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An Efficient and Provable Routing Approach for In-Network Aggregation in Wireless Sensor Networks

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***Abstract*: Wireless Sensor Networks (WSNs) is a class of wireless ad hoc networks in which sensor nodes collect, process, and communicate data acquired from the physical environment to an external Base-Station (BS). But the fundamental challenge in the design of Wireless Sensor Networks (WSNs) is to maximize their lifetimes especially when they have a limited and non-replenishable energy supply. To increase the lifetime of the sensor network, power management and energy-efficient communication techniques at all layers become necessary. In this paper, we present solutions for the data gathering and routing problem with in network aggregation in WSNs. This paper focuses on the maximum lifetime data gathering and routing without packet loss in wireless sensor networks Our objective is to maximize the network lifetime by utilizing data aggregation and in network processing techniques**

***Keywords:* Data aggregation, data-centric routing, packet resensing algorithm, wireless sensor networks.**

I. INTRODUCTION

A Wireless Sensor Network (WSN) consists of spatially distributed autonomous devices that cooperatively sense physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants at different locations. Wireless Sensor Networks (WSNs) is a class of wireless ad hoc networks in which sensor nodes collect, process, and communicate data acquired from the physical environment to an external Base-Station (BS) . Future WSNs are envisioned to revolutionize maintenance free and fault tolerant platform for collecting and processing information in diverse environments. A major technical challenge for WSNs, however, lies in the node energy constraint and its limited computing resources, which may pose a fundamental limit on the network lifetime. Therefore, innovative techniques called data centic routing and packet resensing algorithm is introduced to eliminate energy inefficiencies and to prevent packet loss.

Sensor nodes are energy-constrained devices and the energy consumption is generally associated with the amount of gathered data, since communication is often the most expensive activity in terms of energy. For that reason, algorithms and protocols designed for WSNs should consider the energy consumption in their conception. Moreover, WSNs are data-driven networks that usually produce a large amount of information that needs to be routed, often in a multihop fashion, toward a sink node, which works as a gateway to a monitoring center. Given this scenario, routing plays an important role in the data gathering process.

The main idea of the data centric routing or data aggregation and in-network processing approaches is to combine the data arriving from different sources (sensor nodes) at certain aggregation points (or simply aggregators) and route, eliminate redundancies by performing simple processing at the aggregation points, and minimize the total amount of data transmission before forwarding data to the external Base station. Removing redundancies results in transmitting fewer numbers of bits, and hence reduces energy consumption and increases the sensor nodes lifetime

A possible strategy to optimize the routing task is to use the available processing capacity provided by the intermediate sensor nodes along the routing paths. This is known as data-centric routing or in-network data aggregation. For more efficient and effective data gathering with a minimum use of the limited resources, sensor nodes should be configured to smartly report data by making local decisions. For this, data aggregation is an effective technique for saving energy in WSNs. Due to the inherent redundancy in raw data gathered by the sensor nodes, in-networking aggregation can often beused to decrease the communication cost by eliminating redundancy and forwarding only smaller aggregated information. Since minimal communication leads directly to energy savings, which extends the network lifetime, innetwork data aggregation is a key technology to be supported by WSNs.

II. APPLICATIONS OF SENSOR NETWORKS

In the recent past, wireless sensor networks have found their way into a wide variety of applications and systems with vastly varying requirements and characteristics [6][8]. The sensor networks are used in surveillance systems like Disaster Relief, Emergency Rescue operation, Military, Habitat Monitoring, Health Care, Environmental monitoring, Home networks, detecting chemical, biological, radiological, nuclear, and explosive material etc. moreover The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. How the sensor network is used in these areas are listed in table 1 below.

