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A Study on Existing Protocols and Energy-Balanced Routing Protocol for Data Gathering in Wireless Sensor Networks

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Abstract

Energy is an extremely critical resource for battery-powered wireless sensor networks (WSN), thus making energy-efficient protocol design a key challenging problem. Most of the existing energy-efficient routing protocols always forward packets along the minimum energy path to the sink to merely minimize energy consumption, which causes an unbalanced distribution of forming residue energy among sensor nodes, and eventually results in a network partition. In this paper, with the help of the concept of potential in physics, we design an Energy-Balanced Routing Protocol (EBRP) by constructing a mixed virtual potential field in terms of depth, energy density, and residual energy. The goal of this basic approach is to force packets to move toward the sink through the dense energy area to protect the nodes with relatively low residual energy. To address the routing loop problem emerging in this basic algorithm, enhanced mechanisms are proposed to detect and eliminate loops. The basic algorithm and loop elimination mechanism are first validated through extensive simulation experiments.

Keywords- Energy; Protocol; Routing; Sensor; Wireless

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I. Introduction

Wireless Sensor Networks (WSNs) are deployed to carry out various applications, such as environmental monitoring, industrial control, disaster recovery, and battlefield surveillance. WSNs are expected to play even more important role in the next generation networks to sense the physical world. It is well known that energy is one of the most critical resources for battery-powered WSNs. To extend the network lifetime as long as possible, energy efficiency becomes one of the basic tenets in the WSN protocol design. In order to use the limited energy available at sensor nodes more efficiently, most existing routing schemes attempt to find the minimum energy path to the sink to optimize energy usage at nodes. However, the question arises whether it is sufficient to focus only on the energy efficiency while designing routing protocols for WSNs or other objectives such as network lifetime and coverage should also be taken into account.

Such imbalance of energy consumption imbalance is definitely undesirable for the long-term health of the network. If the sensor nodes consume their energy more evenly, the connectivity between them and the sink can be maintained for a longer time, thus postponing the network partition. This more graceful degradation of the network connectivity can obviously provide substantial gains. Therefore, it should be rational and practical to make an appropriate trade-off between energy efficiency and balanced energy consumption. With this in mind, in this paper we design a novel routing scheme that overcomes the problem of energy consumption imbalance in most existing energy-efficient routing algorithms, and demonstrates the advantage of balanced energy consumption across the network.

II.Wireless Sensor Network

A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor physical or environmental conditions such as temperature, sound, vibration, pressure, motion or pollutants and to cooperatively pass their data through the network to a main location. The more modern networks are bidirectional also enabling control of sensor activity. A Wireless Sensor Network is composed of two types of nodes: sensor nodes and sink nodes. The sensor nodes, also known as motes or simply nodes are tiny and energy constrained device that have the ability of sensing the surrounding environment. The sink, also known as base station, is a powerful node that behaves as an interface between the sensor nodes and the clients. The transmission of sensed data from sensor nodes to the sink nodes takes place at regular intervals of time or at the occurrence of certain events. The sink nodes can also send data to sensor nodes in the network which is usually of broadcast in nature.

Large-scale intensive wireless sensor networks network size, multi-node deployment-intensive, mass data, and self-organization. It is prone to imbalance in the local energy consumption, that resulted in network structure rupture and the network life cycle is over prematurely. Therefore, it is one of the important challenges that reduce the energy consumption of nodes, reasonable and efficient use of the limited energy resources, maximize network life. Many nodes in the network typically use a multi-hop mode to communicate with each other during the transmission, and parts of them both not only collect data but also forwarding packets. Such as the nodes near the base station have to undertake more transmission data load and raise the energy consumption than the others, thus these nodes premature depletion of the nodal energy may result in disjointing of the network, which caused the energy hole. When those nodes increase greatly, it will lead to rapid expansion of energy hole, paralysis of network, and the end of the network life. To prolong the lifecycle of wireless sensor network, the key nodes which consume the maximum energy must be focus on design to balance network energy consumption, reduce energy hole.

