

Data Collection Methods Based on Mobile Sink Node

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Key words: mobile sink sensor networks; data collection

Abstract. Mobile sink node can collect data anytime and anywhere in sensor networks. Therefore, the research on data collection methods is becoming increasingly important. In this paper, we classify the existing data collection methods according to mobile sensor network structure, and give a detailed analysis and evaluation.

Introduction

Humans can directly perceive the objective world through sensor networks, which greatly improve the ability of humans to understand the objective world. American Business Weekly and MIT Technology Review both think that wireless sensor networks will become one of the top 10 most influential technologies in the 21st century. With the improvement of micro-sensors and wireless communication technology, the application prospect of wireless sensor networks are becoming more widely, for example, in the military, environmental, industrial, health, family, and other commercial areas. Moreover, in some special field, space exploration and disaster rescue, sensor networks have unique technical advantages. Sensor networks have broad prospects, but existing applications are not mature, most of them still in a theoretical or experimental stage. The main reason is that the current technology still cannot meet the actual demand.

The data collection quantity is large in practical applications, such as images and videos related applications, which will bring some challenges to design data acquisition schemes. In traditional data acquisition schemes, the location of nodes is fixed. When a sensor node collects some data, it will submit the data to sink nodes. The main problems of node location fixing are as follows: (1) Funnel effect. Sensor nodes near a sink will consume greater energy, which will lead to faster network segmentations; (2) Communication overhead. No matter what kind of routing algorithm is used, control overhead will consume some energy. (3) Connectivity constraints. If sensor networks lose connectivity, they will cause that the data of node cannot be submitted to sinks. The main reason is that the location of sink is fixed, so the mobile sink strategy is the key to solve the problem.

Mobile Wireless Sensor Node Structure and Characteristics

In mobile wireless sensor networks, sensor nodes are divided into normal nodes and sink nodes. Normal sensor nodes are distributed in data aware areas statically. Limitations are as follows: (1) Energy of sensor nodes is limited: Since the sensor node is small and supplies energy by battery. Efficient using energy, improving network lifetime is a primary challenge for sensor networks. (2) Sensor node communication capabilities are limited: Wireless communication bandwidth of sensor nodes is limited, usually only a few hundred KBPS rate. (3) Computing and storage capacity of sensor nodes is limited: Sensor node is a miniature embedded device, processor power of sensor nodes is not strong and storage capacity is also weak. (4) Sensor node is easily fail: As sensor nodes directly exposed in the natural environment, it is very easy to fail.

Sink nodes have strong storage, communications, and processing ability. Sink nodes can move freely in the area of data collection, and it can add energy. Features of Sink nodes are as follows: (1) Autonomy: After initialization, Sink can perform independently without intervention. (2) Reactivity: Sink nodes can sense surroundings and change according to environmental. (3) Collaborative: The

interactive mode between sinks will be adjusted according to the change of task, and then collaborate to complete complex task.

Typical Mobile Sink Sensor Network Data Collection Protocols

Based on the defect of static acquisition methods, a variety of wireless sensor data collection scheme, which use mobile sink nodes, was put forward. According to sink nodes movement type and related network features, mobile data acquisition systems are mainly divided into four categories:

3.1 Ordinary node fixing and sink node moving

Power and cost of ordinary node is low, and processing and communication ability are limited. Mobile Sink nodes have powerful processing unit and can move freely in the sensor network. The biggest advantage of sensor networks is that complex data processing, access processing, data transmission and routing maintenance will be completed by sink nodes. Figure 1 shows a data collection method whose sink is mobile, node is fixed.

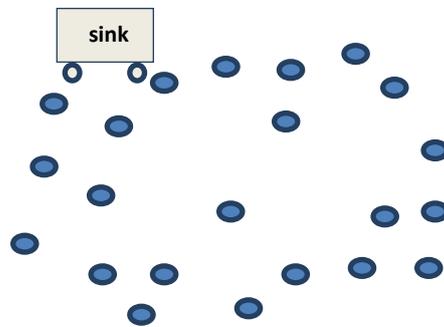


Figure 1 sink mobile data collection method

In only sink mobile sensor networks, due to sink nodes do not know the interesting data's storage location, flooding is more direct and simple way and the success rate is high. However, the biggest drawback of flooding is the energy problem. With the increase of queries, the energy consumption of sensor networks will be increased significantly. And the lifetime of sensor networks will be significantly shortened. In order to reduce the energy consumption of flooding, constrained query algorithm has been proposed. Researcher set a maximum hop number of flooding algorithm. After receiving an inquiry command, the sensor node determines the hop number firstly. If the hop number less than the maximum hop number, the sensor will execute the command. Constrained query algorithm needs to perform multiple queries by gradually increasing the number of hops. Constrained flooding query will bring a certain delay. In [1,2], the constrained flooding query has been studied in detail.

Reference [3] proposed a data collection scheme in only sink mobile networks. The scheme adopts three layer structure (AccessPoints/Sink/Sensors). In the sensor network, sensor nodes store data temporarily, when mobile sinks move to vicinity nodes, the node sends the data to it. The shortcoming of this approach is blind spot. Data within the blind area will be not able to be collected, and easy to cause overflow. In order to collect data in all areas, the area which coverage by sensor wars divided into multiple quite strip areas [4]. In each area, mobile sinks collect data according to a fixed route. A sensor node near a mobile sink will transmit the data to the mobile sink directly. Other nodes use multi-hop way to transfer the data to the mobile sink to ensure that all the data can be collected. Although the improved method uses multiple mobile sinks, but there is still a hot issue, and the collecting area of each mobile sink is independent.

