**orward energy density, **T**raffic congestion, **I**nterference level (ESR-LFTI).

- In this technique, the next-hop node is selected according to the awareness of link weight and forward energy density. Furthermore, a spontaneous reconstruction mechanism for local topology is designed additionally.
- Traffic congestion is experienced by the nodes when incoming traffic is much higher than outgoing traffic. Smart metering nodes buffer the incoming packets in finite size queue and start dropping any new incoming packets when queue is full. Nodes which serve maximum number of nodes in multi hop transmission (like the ones close to sink) are likely to experience maximum traffic load leading to traffic congestion.
- Many routing messages are propagated unnecessarily and may cause different interference characteristics during route discovery phase and in the actual application data transmission phase. As a result, incorrect routes may be selected. The main intent is to design solutions which make more accurate routing decisions by reducing the interference level during the route discovery phase and making it more similar to that during the actual data transmission phase.

So, based on the four factors such as Link weight and Forward energy density, Traffic congestion, Interference level the path is selected for routing.

B) Reliable Guide Path Discovery

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 RREQ's sequence number for reverse route learning [22]. Instead of rebroadcasting the RREQ immediately in existing reactive routing protocols, we introduce a biased back-off scheme at the current RREQ forwarding node. The aim of this operation is to intentionally amplify the differences of RREQ's traversing delays along different paths.

When a node receives an RREP, it checks if it is the selected next-hop (the upstream guide node) of the RREP [25]. 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[28].

C) Route selection algorithm design

In this module, the optimal path is selected based on awareness of link weight and forward energy density, traffic congestion, interference level.

In this method, the remaining energy level is computed based on the subtraction from the initial energy to the processing energy. Based on this the link weight is computed.

$$w_{ij}(t) = \frac{\varsigma(E_i(t)E_j(t))^{\psi}}{(d(i,j)^3)^{\eta}(T_{ij}(t))^{\xi}} \quad (1)$$

$Where,$ $E_i(t)$ and $E_j(t)$ are residual energy, $d(i,j)$= distance between two nodes, $T_{ij}(t)$= data flow of the edge e_{ij}.

Traffic congestion is also a significant factor for improving the routing performance. Traffic congestion is experienced by the nodes when incoming traffic is much higher than outgoing traffic.

$$T_i = (1-\alpha) \times intvl_{old} + \alpha \times intvl_{new} \quad (2)$$

Many routing messages are propagated unnecessarily and may cause different interference characteristics during route discovery phase and in the actual application data transmission phase.

$$INR(v_i) = \frac{J(e_i)}{d(u_i,v_i)^{\alpha}[N_0 + \sum_{j \neq i} \frac{J(e_j)}{d(u_j,v_i)^{\alpha}}]} \geq \beta \quad (3)$$

Algorithm1:To find the optimal path from node N.
Input: Give the number of nodes
Output: Select optimal path
1. Get N //N=Number of nodes
2. Initialize set of nodes $V = v_1, v_2, \ldots v_i$
3. Declare linkweight $\boldsymbol{w_{ij}}$ **at time t**
4. **If** $\boldsymbol{E_{Tx}}$ energy for sending 1-bit packet **Then**
5. $E_{Tx}(l,d) = E_{Tx-elec}(l) + E_{Tx-amp}(l,d)$;
6. // E_{elec} =fixed energy value spent for sending 1-bit data, d=distance
7. **Else**
8. **If** (packet size<1bit) error will receive
9. **If** $\boldsymbol{E_{Rx}}$ energy for receiving data **Then**
10. **If** distance between node I and sink **Then**
11. $w_{ij}(t) = \frac{\varsigma(E_i(t)E_j(t))^{\psi}}{(d(i,j)^3)^{\eta}(T_{ij}(t))^{\xi}}$
12. // $E_i(t)$ and $E_j(t)$ are residual energy, $d(i,j)$= distance between two nodes, $T_{ij}(t)$= data flow of the edge e_{ij}
13. **End**
14. Declare **FED** node i//forward energy density
15. **While** $V_{ed}(i,t) = ED(i,t)$
16.//where $V_{ed}(i,t)$=energy density on the position of node i
17. **End**
18. Declare **Traffic congestion** $\boldsymbol{T_i}$
19. If $T_i = (1-\alpha) \times intvl_{old} + \alpha \times intvl_{new}$
20. **Else**
21. **If** (queue==full)
22. **Then**
23. **Drop** $\boldsymbol{T_i}$
24. **End**
25. Declare SINR //Signal to interference ratio
26. **If** $\boldsymbol{SINR}(v_i) = \frac{J(e_i)}{d(u_i,v_i)^{\alpha}[N_0 + \sum_{j \neq i} \frac{J(e_j)}{d(u_j,v_i)^{\alpha}}]}$
27. // N_0=noise density, α= path loss component, $J(e_i)$= power level which node u_i transmits, β=antenna gain, $d(u_i,v_i)$ = Euclidean distance between nodes
28. **End**
29. **Calculate FAF (i,j)** //Forward aware factor
30. // Based on this select optimal path
31. **End**

Three performance metrics are used in our evaluation.

1. Data transmission cost
2. End-to-end delay
3. Packet delivery ratio

1. Data transmission cost

Data transmission cost is defined as the cost for the process of data transmission.

2. End-to-end delay

It is defined as the average time taken by a data packet to arrive in the destination. It also includes the delay caused by route discovery process and the queue in data packet transmission. Only the data packets that successfully delivered to destinations that counted.

∑ (arrive time – send time) / ∑ Number of connections

3. Packet delivery ratio

It is defined as the ratio of the number of delivered data packet to the destination. This illustrates the level of delivered data to the destination.

