Implementation of Routing Protocol and Integration with IoT For Smart Parking.

SYNOPSIS
Mini Project -I

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ABSTRACT

Wireless sensor networks (WSN) are related to much imprecision and various discrepancies that are inborn to it. Despite of various challenges, WSN finds wide applicability in environmental monitoring, agricultural field, industrial usage, and military applications and so on. Sensors have limited energy, as they are battery driven and are of small size. WSN, when deployed in hostile environments, it is impractical to change batteries. So, the proper consumption of energy plays a major role in deciding performance of WSN.

Wireless ad hoc network is a collection of nodes that act like a host as well as a router. Nodes move randomly and organize themselves arbitrarily. As a result the network topology changes rapidly and unpredictably. Communication among nodes can be point-to-point or multi-hop. Point-to-Point communication is possible when points are within the radio range of each other. However, in multi-hop communication a packet reaches the destination through multiple number of intermediate nodes, in this case they act as relay nodes. These relay nodes transmit their own traffic as well as traffic from other nodes.

In this, mini project we implement routing protol for WSN and try to improve its performance to integrate it with IoT and subject it for smart parking systems for smart cities.

ACRONYMS

BS	Base Station
CH	Cluster Head
DEEC	Distributed Energy Efficient Clustering
DSDV	Destination Sequenced Distance Vector
DSR	Dynamic Source Routing
DWEHC	Distributed Weight based Energy-Efficient Hierarchical Clustering
EEHC	Energy Efficient Heterogeneous Clustering
HEED	Hybrid Energy-Efficient Distributed
IoT	Internet of Things
LEACH	Low Energy Adaptive Clustering Hierarchy
QoS	Quality of Service
REAC-IN	Regional Energy Aware Clustering Scheme with Isolated Nodes
WSN	Wireless Sensor Network

Contents

Chapter 1

Introduction

1.1 Significance of Wireless Sensor Networks

The real-world physical environment consists of large and diverse information sources, such as light, temperature, motion, seismic waves, and many others. For a better understanding of the environment, it is necessary to capture the information from multiple disparate sources, and the wireless sensor network is an easy to deploy infrastructure allowing capturing of such rich information. A wireless sensor network (WSN) consists of spatially distributed autonomous sensors to monitor the physical environment, and to co-operatively pass their data through the network to a main node or central location (base station). Modern wireless sensor networks are bi-directional, allowing transmission of information being monitored from nodes to central node or base station, as well as enabling control of sensor activity from base station to sensors. The development of wireless sensor networks was motivated primarily by military applications such as battlefield surveillance; but today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, environmental detection, and habitat monitoring. The WSN is built of ”nodes” from a few to several hundreds or even thousands of nodes (sometimes called as motes), 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, although functioning ”motes” of genuine microscopic dimensions have yet to be created. The cost of sensor nodes is similarly variable, 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 determined based on routing or flooding protocol [1,2]. A wireless sensor network can be used for various applications; we can summarize some of the useful applications as the following:

1. **Habitat/Area monitoring:** Area monitoring is a common application of WSNs. In area monitoring, the WSN is deployed over a region where some phenomenon is to be monitored. A military example is the use of sensors to detect enemy intrusion; a civilian example is the geo-fencing of gas or oil pipelines. When the sensors detect the event being monitored (heat, pressure), the event is reported to one of the base stations, which then takes appropriate action (e.g., send a message on Internet or to a satellite). Similarly, wireless sensor networks can use a range of sensors to detect the presence of vehicles ranging from motorcycles to trains and cars.

2. **Environmental/Earth monitoring:** The term Environmental Sensor Networks [3], has evolved to cover many applications of WSNs to earth science research. This includes sensing volcanoes oceans, glaciers and forests.

3. **Critical Events/Forest fire detection:** A network of sensor nodes can be installed in a forest to detect when a fire has started. The nodes can be equipped with sensors to measure temperature, humidity and gases which are produced by fire in the trees or vegetation. Early detection is crucial as it will allow protection of highly valued resources.

4. **Data Logging:** Wireless sensor networks are also used to collect data for monitoring information from the environment. For example, monitoring the temperature in a fridge to the level of water in over flow tanks in nuclear power plants.

