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Dynamic Reconfiguration Method for Effective Cluster Based Data Transmission in WSN

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Abstract- WSNs are typically composed of large number of tiny sensors that are capable of sensing, processing and transmitting data via wireless links. Sensor nodes collaborate in a distributed and autonomous manner to accomplish a certain task, with no infrastructure. Power efficiency and fault tolerance are essential properties to keep the network functioning of energy depletion, communication link errors, or adverse environmental conditions, events that are likely to occur quite frequently in WSNs. The fault-tolerant topology control in a heterogeneous wireless sensor network consisting of several resource-rich super nodes, used for data relaying, and a large number of energy constrained wireless sensor nodes. So proposed clustering based code dissemination protocol for providing high link quality information. It will address the transmission efficiency due to poor communication link and identify the fault occurrence during transmission by dynamic reconfiguration. Clustering is the topology control method to reduce energy consumption and improve scalability of WSNs. In a cluster based WSN, cluster heads (CHs) consume required energy when extra work load owing to data collection, data aggregation and their communication to the base station. By choosing, sender selection algorithm estimate the impacts of senders by considering both uncovered neighbors (i.e., neighbor that do not receive an entire page) and the link qualities to those neighbor.

Index Terms- fault tolerance, cluster heads, sender selection, transmission efficiency, data aggregation

1. INTRODUCTION

Over the last few years, we have seen a rapid increase in the number of applications for wireless sensor networks (WSNs). WSNs can be deployed in battlefield applications, and a variety of vehicle health management and condition-based maintenance applications on industrial, military, and space platforms. For military users, a primary focus has been area monitoring for security and surveillance applications.

A WSN can be either source-driven or query-based depending on the data flow. In source-driven WSNs, sensors initiate data transmission for observed events to interested users, including possibly reporting sensor readings periodically. An important research issue in source-driven WSNs is to satisfy QoS requirements of event-to-sink data transport while conserving energy of WSNs. In query based WSNs, queries and data are forwarded to interested entities only. In query-based WSNs, a user would issue a query with QoS requirements in terms of reliability and timeliness. Data sensing and retrieval in wireless sensor systems have a widespread application in areas such as security and surveillance monitoring, and command and control in battlefields. In query-based wireless sensor systems, a user would issue a query and expect a response to be returned within the deadline. While the use of fault tolerance mechanisms through redundancy improves query reliability in the presence of unreliable wireless communication and sensor faults, it could cause the energy of the system to be quickly depleted. Therefore, there is an inherent tradeoff between query reliability vs. energy consumption in query-based wireless sensor systems. In this paper, we develop adaptive fault tolerant quality of service (QoS) control algorithms based on hop-by-hop data delivery utilizing "source" and "path" redundancy, with the goal to satisfy application QoS requirements while prolonging the lifetime of the sensor system. We develop a mathematical model for the lifetime of the sensor system as a function of system parameters including the "source" and "path" redundancy levels utilized. We discover that there exists optimal "source" and "path" redundancy under which the lifetime of the system is maximized while satisfying application QoS requirements. Numerical data are presented and validated through extensivesimulation, with physical interpretations given, to demonstrate the feasibility of our algorithm design. Disjoint Path Vector (DPV) algorithm for constructing a fault-tolerant topology to route data collected by sensor nodes to super nodes. In WSNs, guaranteeing k-connectivity of the communication graph is fundamental to obtain a certain degree of fault tolerance. The resulting topology is tolerant up to k 1 node failures in the worst case. We propose a distributed algorithm, namely the DPV algorithm, for solving this problem in an efficient way in terms of total transmission power of the resulting topologies, maximum transmission power assigned to sensor nodes, and total number of control message transmissions. Our simulation results show that our DPV algorithm achieves between 2.5-fold and 4-fold reduction in total transmission power required in the network, depending on the packet loss rate, and a 2-fold reduction in maximum transmission power required in a node compared to existing solutions.

