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Reliable and Enhanced Energy-Efficient Routing Protocol for Wireless Sensor Networks

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Abstract: Providing reliable and efficient communication under fading channels is one of the major technical challenges in wireless sensor networks (WSNs), especially in industrial wireless sensor networks (IWSNs) with dynamic and harsh environments.The objective of this paper is to increase the resilience to link dynamics for WSNs/IWSNs. The design which introduced here, which inherits the advantages of opportunistic routing also, achieves shorter end-to-end delivery delay, higher energy efficiency, and reliability. Enhanced R3E is designed such that it will be set of reasons given in support of an idea for the existing reactive routing protocols to combat the channel variation by utilizing the local path diversity in the link layer. As a new addition to the cooperative forwarding design space in WSNs/IWSNs, our major contributions are route discovery and cooperative forwarding scheme. A biased back off scheme has introduced during the route-discovery phase to find a robust guide path, which can provide more cooperative forwarding opportunities. Along with this guided path, data packets are greedily progressed toward the destination through nodes' cooperation without utilizing the location information. Thus Enhanced R3E remarkably increases the packet delivery ratio, while maintaining high energy efficiency and low delivery latency. In this paper, we compare the R3E protocol with the existing protocol through NS2 simulation.

Keywords: Industrial wireless sensor networks (IWSNs), opportunistic routing, reliable forwarding, unreliable wireless links.

I. INTRODUCTION

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through thenetwork to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. Thedevelopment of wireless sensor networks was motivated by military applications such as battlefield surveillance; todaysuch networks are used in many industrial and consumer applications, such as industrial process monitoring andcontrol, machine health monitoring. Wireless Sensor Network (WSN) is a collection of spatially deployed wirelesssensors by which to monitor various changes of environmental conditions (e.g., forest fire, air pollutant concentration,and object moving) in a collaborative manner without relying on any underlying infrastructure support. Recently, anumber of research efforts have been made to develop sensor hardware and network architectures in order to effectivelydeploy WSNs for a variety of applications. The base stations are one or more components of the WSN with much more computational, energy and communicationresources. They act as a gateway between sensor nodes and the end user as they typically forward data from the WSNon to a server. Other special components in routing based networks are routers, designed to compute, calculate and distribute the routing tables.

II. ARCHITECTURE OF R3E

R3E, is a middle-ware design across the MAC and the network layers to increase the resilience to link dynamics for WSNs/IWSNs. The R3E enhancement layer consists of three main modules, the reliable route discovery module, the potential forwarder selection and prioritization module, and the forwarding decision module. The helper node and potential forwarderare interchangeable in this work. The reliable route discovery module finds and maintains the route information for each node.

During the route discovery phase, each node involved in the cooperative forwarding process stores the downstream neighborhood information, that is to say, when a node serves as a forwarder, it already knows the next-hop forwarding candidates along the discovered path.

The other two modules are responsible for the runtime forwarding phase. When a node successfully receives a datapacket, the forwarding decision module checks whether it is one of the intended receivers. If yes, this node will cache theincoming packet and start a backoff timer to return an ACKmessage, where the timer value is related with its ranking inthe intended receiver list (called forwarding candidate list).

If there is no other forwarder candidate with higher prioritytransmitting an ACK before its backoff timer expires, it willbroadcast an ACK and deliver the packet to the upper layer,i.e., trigger a receiving event in the network layer.

Then, thepotential forwarder selection and prioritization module attachesthe ordered forwarder list in the data packet header for the nexthop. Finally, the outgoing packet will be submitted to the MAClayer and forwarded towards the destination.

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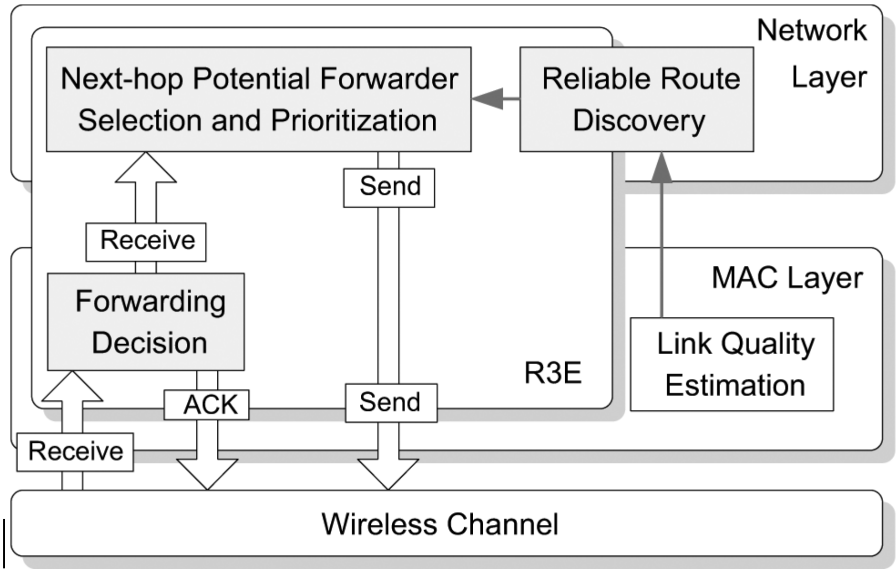