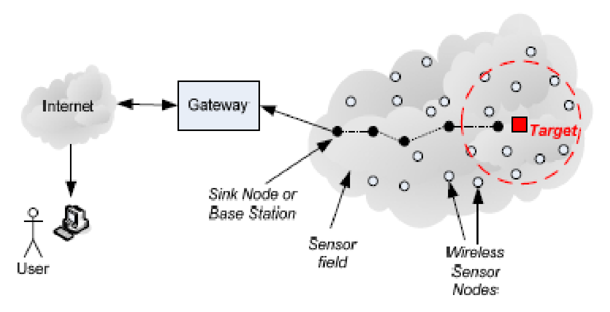

Figure 1: Architecture of wireless sensor networks

III. Existing Protocols

In the existing, the energy-efficient routing protocols always forward packets along the minimum energy path to the sink to merely minimize energy consumption, which causes an unbalanced distribution of residual energy among sensor nodes, and eventually results in a network partition. In order to use the limited energy available at sensor nodes more efficiently, most existing routing schemes attempt to find the minimum energy path to the sink to optimize energy usage at nodes. The nodes that closer to the sink tend to deplete their energy faster than the others. This uneven energy depletion dramatically reduces the network lifetime and decreases the coverage ratio. Such imbalance of energy consumption imbalance is definitely undesirable for the long-term health of the network. If the sensor nodes consume their energy more evenly, the connectivity between them and the sink can be maintained for a longer time, thus postponing the network partition.

Disadvantages

Unbalanced distribution of residual energy among sensor nodes, and eventually results in a network partition.

This uneven energy depletion dramatically reduces the network lifetime and decreases the coverage ratio

The minimum energy path to the sink to optimize energy usage at nodes.

IV. New Protocol-EBRP (Energy- Balanced Routing Protocol)

In this paper, with the help of the concept of potential in physics, we design an Energy- Balanced Routing Protocol (EBRP) by constructing a mixed virtual potential field in terms of depth, energy density, and residual energy. The goal of this basic approach is to force packets to move toward the sink through the dense energy area to protect the nodes with relatively low residual energy. To address the routing loop problem emerging in this basic algorithm, enhanced mechanisms are proposed to detect and eliminate loops. Our scheme called energy-balanced routing protocol, forwards data packets toward the sink through dense energy areas so as to protect the nodes with relatively low residual energy. The cornerstone of the EBRP is to construct three independent virtual potential fields in terms of depth, energy density, and residual energy. The depth field is used to establish a basic routing paradigm, which keeps packets move toward the sink. The energy density field ensures that packets are always forwarded along the high-energy areas. Finally, the residual energy field aims to protect the low energy nodes. The final routing decision is made by considering the three virtual potential fields together.

Advantages

Overcomes the energy imbalance by forwarding the data through high energy density nodes limits the number of paths along which the data packets can flow a feasible approach to prolong the network lifetime, yet maintaining the network connectivity

V.Existing Protocol Lists

5.1 DSR- Dynamic Source Routing Protocol

DSR is one of the most well known routing algorithms for ad hoc wireless networks. It was originally developed by Johnson, Maltz, and Broch. DSR uses source routing, which allows packet routing to be loop free. It increases its efficiency by allowing nodes that are either forwarding route discovery requests or overhearing packets through promiscuous listening mode to cache the routing information for future use. DSR is also on demand, which reduces the bandwidth use especially in situations where the mobility is low. It is a simple and efficient routing protocol for use in ad hoc networks. It has two important phases, route discovery and route maintenance.

5.2 AODV - Ad Hoc On-Demand Distance-Vector Protocol

AODV is another routing algorithm used in ad hoc networks. Unlike DSR, it does not use source routing, but like DSR it is on-demand. In AODV, each node maintains a routing table which is used to store destination and next hop IP addresses as well as destination sequence numbers. Each entry in the routing table has a destination address, next hop, precursor nodes list, lifetime, and distance to destination.

Interesting Concepts of AODV

The concepts of AODV that make it desirable for MANETs with limited bandwidth include the following:

Minimal space complexity: The algorithm makes sure that the nodes that are not in the active path do not maintain information about this route. After a node receives the RREQ and sets a reverse path in its routing table and propagates the RREQ to its neighbors, if it does not receive any RREP from its neighbors for this request, it deletes the routing info that it has recorded.

Simple: It is simple with each node behaving as a router, maintaining a simple routing table, and the source node initiating path discovery request, making the network self-starting.

Most effective routing info: After propagating an RREP, if a node finds receives an RREP with smaller hop-count, it updates its routing info with this better path and propagates it.