Code dissemination is a basic building block for wireless reprogramming. Existing protocols (represented by Deluge and MNP) adopt several key techniques to ensure high reliability and performance. First, they exchange control-plane messages for high reliability. Second, they segment a large code object into fixed-sized pages for pipelining. The page transmission time and inter-page negotiation time (which involves exchanges of control-plane messages) are therefore two major contributors to the overall completion time.

In summary, the contributions of this paper are as follows.

We identify the inefficiency of previous sender selection algorithms in code dissemination and devise a more accurate metric leveraging link quality information, which effectively reduces transmission collisions and transmissions over the poor links. We also propose practical techniques to address specific challenges such as priority inversion and concurrent transmissions.

We propose an impact-based back off timer design to shorten the time spent in coordinating multiple eligible senders so that the largest impact sender is most likely to transmit.

We implement the dissemination protocol based on the Tiny OS operating system. We conduct extensive evaluations via testbed experiments and simulations. Results show that ECD effectively improves the performance in terms of completion time and data transmission overhead.

2. RELATED WORK

Existing research efforts related to applying redundancy to satisfy QoS requirements in query-based WSNs fall into three categories: traditional end-to-end QoS, reliability assurance, and application-specific QoS. Traditional end-to-end QoS solutions are based on the concept of end-to-end QoS requirements. The problem is that it may not be feasible to implement end-to-end QoS in WSNs due to the complexity and high cost of the protocols for resource constrained sensors. An example is Sequential Assignment Routing (SAR) [5] that utilizes path redundancy from a source node to the sink node. Each sensor uses a SAR algorithm for path selection. It takes into account the energy and QoS factors on each path, and the priority level of a packet. For each packet routed through the network, a weighted QoS metric is computed as the product of the additive QoS metric and a weight coefficient associated with the priority level of that packet. The objective of the SAR algorithm is to minimize the average weighted QoS metric throughout the lifetime of the network. The algorithm does not consider the reliability issue.

Deluge [6] is perhaps the most popular code dissemination protocol used for reliable code updates. It uses a three-way handshake and NACK-based protocol for reliability, and employs segmentation (into pages) and pipelining for spatial multiplexing. A problem in Deluge is that when a sender receives requests from receivers, it will start transmitting data packets after a specified timeout. It is probable that multiple senders in a neighborhood start transmitting concurrently, causing serious collisions. To address this issue, MNP incorporates a sender selection algorithm which attempts to guarantee that in a neighborhood there is at most one source transmitting at a time. In MNP, source nodes compete with each other based on the number of distinct requests they have received. The sender selection is greedy in that it tries to select the sender that is expected to have the most impact. MNP also reduces the active radio time of a sensor node by putting the node into ‘‘sleep’’ state when its neighbors are transmitting. This effectively reduces the idle listening problem and avoids overhearing.

There is also a rich literature in sender selection in general broadcast protocols. Sender selection is effective in mitigating the broadcast storm problem in wireless networks. A number of approaches have been proposed to select the next forwarder. In DCB, nodes maintain 2-hop neighbor information. When a sender broadcasts a packet, it selects the next forwarders in such a way that 1) 2-hop neighbors are covered and 2) 1-hop non-forwarders need to be covered by at least two forwarders. In RBP [8], every node rebroadcasts the packet for the first time. Then each node adjusts the number of retries based on the neighborhood density.

Our work differs from those works in three main aspects. First, these protocols are not required to be 100 percent reliable. Second, in broadcast protocols, packet size is mainly determined by the application programs rather than underlying mechanisms which may incur delays.

Third, in ECD, packets within a page are transmitted in a succession, hence we need a special design to align the estimation period, avoid priority inversions, and alleviate collisions.

