Comparison of Data Centric Protocols For Wireless Sensor Network And Proposed Enhanced M-SPIN In Topology Network

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Abstract

Wireless sensor networks (WSN), which consist of randomly deployed tiny sensors, data processing unit, and communicating components, have a wide range of applications, such as agriculture, business, military, and health. WSN are constrained by power, memory, and computational resources and require a novel design approach. The number of WSN deployments for real life applications have rapidly increased. Still, the energy problem remains one of the major barriers preventing the complete exploitation of this technology. Sensor nodes are typically powered by batteries with a limited lifetime and, even with the harvesting of additional energy from the external environment (e.g., using solar cells or piezo-electric mechanisms), it remains a limited resource to be consumed judiciously. Different routing protocols have been proposed to save energy during data transmission in WSN. Routing protocols based on data-centric approach are suitable in this context that performs in-network aggregation of data to yield energy saving data dissemination.

Several energy management schemes have been proposed in the literature, most of which assuming that data acquisition and processing have an energy consumption significantly lower than communication; as such, they are targeted at minimizing the radio activity. Recently, the increasing exploitation of sensor networks for monitoring complex phenomena has highlighted that the above assumption does not hold in many practical application scenarios, mainly due to specific sensors whose power consumption cannot be neglected.The wide ranges of applications that can be deployed on top of WSN make it difficult to develop a single routing protocol. The design of the routing protocol is strictly dependent on the nature of the application requirements. Current trend of research in this area also focuses on routing algorithms designed for achieving better performance and longer network lifetime. As WSNs are qualitatively different from traditional network, they need a different routing approach for their data to route.

Keywords: **Routing protocol, Wireless sensor networks.**

I.INTRODUCTION

A.Overview of Wireless Sensor Network

Efficient design and implementation of wireless sensor networks has become a hot area of research in recent years, due to the vast potential of sensor networks to enable applications that connect the physical world to the virtual world. By networking large numbers of tiny sensor nodes, it is possible to obtain data about physical phenomena that was difficult or impossible to obtain in more conventional ways. In future as advances in micro-fabrication technology allow the cost of manufacturing sensor nodes to continue to drop, increasing deployments of wireless sensor networks are expected, with the networks eventually growing to large numbers of nodes (e.g., thousands). Potential applications for such large-scale wireless sensor networks exist in a variety of fields, including medical monitoring, environmental monitoring, surveillance, home security, military operations, and industrial machine monitoring etc.

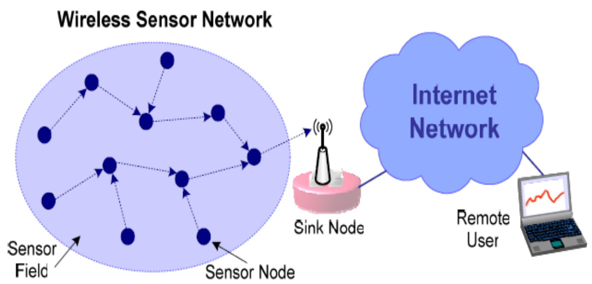

Figure 1. A Typical Sensor Network Architecture

Wireless sensor network (WSN) are highly distributed networks of small, lightweight wireless nodes, deployed in large numbers to monitor the environment or system by the measurement of physical parameters such as temperature, pressure humidity, sound, vibration, pollutants, and collectively relay their sensed data to the sink node. Each node in the networks are connected to each other.

Each sensor node in the network consists of three subsystems:

The sensor subsystem is used to sense the environment. The processing subsystem performs the local computations on the sensed data and the communication subsystem is responsible for sharing the sensed data with the neighbouring sensor nodes.

The sensor subsystem senses the data in the environment and the processing subsystem processes the sensed data where as the communication subsystem sends the aggregated data to the sink node. A sensor network consists of different types of sensors such as seismic, thermal, visual, and infrared. The size of a sensor node may vary from micro to macro and the cost varies from one to few hundred dollars. The sensor nodes communicate through wireless with in the short distance. The competence of each individual sensor node is limited and the comprehensive power of the entire network is adequate for the required task. The sensor nodes are organized themselves autonomously into a wireless network. Sensor nodes operated in the battery power expected to sense for a long time. In most of the situations, the battery cannot be recharged or replaced.

