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Routing Protocols for Multisink Wireless Sensor Networks: A Survey

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Abstract: **Wireless Sensor Network (WSN) contains hundreds or thousands of these sensor nodes. These sensors have the ability to communicate either among each other or directly to an external base-station (BS). A greater number of sensors allows for sensing over larger geographical regions with greater accuracy. Routing is one of the critical issues in WSNs. Researchers proposed routing protocols for single sink WSNs. Most of the WSNs applications have thousands of sensor nodes where single sink WSNs performance is not convincing. In this paper review of routing protocols for multisink WSNs is presented and also need of multisink WSNs are discussed. It highlights critical issues and open challenges posed by the multisink WSNs.**

Keywords: **WSNs, Multisink, Routing**

INTRODUCTION:

A Wireless Sensor Network (WSN) contain hundreds or thousands of these sensor nodes. These sensors have the ability to communicate either among each other or directly to an external base-station (BS). A greater number of sensors allows for sensing over larger geographical regions with greater accuracy. Basically, each sensor node comprises sensing, processing, transmission, mobilizer, position finding system, and power units (some of these components are optional like the mobilizer). Sensor nodes are usually scattered in a sensor field, which is an area where the sensor nodes are deployed. Sensor nodes coordinate among themselves to produce high-quality information about the physical environment[1][2][3]. Each sensor node bases its decisions on its mission, the information it currently has, and its knowledge of its computing, communication, and energy resources. Each of these scattered sensor nodes has the capability to collect and route data either to other sensors or back to an external base station(s). A base-station may be a fixed node or a mobile node capable of connecting the sensor network to an existing communications infrastructure or to the Internet where a user can have access to the reported data.

The WSN marked its importance in a variety of applications. For example, military applications like target identification and intrusions detection, environmental applications like agricultural farm monitoring, Precision Agriculture, habitat monitoring in the forest, forest fire detection, health applications like, remote diagnostic systems, medication reminders as well as medical devices reminder systems[4][5]. It also includes health care systems like predictive diagnostic systems, biomedical feedback control systems and telemedicine systems. Another area of applications like monitoring home appliances, monitoring elder people at home. We can find its applications are monitoring material fatigue, building virtual keyboards, managing inventory, monitoring product quality, constructing smart office spaces, environmental control in office buildings, robot control and guidance in automatic manufacturing environments. In WSNs, sensor nodes are interconnected or self organized to form a network. Sensor nodes send the data to the sink node through multiple hops. It has following advantages:

In single sink sensor networks the nodes which are near to the sink node may exhaust its energy sooner than the other nodes in the network. The nodes with less remaining energy and heavily loaded node may participate in the routing. These situations are avoided in the multi sink wireless sensor networks.

Most of the applications in WSNs have thousands of sensor nodes in phenomena. Sensor nodes in WSNs with thousands of nodes need to send the sensed data to the single sink node.

Single sink node in such large number of sensor nodes is causing high end to end delay, usage of high control messages in the network and results in increased energy consumption and reduced network lifetime. Multiple sink nodes in the WSNs is an alternate to these problems of single sink WSNs.

In this it is attempted to study the routing protocols proposed for multi sink wireless sensor networks. This paper is organized as follows.

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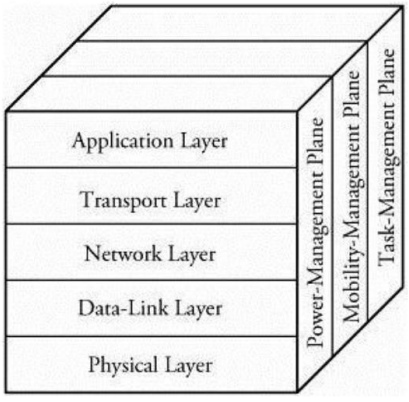
In this article we shed more light on these Routing protocols for multi sink wireless sensor networks. In section 2 background of the WSNs characteristics In section 3, routing protocols for multisink WSNs are discussed. In section 4,Open Issues and Challenges are discussed. section 5, we conclude the paper and introduce future works.

BACKGROUND

WSN architecture consists of four main entities: sensor nodes, sink or sinks, monitored events and users. The sensor nodes are capable of observing, measuring and reacting to events and/or phenomena in a specified environment. The sink (base station or gateway) is the network nodes linking users to the monitored or sensed events, including via other networks such as internet, satellite and LAN. The monitored event or phenomenon that users collect or measure and analyse is detected by sensor nodes [1, 2]. Users, sinks and sensor nodes may be stationary or mobile depending on the nature of the application and network architecture.

