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A Study on the Energy efficient velocity control Protocols in the Wireless Sensor Network

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Abstract

Wireless sensor Network is designed to deal with the intermittent connectivity among mobile nodes due to mobility and it is used to reduce the energy consumption of nodes and to prevent the formation of energy holes. In Order to improve the quality of the Service of the system , we need to obtain best optimal path through the query node however, these benefits are dependent on the path taken by the mobile sink, particularly in delay-sensitive applications, as all sensed data must be collected within a given time constraint. An approach proposed to address this challenge is to form a hybrid moving pattern in which a mobile-sink node only visits rendezvous points (RPs), as opposed to all nodes. Sensor nodes that are not RPs forward their sensed data via multi-hopping to the nearest RP. The fundamental problem then becomes computing a tour that visits all these RPs within a given delay bound. Identifying the optimal tour, however, is an NP-hard problem. To address this problem, a heuristic called weighted rendezvous planning (WRP) is proposed, whereby each sensor node is assigned a weight corresponding to its hop distance from the tour and the number of data packets that it forwards to the closest RP.

Keywords : Wireless sensor Network , energy efficiency , Velocity Control

1. Introduction

Key issue in wireless Sensor Network (WSN) system design is to minimize the overall system cost (deployment, operation, maintenance and abolishment) and power consumption. Most of the existing WSN systems rely on standard full-fledged transceivers equipped on each sensor node for communication with sinks and each other. However, in most cases, the receiver module of a transceiver is more costly and consumes more energy than the transmitter. Each sensor node has the capability to collect and process data, and to forward any sensed data back to one or more sink nodes via their wireless transceiver in a multihop manner. In addition, it is equipped with a battery, which may be difficult or impractical to replace, given the number of sensor nodes and deployed environment. These constraints have led to intensive research efforts on designing energy-efficient protocols [1].

In multihop communications, nodes that are near a sink tend to become congested as they are responsible for forwarding data from nodes that are farther away. Thus, the closer a sensor node is to a sink, the faster its battery runs out, whereas those farther away may maintain more than 90% of their initial energy [2]. To this end, previous works such as [15] and [16] employ one or more mobile sinks. These mobile sinks survey and collect sensed data directly from sensor nodes and thereby help sensor nodes save energy that otherwise would be consumed by multihop communications. The travelling path of a mobile sink depends on the real-time requirement of data produced by nodes. For example, in hard real-time applications such as a fire-detection system [8], environmental data need to be collected by a mobile sink quickly. Moreover, a mobile-sink node may change its position after a certain period of time and select another data collection/ feasible site. The feasible sites and corresponding sojourn time are dependent on the residual energy of sensor nodes [9] – [11].

In general, limitations such as the maximum number of feasible sites [14], maximum distance between feasible sites, and minimum sojourn time [15] govern the movement of a mobile sink. In WSNs with a mobile sink, one fundamental problem is to determine how the mobile sink goes about collecting sensed data. One approach is to visit each sensor node to receive sensed data directly [12]. This is essentially the well-known travelling salesman problem (TSP) [16], where the goal is to find the shortest tour that visits all sensor nodes. However, with an increasing number of nodes, this problem becomes intractable and impractical as the resulting tour length is likely to violate the delay bound of applications. To this end, researchers have proposed the use of rendezvous points (RPs) to bound the tour length [17], [18]. This means a subset of sensor nodes are designated as RPs, and non-RP nodes simply forward their data to RPs.

A tour is then computed for the set of RPs. As a result, the problem, which is called rendezvous design, becomes selecting the most suitable RPs that minimize energy consumption in multihop communications while meeting a given packet delivery bound. A secondary problem here is to select the set of RPs that result in uniform energy expenditure among sensor nodes to maximize network lifetime. In this paper, we call this problem the delay-aware energy efficient path (DEETP). We show that the DEETP is an NP hard problem and propose a heuristic method, which is called weighted rendezvous planning (WRP), to determine the tour of a mobile-sink node.

In WRP, the sensor nodes with more connections to other nodes and placed farther from the computed tour in terms of hop count are given a higher priority. Thus, this paper is summarized as follows. • We define the problem of finding a set of RPs to be visited by a mobile sink. The objective is to minimize energy consumption by reducing multihop transmissions from sensor nodes to RPs. This also limits the number of RPs such that the resulting tour does not exceed the required deadline of data packets. • We propose WRP, which is a heuristic method that finds a near-optimal travelling tour that minimizes the energy consumption of sensor nodes.