Wireless Sensor Networks (WSN) are intended for monitoring an environment. The main task of a wireless sensor node is to sense and collect data from a certain domain, process them and transmit it to the sink where the application lies.

Sensor networks have emerged as a promising tool for monitoring (and possibly actuating) the physical world, utilizing self-organizing networks of battery-powered wireless sensors that can sense, process and communicate. In sensor networks, energy is a critical resource, while applications exhibit a limited set of characteristics. Thus, there is both a need and an opportunity to optimize the network architecture for the applications in order to minimize resource consumed. The requirements and limitations of sensor networks make their architecture and protocols both challenging and divergent from the needs of traditional internet architecture.

A sensor network is a network of many tiny disposable low power devices, called nodes, which are spatially distributed in order to perform an application-oriented global task. These nodes form a network by communicating with each other either directly or through other nodes. One or more nodes among them will serve as sink(s) that are capable of communicating with the user either directly or through the existing wired networks. The primary component of the network is the sensor, essential for monitoring real world physical conditions such as sound, temperature, humidity, intensity, vibration, pressure, motion, pollutants etc. at different locations.

The tiny sensor nodes, which consist of sensing, on board processor for data processing, and communicating components, leverage the idea of sensor networks based on collaborative effort of a large number of nodes. Figure 1.2 shows the structural view of a sensor network in which sensor nodes are shown as small circles. Each node typically consists of the four components namely the sensor unit, central processing unit (CPU), power unit, and communication unit. They are assigned with different tasks. The sensor unit consists of sensor and Analog to Digital Converter(ADC). The sensor unit is responsible for collecting information as the ADC requests, and returning the analog data it sensed. ADC is a translator that tells the CPU what the sensor unit has sensed, and also informs the sensor unit what to do.

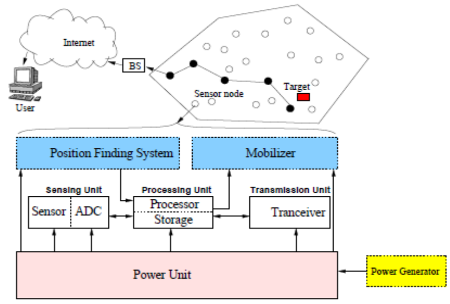

Figure 2. Structural view of sensor networks

Communication unit is tasked to receive command or query from and transmit the data from CPU to the outside world. CPU is the most complex unit which interprets the command or query to ADC, monitors and controls power if necessary, processes the received data, computes the next hop to the sink, etc. Power unit supplies power to sensor unit, processing unit and communication unit. Each node may also consist of the two optional components namely location finding system and mobilizer. If the user requires the knowledge of location with high accuracy then the node should pusses Location finding system and Mobilizer may be needed to move sensor nodes when it is required to carry out the assigned tasks.

Instead of sending the raw data to the nodes responsible for the fusion, sensor nodes use their processing abilities to locally carry out simple computations and transmit only the required and partially processed data. The sensor nodes not only collect useful information such as sound, temperature, light etc., but they also play a role of the router by communicating through wireless channels under battery-constraints. Sensor network nodes are limited with respect to energy supply, restricted computational capacity and communication bandwidth. The ideal wireless sensor is networked and scaleable, fault tolerance, consume very little power, smart and software programmable, efficient, capable of fast data acquisition, reliable and accurate over long term, cost little to purchase and required no real maintenance.

