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Research Paper

IMPROVING DELAY AWARE NETWORK STRUCTURE IN WIRELESS SENSOR NETWORK WITH COVERAGE SET INFORMATION

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Wireless Sensor Networks (WSNs) utilize large numbers of wireless sensor nodes to perform close-range sensing and thus enhance sensing qualities. In typical sensing applications, data packets are flowing from sensor nodes to a base station in a many-to-one network structure. To keep event detection delay at a low value, in applications that require occasion data snapshots, it is always desirable to reduce the duration of a Data Collection Process (DCP). Conversely, for applications that require continuous monitoring, the number of DCPs completed in a given period of time is important for reconstructing an accurate data trend. In Cheng *et al.* (2013) authors have proposed a delay-aware network structure is proposed for WSNs with consecutive DCPs. The proposed network structure is able to increase the number of DCPs per unit time without imposing extra delay on each single DCP. In this paper we extend their work by adding coverage set filtering. Through simulation we prove that our extension is able to reduce the delay even more.

Keywords: Wireless sensor networks, Network structure, Data collection duration, Data collection rate, Schedule

INTRODUCTION

Wireless Sensor Networks (WSNs) are in high demand for connecting and monitoring complex engineered systems (Yoon and Shahabi, 2005; and Jain *et al.*, 2006). Unlike ordinary target detection applications, WSNs for system monitoring should not only provide snapshots of system states with short delays, but also reduce delays between consecutive Data Collection Processes (DCPs) as to support continuous control monitoring.

In a network with N wireless sensor nodes, suppose the nodes are organized into the Delay-Aware Data Collection Network

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Structure (DADCNS) using the bottom-up approach mentioned in Xiaobing Wu *et al.* (2007). Assuming in-network data fusion is feasible, it takes log2(N + 1) time-slots for a Base Station (BS) to collect data from all its wireless sensor nodes. The DADCNS is designed for scenarios that a DCP will be invoked occasionally, but once invoked, it should complete within a short duration. A typical example is an event detecting application, in which an event may rarely happen, but once detected, data should be reported to the base station with a minimum delay.

Delays among consecutive DCPs can be reduced by modifying the network structure into the one as shown in Figure 1(b). In the modified network, two clusters will be formed instead of one. A single DCP will, again, last for 3 time-slots. There will be 2, 3, and 1 nodes involved in data transactions at the first to the third time-slots, respectively (see Figure 3). Note that not all nodes are involved at the first time-slot, the next DCP (data stream B) can therefore begin at the third time-slot of the current DCP (data stream A). The duration of each DCP remains the same. Furthermore, by having the transmission schedules overlap, it takes only $(q – 1) \times 2 + 3$ to complete q DCPs. Therefore, for $q > 1$, the modified network can complete the same number of DCPs with a shorter time

In paper "A Delay-Aware Network Structure for Wireless Sensor Networks With Consecutive Data Collection Processes", authors Chi-Tsun Cheng and Chi K. Tse have proposed a delay aware network structure formation algorithm. Their idea of network formation algorithm is to first consider the network as a fully connected network and then

Figure 1: A Network with N = 4 Wireless Sensor Nodes that are Organized Using (a) The Bottom-Up Approach for the DADCNS and (b) An Optimized Network Structure for Consecutive DCPs. A BS is Represented by a Rectangle, While Wireless Sensor Nodes are Represented by Circles. Numbers Inside the Circles are Showing the Time-Slot that a Node will Transmit its Data