Table 1: Some applications for different areas

Area	Applications
Military	Military situation awareness[6]. Sensing intruders on basis. Detection of enemy unit movements on land and sea [4]. Battle field surveillances [5].
Emergency situations	Disaster management [9]. Fire/water detectors [3]. Hazardous chemical level and fires [4].
Physical world	Environmental monitoring of water and soil [7]. Habitual monitoring [7]. Observation of biological and artificial systems [7].
Medical and health	Sensors for blood flow, respiratory rate , ECG(electrocardiogram),pulse oxymeter, blood pressure and oxygen measurement [10]. Monitoring people's location and health condition [5].
Industrial	Factory process control and industrial automation [6]. Monitoring and control of industrial equipment [3].
Home networks	Home appliances, location awareness (blue tooth [3]). Person locator [10].
Automotive	Tire pressure monitoring [3][4]. Active mobility [8]. Coordinated vehicle tracking [6].

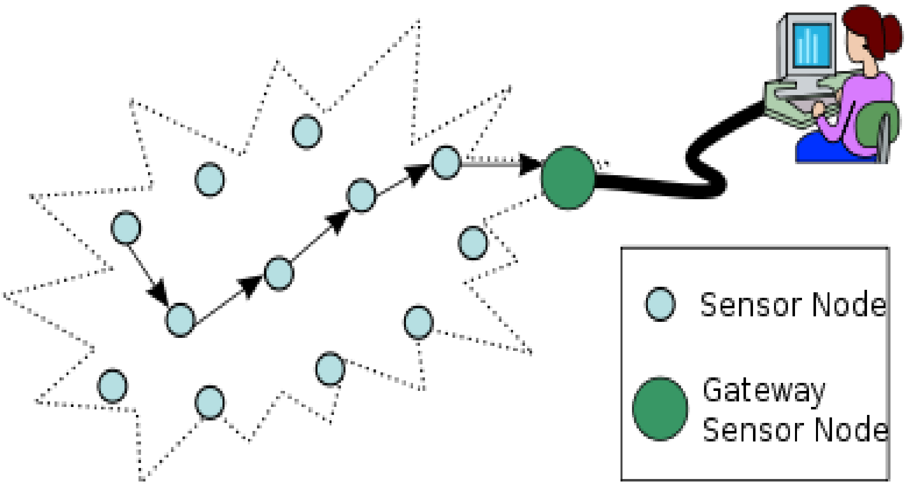

Fig. 1 Architectural Diagram of Wireless Sensor Network

The WSN is built of "nodes" – from a few to several hundreds or even thousands, where each node is connected to one (or sometimes several) sensors. Each such sensor network node has typically several parts: a radio transceiver with an internal antenna or connection to an external antenna, a microcontroller, an electronic circuit for interfacing with the sensors and an energy source, usually a battery or an embedded form of energy harvesting. A sensor node might vary in size from that of a shoebox down to the size of a grain of dust, The cost of sensor nodes is similarly , ranging from a few to hundreds of dollars, depending on the complexity of the individual sensor nodes. Size and cost constraints on sensor nodes result in corresponding constraints on resources such as energy, memory, computational speed and communications bandwidth. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding.

III. SCOPE OF THE PROJECT

Wireless Sensor Network (WSN) consists of spatially distributed autonomous devices that cooperatively sense physical or environmental conditions, such as temperature, sound, vibration, pressure, motion, or pollutants at different locations. Data sensing and retrival in wireless sensor systems have a widespread application in areas such as security and surveillance monitoring and command and control in battlefields. A WSN can be either source driven or query base depending on the data flow. In source driven WSNs, sensors initiate data transmission for observed events to interested users, including possibly reporting sensor readings periodically.

Wireless Sensor Networks (WSNs) will be increasingly implemented in different classes of applications for accurate and efficient monitoring. Due to the high density of nodes in these networks, it is likely that redundant data will be detected by nearby nodes when sensing an event. Since energy conservation is a key issue in WSNs, data fusion and aggregation should be exploited in order to save energy. Redundant data can be aggregated at intermediate nodes reducing the size and number of exchanged messages and thus, decreasing communication costs , energy consumption and increase the network lifetime.