Fig. 1 Functional architecture overview of R3E.

III. PROPOSED ALGORITHM

A. Description of the Proposed Algorithm

The existing system is analyzed to gather requirements. Reactive routing 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. Route discovery usually occurs on demand by flooding an RREQ (RouteRequest) through the network, i.e., when a node has data to send, it broadcasts an RREQ. When a route is found, the destination returns an RREP (RouteReply), which contains the route information (either the hop-by-hop information or complete addresses from the source to the destination) traversed by the RREQ.

The proposed system is designed to overcome the drawbacks of the existing system. Reliable Reactive Routing Enhancement (R3E) is used to increase the resilience to link dynamics for WSNs/IWSNs. Our design inherits the advantages of opportunistic routing, thus achieving shorter end-to-end delivery delay, higher energy efficiency, and reliability. R3E is designed to augment existing reactive routing protocols to combat the channel variation by utilizing the local path diversity in the link layer. We propose a simple yet effective cooperative forwarding scheme. Along the discovered virtual path, data packets can be greedily forwarded toward the destination through nodes' cooperation without utilizing location information.

In this work, we present the Reliable Reactive Routing Enhancement (R3E) to increase the resilience to link dynamics for WSNs/IWSNs. R3E is designed to enhance existing reactive routing protocols to provide reliable and energy-efficient packet delivery against the unreliable wireless links by utilizing the local path diversity. Specifically, we introduce a biased backoff scheme during the route-discovery phase to find a robust guide path, which can provide more cooperative forwarding opportunities. Along this guide path, data packets are greedily progressed toward the destination through nodes' cooperation without utilizing the location information.

R3E remarkably improves the packet delivery ratio, while maintaining high energy efficiency and low delivery latency. Our design inherits the advantages of opportunistic routing, thus achieving shorter end-to-end delivery delay, higher energy efficiency, and reliability. R3E is designed to augment existing reactive routing protocols to combat the channel variation by utilizing the local path diversity in the link layer.

B. Drawbacks of existing system

- Undesirable delay as well as additional energy consumption.
- Wireless channel conditions and sensor node failures may cause network topology and connectivity changes over time.
- In IWSNs, transmission failures can result in missing or delaying of process

C. Advantages of proposed system

- Simple yet effective cooperative Provide the solutions to reliable route discovery and efficient cooperative forwarding problems.
- Forwarding scheme.
- Compatible with most existing reactive routing protocols in WSNs/IWSNs.
- Achieving shorter end-to-end delivery delay, higher energy efficiency, and reliability.

IV. PSEUDO CODE

A. **RREQ Algorithm**

Procedure: void RecvRREQ (Packet *p)
if Non-duplicate RREQ then
    if v_j is the destination node then

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Send out RREP;
else
CN(i,j) = N(i)∩N(j);
//get common neighbor set CN(i,j), $v_k \in CN(i,j)$;
Sort CN(i,j) descendingly ordered by PikPkj;
H(i,j) = {cn_1}, CN(i.j) = CN(i,j)-{cn_1};
// cn_1 is always the first item of CN(i,j);
While CN(i,j) ≠ ∅ do
if CheckConnectivity(H(i,j), cn_1) then
// cn_1 is within the transmission range of any node in H(i,j);
H(i,j) = H(i,j) U {cn_1};
end
CN(i,j) = CN(i,j)- cn_1;
end
Calculate $t_{i,j}$ and call Backoff($t_{i,j}$,p);
//schedule a timer whose value is $t_{i,j}$, then call forwardRREQ(p) when the timer expires;
end
else
Drop p;
End

B. RREP Algorithm

Procedure: void RecvRREP (Packet *p)
if Non-duplicate RREP then
if v_j==v_{i-1} then
// v_j is the selected next-hop & guide node v_{i-1};