As outlined above, a wide spectrum of applications ranging from habitat monitoring to battlefield surveillance can be benefited by deploying the wireless sensor network (WSN) technology [1, 2]. Some of the benefits include low cost, easy deployment, high fidelity sensing, self-organization of WSNs, among several other benefits [2]. However, despite many opportunities the wireless sensor networks provide, using WSN technology comes with great challenges. These challenges are associated with characteristics of wireless sensor networks namely:

1. Power consumption constraints for nodes using batteries or energy harvesting.

2. Ability to cope with node failures.

3. Mobility of nodes.

4. Communication failures.

5. Scalability to large scale of deployment.

6. Ability to withstand harsh environmental conditions.

7. Ease of use.

Out of these characteristics, need to operate under severe resource constraints is one of the biggest challenges with WSNs, which makes efficient design highly necessary.

A wireless sensor network, or WSN for short, is a large-scale network comprising of wirelessly interconnected transducer devices called sensor nodes or "mote". A sensor node, as the name implies, can have one or more sensor modules, for sensing light, temperature, humidity, pressure, and sound. In addition, each sensor node can include four other components, namely: memory, processing, communication, and battery modules. The first use of sensor networks can be traced back to the cold war era, when a distributed network of radars, and hydrophones were deployed to monitor the skies and oceans, respectively [4]. Of late, contemporary monitoring networks use tiny and resource-constrained sensor nodes.

The field of wireless sensor networks (WSN) has become a focus of intensive research in recent years and various theoretical and practical questions have been addressed. It has drawn a lot of attention as a result of the possibility of coupling these devices with their surroundings. Well beyond their direct use, such as surveillance and environmental monitoring, WSNs can help us pursue one of the ultimate goals in information technology, namely ambient intelligence [5]. The small size and wireless communication capability of sensor nodes in a WSN provides us with not only the information about the physical world around us, but also the flexibility to have them integrated deeply within building material, fabrics, and embedded in inaccessible or hostile locations in the real world operating scenarios. By using wireless sensor networks we can develop automated intelligent systems that can co-operate with each other to exchange information concerning their internal states and the conditions of the physical environment around them, and provide services to users, and prevent disasters with better efficiency and robustness without any human intervention [5]. The evolution of sensor networks has extended the computing horizons from desktop computing to the entire physical environment computing (ambient computing). Due to this, the user-driven model of traditional computing has shifted to an event-driven model in sensor networks. Noticeably, the event-driven model entails that the volume of data generated by stimuli of environmental phenomena exceeds the rate of any userinput by multiple folds. The traditional model for interpreting this large volume of measurements normally involves sending large sensory data to a base-station for analysis. The collected data could sometimes be locally processed before being sent in the network, and could involve intermediate sensor nodes for further processing of the data. Finally, the sensory data is integrated centrally at the base station to infer the status of the observed environment at the base-station.

The base station performs optimal detection and tracking mechanism based on conventional signal processing methods. This traditional model, however, suffers from many limitations due to resource-constraints and the bandwidth limitations. The computational power and speed of base station computers can create a processing bottleneck and can cause total system failure if the base-station fails. Further, relaying all sensory data of geographically dispersed sensor nodes to a centralized base-station is generally ineffective as it requires a significant communication overhead leading to resource depletion and shortening of the lifetime of the network. Several researches work in the past [6, 7], tried to address these challenges using the methods drawn from signal communication theory in telephony/telegraphy, where the main purpose is the reliable transmission of data in the presence of noisy channels. However, these approaches did not appear to work well for wireless sensor networks, as the purpose of WSNs is not just the reliable transmission of data from sender to receiver, but also the detection of occurrence of catastrophic events from large sets of sensory data, such as earthquakes, tsunamis, forest fires, land cover usage etc. Most of the current methods focus on solving the local short-term problem of enhancing the communication capacity between nodes or managing the resources efficiently for a small WSN, with studies conducted on simulated setups. Interpreting catastrophic global events from large volumes of data is a challenging task; and research efforts needs to focus on development of novel approaches to improve the detection accuracy and detection quality of high level information, where the WSN is deployed, such as, accurate physical environment event detections, in addition to reduction in amount of data and energy consumption in the sensor nodes in the network. Approaches to reduce the energy consumption is one of the most important requirements, as there is no continuous power support for battery powered sensors in WSNs deployed in the field. The life time of a sensor is very restricted based on very limited power source. Therefore, keeping the energy consumption in the lowest level is one the key requirement.