Most current routing info: The route info is obtained on demand. Also, after propagating an RREP, if a node finds receives an RREP with greater destination sequence number, it updates its routing info with this latest path and propagates it.

Loop-free routes: The algorithm maintains loop free routes by using the simple logic of nodes discarding non better packets for same broadcast-id. Coping up with dynamic topology and broken links: When the nodes in the network move from their places and the topology is changed or the links in the active path are broken, the intermediate node that discovers this link breakage propagates an RERR packet. And the source node reinitializes the path discovery if it still desires the route. This ensures quick response to broken links.

Highly Scalable: The algorithm is highly scalable because of the minimum space complexity and broadcasts avoided when it compared with DSDV

Advanced Uses of AODV

Because of its reactive nature, AODV can handle highly dynamic behavior of Vehicle Ad-hoc networks.

Used for both unicasts and multicasts using the 'J' (Join multicast group) flag in the packets.

Limitations/Disadvantages of AODV

Requirement on broadcast medium: The algorithm expects/requires that the nodes in the broadcast medium can detect each others' broadcasts.

Overhead on the bandwidth: Overhead on bandwidth will be occurred com- pared to DSR, when an RREQ travels from node to node in the process of discovering the route info on demand, it sets up the reverse path in itself with the addresses of all the nodes through which it is passing and it carries all this info all its way.

No reuse of routing info: AODV lacks an efficient route maintenance technique. The routing info is always obtained on demand, including for common cause traffic.

It is vulnerable to misuse: The messages can be misused for insider attacks including route disruption, route invasion, node isolation, and resource consumption.

AODV lacks support for high throughput routing metrics: AODV is designed to support the shortest hop count metric. This metric favors long, low- bandwidth links over short, high-bandwidth links.

High route discovery latency: AODV is a reactive routing protocol. This means that AODV does not discover a route until a flow is initiated. This route discovery latency result can be high in large-scale mesh networks.

5.3 DSDV - Destination Sequenced Distance Vector Protocol

DSDV is one of the most well known table-driven routing algorithms for MANETs. It is a distance vector protocol. In distance vector protocols, every node i maintains for each destination x a set of distances {dij(x)} for each node j that is a neighbor of i. Node i treats neighbor k as a next hop for a packet destined to x if dik(x) equals minj {dij(x)}. The succession of next hops chosen in this manner leads to x along the shortest path. In order to keep the distance estimates up to date, each node monitors the cost of its outgoing links and periodically broadcasts to all of its neighbors its current estimate of the shortest distance to every other node in the network. The distance vector which is periodically broadcasted contains one entry for each node in the network which includes the distance from the advertising node to the destination. The distance vector algorithm described above is a classical Distributed Bellman-Ford (DBF) algorithm.

Advantages of DSDV

DSDV protocol guarantees loop free paths.

Count to infinity problem is reduced in DSDV. We can avoid extra traffic with incremental updates instead of full dump updates.

Path Selection: DSDV maintains only the best path instead of maintaining multiple paths to every destination. With this, the amount of space in routing table is reduced.

5.6 EBRP: Energy Balanced Routing Protocol

The goal of Energy Balanced Routing Protocol is to force the packets to move towards the sink so as to protect the nodes with relatively low residual energy.

The Energy Balanced Routing Protocol is designed by constructing a mixed virtual potential field.

It forces packets to move towards the sink through dense energy area.

Protects the sensor nodes with low residual energy.

Successfully delivers the sensed packet to the sink.

VI. Conclusion

Energy is an extremely critical resource for battery powered wireless sensor networks (WSN) thus making energy efficient protocol design a key challenging problem. Most of the existing energy efficient routing protocols always forward packets along the minimum energy path to the sink to merely minimize energy consumption which causes an unbalanced distribution of residual energy among sensor nodes and eventually results in a network partition. Merely, saving energy is not enough to effectively prolong the network lifetime. The uneven energy depletion often results in network partition and low coverage ratio which decrease the performance. This project focuses on routing that balances the energy consumption. Its main work is to drive packets to move toward the sink through the dense energy area and steer clear of the nodes with low residual energy so that the energy is consumed as evenly as possible in any given arbitrary network deployment. The simulation results show that the proposed solution for EBRP makes significant improvements in energy consumption balance, network lifetime and throughput as compared to the commonly used energy efficient routing algorithm.

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