Wireless Sensor Networks & Its Application Domain

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ABSTRACT

Conventionally, ecological monitoring is achieved by a little number of expensive and high accuracy sense unities. Composed data are retrieved openly from the tools at the end of the testing and after the unit is improved. The implementation of a wireless sensor network provides an substitute answer by deploying a bigger amount of disposable sensor nodes. Nodes are ready with sensors with less accuracy, however, the network as a whole provides better spatial resolution of the area and the users can have access to the data immediately. This paper survey a complete analysis of the existing solutions to maintain wireless sensor network ecological monitoring application.

1. Introduction

Environmental monitoring has a long history. In early times analog mechanisms were used to measure physical environmental parameters. Some of them with the ability to record the values on paper dish. The old mechanisms recorded data at specific intervals and required human intervention to download them. Some years ago, digital data loggers have replaced the old mechanical. The digital data loggers are more easy to operate and to maintain and more cheaper than the old mechanisms. Digital data loggers may also be combined with long-range communication networks, such as GSM, to retrieve data from remote sites. However, digital data loggers have some drawbacks. The digital data loggers solution, usually provide monitoring at one point only and in many cases multiple points need to be monitored.

There is not a standard to store data and to communicate with the data logger, so several different solutions are used. Recent advances in micro-electro- mechanical systems and in low-power wireless network technology have created the technical conditions to build multi-functional tiny sensor devices, which can be used to observe and to react according to physical phenomena of their surrounding environment [1]. Wireless sensor nodes are low-power devices equipped with processor, storage, a power supply, a transceiver, one or more sensors and, in some cases, with an actuator. Several types of sensors can be attached to wireless sensor nodes, such as chemical, optical, thermal and biological. These wireless sensor devices are small and they are cheaper than the regular sensor devices. The wireless sensor devices can automatically organize themselves to form an ad-hoc multi hop network. Wireless sensor networks (WSNs), may be comprised by hundreds or maybe thousands of ad-hoc sensor node devices, working together to accomplish a common task. Self-organizing, self-optimizing and fault- tolerant are the main characteristics of this type of network [2]. Widespread networks of inexpensive wireless sensor devices offer a substantial opportunity to monitor more accurately the surrounding physical phenomena's when compared to traditional sensing methods [3]. Wireless sensor network has it own design and resource constrains [4]. Design constrains are related with the purpose and the characteristics of the installation environment. The environment determines the size of the network, the deployment method and the network topology. Resources constrains are imposed by the limited amount of energy, small communication range, low throughput and reduced storage and computing resources. Research efforts have been done to address the above constrains by introducing new design methodologies and creating or improve existing protocols and applications [1,2]. This paper provides a review on wireless sensor. networks solutions to environmental monitoring applications. The remainder of this paper is organized as follows. Section II gives an overview of sensor network platforms. Section III analyses the standard IEEE 802.15.4 [5] while Section IV overviews recent sensor architectures. WSN environmental monitoring projects are presented in Section V and challenges related with environment sensor networks are studied in Section VI. Section VI concludes the paper and addresses future research challenges related to WSN networks deployment.

Applications of Wireless Sensor Network

Applications of WSNs can be mainly categorize into following five categories-

1.1 NETWORK

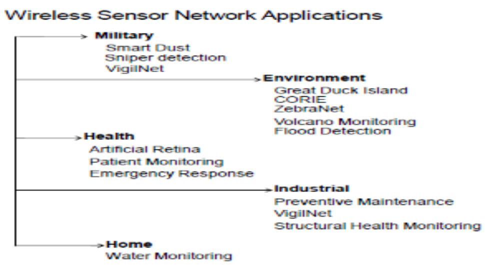
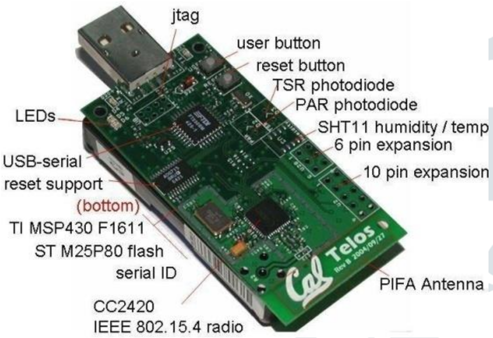


Figure 1.2 contains the following components:

1.2 WIRELESS SENSOR NETWORK PLATFORM

1.2.1 HARDWARE

A sensor node, also known as a mote, is a node in a wireless sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network. A mote is a node but a node is not always a mote .