/*v_{i-2} is v_{i-1} 's upstream guide node; the helper set is ordered descendingly by the PRR toward the downstream guide node;*/
Mark myself as a guide node;
Record v_i and H(i-1, i);
Get RREP's next-hop node id v_{i-2};
Attach v_i, H(i-1, i), v_{i-1} and H(i-2, i-1) to RREP;
Call forwardRREP p;
else if $v_j \in$H(i-1, i) then
// v_j is a helper in H(i-1, i);
Record v_{i+1}, H(i, i+1), v_j and H(i-1, i);
Drop p;
else
Drop p;
end
else
Drop p;
End

V. PERFORMANCE METRICS

1. **Packet delivery ratio**. The ratio of the number of received data packets to the number of total data packets sent by the source.
2. **End-to-end delay**. The average time elapsed for delivering a data packet within a successful transmission.
3. **Packet lost**. The number of data packets that are failed to reach the destination.

Energy consumption. The energy consumption for the entire network, including transmission energy consumption for both the data and control packets.

VI. DATAFLOW DIAGRAM

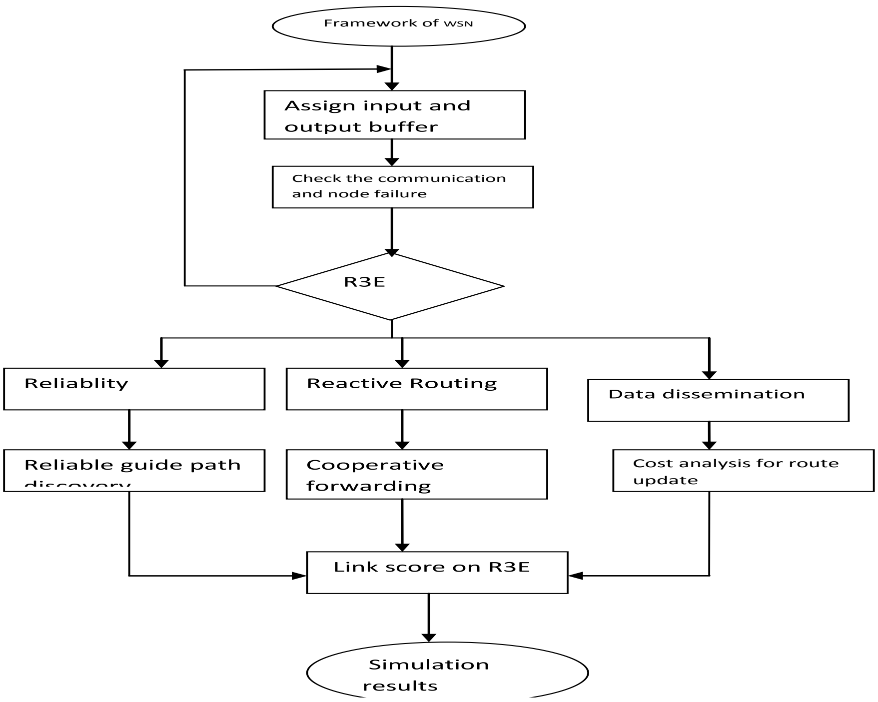

Fig. 2 Data flow diagram

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VI. SIMULATION RESULTS

The simulation analyses for R3E while the data transmission and certificate revocation based security is implementedusing Network Simulator NS2. The simulation is done by comparing the R3E protocol with the AODV protocol. The simulation is done for Energy Consumption, Packet delivery ratio, End-to-End Delay and Packet Lost using R3E whose results are shown inFigure 1, 2, 3& 4 respectively.

