Survey on Data Collection Methods in Wireless Sensor Networks

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Abstract

Data collection is the most important problem in wireless sensor networks. Main goal of data collection is to collect large amount of data and to reduce the data loss due to less memory capacity of sensor nodes. Effective data collection techniques can improve the performance of sensor networks. Many researchers have been proposed various methods to collect data in sensor networks. This paper describes a survey on data collection in wireless sensor networks. We have classifieds the methods into three different categories. First, data collection using static sink approach, then data collection using mobile sensor nodes, finally data collection using mobility based approach, this method is again classified into two groups, and they are data collection using single mobile sinks and data collection using multiple mobile agents. Advantages and disadvantages of each method are also studied and we made the comparison of each method with different constraints such as amount of collected packets, energy efficiency, network lifetime, etc.

1. Introduction

Wireless sensor network (WSN) is a wireless network consisting of spatially distributed autonomous devices to monitor physical or environmental conditions, such as temperature, sound, pressure, motion or pollutants, at different locations. Wireless sensor networks are formed by hundreds or thousands of motes that pass data from one to another. Sensor nodes are responsible for monitoring and collecting environmental data. These networks are applicable in different areas such as Environmental/Habitat monitoring, Acoustic detection, Seismic Detection, Military surveillance, Inventory tracking, Medical monitoring, Smart spaces, Process Monitoring etc. One of the major challenges in wireless sensor networks is data collection.

Data collection methods in wireless sensor network are classified into three groups'. Data collection using mobile sensor nodes, data collection using static sink approach and data collection using mobility based approach. Sensor node memory capacity and energy efficiency are the major challenge in data collection.

In this paper we discussed about the data collection methods to overcome these constraints of wireless sensor networks. Static sink approach is the earliest method used for data collection in wireless sensor networks but this method leads to energy hole problem. Since the sink is static, data has to be travelled more distance to reach the destination this will lead to energy wastage and hence network lifetime is redused.In order to overcome this mobility based approach is introduced, in this method there are two classification, data collection using single mobile sink and data collection using multiple mobile agents, these techniques can improve the data collection in wireless sensor networks.

The paper is organized as follows: Section 2 presents the challenges in data collection in wireless sensor networks. Section 3, 4, 5 and 6 classifies the data collection methods in wireless sensor networks and the advantages and disadvantages of each scheme are discussed. The conclusion of the paper is given in section 7.

2. Problem statement

Data collection methods in wireless sensor network can be classified into three groups' .Data collection using mobile sensor nodes data collection using static sink and mobility based approach for data collection. Main challenges in data collection in wireless sensor networks are sensor memory capacity, energy efficiency, and data storage mechanism. In static sink approach where sink node is static so that energy efficiency is an important problem. Network lifetime is also reduced in such cases. Data collection using mobile sink approach can overcome this problem .In this approach sink has mobility hence energy efficiency is reduced. Another important approach in mobility based approach is to use mobile mule for data collection [3]. These methods are used in sparse sensor networks .We can use multiple mobile mules for data collection, hence improve the amount of collected packets. Data storage mechanism is an important challenge in data collection. Good data storage mechanism can also improve the quality of collected packets. Tree and mesh topologies are used for networks. Mesh topology can improve the quality of collected packets because more number of packet exchanges is possible in mesh structure while in tree structure packets are exchanged between parent and child nodes, hence number and quality of collected packets are reduced [2].

3. Data collection methods in wireless sensor networks

Data collection methods in wireless sensor networks are mainly classified as data collection using mobile sensor nodes, data collection using static sink approach and data collection using mobility based approach. Mobility based approach is again classified into two groups they are data collection using single mobile sink and data collection using multiple mobile agents. Multiple mobile mules are also used for data collection. Path of these mobile agents can be constrained or uncontrollable.Fig.1 shows data collection methods in wireless sensor networks.