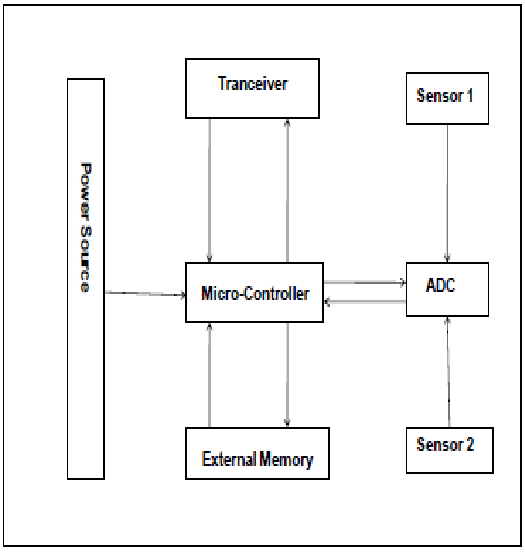


Figure 1.2 Architecture of Sensor Node

Controller: The controller performs tasks, processes data and controls the functionality of other components in the sensor node.

Transceiver: The functionality of both transmitter and receiver are combined into a single device known as transceiver. Transceivers often lack unique identifiers.

External Memory: From an energy perspective, the most relevant kinds of memory are the on-chip memory of a microcontroller and Flash memory**.**

Power Source: The sensor node consumes power for sensing, communicating and data processing. More energy is required for data communication than any other process**.** Power is stored either in batteries or capacitors. Batteries, both rechargeable

Sensors: Sensors are hardware devices that produce a measurable response to a change in a physical condition like temperature or pressure.

TelosB: MEMSIC's TelosB is available as a TPR2400 Processor Radio and TPR2420 Mote, both are open-source platform designed to enable cutting-edge experimentation for the research community. The TPR2400 and TPR2420 bundles all the essentials for lab studies into a single platform including: USB programming capability, an IEEE 802.15.4 radio with integrated antenna, a low-power MCU with extended memory. The TelosB platform was developed and published to the research community by UC Berkeley. This platform delivers low power consumption allowing for long battery life as well as fast wakeup from sleep state.

The TPR2420 is compatible with the open-source TinyOS distribution. The TPR2400 and 2420 boards are powered by two AA batteries and when plugged into the USB port for programming or communication, power is provided from the host computer i.e., when attached to the USB ports no battery pack is needed .Both TPR2400 and 2420 provide users with the capability to interface with additional devices. The two expansion connectors and onboard jumpers may be configured to control analog sensors, digital peripherals and LCD displays.

Software

In wireless sensor network, many number of software are used. These software are-

TinyOS: TinyOS is the first operating system specifically designed for wireless sensor networks. TinyOS is not based on multithreading but it is event-driven programming model based. TinyOS programs are combination of tasks and event handlers with run-to-completion semantics. Event handlers can post tasks that are scheduled by the TinyOS kernel some time later. TinyOS signals the appropriate event handler to handle the event when an external event occurs, such as an incoming data packet or a sensor reading. TinyOS applications are written in nesC, a dialect of the C language optimized for the memory limits of sensor networks. Its supplementary tools are mainly in the form of Java and shell script front-ends.

TinyDB: To use TinyDB [55], you install its TinyOS components onto each mote in your sensor network. TinyDB is used as a query processing

system for extracting information from a network of motes. Unlike other solutions for data processing in TinyOS, TinyDB does not need to write embedded C code for sensors. Instead, it gives a simple, SQL-like interface to identify the data you want to extract. TinyDB provides a simple Java API for writing PC applications that query and extract data from the network; it also comes with a simple graphical query-builder and result display that uses the API. Along with additional parameters, like the rate at which data should be refreshed much as you would pose queries against a traditional database. Given a query specifying your data interests, TinyDB integrates that data from motes in the environment, filters it, aggregates it together, and routes it out to a PC. TinyDB does this task through power-efficient in-network processing algorithms. TinyDB frees you from the burden of writing low-level code for sensor devices, including the sensor network interfaces. The main objective of TinyDB is to make your life as a programmer significantly easier. And allow data-driven applications to be developed and deployed much faster than what is currently possible.

2. COMMUNICATION METHODS IN WSN

As shown on the left in Figure 1.6, when sensors can disseminate the data straight forward to the sink then they can design a star topology [17]. Using a single hop method, each sensor node interacts straight with the sink. However, radio communication power should be saved in order to preserve energy and sensor networks often cover large geographic areas; so **multi-hop method** shown on the right in figure 2.1 is the more conventional case for WSNs.