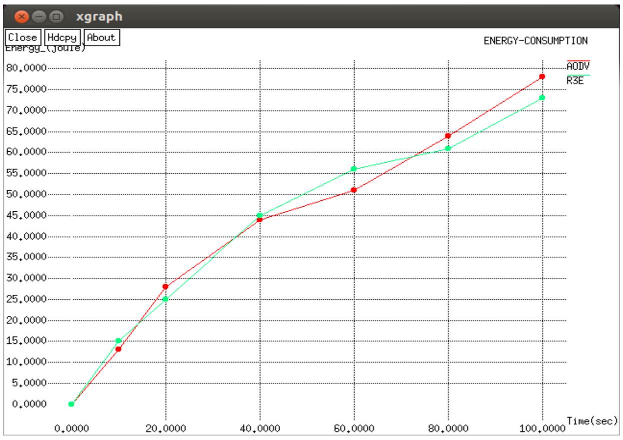

Fig. 3 Energy Consumption

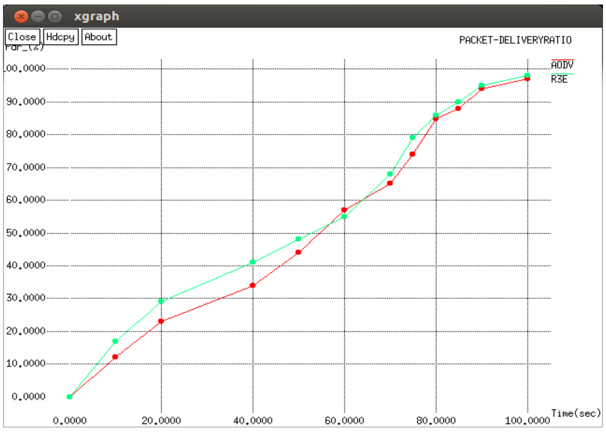

Fig. 4 Packet Delivery Ratio

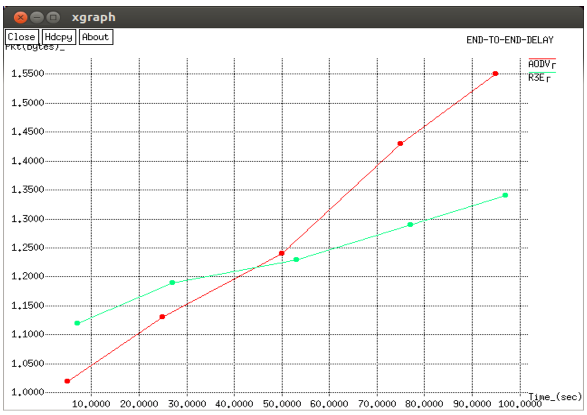

Fig. 5 End-to-End Delay

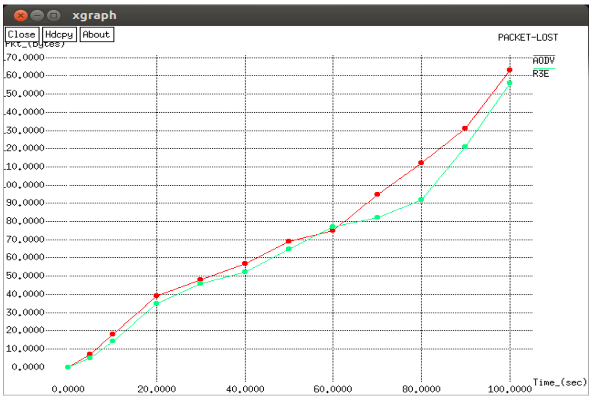

Fig. 6 Packet Lost

The output design includes the following parameters

- Packet drop = Number of packets received – Number of packets sent
- Packet delivery ratio = (Number of packets received/ Number of packets sent)*100
- Energy consumption = Average energy consumption on idle, sleep, transmit & received/ Total energy consumed
- Delay = (Interval of 1st packet delivery time & 2nd packet delivery time)/ Total data packet delivery time

VII. CONCLUSION AND FUTURE WORK

In this paper, a system is developed R3E, which can augment most existing reactive routing protocols in WSNs/IWSNs to provide reliable and energy-efficient packet delivery against the unreliable wireless links. In this research work a biased backoff scheme in the route discovery phase to find a robust virtual path with low over head. Without utilizing the location information, data packets can still be greedily progressed toward the destination along the virtual path. Therefore, R3E provides very close routing performance to the geographic opportunistic routing protocol provides proactive wake up and sleep scheduling can create a local active environment to provide guarantee for the tracking performance. By effectively limiting the scope of this local active environment extended AODV with R3E to demonstrate its effectiveness and feasibility. Simulation results showed that, as compared with other protocols, AODV-R3E can effectively improve robustness, end-to-end energy efficiency, and latency.

Routes are managed based on expected path length and a weighted combination of distance traveled, energy level and RF link performance history. Simulation results have shown that it performs competitively against existing routing protocols in terms of packet delivery ratio, packet latency and energy consumption while operating in a noisy wireless environment where network traffic, link disruptions and node failure rates are high. Shortest routes are initially admitted into the routing table based on hop-count. As RPT packets flow through these links, less desirable ones will start to exhibit high packet loss rate and are eventually *blacklisted* and omitted from the routing table. Links that are omitted from the routing

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table may be re-admitted again only after a period of time. Some RF links are affected by temporary external disruption and should be given the chance to be readmitted.

