



Enhanced Reactive Routing Protocol for Wireless Sensor Networks

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Abstract

In Wireless Sensor Networks providing reliable and efficient communication under fading channels is one of the major technical challenges especially in industrial WSNs (IWSNs) with dynamic and harsh environments. This paper proposes the enhanced reactive routing protocol for wireless sensor networks inherits the advantages of opportunistic routing to provide reliable and energy efficient delivery against the unreliable wireless links by utilizing the local path diversity. The effective route discovery phase finds a robust guide path using this guide path data packets are progressed using cooperative forwarding. Based on the performance comparisons and simulation to other protocols, the proposed protocol remarkably improves the packet delivery ratio, while maintaining higher energy efficiency and low delivery latency.

Keywords: *Industrial wireless sensor network, guide path discovery, cooperative forwarding, unreliable wireless links*

1. Introduction

Traditional wired communication systems are replaced by wireless sensor networks offers several advantages [1] and applications such as factory automation, industrial process monitoring and control, plant monitoring requires reliability and timeliness in forwarding messages among the nodes [2]. Traditional routing protocols such as AODV [3], AOMDV [4] and DSR [5] may find their limitations in industrial installations due to the harsh environmental conditions, interferences and other constraints

that challenge the network performance [6]. Therefore, the reliability, timeliness and energy efficiency of data forwarding are crucial to ensure the proper functioning of an IWSN. Opportunistic routing (OR) [7] has been proposed as an effective cross-layering technique to combat fading channels to improve the energy efficiency and robustness in wireless networks.

2. Related Work

The traditional routing protocols are also known as table driven protocols in these traditional approaches the route between the source and destination are fixed if in case of link failure the routing cannot be done. To overcome this reactive routing protocols [3] [4] [5] has been proposed to reduce the bandwidth and storage cost consumed in table driven protocols. On-demand procedures are used to dynamically build the route between a source and a destination.

In reactive routing protocols routes are created and maintained by two different phase namely route discovery and route maintenance. Route discovery is done by flooding an RREQ through the network and when a route is found the destination sends a RREP to the source which contains the route information.

A. Traditional Reactive routing protocols

Since the various reactive routing protocols have been proposed in recent years C.Perkins et.al presented the Ad-hoc on-demand distance vector routing [3] to ensure the reliable routing. Each node in the network maintains one routing table and routing table entry contains route information such as active neighbor list, destination address, Next-hop address, number of hops, sequence number and lifetime.

Routing in AODV consists of two phases: Route Discovery and Route Maintenance, route discovery broadcast the route request packet to neighbour nodes and so on until it finds a way to reach destination. When intermediate nodes receive a RREQ, it updates the routes to previous node if it satisfies the following conditions:

- (i) There is an available entry which has the same destination with RREQ
- (ii) Its sequence number is greater than or equal to sequence number of RREQ.

If no, it rebroadcast RREQ, if yes, it generates a RREP message to the source node. The source node will forward the data to destination based on the RREP information. Marina presented AOMDV [4] share several characteristics with AODV, the main difference lies in the number of routes found in each route discovery. In AOMDV RREQ and RREP Propagation establishes multiple reverse paths from source and destination, vice versa. D.B.Johnson presented DSR [5] is similar to AODV it uses source routing instead of relying on the routing table at each intermediate device's. DSR optionally defines flow id option that allows packet to be forwarded on a hop-by-hop basis.

B. Opportunistic Routing

Opportunistic Routing takes advantage of the broadcast nature and spatially diversity of the wireless medium to forward more efficiently than traditional routing protocols. Some of the variants of opportunistic routing such as, ExOR and opportunistic any-path forwarding rely, on the global knowledge of the network to select candidates and prioritize them. Biswas.S et.al presented Extremely Opportunistic Routing protocol (ExOR) [7] is to reduce the coordination overhead between candidate relays, in ExOR the packets to be transmitted are grouped into batches according to their destination node. For each packet of the same batch, the source node selects a subset of optimal candidate forwarders, which are prioritized by closeness to the destination. The closeness property of a node is evaluated employing the ETX metric, i.e., estimating the average number of retransmissions needed to reach the destination from that node along the

lowest-ETX path. Thus, the implicit assumption underlying ExOR design is that a link state routing protocol is also running in parallel to the opportunistic routing to efficiently collect links' delivery probabilities.