∑ Number of packet receive / ∑ Number of packet send

A) Comparison graphs

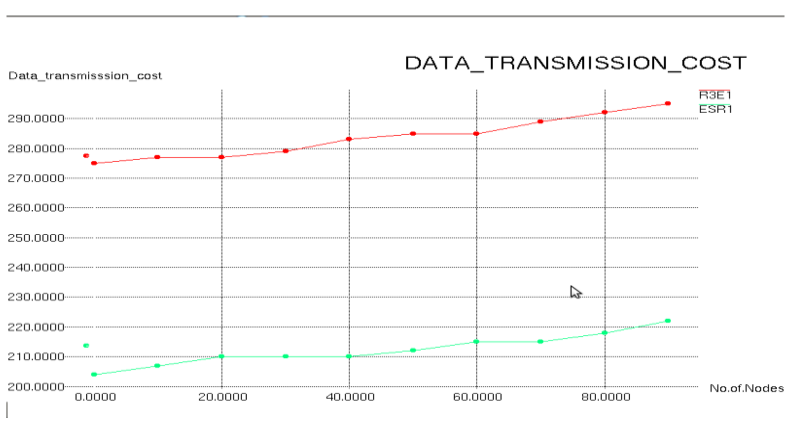

Fig 4.1Data transmission cost

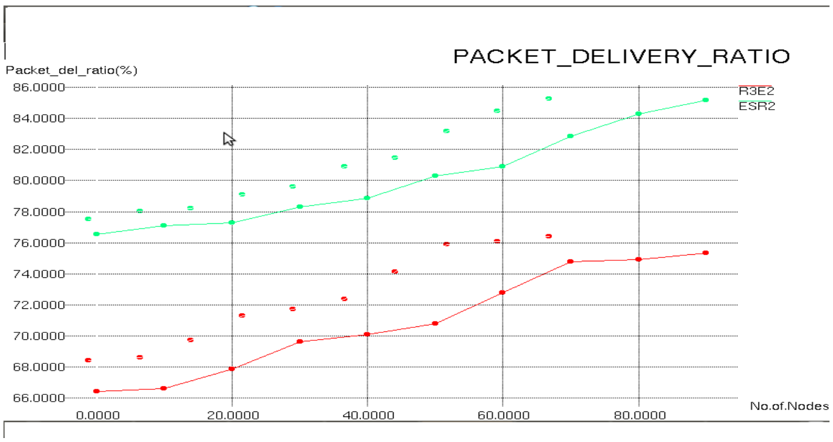

Fig4.2 Packet delivery ratio

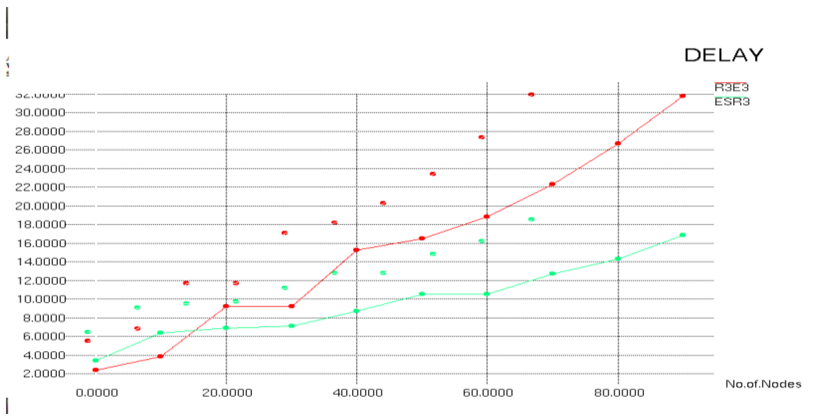

Fig 4.3 Delay

Fig (4.1) plots the data transmission cost is shown in this graph. In the X-axis number of nodes is taken. Y-axis data transmission cost is taken. This graph clearly shows that if the number of nodes is increases the data transmission cost is increased in the existing system. But in the proposed system, there is data transmission cost is decreased.

Fig (4.2) plots the end-to-end delay is shown in this graph. In the X-axis number of nodes is taken. Y-axis end-to-end delay is taken. This graph clearly shows that if the number of nodes is increases the end-to-end delay is increased in the existing system. But in the proposed system, there is end-to-end delay is decreased.

Fig (4.3) plots the packet delivery ratio is shown in this graph. In the X-axis number of nodes is taken. Y-axis packet delivery ratio is taken. This graph clearly shows that if the number of nodes is increases the packet delivery ratio is decreased in the existing system. But in the proposed system, there is packet delivery ratio is increased.

V. CONCLUSION

In this work, we presented R3E, which can augment most existing reactive routing protocols in IWSNs to provide reliable and energy-efficient packet delivery against the unreliable wireless links. A biased back-off scheme is used in the route discovery phase to find a robust virtual path with low overhead. Without utilizing the location information, data packets can still be greedily progressed toward the destination along the virtual path. But the disadvantage is due to the limited energy and communication ability of sensor nodes, it seems especially important to design a routing protocol for WSNs so that sensing data can be transmitted to the receiver effectively. So, in the proposed system a new technique is introduced which is called Efficient Selection of Route (ESR-LFTI) based on awareness of **L**ink weight and **F**orward energy density, **T**raffic congestion, **I**nterference level. In this technique, quantify the forward transmission area; define forward energy density, which constitutes forward-aware factor with link weight, how much traffic congestion is experienced by the nodes and the impact of interference is analyzed. So, based on this the path is to be selected for routing.

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