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Data Gathering Protocols and Methods For WSN

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Abstract:

The most critical issue in wireless sensor networks is data collection. The primary goal of data collection is to collect a large amount of data while minimising data loss due to sensor node memory capacity limitations. Effective data collection techniques can boost sensor network performance. Many researchers have proposed different methods for collecting data in sensor networks. A survey on data collection in wireless sensor networks is described in this paper. We review recent advances in this research area in this paper. We begin by highlighting the unique characteristics of data collection in WSNs. Then we talk about issues and previous solutions for the data gathering protocol design and the data dissemination protocol design. Our discussion also includes various data gathering protocols, which are an important component for energy efficient data gathering and have a significant impact on the overall performance of a data collection WSN system.

Keywords: Wireless sensor networks, routing protocols, data collection, network lifetime, Data Dissemination, Data Gathering.

Introduction:

Wireless sensor networks have been used in a variety of applications. One of the most important applications is data collection, in which sensing data is continuously collected at each sensor node and transmitted wirelessly to a central base station for further processing. Each sensor node in a WSN is powered by a battery and communicates wirelessly. As a result, a sensor node is small in size and can be attached to any location with minimal disruption to the surrounding environment. This flexibility reduces the costs and effort required for deployment and maintenance, making wireless sensor networks a more promising approach for data collection than wired counterparts. However, the unique characteristics of WSNs present a slew of new challenges. For example, the lifetime of a sensor node is constrained by the battery attached to it, and the network lifetime is dependent on the lifetime of sensor nodes; thus, consideration of energy efficiency is often preferred in a WSN design to further reduce the costs of maintenance and redeployment. Furthermore, when sensor nodes communicate with one another, wireless losses and collisions complicate matters [1-4].

In general, it is critical to consider capture, transmission, and routing issues when designing a highly energy efficient WSN, that is, data gathering techniques that specify how ordinary sensors work for gathering information and delivering it to the washbasin. As a result, data collection is the primary and most critical function provided by a WSN.

The main goal of this paper is to compare some of the most advanced data collection techniques in terms of their trade-off between reliability (i.e., packet loss and reconstruction error) and energy consumption (i.e., network lifetime) by taking both compression and networking into account. To the best of our knowledge, this is the first paper that considers such a comparison for data gathering techniques from various research fields (i.e., signal processing, compressive sensing, information theory, and networking-related techniques are discussed and compared in this paper). We developed a simple analytical model that can predict the energy efficiency and reliability of various data collection techniques. Furthermore, we run simulations to validate our model and compare the efficacy of the aforementioned schemes by systematically sampling the parameter space (number of nodes, transmission range, and sparsity). [5-6]

The collection of sensed data in WSN can be done in either a regular or non-regular mode. In regular mode, data must be collected continuously from sensor nodes. In the non-regular mode, data must be collected from sensor nodes at periodic intervals. Table 1 refers to various design metrics for different WSN applications, such as energy efficiency (EE), lifetime (LT), low latency (LL), fault tolerance (FT), security (S), quality of service (Q), and reliability (R), which are prioritised [low (L), medium (M), and high (H).

Table 1: WSN applications based on data collection requirements.

Data collection	Applications		EE	LT	LL	FT	S	Q	R
Regular data collection	Health care	Patient monitoring	M	M	H	H	H	H	H
	Military	Battlefield surveillance	H	H	H	H	H	H	H
		Structural monitoring	H	H	H	H	M	M	H
	Public	Factory monitoring	M	M	H	M	M	M	H
	Industrial	Machine monitoring	M	M	H	M	L	M	H
	Safety	Chemical monitoring	M	M	H	M	M	M	H
	Environmental	Disaster monitoring	H	H	H	H	L	M	M
		Traffic control and monitoring	M	M	H	H	M	H	M
Non-regular data collection	Agriculture	Precision agriculture	H	H	L	M	L	L	H
		Environment control in buildings	M	M	M	L	L	L	M
	Industrial	Managing inventory control	M	M	M	L	L	L	M
	Home	Smart home automation	M	M	L	L	L	L	M
		Animal monitoring	H	H	L	L	L	L	M
	Environmental	Vehicle tracking and detection	H	H	L	L	L	M	M
		Disaster damage assessment	M	M	L	L	L	M	M

EE: energy efficiency; LT: lifetime; LL: low latency; FT: fault tolerance; S: scalability; Q: quality of service; R: reliability; L: low; M: medium; H: high.

Data Collection:

The collected data is then sent back to a central base station for processing. Traditionally, these sensors are linked via wires for data transmission and power supply. However, it has been discovered that the wired approach necessitates significant effort for deployment and maintenance. The deployment of the wires must be carefully planned to avoid disturbing the surrounding environment. And a break in any wire can knock the entire network offline, requiring significant time and effort to locate and replace the broken line. Furthermore, the sensing environment may make wired deployment and maintenance difficult, if not impossible. For example, near a volcano or a wildfire scene, where hot gases and steams can easily damage a wire. Indeed, even in a less harsh environment, such as a wild habitat or a building, rodent threats are critical, making wire protection much more difficult than sensor protection. All of these issues make wireless sensor networks an appealing option as technology advances [7].