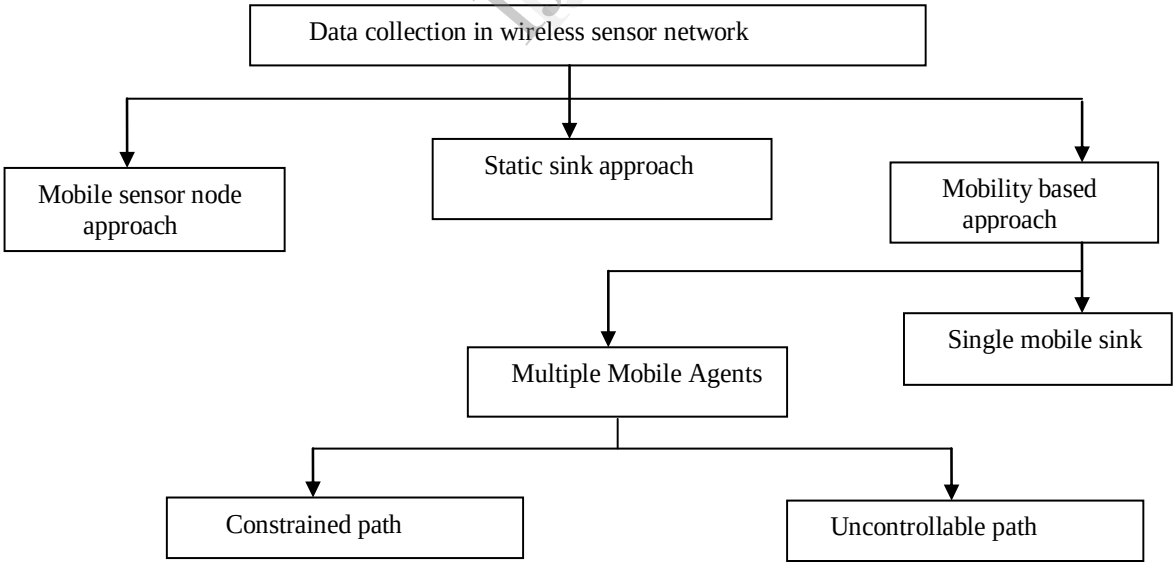

Fig.1. Data collection methods in wireless sensor network

4. Static sink approach for data collection

In this approach static sink is used for data collection. Sink node is responsible for collecting all data from the sensor nodes and send the collected data to the base station. In static sink approach energy efficiency is an important problem. This method leads to energy hole problem, hence network lifetime is reduced. Total amount of collected packets are less compared to other methods. Some examples are given as follows:

4.1. Fault tolerant scheduling for data collection

The main objective of this paper is to collect the sensing data quickly and reliably. Fault tolerant scheduling for data collection (FTS) algorithm is introduced, that leads to short data collection time and high fault tolerance [1]. This algorithm has two parts they are pre scheduling and adaptive scheduling. When a sensor network starts up, Pre-Scheduling is used to find a system wide schedule for the network. When some node or link fails, Adaptive Scheduling will be used to adjust the schedule in order to improve the fault-tolerance performance. Pre scheduling is centralized approach and it is based on system-wide information. Adaptive scheduling is distributed method that only depends on local information in order to adjust the existing schedule. Main advantages of this method are reacting to node or link failure and short data collection time. Energy consumption is the important disadvantage of this paper.

5. Mobile sensor node approach for data collection

In these approach sensor nodes has mobility. Amount of collected packet is increased compared to the static sink approach for data collection, here sensors and sink has no mobility. Sensors are resource limited which means that sensors has less memory capacity and battery power, so energy efficiency is high because of sensor mobility and hence network lifetime is reduced.

5.1. Prophet

This approach is used in intermittently connected networks, in such network there is no guarantee that a connected path is exist between source and the destination. PROPHET is a probabilistic routing protocol for such networks [9]. Mobility of nodes can be used to eventually deliver a message to its destination, probabilistic routing using an assumption of non random mobility of nodes to improve the delivery rate of messages. If a node has visited the location several times before, there is a possibility that it will visit the location again. Using this information probabilistic routing is performed. A delivery predictability is modelled for probabilistic routing, it indicates how likely it is that source node will be able to deliver a message to that destination. PROPHET is able to deliver more messages than previous protocols with a lower communication overhead. Since all nodes have mobility, energy efficiency is an important problem in this approach.