1.2 Motivation

Energy usage and management in network is such a crucial task. Researchers found that energy aware routing comprised numerous concerns in different applications. QoS routing protocols, energy efficient routing, and location-aware routing protocols, data-centralized routing protocols and hierarchically routing protocols are some of classes of routing [8]. The heterogeneous networks contains various type of sensors with diverse sensing, processing and communication capabilities. They are intended to provide facilities to any individual present anywhere at any point of time using anything. The kind of noticeable growth WSN is witnessing it is bound to become main technology for IoT . Though, integrating of WSNs into IoT presents a novel challenge because of sole features of sensors such as miniature size, susceptible to attacks and energy constraints. Taking an example of MicaZ mote, it consumes 809.4 mW while transmitting and 993.6 mW during reception, respectively. Developing an efficient routing protocol will minimize WSNs' energy consumption and extend the lifetime of the IoT networks.

Chapter 2

RELATED WORK AND LITERATURE SURVEY

In this chapter we summarize the related previous works that has been published in various journals , books and chapters.

2.1 Litrature Survey

In [9], authors proposed a radially optimized zone-divided energy-aware WSN protocol using bat algorithm. Proposed scheme considered distance from the BS, along with the angle at which the WSN develops. By considering the angle at which the WSN develops, this protocol enables like chances for each node in WSN to have sufficient fields for communicating and its routing operations.

Low Energy Adaptive Clustering Hierarchy (LEACH) [10] is novel schemes proposed by Heinzelman et al. in 2005. But, due to random CH selection uniform distribution of CH is not guaranteed, which can lead to unbalanced energy consumption in network.

Balance in energy consumption by the nodes was first attempted by the canonical LEACH. The lacunas present in LEACH are:

1. CH selection is not based on residual energy.
2. Probability of becoming CH is based on assumption of same initial energy of all nodes which is not true for heterogeneous networks.
3. Every round has different number of cluster heads as shown in Fig.2.1 : Cluster Heads in LEACH , as CH selection is probabilistic. Chances of same node becoming CH again are more.

Junping et al. [11], proposed TB-LEACH (time based- Leach). TB-LEACH modified the CH assortment algorithm of LEACH to improve the division of clusters. CH selection is not based on

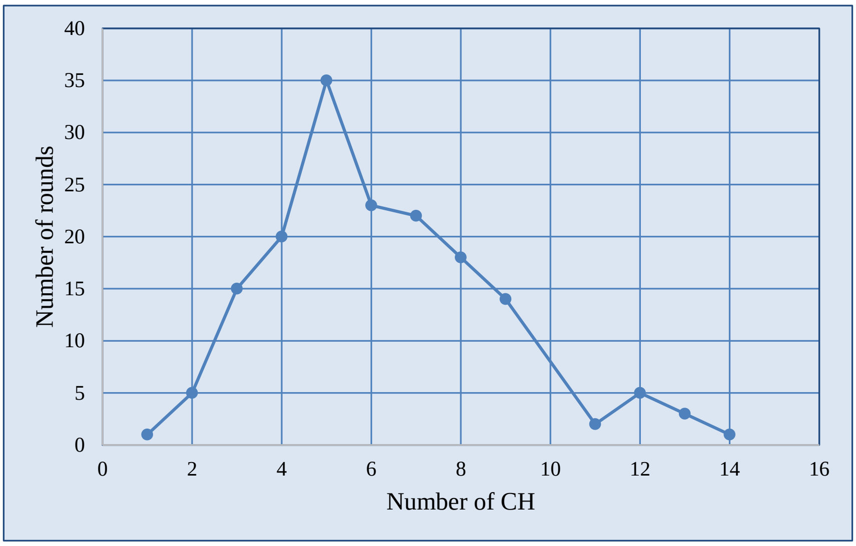

Fig. 2.1: CH in LEACH

probability, instead it depends on random time interval. Nodes in the network generate random time interval and nodes with the shortest time interval will win and elected as CH. Authors tried to maintain balance and uniform partition of CH. Rest of the processing was similar to LEACH. Kumar et al. [12] proposed energy efficient heterogeneous clustering scheme (EEHC) for WSN. They studied the influence of heterogeneity of sensors in context of energy in WSN that are hierarchically clustered. They proposed optimal probability of a sensor being chosen as a CH as a function of spatial density. Using weighted probability, they assisted in improving lifetime of network.