Aggregation reduces the amount of network traffic which helps to reduce energy consumption on sensor nodes. In this paper developed a data centric routing algorithm based on cluster based approach in order to reduce the flow of redundant data towards the base station or monitoring station and thus increasing network life time.

In data routing in wireless sensor networks, packet loss occurs most often, Packet loss occurs when one or more packets of data travelling across a network fail to reach their destination. Packet loss is distinguished as one of the three main error types encountered in digital communications; the other two being bit error and spurious packets caused due to noise. Packet loss can be caused by a number of factors including signal degradation over the network medium due to multi-path fading, packet drop because of network congestion resulting poor performance of network and degrades the network life time. In this paper develop an algorithm to avoid Packet losses in transmission between cluster head and sink node a Packet Re-sensing Algorithm **(PRA)** is used.

IV. RELATED WORK

The use of sensor networks has been envisioned in arrange of settings such as industrial applications, vehicle tracking applications and habitat monitoring [4]. A number of independent efforts have been made in recent years to develop the hardware and software architectures needed for wireless sensing. Of particular note are UC Berkeley's Smart Dust Motes, TinyOS [16], and the PicoRadio project; the Wireless Integrated Network Sensors (WINS) project and PC-104 based sensors [4] developed at University of California Los Angeles; and the µAMPS project at MIT. The challenges and design principles involved in networking these devices are discussed in [9], [10], and. Energy-efficient medium access schemes applicable for sensor networks are presented in [7], and Techniques for balancing the energy load among sensors using randomized rotation of cluster heads are discussed in [15]. Some attention has also been given to developing localized self-configuration mechanisms in sensor networks [5].

The great majority of wireless routing protocols developed in recent years have been for mobile ad-hoc communication networks. The notion of in-network processing during routing is not unique to sensor networks alone. In Active Networks, intermediate routing nodes can perform customized computations on and modify the contents of messages passing through them on a per-user or per-application basis. Limited router-assist techniques have also been proposed for multicast on the internet which would permit intermediate routers to look at special router-assist fields on packets in order to eliminate redundant signaling and perform sub casting [3]. Optimal data aggregation, as we have shown in this paper, requires the formation of a minimum Steiner tree, a well known NP-complete problem arising in many networking contexts.

Finally, we mention here in passing that there is another sense in which the phrase "data-centric networking" has been used [8]; namely to describe an approach to ubiquitous computing in which human users are identified not with static computing devices but with their personalized services and data identified and investigated some of the factors affecting performance, such as the number of placement of sources, and the communication network topology.

