IMPROVMENT OF ROUTING PROTOCOL IN WIRELESS SENSOR NETWORK FOR ENERGY CONSUMPTION TO MAXIMIZE NETWORK LIFETIME

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For my father

Who had major role to support me before he passed away.

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ABSTRACT

Wireless Sensor Networks (WSNs) consist of thousands of tiny nodes having the capability of sensing, computing, and wireless communications. Many routing, power management, and data dissemination protocols have been specifically designed for WSNs where energy consumption is an essential design issues. Due to energy constraints, the deployment and maintenance of WSNs should be easy and scalable to maintain the network lifetime.

A comprehensive energy efficient hierarchical cluster-based routing protocol was proposed for continuous stream queries in wireless sensor network. The routing scheme and algorithm has the common objective of trying to extend the lifetime of the sensor network. We introduce cluster head-set idea for cluster-based routing where several clusters are formed with the deployed sensors to collect information from target field. On rotation basis, a head-set member receives data from the neighbour nodes and transmits the aggregated results to the distance base station.

For a given number of data collecting sensor nodes, the number of control and management nodes can be systematically adjusted to reduce energy consumption quite significantly and prolongs the life time of sensor network. This document is a study about hierarchical cluster-based routing protocol algorithm where the implementation was done using Matlab simulator to study the performance of this algorithm in term of lifetime.

We show that existing energy models over-estimate life expectancy of a sensor node by 30–58% and also yield an “optimised” number of clusters which is too large. Simulation results show that our hierarchical clustering protocol balances the energy consumption well among all sensor nodes and achieves an obvious improvement on the network lifetime.

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LIST OF ABBREVIATIONS

WSN	-	Wireless Sensor Network
SIR	-	Signal to Interference Ratio
DCS	-	Digital cellular system
CDMA	-	Code Division Multiple Access
MT	-	Mobile Terminal
BS	-	Base Station
IS	-	Interim Standard
DS	-	Direct Sequence
TDMA	-	Time Division Multiple Access
RCC	-	Random competition based clustering
SN	-	Sensor Node
FDMA	-	Frequency Division Multiple Access
ADC	-	Analog Digital Converter
SYNC	-	Synchronization Period
DSMAC	-	Dynamic Sensor-MAC
CSMA	-	Carrier Sensor Multiple Access
SPIN	-	Sensor Protocols for Information Via Negation
GBR	-	Gradient Based Routing
IDSQ	-	Information Driven Sensor Querying
CADR	-	Constrained Anisotropic Diffusion Routing
CH	-	Cluster Head
GAF	-	Geographic Adaptive Fidelity
GEAR	-	Geographic and Energy Aware Routing
SAR	-	Sequential Assignment Routing
AWE	-	Single Winner
MWE	-	Multiple Winner

MANETS	-	Mobile Ad Hoc Network
LEACH	-	Low-Energy Adaptive Clustering Hierarchy
RAM	-	Random Access Memory
ms	-	meli second
EEPROM	-	Electronically Erasable Programmable Read Only Memory
OSI	-	Open Systems Interconnection
GPS	-	Global Positioning System

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CHAPTER I

INTRODUCTION

1.1 Overview

With the advance of technology, computers can be built in small size while still maintaining the capability of data processing and communication. A good example is the wireless sensor platform. A typical sensor node usually has a size close to a coin or even smaller, including the battery. It integrates the computing system, the radio component and the sensing units together on a single tiny platform.

The advancement in technology has made it possible to have extremely small, low powered devices equipped with programmable computing, multiple parameter sensingand wireless communication capability. Also, the low cost of sensors makes it possible to have a network of hundreds or thousands of these wireless sensors, thereby enhancing the reliability and accuracy of data and the area coverage as well. Also, it is necessary that the sensors be easy to deploy (i.e., require no installation cost etc). Protocols for these networks must be designed in such a way that the limited power in the sensor nodes is efficiently used. In addition, environments in which these nodes operate and respond are very dynamic, with fast changing physical parameters.

Since WSNs consist of numerous battery-powered devices, the energy efficient network protocols must be designed.