An interesting variant of the ExOR [7] solution is the Simple Opportunistic Adaptive Routing protocol (SOAR) presented by Rozner.Eet..al[8]. Similarly to ExOR, SOAR employs a scheduling scheme relying on priority-based forwarding timers to avoid duplicate and simultaneous transmissions by different nodes, being ETX the metric used to estimate node's closeness to the destination, and its related priority. However, the strategy used by SOAR to establish the schedule among the candidate forwarders is radically different from ExOR [7]. First of all, SOAR does not use batch maps to explicit signal among candidate forwarders on packets' reception status, but it employs overhearing to coordinate forwarders' transmissions. More precisely, whenever a node overhears a transmission from higher priority nodes, it will cancel its forwarding timer and remove that packet from its queue, thus avoiding duplicate transmissions. To ensure that the candidate forwarders are close enough to overhear each other with a high probability, SOAR avoids diverging paths and uses only network paths in close proximity to the shortest route between the source and destination.

C. Geographic Random Forwarding

Zorzi.Met al. presented the Geographic Random Forwarding (GeRaF) [9], which is based on the assumption that sensor nodes have a means to determine their location and that the positions of the final destination and of the transmitting node are explicitly included in each message. In this scheme, a node which hears a message is able (based on its position toward the final destination) to assess its own priority in acting as a relay for that message. All nodes who received a message may volunteer to act as relays and do so according to their own priority. This mechanism tries to choose the best positioned nodes as relays. In addition, since the selection of the relays is done a posteriori, no topological knowledge nor routing tables are needed at each node, but the position information is enough. Geographic routing is used here to enable nodes to be put to sleep and waken up without coordination and to integrate routing, MAC, and topology management into a single layer.

3. Proposed System

Enhanced reactive routing protocol for wireless sensor networks uses opportunistic routing is normally effective in networks with high node densities. Opportunistic routing is used to utilize the path diversity for cooperative caching. The path with higher spatial diversity may provide more reliable and efficient packet delivery against the unreliable links.

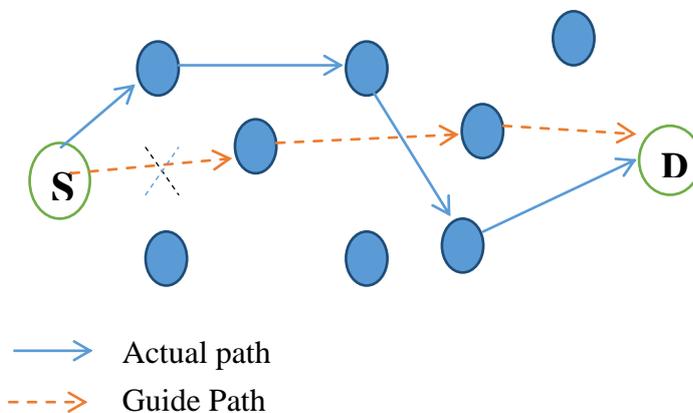


Fig.1 Illustration of Guide path

The aim is to find the such reliable virtual path to guide the packets to be progressed toward the destination. In Fig.1 the solid lines shows the actual path from source to destination. If the actual path is failed due to fading the data will be progressed through the guide path, in which nodes are called guide nodes.

The proposed enhanced protocol acts as a interface between the media access control layer and network layer to increase the availability to link dynamics for WSNs/IWSNs. The proposed protocol consists of three main modules namely route discovery module, forwarder selection and prioritization module and forwarding decision module. The route discovery module is responsible for finding and maintaining the route information for each node, also each node in the cooperative forwarding process stores the downstream neighbourhood information. The forwarding decision module is responsible for checking whether the data packet belongs to one of the intended receivers. If yes incoming packet will be cached and back off timer will start to return an ACK, finally forwarder selection and prioritization module attaches the ordered forwarder list in the data packet header for the next hop and outgoing packet will be forwarded towards the destination.