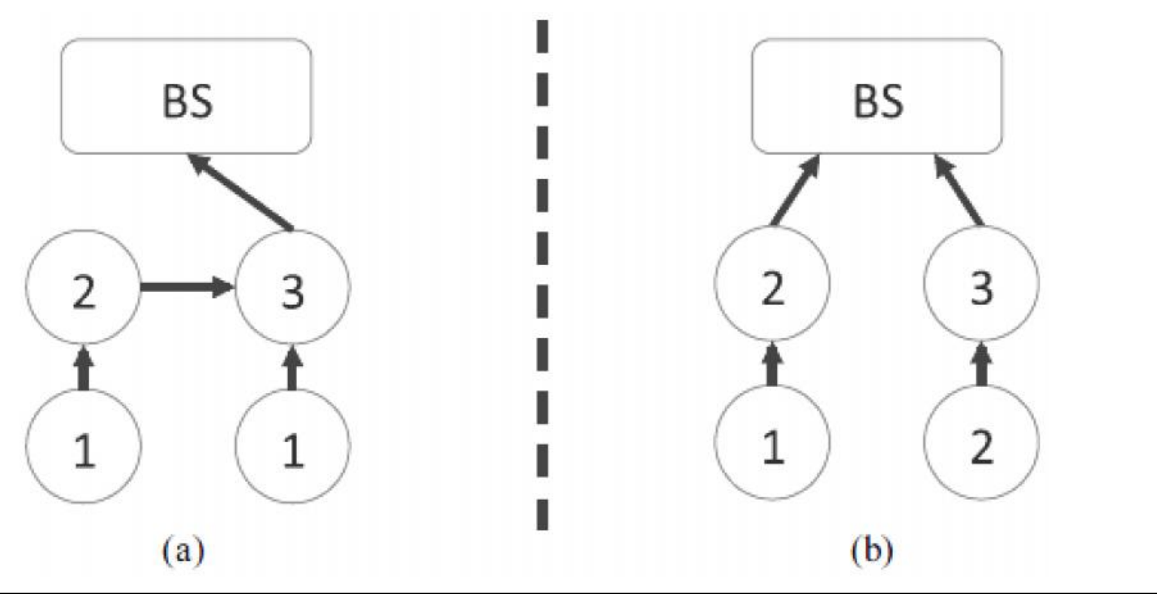


Figure 2: Transmission Schedule of the Network Shown in Figure 1a

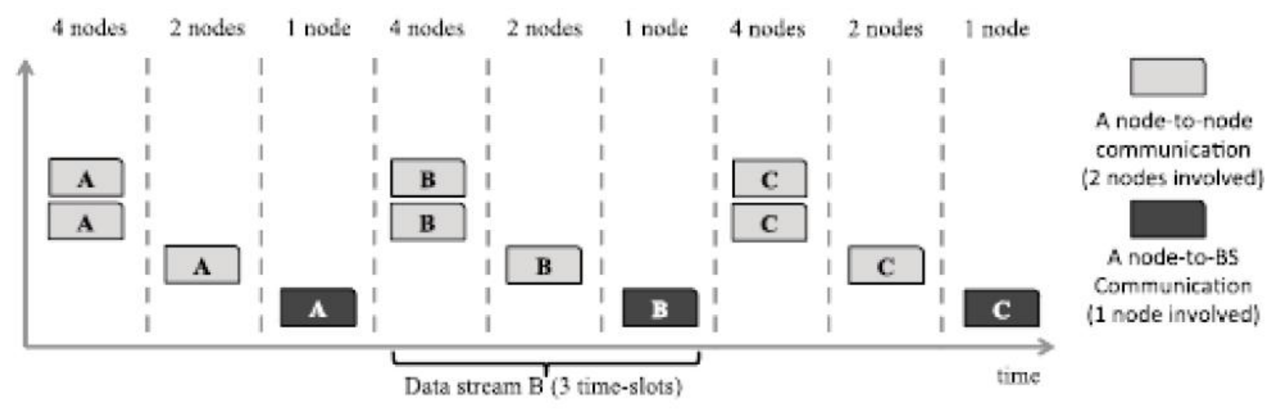
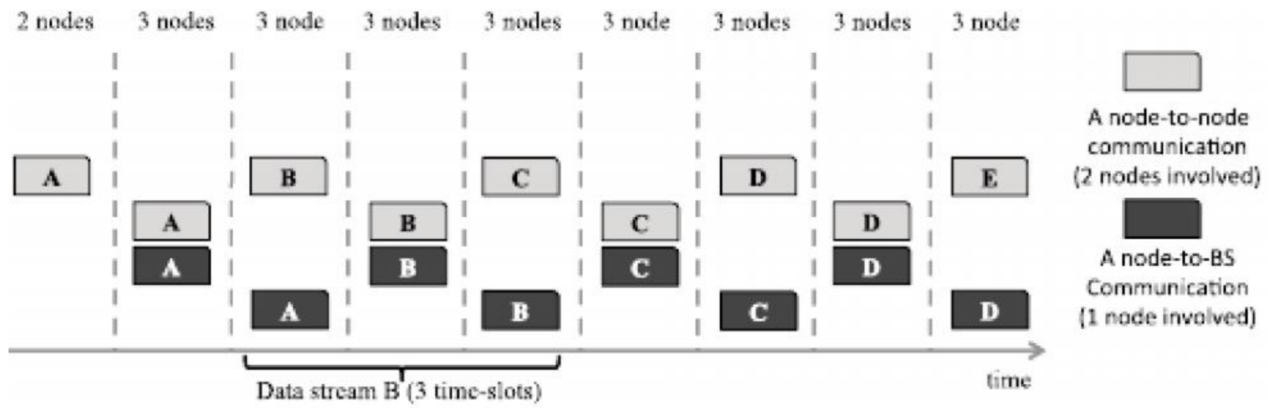