CF is a recent work that exploits spatial link correlation to mitigate ACK overhead. ECD differs CF in three aspects. First, CF is used for flooding a single packet while ECD is used for disseminating large code objects consisting of multiple pages and packets. CF does not guarantee 100 percent reliability while ECD employs handshake and negotiation to achieve 100 percent reliability. Second, the basic intentions for sender selection are the same for both protocols, i.e., selecting the sender which can cover the most number of uncovered (i.e., not yet received) receivers in a neighborhood.

Third, both protocols rely on backoff timers to prioritize the transmissions. In CF the backoff period is simply calculated as the reciprocal of the impact. In ECD, the backoff period is more carefully optimized by minimizing the probabilities of ‘‘priority inversion’’ and transmission collisions.

3. EXISTING SYSTEM

For networks that contain a large number of sensors (for example, thousands of sensor nodes), it becomes infeasible to network sensors using a flat netwo0rk. As data is forwarded hop by hop to the sink, it becomes inefficient and unreliable to travel a long way in the WSN, depleting the energy of the sensors participating in data relaying.

Existing research efforts related to applying redundancy to satisfy QoS requirements in query-based WSNs fall into three categories: traditional end-to-end QoS, reliability assurance, and application specific QoS .

The problem is that it may not be feasible to implement end-to-end QoS in WSNs due to the complexity and high cost of the protocols for resource constrained sensors. The Disjoint Path Vector (DPV) algorithm for constructing a fault-tolerant topology to route data collected by sensor nodes to super nodes. In WSNs, guaranteeing k-connectivity of the communication graph is fundamental to obtain a certain degree of fault tolerance. The resulting topology is tolerant up to k 1 node failures in the worst case. The links between sensors and actors are assumed to be less reliable.

4. SYSTEM MODEL

In this paper, the Clustering based Code Dissemination protocol leveraging 1-hop link quality information. Compared to prior works, Clustering based Code Dissemination protocol is more efficient. We dynamically estimate the impacts of senders by considering both uncovered neighbors (i.e., neighbors that do not receive an entire page) and the link qualities to those neighbour's. A node's transmission is considered more effective if the node has more uncovered neighbors with good link qualities.

Here develop fault tolerant quality of service (QoS) control algorithms based on hop-by-hop data delivery utilizing "source" and "path" redundancy, with the goal to satisfy application QoS requirements while prolonging the lifetime of the sensor system. We develop a mathematical model for the lifetime of the sensor system as a function of system parameters including the "source" and "path" redundancy levels utilized. We discover that there exists optimal "source" and "path" redundancy under which the lifetime of the system is maximized while satisfying application QoS requirements.

Effective code dissemination protocol improves the performance and reduce data transmission overhead.

It support dynamically configurable packet sizes to support large packets to improve the dissemination performance.

The data throughput efficiency and no delay constraints. Improves sender data accuracy and high reliability, Multi-path forwarding.

4.1 ADVANTAGES:

- Effective code dissemination protocol improves the performance and reduce data transmission overhead.
- It support dynamically configurable packet sizes to support large packets to improve the dissemination performance.
- The data throughput efficiency and no delay constraints.
- Improves sender data accuracy and high reliability, Multi-path forwarding.

5. SYSTEM IMPLEMENTATION

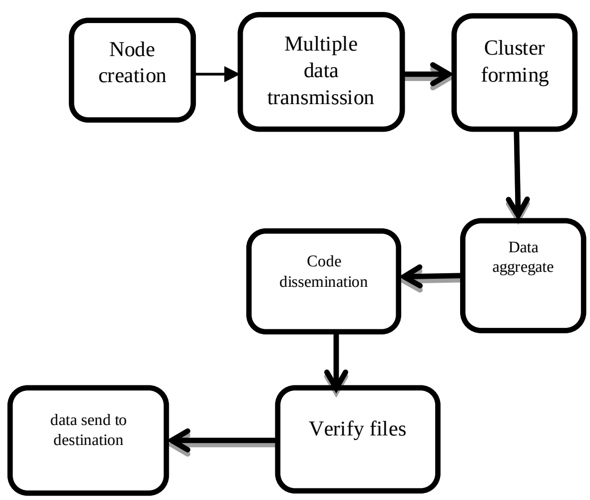

Figure 1: Cluster-based WSN Architecture.