In reference [5] a mobile relay model is put forward based on the forecast. Mobile sinks move along a planned route in sensor networks, sensor nodes adjust the monitor time by predicting mobile sinks arrival time to save energy. But this model is dependent on the

actual deployment of sensor nodes. If sensor nodes layout is dense, this model can't solve the channel contention problem of multiple nodes communication well. In order to balance the network load, literature [6] divided a network area into inner region and outer region. Mobile sinks move along an outer annular area to collect data. The data of inner regions transmit to mobile sinks by using the shortest path routing algorithm. This approach extends the life of sensor networks to ensure energy balance of sensor nodes. However, in practical applications, network regions are not perfectly circular region, the updating cost of mobile sinks is very high.

In practical applications, sensor networks status is not static with the impact of sensor node itself and environmental. Data obtained by sensor node is unstable, it will lead to poor data collection efficiency. In reference [7], a mobile sink inform its position to sensor node with flooding. A sensor node sends index information to the mobile sink, when the sensor node detects an event. Then, the mobile sink moves to the node to collect data. Facts have proved that this algorithm is effective in a dense sensor network. If the flooding is used to update the mobile sink location information, sensor's energy will be consumed rapidly and the communication conflict probability will increase quickly. Reference [8] proposed a routing protocol to update mobile sink location information. In this protocol the mobile sink only broadcast their location information to sensor nodes of adjacent areas. If the mobile sink moved out of the collection area, it will update the location information in global way. However, if the mobile sink moves faster, such a partial location information update will degenerate into a global flooding update.

Data collection method based copy is used in the only sink mobile network. In this way, when a node monitored an event, the data will be stored in some nodes as a copy. In the query process, the sink node uses the greedy algorithm and geographic information to find copy nodes. Reference [9] divided all the nodes into grid according to geographic relationships. Each grid has a cluster head node to collect the event information of the grid. However, this model still has the problem of energy unbalanced.

3.2 Mobile Agent data collection method

Reference [10] proposed a data collection method based on mobile Agent. In the process of moving, the mobile sink monitors the status of the network and recalculates the migration path of agent. Data salmon protocol [11] takes into account energy and time effectiveness. In the protocol, mobile sink always moves to a node whose data flow is the largest. The method can solve node storage capacity shortage and time efficiency problems. But the greedy mobile strategy only evaluates the data traffic of neighbor node. When a data-aware region is far away, the mobile sink cannot navigate to the area quickly. In addition, the extensibility of flat structure method is not well. And the maintenance cost of forwarding tree is high if the network size is large.

Reference [12] proposed a data collection method for large-scale, multi-hop sensor networks. The algorithm uses a data collector which can move with pre-set path to collect and upload data. The algorithm combines sensor car and multiple hops data acquisition system to solve the distance limitation problem in data collection.

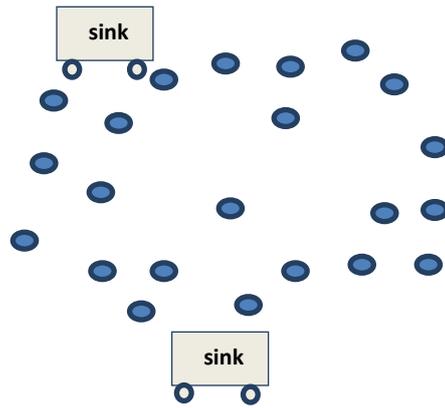


Figure 2 Mobile Agent data collection method

Reference [13] proposed a data collection algorithm with a mobile data collector. In this way, nodes are divided into several clusters according to a certain rule. Then a cluster head node is elected. The mobile data collector moves along a pre-set route to collect data. After a period, the mobile data collector returns to the sink node and gives it the data. The clustering algorithm can balance the energy consumption of each node and prolong the lifetime of the network. Figure 2 shows a mobile agent data collection method.

3.3 The data acquisition system of the common node mobile and sink fixed

Such a system is used in an environment which has a large number of mobile nodes and multiple sink nodes. At present, such a system has been applied to intelligent transportation successfully. For an intelligent traffic data collection system, the sensor nodes are generally fixed on all types of vehicles and move with the car. Fixed sinks are disposed in surrounding roads, so that the dispatch center can detect the road in real-time.

The Zebra.net project [14] of Princeton University proposed a model which used historical data forwarding mechanism to collect Zebra migration information of vast steppe. Researchers arranged a sensor in a zebra, when the zebra with sensor thought the base station, it will send data to the base station.

3.4 Data acquisition system of the common node and sink both moved

Such a system is generally used in the case of the node mobility irregular network. For example, monitoring Marine fish migration, the moving paths of all nodes have no regularity. The network topology is also changeable at any time. Reference [15] proposed a data acquisition algorithm for mobile users. When a user moves, the system calculates the distance between the user terminal and the respective sensor node. Then select the sensor node which distance is the nearest to the user terminal as a sink node. A multi-hop data collection tree will be constructed with the sink node as root. The information of each node is progressively transmitted to the mobile user. Mobile users can receive information across the network at any location by using this algorithm.

Conclusion

Wireless sensor networks provide a new platform for distributed information processing and computing models, which combined the natural world and human organically. In this paper we summarize the existing data collection protocols of mobile sink type networks. By overview of existing protocols and algorithms we believe that the mobile data collection can avoid the bottleneck node in sensor networks. However, data aggregation rate is largely restricted by the moving speed and course of mobile node, need for further improvement and enhancement.

Acknowledge

Thank Liaoning Province Natural Science gold support, fund number: 2013024020 and

No.2013024001; Thank AVIC Technology Innovation Fund to support, fund number: 2013S60109R.

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