Younis et al., [13] proposed a hybrid energy-efficient distributed clustering (HEED). In HEED, CH are selected spasmodically as directed the residual energy of the node and an optional variable inter cluster cost of communication. Sensor with highest residual energy is selected as CH and are well spread over the area to be monitored. Every node in HEED is associated with one cluster and communicates with its CH. However, due to complex routing this limits the latency of collecting information.

Ding et al., [14], to achieve optimum cluster size, proposed distributed weight based energy-efficient hierarchical clustering (DWEHC). In DWEHC firstly, each node traces out its neighbors and then calculate its weight depending upon residual energy and distance from its neighbors. The node with highest weight is elected as CH. The number of clusters and amount of energy required to reach CH decides the number of levels in hierarchy. The clusters produced by the algorithm are familiar to HEED and intra-cluster communication is way too high.

The authors of [15], proposed a distributed clustering scheme to form hierarchical control for multi-hop wireless networks. The authors proposed a clustering on different levels depending upon cluster size and extent of overlap expecting topology alteration to be reasonable and occasional. Although placing various nodes on various levels consumed a lot of extra energy.

Sing et al., [16], proposed a new method of an energy-efficient homogeneous clustering algorithm for WSN, where networks lifetime is enhanced by confirming uniform deployment of the nodes in the clusters. Cluster heads are selected on the basis of (a) the residual energy of present CH, (b) holdback, and (c) nearest hop distance of the sensor. Throughput of the network is also improved, although, limiting the number of sensors for cluster is not feasible.

Qing et al., developed a clustering scheme entitled distributed energy efficient clustering (DEEC) in [17], to improve energy efficiency for WSN. In DEEC, residual energy of node was taken into consideration. Then the ratio between the residual energy of a sensor node and the average energy of the network was evaluated. Nodes having higher residual energy ratio had higher probability of being designated as CH.

In [18], authors proposed medium-contention based energy- efficient distributed clustering (MEDIC) scheme, which is self- organized energy efficient clustering scheme. Sensor makes decision whether to bid or not to bid for cluster head selection.

In [19], authors proposed a regional energy aware clustering scheme with isolated Nodes (REAC-IN) for WSN. Here, CH are designated based on the weights of sensor nodes. Weights are evaluated taking into consideration the residual energy of sensor nodes along with the regional average energy of the cluster to which node belongs. This again suffers from disadvantage of same node being opted as CH reducing networks lifetime.

Authors in [20] proposed EECRP for enhancing networks performance for sensor network based IoT. The proposed algorithm consists of new distributed cluster formation skill that allows the self-organization of sensor nodes, a rotation of cluster head based on centroid of nodes and a scheme to plummet the consumption of energy for communication over long distance.

A grid-based clustering algorithm with network load is presented in [21]. Authors estimated the load of the network and prepared the load model. They deduced that the number of packets carried in every platform is directly connected with the length of the grid. Finally, after calculating the optimal grid length, the network is partitioned into unequal grids depending upon optimum cluster and all nodes of grid are made to join clusters.

In [22] authors proposed a novel energy aware hierarchical cluster-based (NEAHC) routing protocol with two goals: minimizing the total energy consumption and ensuring fairness of energy consumption between nodes. They model the relay node choosing problem as a nonlinear programming problem and use the property of convex function to find the optimal solution and also evaluate the proposed algorithm via simulations at the end of this paper. To summarize; following observations were made in studies till date.

a) Uniform distribution of cluster head was not taken care of for maximal coverage.

b) No endeavor was made to group isolated nodes to save energy. The studies have considered routing efficiency for the isolated nodes by providing them connectivity with the already connected members rather than grouping them independently to further ensure the reduced energy consumption.

We propose a novel algorithm in which clustering would be done keeping track of residual energy . moreover once a node is selected as cluster head it will not take part in selection process for next ten rounds.

Chapter 3

RESEARCH DIRECTIONS

3.1 Research Gaps

As we have discussed in the last section, clustering techniques are required and beneficial even for highly dynamic IoT systems. With 3GPP standard communication, the deployment becomes more flexible and the connectivity problem is solved straightway. The first challenge comes from the fundamental nature of IoT systems—the vastly diversity. The things in the field are highly heterogeneous. Some of the nodes can have low capabilities and some of them can be extremely advanced. In order to connect everything in smart cities, cheap and energy efficient transmit-only devices will be massively deployed [154] alone with other highly advanced sensors.