First, an accurate metric should be devised to estimate senders' impacts. Second, efficient mechanisms should be designed to coordinate transmissions of eligible senders so that the largest impact sender is most likely to transmit.

5.1 SENDER SELECTION

We select the best sender for forwarding the data while avoiding simultaneous transmissions fromother neighboring nodes. This involves two main aspects.

5.2 CHANNEL ASSESSMENT

The MAC layer performs clear channel assessment (CCA) to check whether the channel is busy.

If the channel is clear, the data packet is transmitted immediately. If the channel is busy, the MAC layer performs a congestion backoff.

5.3 SEGMENTATION

In this a node receives the pages in the sequential order. When a node receives a page, it advertises about its available pages. When a node learns that another node has more available pages, it requests for the page and the page transmission starts.

In this way, ECD does not require a node to have an entire code image to serve other nodes. Instead, whenever a node has more available pages, it can serve other nodes having fewer available pages. So as long as the transmissions at two links do not collide, different pages can be transmitted concurrently at these two links.

5.4 DATA AGGREGATION

The data packet size is the same. For more sophisticated scenarios, conceivably the CH could also aggregate data for query processing and the size of the aggregate packet may be larger than the average data packet size. The first is to set a larger size for the aggregated packet that would be transmitted from a source CH to the PC(processing centre).

This will have the effect of favouring the use of a smaller number of redundant paths (i.e., *mp*) because it would be expended to transmit aggregate packets from the source CH to the PC. The second is for the CH to collect a majority of sensor readings from its sensors before data are aggregated and transmitted to the PC.

6. ALGORITHM

An Efficient Continuous Neighbor Discovery Algorithm (Sender Selection Algorithm):

6.1 FAULT TOLERANT QOS CONTROL (FTQC) ALGORITHM

Algorithm developed in this paper takes two forms of redundancy. The first form is path redundancy. That is, instead of using a single path to connect a source cluster to the processing center, *mp* disjoint paths may be used. The second is source redundancy

That is, instead of having one sensor node in a source cluster return requested sensor data, *ms* sensor nodes may be used to return readings to cope with data transmission and/or sensor faults. The above architecture illustrates a scenario in which *mp* = 2 (two paths going from the CH to the processing center) and *ms* = 5 (five SNs returning sensor readings to the CH).

6.2 CLUSTERING ALGORITHM

A clustering algorithm that aims to fairly rotate SNs to take the role of CHs has been used to organize sensors into clusters for energy conservation purposes. The function of a CH is to manage the network within the cluster, gather sensor reading data from the SNs within the cluster, and relay data in response to a query. Clustering algorithm is executed during the system lifetime.

- Aggregation of readings
- Each cluster has a CH
- Users issue queries through any CH.
- CH that receives the query is called the Processing Center (PC)
- Each non-CH node selects the CH candidate with the highest residual energy, sends it a cluster join message (includes the non-CH node's location). The CH will acknowledge this message.
- Randomly rotates role of CH among nodes -> nodes consume their energy evenly

7. EVALUATION

We evaluate the performance of ECD and Deluge on a 25-node TelosBtestbed. In the testbed, the wires (USB lines) are used to burn programs to the sensor nodes. The wires can also be used to collect detailed logging information so that the collection process does not affect the performance of wireless protocols. We want to emphasize that our dissemination process is performed via the wireless channel.

