A Review on Reliable and Energy-Efficient Routing Protocol in Dense Wireless Sensor Networks

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Abstract- **Based on the geographical information, REER's design harnesses the advantage of high node density and relies on the collective efforts of multiple cooperative nodes to deliver data, without depending on any individual ones. We first select reference nodes (*RN*s) between source and sink. Then, multiple cooperative nodes (*CN*s) are selected for each *RN*. The reliability is attained by cooperative routing: each hop keeps multiple *CN*s among which any one may receive the broadcast data packet from the upstream hop to forward the data successfully. The distance between two adjacent *RN*s provides a control knob to trade off robustness, total energy cost and end-to-end data latency.**

Keywords- **cooperative nodes, wireless sensor networks, a reliable energy-efficient routing (REER)**

I. INTRODUCTION

The goal of reliability and energy-efficiency usually conflict each other. We consider two extremes of routing protocols in terms of these two design objectives: unicast routing and flooding. Unicast routing is energy-efficient for reliable networks, but is not robust for dynamic networks. Flooding is very robust for dynamic and error-prone networks, but incurs a high overhead for sensor networks. Some routing protocols try to achieve a trade-off between the two extremes to make   this adaptive to different types of networks (with different link/node failure rate, node density, etc.).

For example, in directed diffusion (DD) [18], exploratory data is periodically flooded for reliability. When a path is reinforced, it is used for a while with unicast routing in order to save overhead. In this work a reliable energy-efficient routing (REER) protocol is proposed to construct a "unicast-like" path, while exploiting broadcast to attain high reliability during data dissemination. REER achieves both reliable and energy-efficient data delivery for dense wireless sensor networks (WSNs).When sending a packet from source to the sink over multiple hops, REER controls the distance r between two adjacent hops.

At each hop, an appropriate number of nodes for cooperatively forwarding the data is selected. The smaller is r, the more nodes can be selected for cooperative data forwarding. Since r decides how many nodes will be selected, it efficiently provides a tradeoff between reliability   and energy cost. When r is equal to the transmission range of data packet, REER behaves almost like a unicast fashion. By comparison, if r is very small, REER can be deemed as scope-controlled flooding around the path from the source to the sink. Unlike directional/controlled flooding, REER only selects the nodes which need to participate data broadcasting to achieve required reliability in a hop-by-hop fashion. Thus, the number of nodes involved in data delivery is minimized while achieving required reliability. Furthermore, the unselected nodes will enter sleeping mode to save energy. Since REER exploits geographical information to construct path, it will be compared with GPSR, a popular position-based approach, by both analysis and simulation. We present extensive simulations to show that REER normally yields higher reliability than GPSR. And more importantly, REER also achieves less energy consumption. The overall performance (e.g. reliability, lifetime, and data delivery latency) gain of REER increases as the link/node failure rate increases.

II. RELATED WORK

Our work is closely related to the reliable data transfer scheme in WSN, and geographic routing in WSN. We will give a brief review of the work in these two aspects. There are increasing research efforts on studying the issue of reliable data transfer in WSN [3]–[9]. In these work, hop-by-hop [3], [4] recovery, end-to-end, [8], [9] recovery, and multi-path forwarding [5]–[7] are the major approaches to achieve the desired reliability by previous work. PSFQ [3] works by distributing data from source nodes in a relatively slow pace and allowing nodes experienced data loss to recover any missing segments from immediate neighbors aggressively. PSFQ employs hop by hop recovery instead of end to end recovery. In [4], the authors proposed RMST, a transport protocol that provides guaranteed delivery for applications requiring them. RMST is a selective NACK-based protocol that can

be configured for in-network caching and repair. Several acknowledgement based end- to-end reliable event transfer schemes are proposed to achieve various levels of reliability in [9]. We also proposed a virtual MIMO based cross layer design in [10]. In the design, the nodes can form adaptively the cooperative nodes set to transmit data among clusters. Then, the hop-by-hop recovery scheme and multi-hop routing scheme are integrated into the virtual MIMO scheme to jointly provide energy efficiency, reliability and end-to-end QoS guarantee. In [5], multiple disjoint paths are set up first, then multiple data copies are delivered using these paths.

In [6], a protocol called ReIn For M is proposed to deliver packets at desired reliability by sending multiple copies of each packet along multiple paths from sources to sink. The number of data copies (or, the number of paths used) is dynamically determined depending on the probability of channel error. Instead of using disjoint paths, GRAB [7] uses a path interleaving technique to achieve high reliability. It assigns the amount of credit α to the packet at the source. α determines the "width" of the forwarding mesh and should be large enough to ensure robustness but not to cause excessive energy consumption.