WRP assigns a weight to sensor nodes based on the number of data packets that they forward and hop distance from the tour, and selects the sensor nodes with the highest weight. • We mathematically prove that selecting the sensor node that forwards the highest number of data packets and have the longest hop distance from the tour reduces the network energy consumption, as compared with other nodes. Moreover, we show that, in contrast to cluster-based (CB) [17], rendezvous design for variable tracks (RD-VT) [33], and rendezvous planning utility-based greedy (RP-UG) [17] algorithms, WRP is guaranteed to find a tour if the latter exists. • We demonstrate via computer simulation the properties and effectiveness of WRP against the CB [17], RD-VT [18], and RP-UG algorithms [18]. Our results show that WRP achieves 14% more energy savings and 22% better distribution of energy consumption between sensor nodes than the said algorithms. The remainder of this paper is structured as follows. Section II reviews methods. Section III presents energy efficient models of the system. In Section IV, we conclude.

2. Related Work

2.1. Multi-Hoping:

Wireless sensor Networks composed of several nodes and they are communicating with each other and describe several paths to several node. Here actually the packet traverses from one node to another node to reach the destination through several paths. Due to this Multi-hop features energy associated with each node can be conserved.

2.2. High Throughput Multi Routing in the Wireless net with path Metric computation :

Many applications and areas of wireless sensor nets (WSN), have diverse data traffic with different quality of service (QOS) requirements. So we address the problem in this paper by Employing a High Throughput Metric (HTM), which finds high-throughput paths on multi-hop wireless nets. HTM minimizes the expected total number of packet transmissions (including retransmissions) required to successfully deliver a packet to the ultimate destination.

2.3. Routing towards a mobile sink for improving lifetime in sensor networks :

Improving network lifetime and reliability are the fundamental challenges in Wireless Sensor Networks (WSNs). The main issue in events sensing and relaying in WSN is the formation of energy-holes near the sink. Nodes near the sink are more likely to use up their energy because they have to forward all the traffic generated by the nodes farther away to the sink. In this end, we analysed a routing algorithm termed Termite-hill that support sink mobility. The performance of our proposed algorithm was tested on static and mobile sink scenarios with varying speed, and compared with other state-of-the-art routing algorithms in WSN.

2.4. Data capacity improvement of wireless sensor networks using non-uniform sensor distribution :

Energy conservation is an important design consideration for battery powered wireless sensor networks (WSNET). Energy constraint in WSNETs limits the total amount of sensed data (data capacity) received by sinks. In the commonly used static model of sensor networks with uniformly distributed homogenous sensors with a stationary sink, sensors close to the sink drain their energy much faster than sensors far away from the sink due to the unevenly distributed forwarding workloads among sensors. A major issue, which has not been adequately addressed so far, is the question of how sensor deployment governs the data capacity, and how to improve data capacity of WSNETs. In our previous work, we provided a simple analytical model to address this issue for one specific type of WSNETs. In this paper, we extend our previous work to address this issue for general WSNETs. In the extended static models, for large networks, we find that after the lifetime of a sensor network is over, there is a great amount of energy left unused, which can be up to 90% of the total initial energy. Thus, the static models with uniformly distributed homogenous sensors cannot effectively utilize their energy.

This energy waste implies that the potential data capacity is much larger than the capacity achieved in these static models. To increase the total data capacity, we propose a non-uniform sensor distribution strategy. Simulation results show that, for large, dense WSNETs, the non-uniform sensor distribution strategy can increase the total data capacity by an order of magnitude.

3. Energy Efficient Path Selection Protocol

Energy Efficient path selection Protocol is contributed more in the literature as follows :

The energy consumption is proportional to the hop count between source and destination nodes, and the number of forwarded data packets.

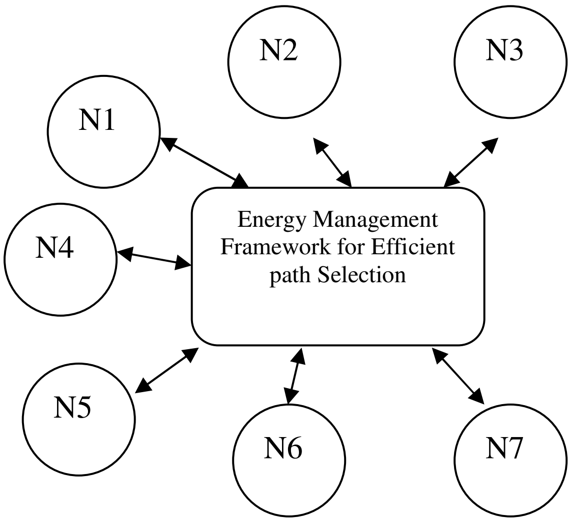

Figure 1: Energy Management of the Wireless Sensor Network

Hence, visiting the highest weighted node will reduce the number of multihop transmissions and thereby minimizes the energy consumption is been explained in figure 1. In addition, as dense areas give rise to congestion points due to the higher number of nodes, energy holes are more likely to occur in these areas.