In conventional methods, sensor networks are composed of thousands of resource constrained sensor nodes and also some resourced base stations are there. All nodes in a network communicate with each other via wireless communication. Moreover, the energy required to transmit a message is about twice as great as the energy needed to receive the same message. The route of each message destined to the base station is really crucial in terms network lifetime: e.g., using short routes to the base station that contains nodes with depleted batteries may yield decreased network lifetime. On the other hand, using a long route composed of many sensor nodes can significantly increase the network delay.

But, some requirements for the routing protocols are conflicting. Always selecting the shortest route towards the base station causes the intermediate nodes to deplete faster, these results in a decreased network lifetime. At the same time, always choosing the shortest path might result in lowest energy consumption and lowest network delay.

Finally, the routing objectives are tailored by the application; e.g., real-time applications require minimal network delay, while applications performing statistical computations may require maximized network lifetime. Hence, different routing mechanisms have been proposed for different applications. These routing mechanisms primarily differ in terms of routing objectives and routing techniques, where the techniques are mainly influenced by the network characteristics.

To overcome energy efficient and improve the recovery from wireless sensor network there are several energy efficient communication models and protocols that are designed for specific applications, queries, and topologies. The routing algorithm proposed in this research is suitable for continuous monitoring of numerous widespread sensors, which are at a large distance from the base station. This research will explain our hierarchical cluster-based routing protocol, about how works perform quantitative analysis for our protocol and apply in Matlab to see the results obtained and evaluate the performance of the proposed protocol.

1.2 Problem Statements

The main problem in today wireless communications is to design wireless sensor network in which the energy consumption in sleep mode; be it hardware or software and should be solved in order for the protocol to achieve the desired network lifetime.

The problem in the traditional routing protocols are not well suited due to adjacent nodes may have similar data. So, rather than sending data separately from each node to the requesting node, it is desirable to aggregate similar data and send it.

In traditional wired and wireless networks, each node is given a unique id, used for routing. This cannot be effectively used in sensor networks. This is because, these networks being data centric, routing to and from specific nodes is not required.

The number of control and management nodes could not be acclimatized with the network environment. So, the sensor cannot be obtained the suitable state to be more of the time in sleep model when there is no signal.

This protocol explains how the routing algorithm proposed work to be suitable for continuous monitoring of numerous widespread sensors, which are at a large distance from the base station.

The results using Matlab are shown to see the energy consumption and the time estimation with respect to cluster diameter and the head set size.

1.3 Project Objectives

The objectives of this project are:

i. To Simulate wireless sensor network system based on a new approach method by using Matlab.
ii. Reduce the energy consumption.
iii. To design and develop a communication protocol which increases the network lifetime.

iv. To efficiently disseminate query and query results into the network.
v. To control and manage nodes according to the environment.

1.3 Project Scopes

The scopes of this project have various strategies such as:

i. Performance assurance & optimization module.

Protocol design to optimize the system current performance as to how the energy consumption is low duty sleep model and also the communication protocol. This module is responsible to adjust the network configuration and parameters, such like link weight, to achieve better energy utility and satisfy with the given constraints and capacity constraints.

ii. Routing algorithm protocol.
Developing the routing algorithm protocol command software for specific application, queries, and topologies. The hierarchical cluster-based routing schemes and algorithms have the common objective of trying to get better throughput and to extend the lifetime of the sensor network.

iii. Simulation and verification.
This algorithm is simulated and verified using Matlab. Performing quantitative analysis for our protocol and evaluating the performance of the proposed protocol was observed.

CHAPTER II

LITERATURE REVIEW

2.1 History of wireless communication

The history of wireless communications began in 1886 when H. Hertz generated and, thus, proved the presence of J. C. Maxwell's theoretically predicted electromagnetic waves. In the following year G.Marconi showed the possible of wireless communications, as clearly documented by the words delivered before the Royal Institution in 1897 from the Technical Director of the British Post Office, who supported G. Marconi:

"It is curious that hills and apparent obstructions fail to obstruct... Weather seems to have no influence; rain, fogs, snow and wind, avail nothing... The distance to which signals have been sent is remarkable. On Salisbury Plain Mr. Marconi covered a distance of four miles. In the Bristol Channel this has been extended to over eight miles and we have by no means reached the limit. It is interesting to read the surmises of others. Half a mile was the wildest dream."