WSNs protocol architecture integrates networking protocols and power through the wireless medium and promotes cooperative efforts of sensor nodes. The protocol stack consists of the physical layer, data-link layer, network layer, transport layer, and application layer, backed by a power-management plane, mobility-management plane, and task-management plane. The physical layer is responsible for robust modulation, transmission, and receiving signals. Media access control (MAC) at the data-link layer must minimize packet collision with neighboring nodes, as power is a restricted factor. The network layer routes packets provided by the transport layer. The application layer uses software for preparation of data on an event. The power-management plane monitors the sensor's power level among the sensor nodes and manages the amount of power a sensor node has used.



Characteristics of WSNs

WSNs has specific characteristics which defines the nature and operational behaviors of WSNs. Following are the characteristics of WSNs.

Deployment of Sensor node: Sensor nodes in WSNs are deployed as per the requirement of the different applications of WSNs. It may be deployed as densely or sparsely or as fixed locations.

Battery-power: Battery power is the source of energy for sensor nodes to perform its basic operations like computation and communication.

Limited energy, computation, and storage: Sensor nodes has limited energy, computation power and memory capacity.

Self-configurable Network: Deployed nodes in the WSNs are self configured and establish the network themselves.

Redundant Data: The sensor nodes which sensed the data has a certain degree of data redundancy. Because, the sensor nodes which are densely populated in most of the applications of WSNs.

Application Oriented: WSNs has diversified applications. WSNs is usually designed and deployed for a specific application. The WSNs design requirements of a sensor network change with its nature of application.

Many to one traffic: *In WSNs , the sensed data by the multiple sensor nodes are sends the data to the common sink node.*

Frequent topology change: Network topology changes frequently due to the node failures, damage, addition, energy depletion, or channel fading.

Design Issues of WSNs [6][7][8]:

Quality of Service: Closely related to the type of a network's service is the quality of that service. Traditional quality of service requirements usually coming from multimedia-type applications like bounded delay or minimum bandwidth are irrelevant when applications are tolerant to latency or the bandwidth of the transmitted data is very small in the first place. What is relevant is the amount and quality of information that can be extracted at given sinks about the observed objects or area.

Fault tolerance: Since nodes may run out of energy or might be damaged, or since the wireless communication between two nodes can be permanently interrupted, it is important that the WSN as a whole is able to tolerate such faults. To tolerate node failure, redundant deployment is necessary.

Lifetime: In many scenarios, nodes will have to rely on a limited supply of energy (using batteries). Replacing these energy sources in the field is usually not practicable, and simultaneously, a WSN must operate at least for a given

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mission time or as long as possible. Hence, the lifetime of a WSN becomes a very important figure of merit. Evidently, an energy-efficient way of operation of the WSN is necessary. The precise definition of lifetime the time until the first node fails (or runs out of energy) as the network lifetime[9][10].

Scalability: Since a WSN might include a large number of nodes, the employed architectures and protocols must be able scale to these numbers.

Maintainability: As both the environment of a WSN and the WSN itself change (depleted batteries, failing nodes, new tasks), the system has to adapt. It has to monitor its own health and status to change operational parameters or to choose different trade-offs (e.g. to provide lower quality when energy resource become scarce). In this sense, the network has to maintain itself; it could also be able to interact with external maintenance mechanisms to ensure its extended operation at a required quality.

Designing a routing protocol for wireless sensor networks is a critical need of WSNs operations.

WSNs are infrastructure network. The communication links are unreliable due to inherent wireless communication threats. The sensor nodes have limited communication range. Usually it has few meters of communication range. The sink node in the network placed few hundred of meters away. The sensor nodes are not able to reach the sink node in single hop. The sensor node reaches the destination or sink node in multiple hops. Sending the data in multiple hops to the destination in a optimized network resource utilization is a challenge.

The multiple sink nodes in a WSNs improves the performance of WSNs in respect of performance issues such as end to end delay, throughput, control message utilization, average energy utilization, network lifetime of the network, lifetime of the sensor nodes and QoS.

ROUTING PROTOCOLS FOR MULTI-SINK WIRELESS SENSOR NETWORKS

Several researchers presented the routing protocols for multiple sink WSNs. The protocols aims to reduce the average enrgy

Many researchers proposed the routing protocol for multisink wireless sensor networks[8]-[17]. Renke et.al [14] Proposed QoS routing protocol for multisink wireless sensor networks. QoS routing method based on field theory for the QoS guarantee in WMSNs. The method abstract the WMSNs as a gravitational field inspired by the sink node, each node in the network has a corresponding potential, which represents the distance to the sink node. The intermediate nodes select the next hop node according to QoS evaluation function. Under the guidance of the potential, all data will eventually flow to the sink node. The proposed Multisink QoS routing protocolcan spend lower cost to establish the QoS path compared with SMR, and our algorithm also can lead to more rational energy distribution among nodes and higher energy efficiency during data transmission. The proposed protocol not discussed the multisink placement and how the energy is minimized.