3.1. An energy-efficient MAC protocol for wireless sensor networks:

In this literature we have focused on S-MAC, a medium-access control (MAC) protocol designed for wireless sensor networks. Wireless sensor networks use battery-operated computing and sensing devices. A network of these devices will collaborate for a common application such as environmental monitoring.

$$Jdn(m_i) = Jdnp\, C\left[\begin{pmatrix} N_{FAF(n_1)}(m_1) \vee N_{FAF(n_2)}(m_2) \vee .... \\ ......\vee N_{FAF(n_k)}(m_{k-1}) \end{pmatrix}\right] \rightarrow \text{Eqn(1)}$$

We expect sensor networks to be deployed in an ad hoc fashion, with individual nodes remaining largely inactive for long periods of time, but then becoming suddenly active when something is detected. These characteristics of sensor networks and applications motivate a MAC that is different from traditional wireless MACs such as IEEE 802.11 in almost every way: energy conservation and self-configuration are primary goals, while per-node fairness and latency are less important. S-MAC uses three novel techniques to reduce energy consumption and support self-configuration. To reduce energy consumption in listening to an idle channel, nodes periodically sleep.

Neighboring nodes form virtual clusters to auto-synchronize on sleep schedules. Inspired by PAMAS, S-MAC also sets the radio to sleep during transmissions of other nodes. Unlike PAMAS, it only uses in-channel signalling. Finally, S-MAC applies message passing to reduce contention latency for sensor-network applications that require store-and forward processing as data move through the network. We evaluate our implementation of S-MAC over a sample sensor node, the Mote, developed at University of California, Berkeley. The experiment results show that, on a source node, an 802.11-like MAC consumes 2–6 times more energy than S-MAC for traffic load with messages sent every 1–10s.

3.2. Exploiting Sink Mobility for Maximizing Sensor Networks Lifetime

The idea of exploiting the mobility of data collection points (sinks) is used for the purpose of increasing the lifetime of a wireless sensor network with energy-constrained nodes. We give a novel linear programming formulation for the joint problems of determining the movement of the sink and the sojourn time at different points in the network that induce the maximum network lifetime. Differently from previous solutions, our objective function maximizes the overall network lifetime (here defined as the time till the first node "dies" because of energy depletion) rather than minimizing the energy consumption at the nodes. For wireless sensor networks with up to 256 nodes our model produces sink movement patterns and sojourn times leading to a network lifetime up to almost five times that obtained with a static sink. Simulation results are performed to determine the distribution of the residual energy at the nodes over time. These results confirm that energy consumption varies with the current sink location, being the nodes more drained those in the proximity of the sink.

3.3. Joint mobility and routing for lifetime elongation in wireless sensor networks

Although many energy efficient/conserving routing protocols have been proposed for wireless sensor networks, the concentration of data traffic towards a small number of base stations remains a major threat to the network lifetime. The main reason is that the sensor nodes located near a base station have to relay data for a large part of the network and thus deplete their batteries very quickly. The solution we propose in this paper suggests that the base station be mobile; in this way, the nodes located close to it change over time. Data collection protocols can then be optimized by taking both base station mobility and multi-hop routing into account. We first study the former, and conclude that the best mobility strategy consists in following the periphery of the network (we assume that the sensors are deployed within a circle). We then consider jointly mobility and routing algorithms in this case, and show that a better routing strategy uses a combination of round routes and short paths.

3.4. Versatile low power media access for wireless sensor networks:

We propose B-MAC, a carrier sense media access protocol for wireless sensor networks that provides a flexible interface to obtain ultra low power operation, effective collision avoidance, and high channel utilization. To achieve low power operation, B-MAC employs an adaptive preamble sampling scheme to reduce duty cycle and minimize idle listening. B-MAC supports on-the-fly reconfiguration and provides bidirectional interfaces for system services to optimize performance, whether it is for throughput, latency, or power conservation.

$$S_P(new) = \frac{\alpha_i}{v_i} S_P(old) \dashrightarrow \text{Eqn .2}$$

We build an analytical model of a class of sensor network applications. We use the model to show the effect of changing B-MAC's parameters and predict the behaviour of sensor network applications. By comparing B-MAC to conventional 802.11-inspired protocols, specifically S-MAC, we develop an experimental characterization of B-MAC over a wide range of network conditions. We show that B-MAC's edibility results in better packet delivery rates, throughput, latency, and energy consumption than S-MAC. By deploying a real world monitoring application with multi hop networking, we validate our protocol design and model.

4. Conclusion

In this paper, we have presented WRP, which is a novel algorithm for controlling the movement of a mobile sink in a WSN. WRP selects the set of RPs such that the energy expenditure of sensor nodes is minimized and uniform to prevent the formation of energy holes while ensuring sensed data are collected on time. In addition, we have also extended WRP to use an SPT and an SMT. Apart from that, we have also considered visiting virtual nodes to take advantage of wireless coverage. Our results, which are obtained via computer simulation, indicate that WRP-SMT reduces the energy consumption of tested WSNs by 22% in comparison to CB. We also benchmarked WRP against existing schemes in terms of the difference between sensor node energy consumption.

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