In 1901 G. Marconi established a radio connection over the Atlantic. Sequence results, research and development to use one of the most widely applications in the wireless communication system, that of radio broadcasting. Using this medium, G. Marconi in 1937, said in a radio message:

“Radio broadcasting, however, despite the great importance reached and the still unexplored fields open to investigation, is not, in my opinion, the most significant application of modern Communications, because it is a one way communication only. Greater importance is related, in my opinion, to the possibility offered by radio of exchanging communications anywhere the correspondents are located, in the middle of the ocean, in the ice pack in the pole, in the desert plains or over the clouds in an airplane."

These words should prove to be true and one hundred years after G. Marconi's first experiments, the market of wireless mobile communications with duplex transmission is one of the fastest expanding of the world. The establishment for a widespread of wireless mobile communications was laid with the standardization of the first generation cellular mobile radio systems in the 1980s. The origins of digital communications go back to the work of S. Morse in 1837, demonstrating an electrical telegraphy system. The so-called Morse code represents the letters of the alphabet by sequences of dots and dashes and was the major of modern variable-length source coding.

The rapid development in the area of microelectronics with a continuous increase in device density of integrated circuits and the development of low-rate digital speech coding techniques made completely digital second generation cellular mobile radio systems created. Various second generation cellular systems were developed in the 1990s. Most of these systems use Time Division Multiple Access (TDMA), such as the Global System for Mobile Communications (GSM) and the Digital Cellular System 1800 (DCS1800) in Europe, the Interim Standard (IS-54) in the USA, and the Personal Digital Cellular (PDC) system in Japan. With TDMA, the time axis is subdivided into different non-overlapping time slots where each user has time slot; TDMA is combined with Frequency Division Multiple Access (FDMA) to reduce the hardware complexity of an otherwise extremely broadband system and to increase the flexibility of the system.

(Heinzelman et al., 2000) describes the LEACH protocol, which is a hierarchical self-organized cluster-based approach for monitoring applications. The data collection area is randomly divided into several clusters. Based on Time Division Multiple Accesses (TDMA), the sensor nodes transmit data to the cluster heads, which aggregate and transmit the data to the base station. A new set of cluster heads are chosen after specific time intervals. A node can be re-elected only when all the remaining candidates have been elected.

Parallel to the TDMA based second generation standards, the IS-95 was developed in the USA, used Code Division Multiple Access (CDMA) with direct sequence (DS) spectrum spreading, and combined with FDMA. The origins of CDMA go back to the beginnings of spread spectrum communications in the first half of the 20st century (Gilhousen et al., 1991).

Primary applications of spread spectrum communications put in the development of secure digital-communication systems for military use. Since the second half of the 21st century, spread spectrum communications became of great interest also for commercial applications, including mobile multi-user Communications.

In 1981, Baker and Ephremides proposed a clustering algorithm called “Linked Cluster Algorithm (LCA)” (Baker and A. Ephremides, 1981) for wireless networks. To enhance network manageability, channel efficiency and energy economy of MANETS, clustering algorithms have been investigated in the past. Lin and Gerla investigated effective techniques to support multimedia applications in the general multi-hop mobile ad-hoc networks using CDMA based medium arbitration in (C.R. Lin and Gerla, 1997). Random competition based clustering (RCC) (K. Xu and Gerla, 2002) is applicable both to mobile ad hoc networks and WSN. RCC mainly focuses at cluster stability in order to support mobile nodes.

Cluster-based approaches are suitable for habitat and environment monitoring, which requires a continuous stream of sensor data. Directed diffusion and its variations are used for event-based monitoring. (Intanagonwiwat et al., 2000) describes a directed diffusion protocol where query (task) is disseminated into the network using hop-by-hop communication. When the query is traversed, the gradients (interests) are established for the result return path. Finally, the result is routed using the path based on gradients and interests. (Braginsky and Estrin, 2002), a variation of directed diffusion, use rumor routing to flood events and route queries; this approach is suitable for a large number of queries and a fewer events.