The second challenge is that cost for transmission. The energy cost is still a critical concern in IoT systems. Besides, since mobile network is also involved, the financial cost should be well controlled. For example, the use of LTE will be more expensive than that of WiFi. The third challenge is how to improve user utility.

The fourth challenge is how to utilize the intelligent components in the core network.

The fifth challenge is how to manage and utilize mobility in the networks. Some work has been done specifically addressing mobility problem in WSNs [155], [157], [158]. With the development of IoT systems, supporting the connectivity of the fast moving things (such as vehicles in the connected cars system) and utilizing the mobility to improve the communication efficiency are challenging. One of the general objectives for 5G is to improve QoS and QoE. Clustering techniques, in order to adapt to 5G and more complicated scenarios in IoT systems, the above challenges need to be addressed. The corresponding research in those directions should be further investigated. Cross layer design is also highly recommended to address multiple issues collaboratively. We sincerely indicate that more advanced studies should be undertaken in the current scenario with 5G rather than the traditional WSN usages.

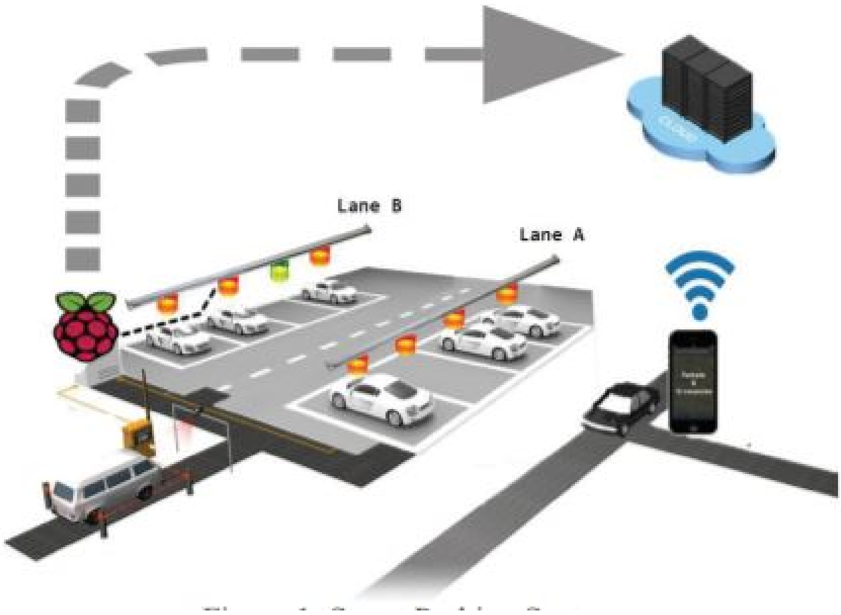

Fig. 3.1: Smart Parking

3.2 Objectives

1. Challenges in wireless sensor networks: To Implement LEACH. To summarize the physical parameters like environment monitoring, such as the energy efficiency, the event detection/monitoring accuracy, and quality of service aspects, based on evidence-based data driven machine learning techniques.

2. Improvement in Energy Efficiency: To propose the novel algorithm that may improve the performance of Routing Protocol

3. Integrating Clustering Technique for Internet of Things (IoT): Internet of Things is a paradigm shift in networking that seeks to connect virtually all things on the planet. Given the constrained nature of smart devices, energy efficient routing would play a key role in successful deployment of such networks. Clustering algorithms organize nodes of a network into groups or clusters and a specific designated node, cluster head is responsible for its cluster. Clustering algorithms have been particularly suggested in the context of WSN but their application may also address similar challenges in Internet of Things IoT.

4. Integrating WSN with IoT for smart Parking scenario. In recent times the concept of smart cities have gained grate popularity. Thanks to the evolution of Internet of things the idea of smart city now seems to be achievable. Consistent efforts are being made in the field of IoT in order to maximize the productivity and reliability of urban infrastructure. Problems such as, traffic congestion, limited car parking facilities and road safety are being addressed by IoT. Fig.3.2: Smart Parking, shows the praposed smart parking scenerio. In this objecte, we present an IoT based cloud integrated smart parking system.

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