However, finding a suitable value of α for various reliability requirements of sensor networks is not trivial. Furthermore, when the quality of channel changes frequently, out-of-date α makes GRAB either waste energy to unnecessarily use more paths or fail to achieve the required reliability. It is worth noting that although GRAB [7] also exploits data broadcasting to attain high reliability, it may not be energy-efficient because it may involve many next-hop nodes in order to achieve good reliability and an unnecessarily large number of packets may be broadcast. By comparison, in STEER a data packet is only broadcast once at each hop, and it is quite robust to link/node failures. Some researchers explore the special features of sensor applications in reliable protocol design.

For example, considering asymmetric many-to-one communication pattern from sources to sink in some sensor applications, data packets collected for a single event exhibit high redundancy. Thus, some reliable techniques [3], [4] proposed for WSN would either be unnecessary or spend too much resources on guaranteeing 100% reliable delivery of data packets. Exploiting the fact that the redundancy in sensed data collected by closely deployed sensor nodes can mitigate channel error and node failure, ESRT [8] intends to minimize the total energy consumption while guaranteeing the end-to-sink reliability. In ESRT, the sink adaptively achieves the expected event reliability by controlling the reporting frequency of the source nodes. However, in the case that many sources are involved in reporting data

simultaneously to ensure some reliability (e.g., in a high unreliable environment), the large amount of communications are likely to cause congestion.

Geographic routing is a routing scheme where the location of the network nodes is used for packet forwarding. Geographic routing can be stateless, because the next hop is chosen using the geographic location of the destination, which is stored in the packet header. In contrast to that, non-geographic algorithms let the nodes keep information about routes. In most position-based routing approaches, the minimum information a node must have to make useful routing decisions is its position (provided by GPS, Galileo, etc.), the position of its neighbors (through beaconing), and the final destination's location (through a so-called location service [15]).
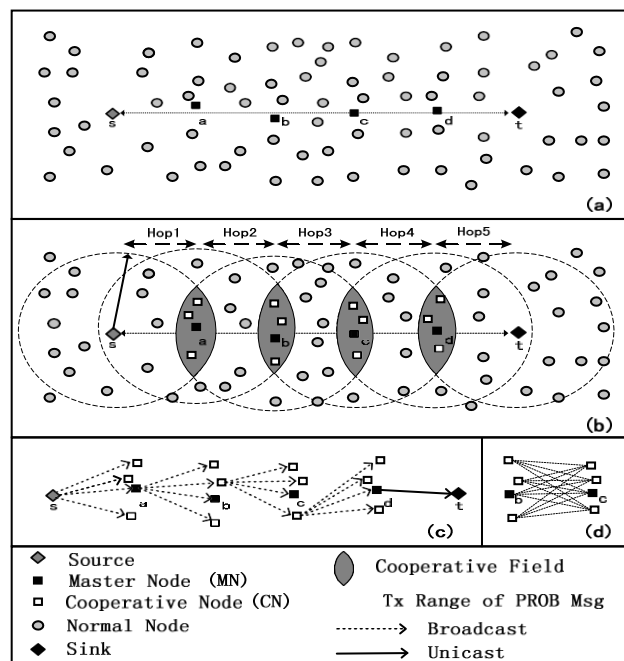

Fig. 1 Illustration of the REER Routing Protocol: (a) RNs along the shortest path; (b) CNs in the cooperative fields; (c) cooperative data forwarding; (d) the forwarding mesh between two cooperative fields

The most popular forwarding method in this category is greedy forwarding, where forwarding decisions are made locally based on information about their one- hop neighborhood. An overview of geographic routing algorithms can be found in [11]. A well-known geographic routing algorithm is GPSR [13]. In GPSR, each node maintains a neighbor table which is updated by periodically sending beacon messages. To route around areas where greedy forwarding cannot be used, Greedy Perimeter State Routing (GPSR) [13] tries to find the perimeter of the area. Packets are then routed along this perimeter, around the area.

III. CONCLUSIONS

This paper proposes REER to achieve both reliability and energy-efficiency simultaneously. In REER, we first select reference nodes (RNs) between source and sink. Then, multiple cooperative nodes (CNs) are selected for each reference node. The smaller is the distance (r) between two adjacent RNs , the larger number of CNs will be selected for each flow. r provides a control knob to trade off robustness, energy- efficiency and data delay. In unreliable communication environments, traditional routing protocols may fail to deliver data timely since link/node failures can be found out only after trying multiple transmissions. In REER, each data is relayed by broadcasting at each hop, such that among all the CNs at next hop   that received the data successfully, only one CN will rebroadcast the data.

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