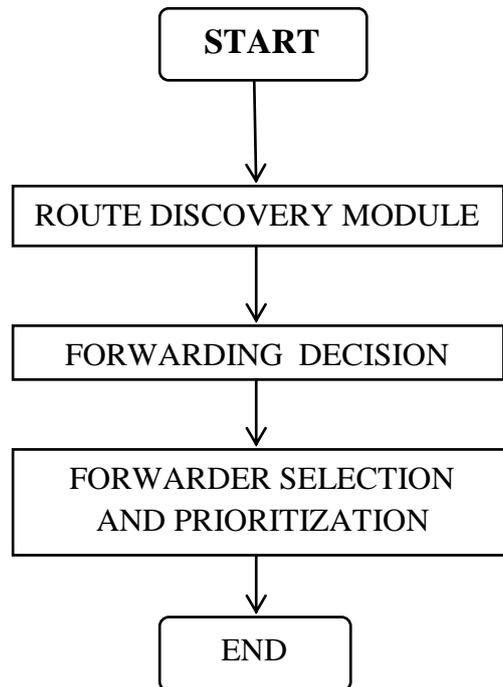


Fig.2 Flowchart of Proposed system

A. Route Request (RREQ) Propagation

If the source node has a data packets to send to a destination, by using route discovery module the RREQ message is flooded through the network. Upon receiving the non-duplicate RREQ the intermediate nodes stores the upstream node id and RREQ sequence number for reverse route learning. By introducing the effective route discovery scheme at the current RREQ forwarding node, the aim of this route discovery scheme is to intentionally amplify the differences of RREQ’s traversing delays along the different paths, which enables the RREQ to travel faster along the preferred path according to a certain defined metric.

B. Route Reply (RREP) Propagation

When the node receives RREP from destination node or intermediate nodes, it checks whether the selected next-hop of the RREP. If yes the node itself marks as a guide node and records its upstream guide node id and forwards it until it reaches the source node via the RREQ message propagated, finally the guided path is obtained from source to destination for forwarding the data packets.

In the proposed system Route Reply (RREP) propagation has two functions. It not only implements the forward path setup and also notifies the potential helpers to perform the cooperative forwarding. Specifically two sets of helpers and their relay priority assignments are included in the RREP.

C. Cooperative Forwarding

In the Cooperative forwarding the source node broadcasts a data packet, which includes the list of forwarding candidates and their priorities. The forwarding candidates follow the assigned priorities to transmit the packet if the data packet received correctly in the candidate, will start a timer whose value depends on its priority, the priority will be high if the timer value is shorter. The candidates will reply with an acknowledgement to notify the sender and to suppress the other contenders. Finally it rebroadcasts the data packet to its downstream link.

4. Simulation Scenario

A Simulation of the algorithm for fault node recovery as described in section 3 was performed to verify the method. The experiment is based on 2-D space and it is simulated in Network-Simulator 2 (ns-allinone-2.35).

The proposed method addresses the packet delivery ratio, throughput, packet drop and end-to-end delay. In order to evaluate the performance of the proposed enhanced reactive routing protocol and compare it with the traditional reactive routing protocols. The below mentioned parameters are configured in the network simulator.

Parameters	Values
Routing protocol	DSDV
No of mobile nodes	40
Transmit power	1.35W
Receive power	1.7W
Traffic Type	Constant Bit Rate
Antenna Type	Omni Antenna
Simulation Time	50 seconds
Environment size	1150*800
Channel Type	Wireless Channel
Radio Propagation	Twowayground

The First step in the Enhanced Reactive Routing Protocol is Route Request propagation. Route Request Packet will be broadcasted to all the neighbour nodes from source node until it reaches the destination node as shown in Fig.3.

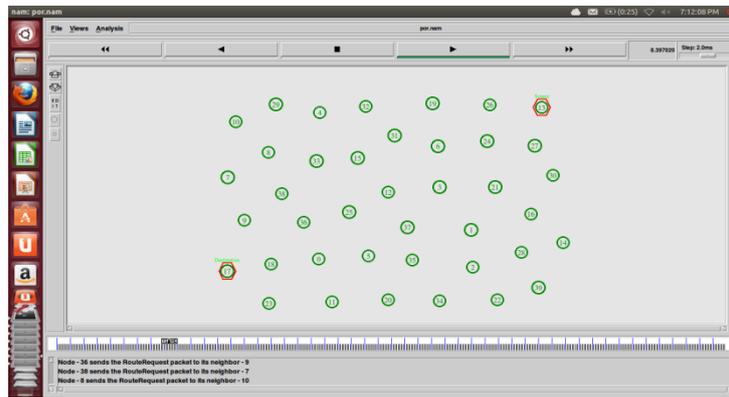


Fig.3 Route Request Propagation in Proposed system

The Second step in the Enhanced Reactive Routing Protocol is Route Reply propagation. Route Reply Packet will be sent to all the intermediate nodes from destination node towards the source node to indicate the actual route as shown in Fig.4.