REFERENCES

[1] V. Gungor and G. Hancke, “Industrial wireless sensor networks: Challenges, design principles, and technical approaches,” IEEE Trans. Ind. Electron., vol. 56, no. 10, pp. 4258–4265, Oct. 2009.
[2] S. eun Yoo, P. K. Chong, D. Kim, Y. Doh, M.-L. Pham, E. Choi, and J. Huh, “Guaranteeing real-time services for industrial wireless sensor networks with IEEE 802.15.4,” IEEE Trans. Ind. Electron., vol. 57, no. 11, pp. 3868–3876, Nov. 2010.
[3] C. Perkins and E. Royer, “Ad-hoc on-demand distance vector routing,” in Proc. IEEE WMCSA, 1999, pp. 90–100.
[4] M. Marina and S. Das, “On-demand multipath distance vector routing in ad hoc networks,” in Proc. IEEE ICNP, Nov. 2001, pp. 14–23.
[5] D. B. Johnson and D. A. Maltz, “Dynamic source routing in ad hoc wireless networks,” Mobile Computing, pp. 153–181, 1996.
[6] K. A. Agha, M.-H. Bertin, T. Dang, A. Guitton, P. Minet, T. Val, and J.-B. Viollet, “Which wireless technology for industrial wireless sensor networks? the development of Ocari technology,” IEEE Trans. Ind. Electron., vol. 56, no. 10, pp. 4266–4278, Oct. 2009.
[7] K. Yu, M. Gidlund, J. Åkerberg, and M. Björkman, “Reliable RSS-based routing protocol for industrial wireless sensor networks,” in Proc. IECON, 2012, pp. 3231–3237.
[8] “U. D. of Energy, Industrial wireless technology for the 21st century,” Office of Energy and Renewable Energy Report, 2002.
[9] Y. Gu and T. He, “Dynamic switching-based data forwarding for lowduty-cycle wireless sensor networks,” IEEE Trans. Mobile Comput., vol. 10, no. 12, pp. 1741–1754, Dec. 2011.
[10] V. Gungor, O. Akan, and I. Akyildiz, “A real-time and reliable transport protocol for wireless sensor and actor networks,” IEEE/ACM Trans. Netw., vol. 16, no. 2, pp. 359–370, Apr. 2008.
[11] S. Biswas and R. Morris, “ExOr: opportunistic multi-hop routing for wireless networks,” in Proc. ACM SIGCOMM, 2005, pp. 133–144.
[12] S. Katti, H. Rahul, W. Hu, D. Katabi, M. Medard, and J. Crowcroft, “XORs in the air: Practical wireless network coding,” IEEE/ACM Trans. Netw., vol. 16, no. 3, pp. 497–510, Jun. 2008.
[13] S. Chachulski,M. Jennings, S. Katti, and D. Katabi, “Trading structure for randomness in wireless opportunistic routing,” in Proc. AGM SIGCOMM, 2007, pp. 169–180.
[14] K. Zeng, W. Lou, J.Yang, and D. Brown, “On geographic collaborative forwarding in wireless ad hoc and sensor networks,” in Proc. WASA, 2007, pp. 11–18.
[15] X. Mao, S. Tang, X. Xu, Li X.-Y, and H. Ma, “Energy-efficient opportunistic routing in wireless sensor networks,” IEEE Trans. Parallel Distrib.Syst., vol. 22, no. 11, pp. 1934–1942, Nov. 2011.
[16] R. Bruno and M. Nurchis, “Survey on diversity-based routing in wireless mesh networks: Challenges and solutions,” Computer Commun., vol. 33, no. 3, pp. 269–282, Feb. 2010.
[17] E. Royer and C.-K. Toh, “A review of current routing protocols for ad hoc mobile wireless networks,” IEEE Pers. Commun., vol. 6, no. 2, pp. 46–55, 1999.
[18] R. Shah, S. Wietholter, A. Wolisz, and J. Rabaey, “When does opportunistic routing make sense?,” in Proc. IEEE PerCom Workshops, 2005, pp. 350–356.
[19] K.-H. Kim and K. G. Shin, “On accurate measurement of link quality in multi-hop wireless mesh networks,” in Proc. ACM MobiCom, 2006, pp. 38–49.
[20] X. Huang, H. Zhai, and Y. Fang, “Robust cooperative routing protocol in mobile wireless sensor networks,” IEEE Trans. Wireless Commun., vol. 7, no. 12, pp. 5278–5285, Dec. 2008.
[21] Network simulator [Online]. Available: http://www.isi.edu/nsnam/ns/
[22] “Hart Specification,” [Online]. Available: http://www.hartcomm.org
[23] “Isa-100, Wireless Systems for Automation,” [Online]. Available: http://www.isa.org/isa100