5.2. DFT/MSN: the delay/fault tolerant mobile sensor network for pervasive information gathering

This approach focuses on delay and fault tolerant mobile sensor network. It develops a simple and efficient data delivery scheme. The main characteristic of mobile sensor network is sensor mobility, fault tolerability and delay tolerability. Here two basic techniques are introduced namely, an optimized flooding scheme which minimizes transmission overhead ,then a simple and effective data delivery scheme [10]. This delivery scheme is responsible for data transmission and queue management. Data transmission scheme transmit data based on delivery probability, it is the probability that a sensor can deliver data messages to the sink. The DFT/MSN consists of two types of nodes, first one is wearable sensor node and the second one is high end sensor nodes. The wearable sensor nodes are attached to people to gather information from the environment. The mobile sensors transmit data to the high end sensors which has direct connection to the access points. Advantages of this approach are high message delivery ratio, reduced delay and less transmission overhead. Energy consumption is high in this type of networks because mobility of sensor nodes.

6. Mobility based approach for data collection

In this approach data collection is based on mobility. It is further divided into two groups' data collection using single mobile sink and data collection using multiple mobile agents. Data collection using multiple mobile agent is again divided into two categories, they are, agents moves along constrained path and agents moves along uncontrollable path. In single mobile sink

approach, mobile sink is responsible for collecting packets so that energy consumption is reduced in this approach compared to static sink and mobile sensor approaches. Data loss is occurred if the mobile sink failed to visit the entire network. This problem can overcome by data collection using multiple mobile agents, in this approach multiple mobile sinks are used for data collection; hence amount of collected packet is increased. Multiple mobile mules can be used for data collection in disconnected wireless sensor networks. In this approach amount of collected packets in increased compared to previous methods.

6.1. Single mobile sink for data collection

In this approach sink has mobility. Sink moved towards the sensor nodes and collect the data stored in the sensor nodes, so that energy consumption is reduced and hence network life time is also increased. Some examples are given as follows:

6.1.1. Efficient data propagation strategies in wireless sensor network using a single mobile sink.

This paper introduces the basic idea of having a sink moving in the network area and collecting data from sensors. There are different mobility pattern for sink for collecting data from sensor nodes, mostly randomized (such as the simple random walk) as well as predictable mobility (moving on a straight line or cycle) and controllable mobility where mobile element can vary its movement in a deterministic way [11]. To get data from the sensor nodes, these movements of sink is combined with three data collection strategies: a passive multihop and a limited multihop. The main advantage of this approach are Increase lifetime, reduce energy, sparse and disconnected network can be handled easily, reduce cost and finally security enhanced. Disadvantages are challenges in protocol design, latency and failure to visit some areas of the network will result in data loss.

6.1.2. Using predictable observer mobility for power efficient design of sensor networks

This approach proposes a novel concept of saving power in sensor network based on predictable mobility of the data sink. Here model data collection as a queuing system [12]. Using this queuing model analyze the success in data collection and power consumption of the network. Then model a simple observer driven communication protocol. Queuing model is designed to achieve a pre specified outage, which is the fraction of nodes which fails to send their packets. Communication model is designed to guarantee zero outage if the sensor separation is above a threshold. Communication model is operate in three phase, they are start up, steady and failure. Advantages of this approach are less communication power and increase network lifetime. Since there is only one mobile sink is used, failure to visit some areas of the network will result in data loss.

6.1.3. Message ferry routing algorithm for data collection in partitioned and buffer limited wireless sensor networks.

It is an important research issue of how to deliver data in disconnected wireless sensor networks. Disconnected means that network has no direct connection to the outside world. There are different separated sub networks. Each sub network has a rendezvous node to collect the buffered data from all other sensor node in that sensor network. A node called message ferry, visit these rendezvous node to collect buffered data .It is travelled through pre defined path. This paper presents two efficient algorithms MFRA1 and MFRA2 to find feasible route for the message ferry such that the buffer of the sensor nodes will not over flow and hence data loss can be reduced [13]. This algorithm first finds shortest sequence for the ferry. If there is an over flow in sensor nodes MFRA1 and MFRA2 fix the overflow by dividing the initial visit sequence into subsequence's. The above process continues until a feasible solution is found. Advantages of this approach are buffer overflow can be avoided and less data loss, but this method is complex since the network is disconnected.