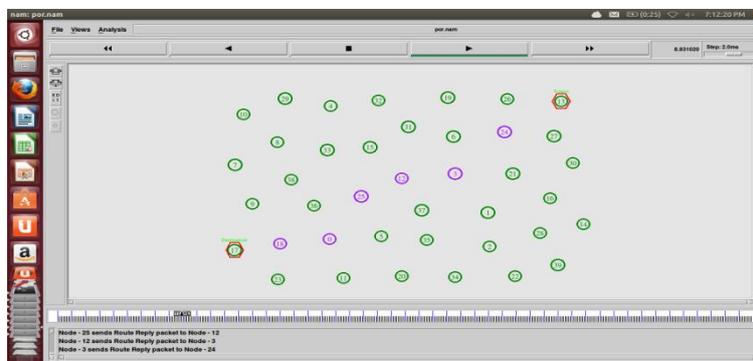


Fig.4 Route Reply Propagation in Proposed system

Fig.5 shows the cooperative forwarding process in the proposed system where the orange colored nodes are called guide nodes in which the guided path will transmit packet if there is any failure in the node or link due to fading channels. Through the guided path data will be transmitted.

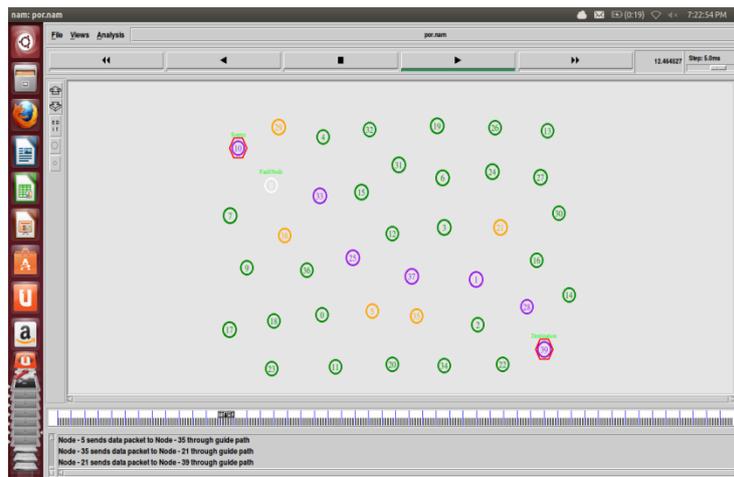


Fig.5 Cooperative Forwarding in Proposed system

Fig.6 shows the comparison of Delay versus time for AODV, GOR and Proposed protocol. Delay in proposed protocol is minimum compared to AODV, GOR Protocols. The Blue line in the graph indicated the Delay of AODV, Green line in the graph indicates the Delay of GOR, and Red line in the graph indicates the Delay of proposed protocol.

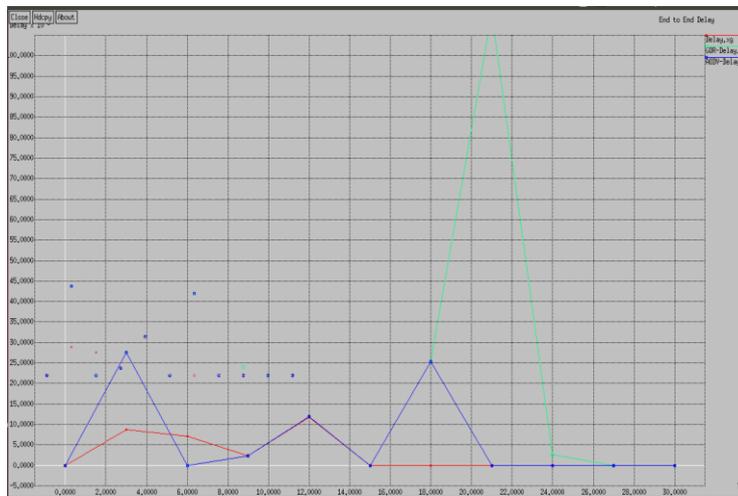


Fig.6 Performance Comparison of Delay vs Time for AODV, GOR and Proposed protocol

Fig.7 shows the comparison of Packet Drop versus time for AODV, GOR and Proposed protocol. Packet Drop in proposed protocol is minimum compared to AODV, GOR protocols. The Blue line in the graph indicated the packet drop of AODV, Green line in the graph indicates the packet drop of GOR, and Red line in the graph indicates the packet drop of proposed protocol.