(Ye et al., 2004) describe a contention-based medium access protocol, S-MAC, which reduces energy consumption by using virtual clusters. The common sleep schedules are developed for the clusters. Moreover, in-channel signalling is used to avoid overhearing. (Cerpa and Estrin, 2004) propose ASCENT that operates between routing and link layers. Any routing or data dissemination protocol can use ASCENT to manage nodes redundancy. In ASCENT, nodes monitor their connectivity and decide whether to become active and participate in the multihop networking. Moreover, nodes other than active nodes remain in passive state until they get a request from active nodes.

As an extension of LEACH (Heinzelman et al., 2000), our proposed protocol introduces a head-set for the control and management of clusters. Although S-MAC (Ye et al., 2004) divides the network into virtual clusters, the proposed protocol divides the network into a few real clusters that are managed by a virtual cluster-head.

2.2 Wireless Sensor Networks (WSN)

According to definition given in (Sohraby et al., 2007), “A wireless sensor networks (WSNs) consists of densely distributed nodes that support sensing, signal processing, embedded computing, and wireless connectivity; sensors are logically linked by self-organizing means. WSN typically transmit information to collecting (monitoring) stations that aggregate some or all of the information. WSN have unique characteristics, such as, but not limited to power constraints and limited battery life for the WNs, redundant data acquisition, low duty cycle, and, many-tooneflows.” Although the development of this kind of networks was initially for military applications, but nowadays they are used in many different industrial and civilian application areas, including industrial process monitoring and control, healthcare applications or traffic control. WSNs are composed of a set of sensor nodes, typically equipped with some sensors, a radio transceiver or other wireless communications device, a small microcontroller, and an energy source, usually a battery. Therefore, these devices make up a network with sensing, data processing and routing capabilities.

Advantages of wireless sensor networks knowing about the advantages of WSNs, it is enough to be conscious of the wide variety of applications where WSNs are present, typically, WSNs applications involved in some kind of monitoring, tracking, or controlling. Some of the numerous applications and the benefits that WSNs bring are:

i. Environmental Monitoring: watershed management, forest fire prediction or irrigation management. It helps to preserve and maintain the natural resources.

ii. Structural Health and Industrial Monitoring: machinery failure detection. It reduces the maintenance costs and prevents from catastrophic failures.

iii. Civil Structure Monitoring: health monitoring of large civil structures, like bridges or skyscrapers. It prevents from human catastrophes.

iv. Medical Health-Care: telemedicine, remote health monitoring. Allows doctors in remote and rural areas to consult with specialists in urban areas, remote handling medical equipment (tele-surgery), etc.

2.2.1 Drawbacks of wireless sensor networks

Although WSNs offer many advantages in a numerous application, there are several constraints which will affect directly the networks and devices' design. Some of the most significant constraints are:

i. Power consumption: this constraint affects directly on the nodes'operating lifetime. With energy-aware and transmitting power adjusting capacity protocols, the energy consumption can be highly reduced, and thus increased the network lifetime.

ii. Self-configuration capability and good scalability: this issue can be solved by choosing and implementing the suitable network protocol.

iii. Fault tolerance: if all the devices process the same signal (temperature, humidity, etc.), the network will offer replication in a native manner. If the devices do not develop the same function, the device replication can solve the fault tolerance problem, and this solution shouldn't affect the scalability due to the nature of the network.

This thesis proposed a mechanism to will counter the first drawback of WSNs which is the power consumption by designing and implementing the appropriate algorithm in a routing protocol.

2.3 Wireless Sensor Network Model

Unlike their ancestor ad-hoc networks, WSNs are resource limited, they are deployed densely, they are prone to failures, the number of nodes in WSNs is several orders higher than that of ad hoc networks, WSN network topology is constantly changing, WSNs use broadcast communication mediums and finally sensor nodes don't have a global identification tags (Karpand K, 2000). The major components of a typical sensor network are:

- Sensor Field: A sensor field can be considered as the area in which the nodes areplaced.
- Sensor Nodes: Sensors nodes are the heart of the network. They are in charge of collecting data and routing this information back to a sink.
- Sink: A sink is a sensor node with the specific task of receiving, processing and storing data from the other sensor nodes. They serve to reduce the total number of

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