V. SYSTEM ARCHITECTURE

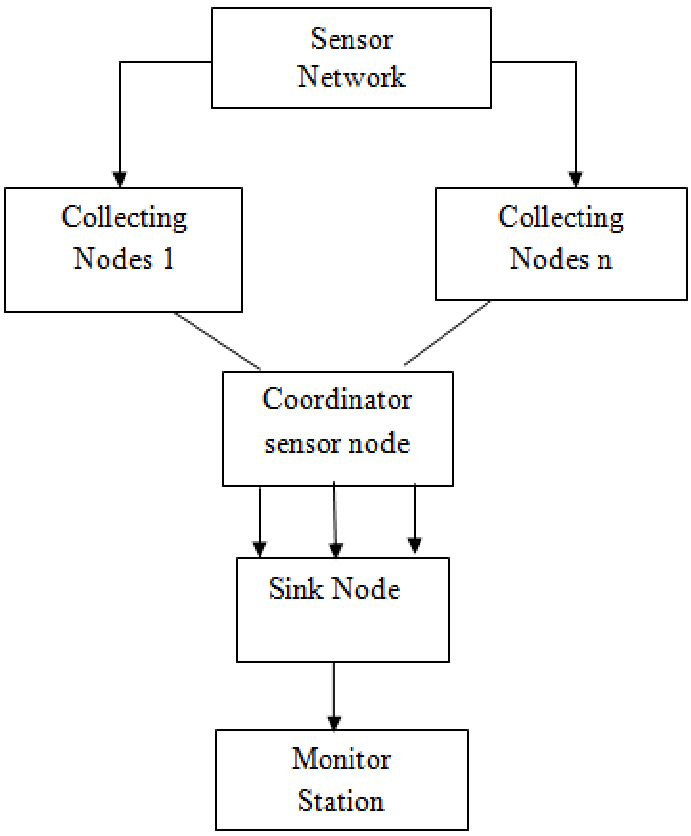

Fig. 2: Architecture of DCR algorithm

In DCR algorithm, for each new event, it is performed the clustering of the nodes that detected the same event as well as the election of the cluster-head. After that, routes are created by selecting nodes in the shortest path, to the nearest node that is part of an existing routing infrastructure, where this node will be an aggregation point. The data centric routing infrastructure tends to maximize the aggregation points and to use fewer control packets to build the routing tree. DCR algorithm does not flood a message to the whole network whenever a new event occurs. The main goal of our proposed the DCR algorithm is to build a routing tree with the shortest paths that connect all source nodes to the sink while maximizing data aggregation. The DCR algorithm considers the following roles in the routing infrastructure creation:

- Collecting nodes. A node that detects an event and report the gathered data to a coordinator node.
- Coordinator. A node that also detects an event and is responsible for gathering all the gathered data sent by collaborator nodes, aggregating them and sending the result toward the sink node.
- Sink. A node interested in receiving data from a set of coordinator and collaborator nodes.

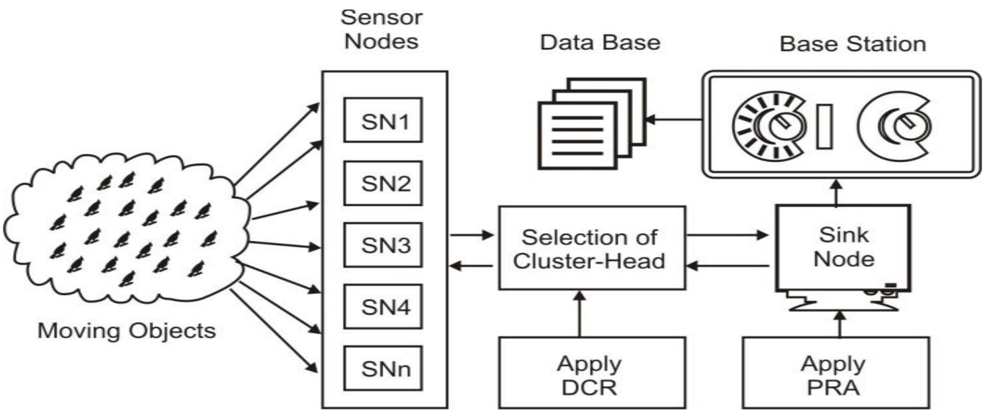

Fig. 3 Architecture of the proposed work

The architecture given above explains the functionality of the proposed work. When there is an event occurs, the sensor nodes will ready to observe the movement of objects along different location. The sensor nodes are placed in different locations so that the movement can be accessed by some of the nodes based on the density of the movement objects. The sensor nodes after the recording movements will evolve in the process of selection of cluster-head to aggregate and redundancy removal in the recorded records. While selecting the cluster-head the present load in each of the clusters and distance to the sink nodes are considered. By applying the DCR the movement records registered are aggregated and redundant free. These records are then transmitted to their sink node which is responsible for the final transmission of all records to the base station. In the sink node all received records from various cluster head are analyzed with the help of PRA for the verification of any packet loss due to transmission from cluster-head. If there is any lose is found then the particular transmission will be retransmitted from the cluster-head to the corresponding sink node. The sink node will then send the final received records to the base station

i. Cluster-head:

In the Low-Energy Adaptive Clustering Hierarchy (LEACH) algorithm clustered structures are exploited to perform data aggregation. In this algorithm, cluster heads can act as aggregation points and they communicate directly to the sink node. In order to evenly distribute energy consumption among all nodes, cluster-heads are randomly elected in each round. LEACH-based algorithms assume that the sink can be reached by any node in only one hop, which limits the size of the network for which such protocols can be used. The Information Fusion-based Role Assignment (InFRA) algorithm builds a cluster for each event including only those nodes that were able to detect it. Then, cluster-heads merge the data within the cluster and send the result toward the sink node. The InFRA algorithm aims at building the shortest path tree that maximizes information fusion. Thus, once clusters are formed, cluster-heads choose the shortest path to the sink node that also maximizes information fusion by using the aggregated coordinators distance. A disadvantage of the InFRA algorithm is that for each new event that arises in the network, the information about the event must be flooded throughout the network to inform other nodes about its occurrence and to update the aggregated coordinators-distance. This procedure increases the communication cost of the algorithm and, thus, limits its scalability.

ii. Cluster formation:

When an event is detected by one or more nodes, the leader election algorithm starts and sensing nodes will be running for leadership (group coordinator); this process is described here. For this election, all sensing nodes are eligible. If this is the first event, the leader node will be the one that is closest to the sink node. Otherwise, the leader will be the node that is closest to an already established route. In the case of a tie, i.e., two or more concurrent nodes have the same distance in hops to the sink (or to an established route), the node with the smallest ID maintains eligibility. Another possibility is to use the energy level as a tiebreak criterion. At the end of the election only one node in the group will be declared as the leader (Coordinator). The remaining nodes that detected the same event will be the

iii. Packet Re-sensing Algorithm (PRA):

To avoid Packet losses in transmission between cluster head and sink node a Packet Re-sensing Algorithm (PRA) is used. This algorithm works in a framework in which the PRA counts the packet size to be transmitted from the Cluster head to the sink node before transmitting a particular record set. The size of text data to be transmitted per transmission is transmitted along with each transmission and it will be the first packet received by the sink node. The sink node will count the size of text data received at each set of transmission at the receiving sink node. If the size of data received is match with the actual size then the transmission will be accessed, if not the sink node will request the cluster-head to re-transmit the entire set of records. The actual goal is to reduce the direct transmission from each node to Base station, we introduced sink node. While selecting the cluster-head, the present load in each of the clusters and distance to the sink nodes are considered. The base station is registered with number of Sink nodes, the sink nods are acting as a gateway for cluster-heads or sensor nodes for transmitting the observed data. Set of sensor nodes are registered under a single sink node; for an event some of the nodes will observe the data not all nodes. The nodes which are located near to the event location will observe the data. The shortest path will be calculated based on the distance (path) of each node to a cluster head from which the movement of aggregated data will be delivered to the sink node.

VI. CONCLUSION AND FUTURE WORK

A fundamental challenge in the design of wireless sensor networks (WSNs) is to maximize their lifetimes. This paper focuses on the maximum lifetime data gathering and routing without packet loss in wireless sensor networks. Data aggregation process is used to reduce the number of transmissions of sensor nodes, and hence minimizing the overall power consumption in the network. The proposed approach uses cluster-based algorithms along with data aggregation called data centric routing algorithm which can achieve significant energy savings in wireless sensor networks. The proposed scheme for WSNs that combines the mechanism of preventing the packet loss together with application specific data aggregation in order to enhance the wireless sensor network performance in terms of extending the network lifetime, while expose acceptable levels of latency under data aggregation.

As future work, spatial and temporal correlation of the aggregated data will also be taken into consideration as well as the construction of a routing tree that meets application needs. The goal is to find a balance between the overhead and the quality of the routing tree. In addition, new strategies will be devised to control the waiting time for aggregator nodes based on two criteria: average distance of the event coordinators, and spatial and semantics event correlation.

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