Haifeng et al[15] proposed Energy Optimized Routing Algorithm (EORA) for multi-sink wireless sensor networks using the concept of potential in classical physics. The cornerstone of the EORA is to construct a hybrid virtual potential field based on the hop and residual energy of sensor nodes. Avoid strategy for low-energy nodes and load balancing strategy for multiple sinks are designed to adjust the potential value of sensor nodes, so as to achieve the balanced energy consumption of sensor nodes. EORA has a better balancing for node energy consumption and has prolonged network lifetime. The proposed protocol not discussed the multisink placement and how the energy is minimized in routing.

Hui et al [16] proposed multiple dimensional tree routing protocol for multisink WSNs based on listening and ant colony optimization. The proposed protocol establishes routing and maintenance, the waste of resources is avoided and the reliability of routing is improved by utilizing the listening mechanism and the power control, respectively. The fault tolerance and robustness of routing are increased because multidimensional tree routes from each sensor node to all sink nodes are set up. The QoS optimization of multisinkWSNs is achieved. The proposed protocol not shown how the energy efficiency is achieved in the routing and balanced energy distribution is not shown.

Jayashre et al [17] propose a multi-sink wireless sensor network architecture where the network is partitioned into clusters with multiple sinks to increase the manageability of the network and also to reduce the energy dissipation at each node. All the sources in a cluster were assigned to send the video and imaging data to the sink designated to that particular cluster in order to ensure efficient usage of the sensors and effective access to the gathered information. The proposed EEQR protocol ensures end-to-end delay requirement of real time data, as well as maximizes the throughput of non real-time data by transmitting the gathered data to the appropriate sink. The proposed EEQR is not justified how the energy efficiency is achieved and how the multiple sinks are placed and selection of sinks among the multiple sinks are not shown.

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Haifeng Jiang et al[20] proposed an energy optimized routing algorithm for multi-sink wireless sensor network. It uses virtual force of the virtual potential field as the routing decision criteria. To achieve load balancing and low energy nodes in the routing, potential values of the nodes were used to balance the energy consumption in the sensor nodes. Nodes with less residual energy are avoided to be selected as the intermediate node through dynamically adjusting its potential value in residual energy potential field. Authors set the node as low-energy node when its residual energy is less than 10% of the initial energy. In the routing process, the low-energy node with fewer hops is avoided by adjusting its potential value and the node with the same hop will be selected as relay node.

The avoid strategy for low-energy nodes and load balancing strategy for multiple sinks are adopted to achieve effective and balanced energy consumption. Results show that the routing extended the network lifetime and balanced energy consumption.

Do Duy Tan et al[18] proposed a distributed traffic-balancing routing algorithm is proposed for multi-sink wireless sensor networks. It distributes traffic from sources to sinks. Distribution of traffic based on node's gradient field. It is used to find the neighbor node to route the data to the sink node.The node gradient index contains the distance cost from a source to respective sink and traffic through the neighboring nodes. The nodes forward the data using gradient search for routing and providing optimal paths and possible congestion on the path from source to corresponding sink nodes. Do Duy Tan et al aims to achieve traffic-balancing by detecting congested areas along the route and distributing packets along paths that have idle and under loaded nodes.

Zheng Ma et al[19] proposed a spatial query processing algorithm for multisink WSNs. The proposed algorithm reduces the data messages to be communicated in the network by effective query processing. It reduces the energy consumption and minimum response time of query processing. Each region has a node which collects the sensory data in it, aggregates the data to derive partial query result and send it to the next region.

Many researchers proposed the energy efficient routing protocol for multisink wireless sensor networks. Major issue with multisink wireless sensor network is how to place the sink nodes in the phenomena and balancing the energy cost uniformly across the sensor networks.

OPEN ISSUES AND CHALLENGES

Multisink WSNs poses several open research issues and

challenges to improve the its performance.

Based on the above discussed work and issues; it is clear that the design of a routing protocols for multisink WSNs. The following open research issues are:

- Deployment of multiple sinks in phenomena which reduces the end to end in the data routing.
- The design of scalable, robust and reliable routing protocol is needed which support in presence of multiple sink nodes in the networks.
- When a sensor node sends a data, selection of sink node among multiple sink nodes is a challenge
- Optimal Balance the traffic load across the network which improves the overall network lifetime is a critical issue.
- To minimize the energy consumption of sensor nodes during the deployment in dense and harsh environment.
- Handling of realtime data routing and improving the QOS is another challenge in multisink WSNs.

CONCLUSION AND FUTURE DIRECTIONS

The design of routing protocol in multisink WNSs environment is also one kind of the challenging issue. This research article focuses the issues in designing of routing protocols based on protocol operations. The paper presents the review of routing protocols for multisink WSNs. The protocols presented for for multisink WSNs are interested to balance the traffic load, energy minimization and end to end delay. Open research issues in multisink WSNs environment is presented. Future research is based on network performance through quality of service (QoS) for real time applications and security is also the major issue for WSNs. Future directions focuses the network scalability and increasing of network lifetime are major issues.

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