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**Energy-aware Dual-path Geographic Routing to Bypass Routing Holes in Wireless Sensor Networks**

**Abstract:**

Geographic routing has been considered as an attractive approach for resource-constrained wireless sensor networks (WSNs) since it exploits local location information instead of global topology information to route data. However, this routing approach often suffers from the routing hole (i.e., an area free of nodes in the direction closer to destination) in various environments such as buildings and obstacles during data delivery, resulting in route failure. Currently, existing geographic routing protocols tend to walk along only one side of the routing holes to recover the route, thus achieving suboptimal network performance such as longer delivery delay and lower delivery ratio. Furthermore, these protocols cannot guarantee that all packets are delivered in an energy-efficient manner once encountering routing holes. In this paper, we focus on addressing these issues and propose an energy-aware dual-path geographic routing (EDGR) protocol for better route recovery from routing holes. EDGR adaptively utilizes the location information, residual energy, and the characteristics of energy consumption to make routing decisions, and dynamically exploits two node-disjoint anchor lists, passing through two sides of the routing holes, to shift routing path for load balance. Moreover, we extend EDGR into three-dimensional (3D) sensor networks to provide energy-aware routing for routing hole detour. Simulation results demonstrate that EDGR exhibits higher energy efficiency, and has moderate performance improvements on network lifetime, packet delivery ratio, and delivery delay, compared to other geographic routing protocols in WSNs over a variety of communication scenarios passing through routing holes. The proposed EDGR is much applicable to resource-constrained WSNs with routing holes.

**Existing System:**

Geographic routing, also referred to as position-based or localized routing, has been regarded as an attractive approach for resource-constrained WSNs, since it exploits local location information instead of global topology information for data delivery. It is based on the prerequisite that the nodes know their actual or virtual locations, which can be made available either through a Global Position System (GPS) receiver or through some other ways, and exchange such information with neighbors periodically or actively. Being almost stateless and distributed, geographic routing does not require dissemination of route establishment information and maintenance of routing tables at each node, thus making it efficient, scalable and promising for WSNs.

**Proposed System:**

EDGR establishes dual-path routing following two node-disjoint anchor lists which pass through two sides of the routing holes to route data, preventing data from being forwarded along the boundary of the routing holes. In this way, each data packet is routed to destination along two different paths in greedy mode only instead of bypass mode if possible, thereby shortening the routing length and balancing load.

EDGR proposes a novel alternative approach to find efficient forwarder in the presence of node failure in the relay area, by introducing a random shift to the location of subdestination. Such an approach is feasible, reasonable, and energy-efficient without additional communication overhead.

We prove that EDGR is anchor list node-disjoint and routing loop-free, and draw out its essential characteristics in terms of time complexity for anchor list building and successful routing probability.