6.2. Multiple mobile agents for data collection

In this approach multiple mobile agents are used for data collection in wireless sensor networks, this will improve the amount of collected packets and data loss is also reduced. This technique can be further classifieds into two based on the mobility of agents. Mobile agents can be moved along constrained path or their mobility can be uncontrollable. Some examples are given as follows:

6.2.1 Mobile elements with constrained mobility

6.2.1.1. Efficient data collection in wireless sensor network with path constrained mobile sink. This approach proposes a novel data collection scheme, called Maximum Amount

Shortest Path (MASP), that increases the network throughput and conserve energy [14]. MASP is implemented as two-phase communication protocol based on zone partitioning. MASP divide the monitored region into two parts, Direct Communication Area (DCA) and Multihop Communication Area (MCA) Sensor node within the DCA can directly communicate with mobile sink, these sensor nodes are called sub sink. Sensor node within the MCA are called members, which will send data to the sub sink and these sub sink are responsible for sending data to the mobile sink. MASP is designed such a way that members are assigned to sub sink according to the length of communication time between mobile sink and sub sink, this will improve network throughput. Advantages of this approach are reduced data loss, increased amount of collected packet. But assignments of sensor nodes should be done carefully in such networks.

6.2.1. Mobile element with uncontrollable mobility

6.2.2.1. Envirostore: a cooperative storage system for disconnected operation in sensor networks. For efficient data collection in wireless sensor network, data storage is an important factor. This approach presents a new cooperative storage system for disconnected wireless sensor network. This storage system leads to significant improvement in amount of data collected compared to non cooperative storage [15]. The main goal is to maximize the effective storage capacity such that it accommodate large amount of data and to take best advantage of data upload opportunities. Envirostore employs data redistribution scheme to improve the storage capacity of network. In sensor network some node will record more data than others, in such cases data loss can be minimized by sending data from nodes that are full to those that are not. Good redistribution scheme can migrate data from highly utilized to less utilized storage spaces in order to improve overall storage utilization. Advantages of this approach are improving amount of data collected, less expensive, avoid data loss due to energy consumption. The main disadvantage of this approach is it will not consider the importance of data packets.

6.2.2.2. Using mobile sinks in wireless sensor network to improve emergency response. This approach considers a sensor field for sensing and reporting on building during fires. Here they used fire-fighters equipped with small computers, which are act as mobile sink nodes [7]. These nodes are responsible for carrying data and provide connectivity to disconnected networks. This paper proposes many approaches for improving data collection by advertising the presence of the mobile sink, gathering data for forwarding. The mobile sink are aware of its own position .The movement of the mobile sink is uncontrollable. The advantage of this approach is it can improve the data delivery rate. The methods used for data collection is complex in this type of networks

6.2.2.3. Opportunistic data collection for disconnected wireless sensor network by mobile mules. To improve the quality and amount of collected packets in disconnected wireless sensor network two strategies are proposed ,Distributed storage management(DSM) and opportunistic exchange (ODE) [2].The network scenario consist of multiple disconnected sensor network ,each disconnected network consist of a static sink and many sensor nodes. Sensor nodes collect data from the environment and send it to the sink node. Mobile mules are used for collecting data from the sink node. These mobile mules collect data from sink nodes and finally send it to the base station. Communication between sink node and mobile mule is opportunistic. Mobile mule transfer data to the base station in an opportunistic way.DSM strategy is used to store higher priority data closer to the sink so that quality of collected packet is increased.DSM is similar to that of heap sort.ODE strategy is used between the mobile mules so that data is transferred to the base station in shorter time. Mules have different probability to meet the base station based on that probability data is transfers from one mule to another mule.DSM and ODE strategies can improve the quality of collected packets and data loss is reduced. In this approach since the movements of mules are uncontrollable energy consumption is increased.

7. Conclusion

In this paper we study various data collection methods in wireless sensor network. We classify the methods into three groups. First method is data collection using a static sink. In this approach a sink node is responsible for collecting data from sensors and the sink node is static. Energy consumption is an important problem in such type of networks. In the second case, data collection using mobile sensor nodes .In this approach sensor nodes has mobility, these mobile sensors transmit data to the sink node using their mobility so that energy consumption is reduced. Third classification is data collection based on mobility. It is again divided into two groups, data collection using a single mobile sink and data collection using

multiple mobile agents. In this approach different mobility pattern is also introduced, they are mobility along a constrained path and uncontrollable mobility. Finally we made a comparison between various distributed data collection schemes under several constraints such as amount of collected packets, energy efficiency, and network lifetime.

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