Figure 3: Transmission Schedule of the Network Shown in Figure 1b



construct the proposed network structure by removing unnecessary edges. Their algorithm was able to reduce the delay in data collection process. We extend their solution by adding coverage set information. With our proposed modification we were able to reduce the delay even more.

RELATED WORK

Conservation of energy is done by clustering. A network with large number of sensor nodes is divided into several clusters. Within each cluster, one of the sensor node is elected as Cluster Head (CH). Nodes other than Cluster Head (CH) are Cluster Members (CM).The Cluster Member can communicate with the cluster head and the cluster head can communicate with the remote Base Station (BS). Collection of data from cluster member to cluster head can be done in multi-hop manner. The cluster head has several responsibilities such as collection of data from the cluster members, fusing those data by data fusion techniques and reporting those fused data to remote Base station (Shah *et al.*, 2003). In long distance transmission, number of nodes involved will be decreased, so that energy dissipation will also be reduced (Seino *et al.*, 2010). Delay will be decreased in clustering. Disadvantage of clustering is energy draining of the cluster head will occur because all nodes in the cluster communicates with the cluster head and the cluster head communicates with the remote base station. This will affect the entire cluster hierarchy (Shah *et al.*, 2003).

In Shah *et al.* (2003), Sparse network is used it consist of Mules, Access point, sensors node. For the Data Mules and mobility this model consist of two dimensional random walk. In this model sensor is organized in the form of two dimensional grids and using this technique the short range communication of sensors gives large power saving and Model gives fewer infrastructures, con's are sensor had to wait for mules to collect data therefore latency is the main disadvantage.

In CAG method propose by Yoon and Shahabi (2005) provides the approximate result to aggregation query for the reduction of transmissions. This model provides the lossy CAG algorithm which requires only one value to be participated in aggregation. This Algorithm divided into two parts: 1) Query, 2) Response and use only one value per cluster. Cluster head is used in aggregation process, main advantage is spatial correlation is used for the improvement of efficiency in wireless sensor network, this save communication overheads up to 70.9%.

Two sink nodes are used for data collection process called Dual Sink proposed by Xiaobing Wu *et al.* (2007). Dual sink is a protocol for data collection in fully distributed wireless sensor network, uses two node called static sink node and mobile sink node. The algorithm consists of static sink node broadcast Hello message at only one time at the beginning time. Mobile sink node broadcast Hello message but only subset nodes in wireless sensor network and sensor node which processed four messages like hello, data, EnQry, EnRpl. Which gives a steady lifetime improvement for Wireless sensor network but No lifetime gain is achieved for only one mobile sink node when network size grows to over threshold.

Anastasi *et al.* (2008) proposed the data Mules collect data from sensor deployed in sensing field and stored at access point. Here protocol is developed for the energy efficient and reliable data collection in wireless sensor network. This protocol mainly focused on the discovery and data transfer phase. Data collection process divided into three parts: 1) static node perform discovery, 2) Mule present data transferred, 3) sleep state of static node this improvement in this paper gives a protocol with low duty cycles is very energy efficient, No energy wastage as correct assumption is there for discovery part.