The basic goals of a WSN are to:

(i) determine the value of physical variables at a given location

(ii) detect the occurrence of events of interest, and estimate parameters of the detected event or events

(iii) classify a detected object

(iv) track an object

The important requirements of a WSN are

(i) Use of a large number of sensors

(ii) Attachment of stationary sensors

(iii) Low energy consumption

(iv) Self organization capability

(v) Collaborative signal processing

(vi) Querying ability

2.Data reporting method

Data reporting in WSNs is application-dependent and also depends on the time criticality of the data. Data reporting can be categorized as either time-driven, event driven, query-driven, or a hybrid of all these methods. The time-driven delivery method is suitable for applications that require periodic data monitoring. As such, sensor nodes will periodically switch on their sensors and transmitters, sense the environment, and transmit the data of interest at constant periodic time intervals. In event-driven and query-driven methods, sensor nodes react immediately to sudden and drastic changes in the value of a sensed attribute due to the occurrence of a certain event, or respond to a query generated by the BS or another node in the network. As such, these are well suited to time-critical applications. A combination of the previous methods is also possible. The routing protocol is highly influenced by the data reporting method in terms of energy consumption and route calculations.

3.Node/link heterogeneity

In many studies, all sensor nodes were assumed to be homogeneous (i.e., have equal capacity in terms of computation, communication, and power). However, depending on the application a sensor node can have a different role or capability. The existence of a heterogeneous set of sensors raises many technical issues related to data routing. For example, some applications might require a diverse mixture of sensors for monitoring temperature, pressure, and humidity of the surrounding environment, detecting motion via acoustic signatures, and capturing images or video tracking of moving objects. Either these special sensors can be deployed independently or the different functionalities can be included in the same sensor nodes. Even data reading and reporting can be generated from these sensors at different rates, subject to diverse QoS constraints, and can follow multiple data reporting models. For example, hierarchical protocols designate a cluster head node different from the normal sensors. These cluster heads can be chosen from the deployed sensors or be more powerful than other sensor nodes in terms of energy, bandwidth, and memory. Hence, the burden of transmission to the Base Station (BS) is handled by the set of cluster heads.

4.Fault tolerance

Some sensor nodes may fail or be blocked due to lack of power, physical damage, or environmental interference. The failure of sensor nodes should not affect the overall task of the sensor network. If many nodes fail, medium access control (MAC) and routing protocols must accommodate formation of new links and routes to the data collection BSs. This may require actively adjusting transmit powers and signaling rates on the existing links to reduce energy consumption, or rerouting packets through regions of the network where more energy is available. Therefore, multiple levels of redundancy may be needed in a fault-tolerant sensor network.

5.Sensor Networks

Wireless sensor network is a network of spatially distributed sensor nodes equipped with sensing, computing, power, and communication modules to monitor a certain phenomenon such as environmental data or object tracking. The positions of the sensor nodes may not be pre-determined and may require sensor nodes to be equipped with self organizing protocols. Sensor nodes observe and sense the phenomenon with a sensing module, process the data with a computing module, and send the data to a required destination over a radio interface with a communication module. A various survey has been carried out for the power consumption in the wireless sensor networks. Several energy management schemes have been proposed in the literature survey.

The development of sensor networks requires technologies from three different research areas: sensing, communication, and computing (including hardware, software, and algorithms)[6]. Thus, combined and separate advancements in each of these areas have driven research in sensor networks. Examples of early sensor networks include the radar networks used in air traffic control. The national power grid, with its many sensors, can be viewed as one large sensor network. These systems were developed with specialized computers and communication capabilities, and before the term "sensor networks" came into vogue.

6.Simulator Tool for WSN

Simulation tool for wireless sensor networks are increasingly been used to study sensor webs and to test new applications and protocols in this evolving research field. However, it requires a suitable model based on solid assumptions and an appropriate framework to ease implementation. In addition, simulation results rely on the particular scenario under study (environment), hardware and physical layer assumptions, which are usually not accurate enough to capture the real behavior of a WSN, thus, jeopardizing the credibility of results, the key properties to select suitable simulation environment are:

1) Reusability and availability.
2) Performance and scalability
3) Support for rich-semantics scripting languages to define experiments and process results
4) Graphical, debug and trace support

However there are various challenges associated with the available WSN simulators. For instance some simulator lack of available protocol models, which causes the increase of developing time, some simulators limit the scalability, etc. Additionally modeling problems arise when considering the new environment and the energy components . They also comprise scalability and accuracy.

Unique characteristics of the WSN

Streaming data

Sensor nodes[21] produce data continuously, usually at well defined time intervals, without having been explicitly asked for that data.

