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ORIGINAL ARTICLE

Location aware event driven multipath routing in Wireless Sensor Networks: Agent based approach

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Abstract Wireless Sensor Networks (WSNs) demand reliable and energy efficient paths for critical information delivery to sink node from an event occurrence node. Multipath routing facilitates reliable data delivery in case of critical information. This paper proposes an event triggered multipath routing in WSNs by employing a set of static and mobile agents. Every sensor node is assumed to know the location information of the sink node and itself. The proposed scheme works as follows: (1) Event node computes the arbitrary midpoint between an event node and the sink node by using location information. (2) Event node establishes a shortest path from itself to the sink node through the reference axis by using a mobile agent with the help of location information; the mobile agent collects the connectivity information and other parameters of all the nodes on the way and provides the information to the sink node. (3) Event node finds the arbitrary location of the special (middle) intermediate nodes (above/below reference axis) by using the midpoint location information given in step 1. (4) Mobile agent clones from the event node and the clones carry the event type and discover the path passing through special intermediate nodes; the path above/below reference axis looks like an arc. While migrating from one sensor node to another along the traversed path, each mobile agent gathers the node information (such as node id, location information, residual energy, available bandwidth, and neighbors connectivity) and delivers to the sink node. (5) The sink node constructs a partial topology, connecting event and sink node by using the connectivity information delivered by the mobile agents. Using the partial topology information, sink node finds the multipath and path weight factor by using link efficiency, energy ratio, and hop distance. (6) The sink

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node selects the number of paths among the available paths based upon the criticalness of an event, and (7) if the event is non-critical, then single path with highest path weight factor is selected, else multiple paths are selected for the reliable communication. The performance of the proposed scheme is tested in terms of performance parameters such as packet delivery ratio, energy consumption, latency, and overhead.

1. Introduction

Due to recent technological advances, manufacturing of tiny and low cost sensors has become technically and economically feasible. Wireless Sensor Networks (WSNs) consist of sensor nodes with sensing, computation, and wireless communication capabilities [1–5]. Sensor nodes have the ability to communicate either among each other or directly to an external base station (BS) called as sink. The deployments of more number of sensors allow sensing over larger geographical regions with greater accuracy. The sensors can monitor diversified entities such as temperature, pressure, humidity, salinity, metallic objects, and mobility. The monitoring competence can be effectively used in applications like military, fire detection, earthquake monitoring, disaster management, habitat monitoring, and environmental monitoring, which require unattended operations.

In traditional WSNs, sensor nodes periodically gather data and report to the sink node by using the multihop communication. During data gathering, sensors have the ability to perform in-network aggregation of data packets enroute to the sink node. Using conventional methods of data gathering and processing in WSNs may lead to some of the limitations like excess energy consumption, redundant data transmission, increased latency, and bandwidth overheads. The critical issue in a WSN is the network lifetime which is mainly dependent on the energy of sensor nodes [6].

Recently, multipath routing approach is widely used in WSNs to improve network performance by efficiently utilizing the network resources as well to improve the reliability of information delivery. Routing techniques are classified based on the network structure into three categories: flat, hierarchical, and location based routing protocols. Furthermore, these protocols are classified into multipath-based, query-based, negotiation-based, or QoS-based routing techniques based on the protocol operation. Some of the challenges in routing for WSNs are data reporting, node/link heterogeneity, fault tolerance, scalability, network dynamics, coverage, connectivity, etc. [7–9].

In WSN, the communication cost is often several orders of magnitude higher than the computation cost. During the routing phase, the sensed data, query, and control messages travel from a node to another to reach their destination. This consumes a considerable amount of sensors energy. Therefore, many routing protocols are presented for saving the sensor node's energy and prolong their lifetime. Due to restricted communication range and high density of sensor nodes, packet forwarding is done through multihop data transmission.

Multipath routing between a given (sink, source) pair based on Bezier curves that helps in load balancing among the relay nodes for the purpose of prolonging the WSNs lifetime is presented in [10]. Selecting the Bezier curve control points is one of the crucial tasks between the source node and the sink node. The construction of the routes based on Bezier curves can be done locally with a small overhead in terms of transmitted parameters; each relay node can decide who should be the next hop along that particular route toward the sink. The major overheads in using Bezier curve for multipath routing is entire trajectory points are to be encoded with the every transmitted packet from source to sink node.

1.1. Related works

Some of the related works are as follows: A low interference energy efficient multipath routing protocol (LIEMRO) to improve the QoS requirements of event driven applications is presented in [11]. An on-demand multipath routing protocol based on parametric probability for WSNs presented in [12] discusses balanced energy consumption among sensor nodes and maximizes the network lifetime. The different data generated at the same sensor node may pick up different transmission paths according to a probability that depends on various parameters, such as the hop distance from intermediate node to sink and residual energy of intermediate node. Furthermore, balance among multipath based on the energy usage at neighbors is considered in selection of the path.

Secure multipath routing algorithm (SeMuRa) for WSN is presented in [13]. It discusses the extended version of k-connectivity to k–x-connectivity, where x is the value of threshold representing the maximal number of nodes shared between any two paths in the set of the k established paths. This protocol is based on demand routing and uses label in the datagram exchanged during the route discovery to carry the threshold.

A technique to find multiple paths between sink and multiple sources for reduced collisions is presented in [14]. It has taken the advantage of the mass deployment of sensor nodes to search for disjoint paths for multiple source nodes in order to avoid collisions.

An energy efficient and collision aware (EECA) node disjoint multipath routing algorithm for WSNs is presented in [15]. Using the location information, EECA algorithm finds two collision-free routes using constrained and power adjusted flooding and then transmits the data with minimum power needed through power control component of the protocol.

A distributed, scalable, and localized multipath search protocol to discover multiple node disjoint paths between the sink and the source node is presented in [16]. The distributed multipath routing protocol is capable to search multiple node disjoint paths. The load balancing algorithm aims to optimally allocate the traffic rate to each path.

A robust and energy efficient multipath routing protocol (REER) is presented in [17]. REER uses the residual energy,