In wireless sensor networks, data collection methods are broadly classified as data collection using mobile sensor nodes, data collection using a static sink approach, and data collection using a mobility-based approach. The mobility-based approach is divided into two categories: data collection using a single mobile sink and data collection using multiple mobile agents. Multiple mobile mules are also used to collect data. These mobile agents' paths can be constrained or uncontrollable.

Data Dissemination

Data dissemination is the process of routing data and data queries in a sensor network. A source is the node that generates the data in the context of data dissemination, and an event is the information to be reported. A sink is a node that is interested in data, and the interest is a descriptor for some event that the sink is interested in. As a result, the event is transferred from the source to the sink after the source receives an interest from the sink. As a result, data dissemination requires two steps. To begin, a node that is interested in some events, such as temperature or air humidity, broadcasts its interests to its neighbours on a regular basis. The interests are then spread throughout the entire sensor network. After receiving the request, nodes that have requested data send back data in the second step. The sensor network's intermediate nodes also keep a cache of received interests and data [1]. There are numerous methods for disseminating data. Flooding, gossiping, and SPIN are discussed in greater depth in this paper.

Taxonomy of data collection protocols:

Akkaya et al. [1] presented network architecture-based classification in 2005. Routing protocols are classified as data-centric, hierarchical, or location-based, according to Akkaya et al. Data-centric protocols work by sink disseminating queries in the network to obtain sensor data from sensor nodes. Cluster- or hierarchical-based protocols divide a network of nodes into clusters, with each cluster managed by a cluster head (CH). The sensed data will be received by each CH from the corresponding cluster member and forwarded to the BS. The CH can use aggregation techniques to save energy while forwarding to BS. Geographic- or location-based protocols use sensor node position information to route traffic. According to Karaki et al. [8], routing protocols are classified as multipath, query-based, negotiation-based, quality of service (QoS)-based, and coherent-based. Multiple paths are chosen in multipath routing to achieve a variety of benefits such as reliability, fault tolerance, and increased bandwidth.

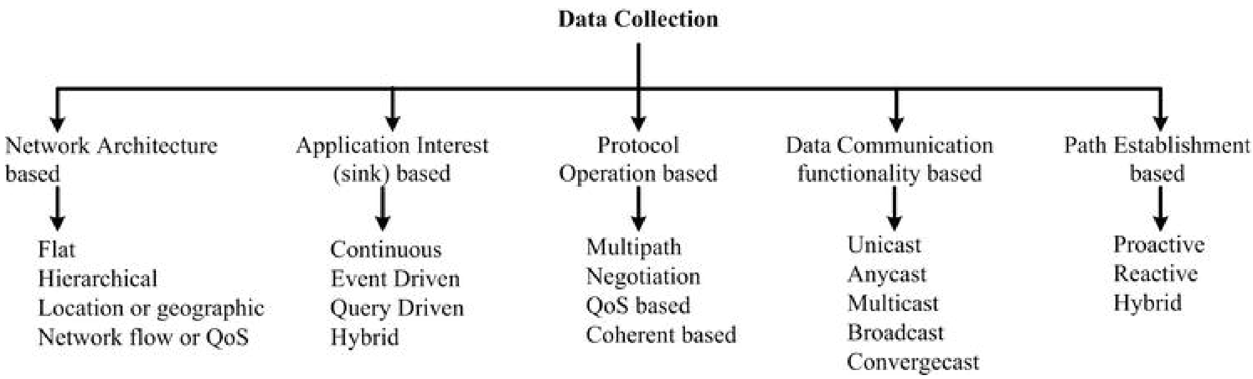

Figure 1: Taxonomy of data collection protocols.

In query-based routing, the sink node acquires data with the help of query dissemination. All sensor nodes will save data based on the nodes' interests. The data is then forwarded only if the sensed or received node data matches the received queries.

Design issues in data collection

1. **Energy and lifetime**

Because energy is a critical constraint for sensor nodes, managing it is the primary concern in WSN. Saving node energy extends the network's lifetime. Sensor nodes use a lot of energy in two major operations: sensing the environment and communicating sensed data to the BS. Energy consumption is stable for sensing operations because it is determined by the sampling rate and is unaffected by other factors such as network topology or sensor location. They are responsible for the data forwarding process. As a result, designing an efficient data forwarding process allows for energy conservation. Network lifetime [9] is defined as the time elapsed between the start of the WSN operation and the death of any or a specified percentage of sensor nodes.

2. **Latency**

Latency is the time elapsed between the start of data generation at the sensor node and the completion of data reception at the base station. It is a major concern in time-sensitive applications such as military and medical health-care monitoring. Maintaining low latency is critical for the following reasons: [10]

- Collisions and network traffic will increase due to the broadcast nature of radio channel.
- The same type of data will be sensed by densely deployed sensors, and transfer to the BS will increase network traffic and exhaust communication bandwidth.