Real-time processing

Sensor data usually represent real-time events. Moreover, it is often expensive to save raw sensor streams to disk at the sink. Hence, queries over streams need to be processed in real time

Communication errors

Since sensors deliver data through multi-hop wireless communication, wireless errors affect the reliability and the delay of the distributed information reaching the sink.

Uncertainty

The information gathered by the sensors contains noise from environment. Moreover, factors such as sensor malfunction, and sensor placement might bias individual readings.

Limited disk space

Sensor nodes have strictly limited disk space. Hence, the information sent by the Sensors cannot be queried later.

Processing vs. communication

Energy expenditure[16] in data processing in WSN is much less compared to data communication. Hence, the data processing capabilities of Sensor nodes should be exploited in query process.

B.Importance's of Energy Efficient Routing Protocols

In order to meet the different types of application[13] the correct processing of collected information and their appropriate routing are the important considerations in routing protocols. These steps can be accomplished by introducing an efficient use of energy in sensor nodes. Each sensor node in he network is battery equipped and is therefore limited in terms of the energy. Consequently the network lifetime in sensor networks becomes limited. In most of the sensor network applications replenishment of power resources is nearly impossible. Another important factor that influences the consumption of more power in sensor networks is that each sensor node consumes power not only for sensing but also for processing the sensed data and transmitting/receiving them to/from neighbors. These explains why the efficient use of the power is the primary and most important considerations for designing a sensor network protocols.

Motivation of SPIN

Dissemination is the process of distributing individual sensor observations to the whole network, treating all sensor protocol as sink nodes

- Replicating complete view of the environment
- Enhance fault tolerance
- Broadcast critical piece of information.
- Limited supply of energy
- Energy-Conserving communication and computation
- Limited computational power
- Sophisticated network not suitable
- Limited communication resources
- Communication bandwidth is limited to a few hundred Kbps

SPIN protocol

- Negotiation
  - Before transmitting data, nodes negotiate with each other to overcome implosion and overlap
  - Only useful information will be transferred

  - Observed data must be described by meta-data
- Resource adaptation
  - Each sensor node has resource manager
  - Applications probe manager before transmitting or processing data
  - Sensors may reduce certain activities when energy is low

The Working Mechanism of SPIN 1

The working mechanism of SPIN 1 is a negotiation process, which establishes a connection based on a three-way handshake.

1) **Data broadcasting stage**

   When a sensor node (source node) has new data to send or forward, it first broadcasts ADV message to all its neighbours, and starts the timer. ADV message contains the metadata describing the data properties.

2) **Data requesting stage**

   After the neighbors have received ADV message, they first determine if they have enough energy to complete the task of the three stages. If its energy value is below the threshold, it will not make any response; otherwise, it checks whether it already has the data. If it already has the broadcast data, then it sets the flag of REQ message to 1, and back its energy value to the source node by REQ message. In SPIN protocol, if the node has the data already, it won't make any response. This point is also the biggest difference between SPIN 1 and SPIN. If the neighbors do not have the data but their energy is enough, in order to request to send data, the flag of REQ message will be set to 0, and back to the source node together with its energy value using the REQ message.

3) **Data transmission phase**

   The source node updates its neighbor list according to the flag of REQ message it receives and energy values. In the threshold time, the source node judges nodes' flag in its neighbor list, if the flag in the neighbor list are both 1 or 0, then filters the nodes whose flags are 0 and forwards data to the node who has the largest energy value; if there are the same energy value, it will randomly select a node to forward; if all the flags of nodes are 0, chooses the node who has the largest energy value to forward the data. If the time is longer than threshold, and all the flags are 1, it is the point that "data unaccessible" problem appears, the source node selects a node who has the largest value from its neighbor list and forwards data mandatory, then removes nodes who do not send REQ message from the neighbor list.

Modified SPIN (M-SPIN)

M-SPIN protocol to transmit information only to sink node instead of transmitting throughout the network. The protocol is based on SPIN family of protocol. In this proposed protocol, total number of packet transmissions is less. Therefore a significant amount of total energy can be saved.