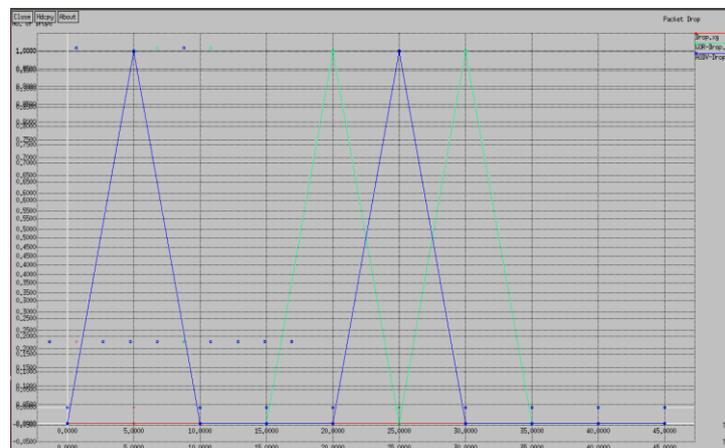


Fig.7 Performance comparison of Packet Drop vs Time for AODV, GOR and Proposed protocol

Fig.8 shows the comparison of Packet Delivery Ratio vs Time for AODV, GOR and Proposed protocol. PDR in proposed protocol is maximum compared to AODV, GOR protocols. The Blue line in the graph indicates the PDR of AODV, Green line in the graph indicates the PDR of GOR and Red line in the graph indicates the PDR of proposed protocol.

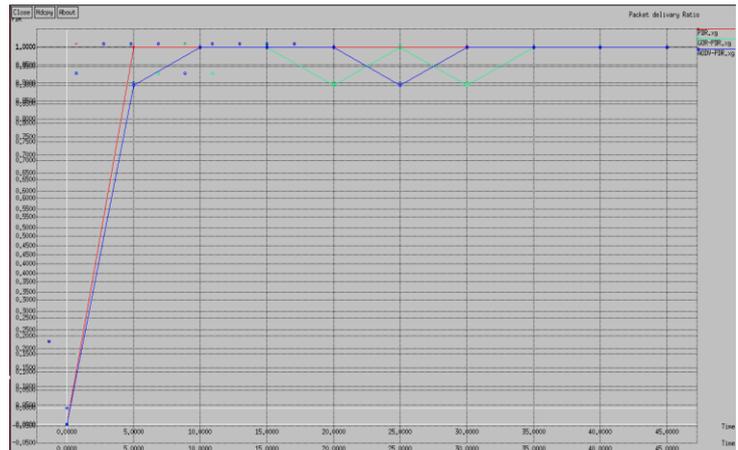


Fig.8 Performance Comparison of PDR vs Time for AODV, GOR and proposed protocol

Fig.9 shows the comparison of Throughput vs time for AODV, GOR and proposed protocol. Throughput in proposed protocol is maximum compared to AODV, GOR protocols. The Blue line in the graph indicates the throughput of AODV, Green line in the graph indicates the throughput of GOR and Red line in the graph indicates the throughput of proposed protocol.

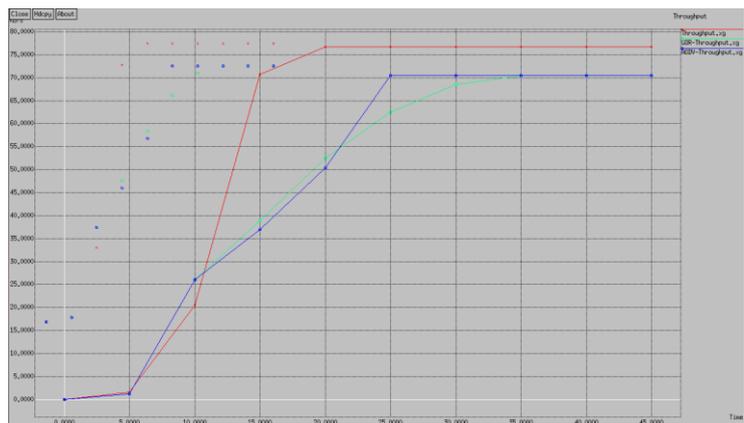


Fig.9 Performance comparison of Throughput vs time for AODV, GOR and proposed protocol

5. CONCLUSION

Therefore, the proposed enhanced reactive routing protocol provides very close routing performance to the geographic opportunistic routing protocol. Extending AODV with enhancement to demonstrate its effectiveness and feasibility. Simulation results showed that, as compared to other protocols, The Enhancement to the AODV protocol can effectively improve robustness, end-to-end energy efficiency and latency.

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