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3. **Fault tolerance**

Fault tolerance [11] improves system availability, reliability, and dependability by ensuring system usage availability without interruption in the presence of faults. Fault tolerance is a challenging issue in WSN because sensor nodes are more vulnerable to failure due to energy depletion, desynchronization, communication link errors, and so on, which are caused by hardware and software failures, environmental conditions, and so on.

Data Gathering in WSN:

The goal of data collection is to send data collected by sensor nodes to the base station. The goal of data gathering algorithms is to maximise the number of rounds of communication between nodes and the base station, with one round indicating that the base station has collected data from all sensor nodes. As a result, data gathering algorithms strive to reduce power consumption and processing time. Data collection may appear to be similar to data dissemination, but there are some distinctions. Data dissemination allows nodes other than the base station to request data, whereas data gathering sends all data to the base station. Furthermore, data in data gathering can be transmitted on a regular basis, whereas data in data dissemination is always transmitted on demand[12]. Various data collection methods, such as direct transmission, PEGASIS, and the binary scheme, will be discussed in greater detail here.

1. **Direct Transmission**

All sensor nodes in the direct transmission method send their data directly to the base station. While direct transmission is a straightforward method, it is also inefficient. Because some sensor nodes are located far from the base station, the amount of energy consumed can be extremely high. [13]

2. **Pegasis**

Power-Efficient Gathering for Sensor Information Systems (PEGASIS) is a data gathering protocol that assumes all sensor nodes understand the network's topology. PEGASIS aims to reduce transmission distances across the entire sensor network, reduce broadcast overhead, reduce the number of messages sent to the base station, and distribute energy consumption evenly across all nodes. [14]

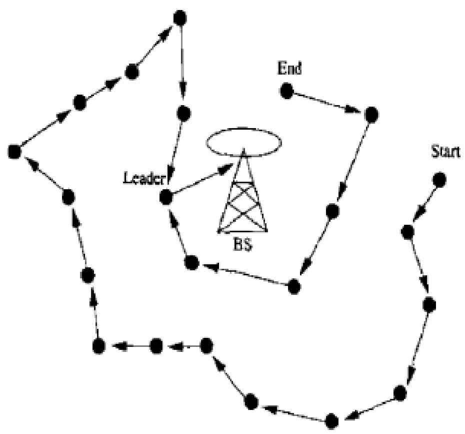

Figure 2: Data gathering with PEGASI

3. Binary Scheme

Binary schemes, like PEGASIS, are chain-based schemes. It categorises nodes into various levels. All nodes that receive messages at one level advance to the next level, which has half the number of nodes. To reduce delay, transmission on a single level occurs simultaneously.

4. Leach

LEACH is a self-organizing, adaptive clustering protocol that uses randomization to distribute the network's energy load evenly. Looking back at the old algorithms, one could see how picking a random sensor and having it fixed to be the CH throughout the system lifetime would cause it to die very quickly, shortening the lifetime of all other cluster nodes. LEACH changes this by randomly rotating among the various sensors in order to avoid draining a single sensor's battery. It also reduces energy dissipation while increasing system lifetime by performing local data fusion to compress the amount of data sent from clusters to base station.

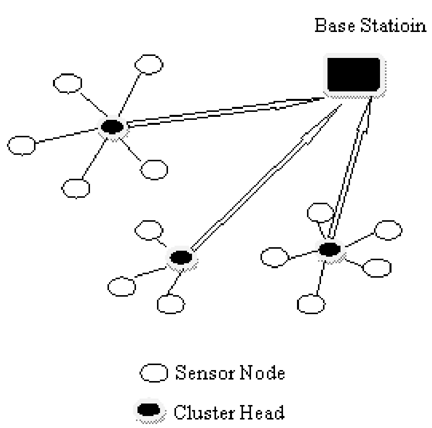

Figure 3. Graph showing construction of cluster in LEACH.

5. Treepsi

The Tree-based Efficient Protocol for Sensor Information (TREEPSI) is a tree-based protocol that differs from the previous ones. WSNs choose a root node from among all sensor nodes prior to the data transmission phase. id = j identifies the root. The tree path can be built in two ways: the first is to compute the path centrally using the sink and broadcast the path information to the network. The second option is to use the same tree structure with a different algorithm in each node. Initially, the root will create a data collection process for the child nodes using any standard tree traversal algorithm [15]. After the tree is constructed, the data transmission phase begins. All leaf nodes will begin sending sensed data to their parent nodes.

Conclusion:

Since their inception, wireless sensor networks have been used in a wide range of applications. We presented an in-depth survey of recent advances in the design issues and solutions for data collection systems using WSNs in this paper. We first highlighted the unique characteristics of data collection in WSNs, using a wireless data collection network and other WSN-based applications. With these characteristics in mind, we discussed issues and solutions related to the design of data collection protocols and data dissemination.

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