Another interesting fact is that energy consumption not only depends on sensing the data but also on processing the sensed data and transmitting or receiving them to or from its neighbor nodes. So if it is possible to control number of transmission and receipt of messages, a significant amount of energy can be saved. An event that occurs in the WSN divides the entire network into two regions, A and B. Sensor nodes in region A are on the other side in the network in comparison with the sink node and sensor nodes in region B are on the same side and nearer to the sink node. Sensor nodes of region A can receive data from the event node, however, they will unnecessarily waste their energy in receiving or transmitting the data. In order to reach data to the sink node, data will have to travel more hops if they are sent via the nodes in region A. Thus, when an event occurs, it is always desirable that the data is sent through the nodes in region B. This would save the energy spent for transmission of a piece of data from an event node to the sink node. However, such selective transmission is not supported in the existing SPIN protocols.

In few applications such as alarm monitoring applications need quick and reliable responses. Suppose in forest fire warning system, quick response is needed before any disaster occurs. In this case, it is desirable that data must be disseminated towards the sink node very quickly. M-SPIN routing protocol is better approach for such type of applications than SPIN.

II.PROPOSED EEM-SPIN PROTOCOL

To overcome the problem faced in the M-SPIN protocol, an enhanced version of the M-SPIN protocol called Energy Enhanced M-SPIN (EEM-SPIN) is proposed.

EEM-SPIN uses cluster methodology and dynamic cluster head election to overcome the problem of using only few nodes for the forwarding of the data. For the formation of clusters and the election of cluster heads the Weighted Cluster Algorithm (WCA) is used.

Benefits of the EEM-SPIN are

- Avoids the problem of sensors destroyed earlier than other nodes due to usage of few sensor nodes for several transmissions
- Increase in the network lifetime due to the introduction of dynamic election of cluster heads

Simulator Tool for WSN

- Simulation tool for wireless sensor networks[1] are increasingly been used to study sensor webs and to test new applications and protocols in this evolving research field. However, it requires a suitable model based on solid assumptions and an appropriate framework to ease implementation. In addition, simulation results rely on the particular scenario under study (environment), hardware and physical layer assumptions, which are usually not accurate enough to capture the real behavior of a WSN, thus, jeopardizing the credibility of results, the key properties to select suitable simulation environment are:
- 1) Reusability and availability.
- 2) Performance and scalability
- 3) Support for rich-semantics scripting languages to define experiments and process results
- 4) Graphical, debug and trace support

III.CONCLUSIONS

In this research work, an energy enhanced version of the M-SPIN (EEM-SPIN) protocol has been proposed using weighted clustering algorithm (WCA) for WSN. It has the flexibility of assigning different weights and takes into account a combined metrics to form clusters automatically. Limiting the number of nodes inside a cluster allows restricting the number of nodes catered by a cluster head so that it does not degrade the MAC functioning. For a fixed cluster head election scheme, a cluster head with constrained energy may drain its battery quickly due to heavy utilization. In order to spread the energy usage over the network and achieve a better load balancing among cluster heads, reelection of the cluster heads may be a useful strategy.

EEM-SPIN utilizes factors like the node degree, remaining battery power, and node mobility for the cluster heads' election.

Such approach provides a reliable method of cluster organization for WSN. Simulation results indicated that the model agrees well with the behavior of the algorithm. The EEM-SPIN algorithm showed that the performance is better than SPIN, SPIN-1 and M-SPIN algorithms in the power strategies and the simulation set up showed the increase in the life time of a WSN.EEM-SPIN avoids the problem of sensors destroyed earlier than other nodes due to usage of few sensor nodes for several transmissions and increases the network lifetime due to the introduction of dynamic election of cluster heads.

Clustering technique is used in the EEM-SPIN and the cluster heads are elected using Weighted Clustering Algorithm (WCA). By these enhancements the problem of few nodes used several times for transmission is avoided.

Though the performance of the EEM-SPIN is better than other protocols analyzed, it may be possible to reduce the energy consumption for the cluster head elections. In future it may be possible to work in this problem by using different clustering algorithms that may be better suitable for the WSN.

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