Xu *et al.* (2010) proposed the wireless sensor network with mobile sink node travel along a fixed trajectory (Route) and gateway is deployed in the sensing field to collect the data from sensor and then it is forwarded to the mobile sink node. This model is divided into three tiers: 1) at bottom sensor node, 2) middle tier gateway, 3) top tier mobile sink node. Therefore Energy efficient routing protocol is developed so that mobile sink node efficiently collects data. But deployments of gateway give costly formation of a network. Data collection method using sink node for communication traffic reduction is proposed Seino *et al.* (2012). This method consists of the single sink node travel along fixed route and collect data from sensor based on the predicated values. Mobile sink node travel in sensing area and collect sensor data for first round and stored that data on database, but for second round mobile sink node broadcast predicated sensor value to the sensor and only those sensor can send the data which exist admissible error margin called threshold. This Sink node efficiently collects data from sensor and communication traffic reduces but when mobile sink node fail system is not in used for communication and data collection purposed.

Chi-Tsun Cheng *et al.* (2011) proposed a delay-aware data collection network structure for wireless sensor networks. The main objective of this delay-aware data collection network structure is to minimize delays in the data collection processes of wireless sensor networks. A centralized and a decentralized approach are used two network formation algorithm designed to construct the proposed network structure. This two network formation approaches are derived to provide optimized results for networks with different sizes. The performance of the proposed delay aware data collection network structure is compared with a multiple-cluster two-hop network structure, a single-chain network structure, a minimum spanning tree network structure, and a collection tree network structure. This network structure is most efficient in terms of data collection time among all the network structures. The delay-aware data collection network structure can greatly reduce the data collection time while keeping the total communication distance and the network lifetime at acceptable values.

Again one techniques of data collection in wireless sensor network is Adaptive approximate data collection method. In this technique the adaptive data approximation algorithm should be self-adaptive to the changes of the sensor readings timely as sensor readings change slowly according to the change of physical phenomena. This data approximation algorithm consists of two parts; data approximation learning algorithm and data approximation monitoring algorithm as in Chao Wang *et al.* (2012).

Chia-Hsin Cheng *et al.* (2012) proposed schemes for data collection with data aggregation for static sink in wireless sensor networks. In this scheme Block partition is used and then each block selects a sensor node as local sink for the data collection of the local area. Local sink then transmit their data to the global sink after aggregating to achieve less energy consumption.

Konstantopoulos *et al.* (2012) proposed Mobicluster protocol for sensor node under the assumption of SNs are location aware. The protocol consist of five phases first clustering approach is used for WSN, second Rendezvous Nodes (RNs) selection which guarantee connectivity of sensor islands with MS, third Cluster Heads (CHs) Attachment to RNs, fourth Data Aggregation and Forwarding to the RNs and finally Communication between RNs and Mobile Sinks.

DESIGN METHODOLOGY

By organizing the network structure, the data collection process is fastened by reducing the delay. But in the network where node density is higher, for a event happening in a particular location there may be many sensor to detect the event and report to base station. It is not necessary for all the sensor nodes in the same coverage area to detect and forward event. By removing this redundancy in network organization we can reduce the delay even more.

Our solution is based on concept of applying coverage set filtering.

The solution consist of 3 stages

1. Coverage set calculation.
2. Selection of coverage node.
3. Construct network organization structure.

Coverage Set Calculation

We initially partition the network into multiple small zones. For each zone we find the nodes covering any events happening in that zone. This forms a coverage set. Likewise we find the coverage set for all the zones in the network.