To simulate the multihop behavior, we set the CC2420 power level to 1 and 2. The topology used for evaluation is a 5x5gridwhere the base node is located at the bottom left corner. We use Deluge's default configurations (e.g.,23 bytes protocol payload, 48packets per page). The page size of ECD is 1104 bytes (the same as in Deluge). We inject a program consisting of 10 pages (i.e., approximately 10 kB). Each experiment is conducted five times. To get the performance metrics, we have written a statistic reporting component and a sniffer component. The statistic reporting component is wired to each of the 25nodes. With this component, the base node broadcasts time synchronization beacons at the maximum power to synchronize all the other nodes. All the other nodes locally record their transmitted data packets and completion time (synchronized to the base node). After the experiments, all the nodes (including the base node) broadcast their statistics at the maximum power.

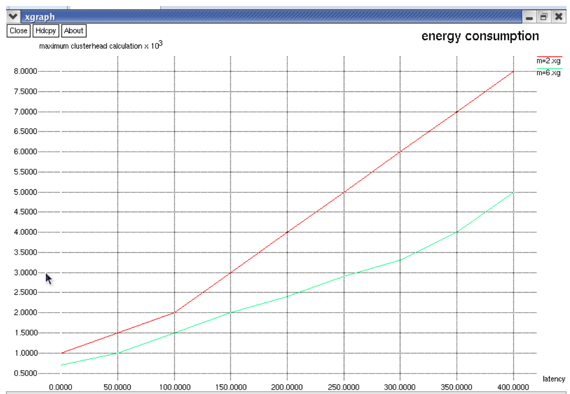

Fig 1: Energy consumption

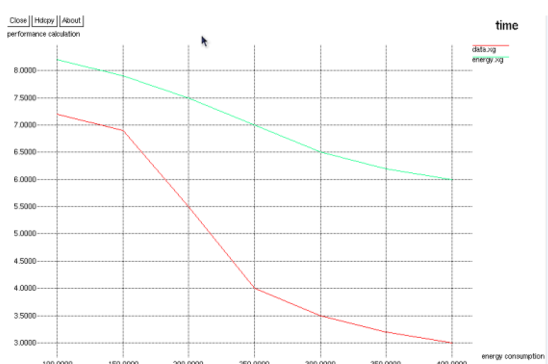

Figure 2: time

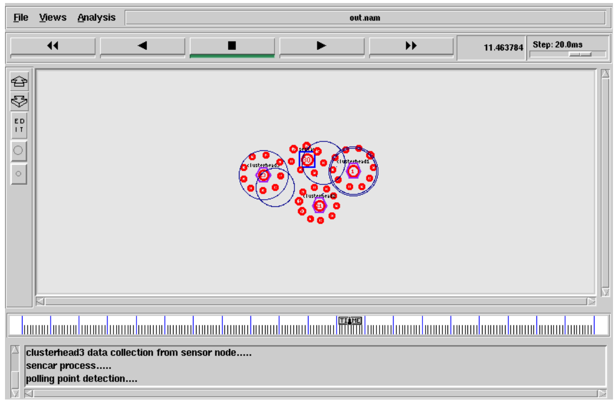

Figure 3: cluster formation

8. CONCLUSION

In this paper, we addressed the problem in heterogeneous WSNs, with the objective of minimizing the total energy consumption while providing k-vertex independent paths from each sensor node to one or more super nodes. We present ECD, an Efficient Code Dissemination protocol for wireless sensor networks. First, it supports dynamically configurable packet sizes. By increasing the packet size for high PHY rate radios, it significantly improves the transmission efficiency. Second, it employs an accurate sender selection algorithm to mitigate transmission collisions and transmissions over poor links. Third, it employs a simple impact-based back off timer design to shorten the time spent in coordinating multiple eligible senders so that the largest impact sender is most likely to transmit.

For future work, we plan to extend our work for applications that require a fault-tolerant bidirectional topology that provides communication paths both from sensors to super nodes and from super nodes to sensors. We would like to incorporate effective sleep scheduling algorithm into our design and to examine effectiveness of our design in large-scale WSN systems.

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