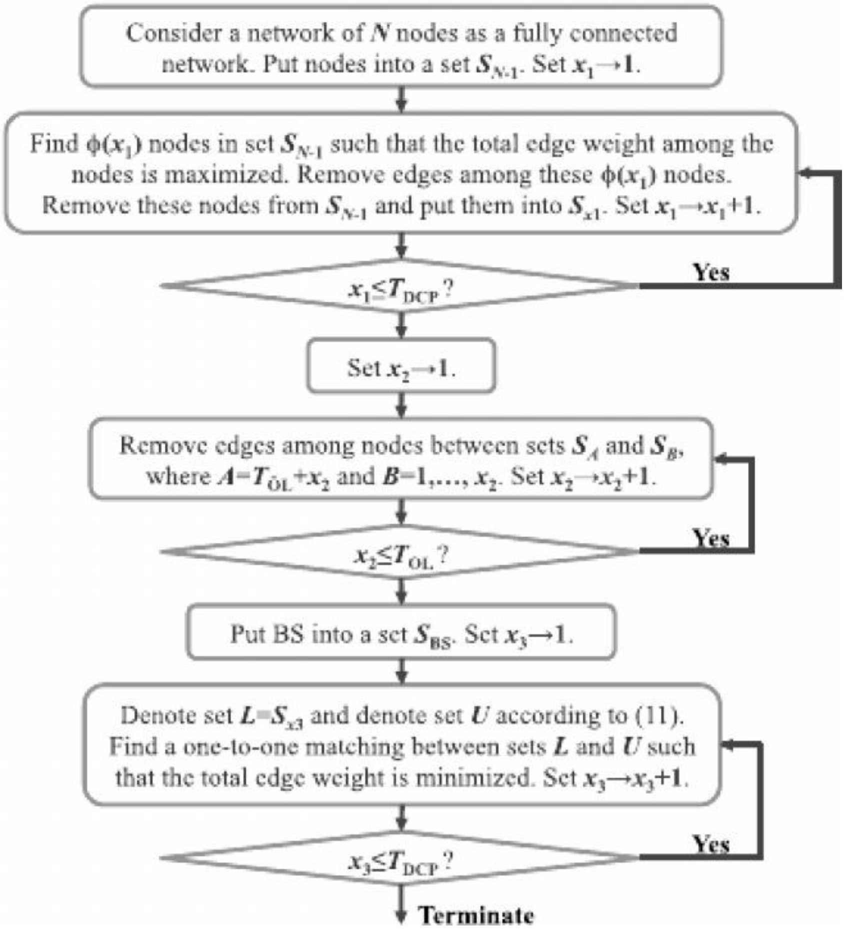
Selection of Coverage Node

For each coverage set, node with maximum energy is selected to remain on and all other nodes are moved to sleep cycle. This process of coverage node selection is repeated periodically after certain data collection period interval.

Constructing Network Organization Structure

With the nodes selected in each zone a fully connected network is created. The algorithm for edge removal is followed as in Cheng *et al.* (2013) to organize the network.

Figure 4: Constructing Network



RESULTS

We implemented the proposed algorithm for energy network organization in Jprowler simulator.

We measured the delay and the energy consumption of the proposed solution with solution in Cheng *et al.* (2013). We simulated for different network configuration and measured the delay and energy consumption.

From the data collection period graph, we see that the delay in data collection period is comparatively less in the case of coverage set filtering on network organization.

From the energy consumption graph, we see that the energy consumption for a data collection period is less with our proposed solution then in Cheng *et al.* (2013). This is because of less nodes participating in data collection period and the reduction in span length.

Figure 5: Data Collection Period

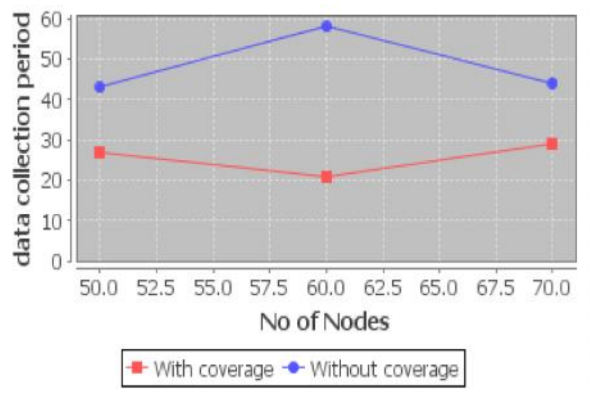
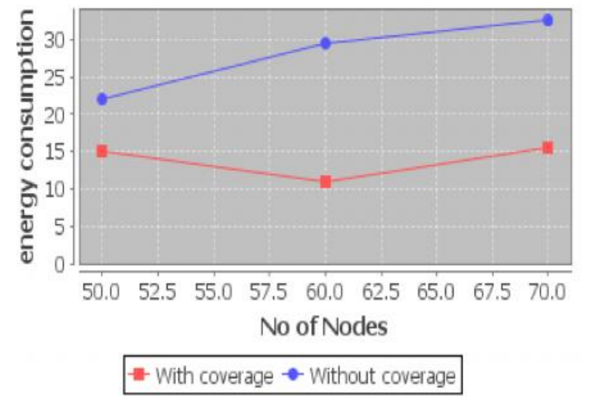


Figure 6: Energy Consumption



CONCLUSION

We have detailed our proposed solution for reducing the delay and energy in data collection. Through simulation we have proved that our proposed solution is able to reduce the delay in data collection and also consumes less energy.

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