In multi-hop, nodes must transmit and apprehend their data, and aid as relays for other nodes. In other words, multi-hop nodes must cooperate to convey sensor data towards the sink. Multi-hop nodes often have the chance to pre-process and evaluate sensor data in the network when that node assists as a relay for different routes. Relay is used for aggregation of data that may be smaller than the original data or it can lead to the removal of duplicate information. The job of getting a multi- hop route from a sensor node to the sink is one of the most significant arguments and challenges. This routing problem has taken great concern from the research community.

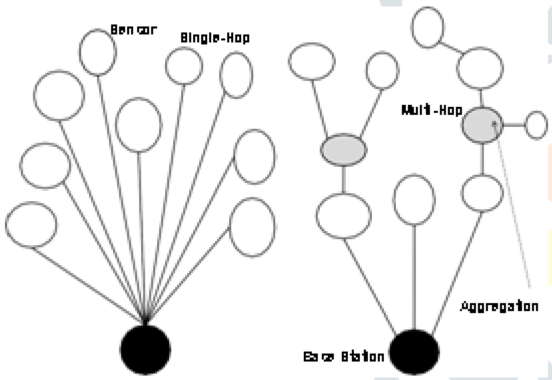


Figure 2.1 Single-hop and Multi-hop Communications in WSN

2.1 Data Collection and Distribution in Wireless Sensor Network

Data collection is a main task in wireless sensor network. Data aggregation is an efficient technique to collect data from sensor nodes which diminishes the number of messages transmitted. During the communication, this leads to a vital decrease in energy consumption. After aggregation and collection data are distributed to the users.

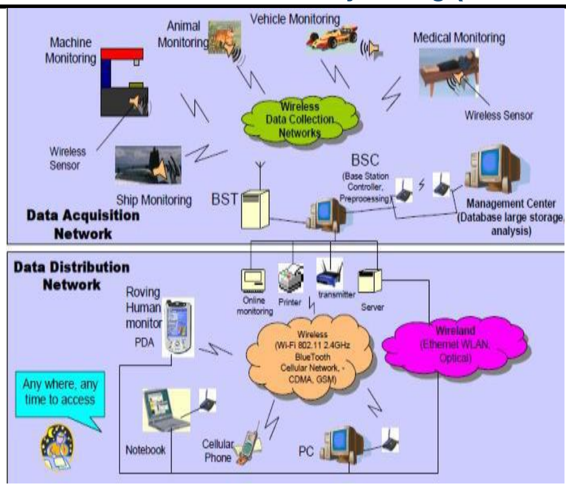


Figure 2.2 Data Collection and Distribution in

Wireless Sensor Network

Figure 2.2 contains the different type of sensor that senses the data and sends these data to the base station. The base station collects this data and performs analysis. After analysis on that data, the results are distributed to the different type of user using the data distribution network.

3. CLUSTERING IN WIRELESS SENSOR NETWORK

Sensor nodes are densely distributed in wireless sensor network area. It means very analogous data in close by sensor node would produce by physical environment. So such type of data transmission is more or less duplicating [2]. To overcome this problem number of sensor nodes can be grouped or compress data together in network and only compact data are transmitted. This can minimize localized traffic in particular group and also minimize global data. This grouping process of sensor nodes is known as clustering. The method of compressing and combining data related to a single cluster called data fusion (aggregation) [51]. Each cluster has only a single cluster head and different number of member nodes. In each cluster, member nodes are directly deal with the cluster head and cluster head communicate to the base station.

Issues of clustering in wireless sensor network:-

- How many sensor nodes should be taken in a single cluster? Selection procedure of cluster head in an individual cluster.
- Heterogeneity in a network, it means user can put some powerful nodes, in term of energy in the network which can behave like cluster head and simple node in a cluster work as a cluster member only.

Many protocols and algorithm have been proposed which deal with each individual issue.

3.1 LEACH

LEACH [45] follows a sequential approach to set up the network into a set of clusters. Selected cluster head of each cluster governs its own cluster. The cluster head assumes the concern to carry out number of tasks. The first task is the collection of data periodically by members of the cluster. Upon collecting the data, to abolish redundancy among correlated values the cluster head aggregates that data. The second pertinent task is aggregated data transmitted directly to the sink by the cluster head. Single hop is used in transmission of the aggregated data. LEACH shows the network model in

Figure 3.1. The third task a schedule based on TDMA is made by cluster head. Each node of cluster is allocated a time slot so that it can apply for transmission. The cluster head broadcasts the schedule to its cluster members. To reduce the collisions among sensors within and outside the cluster, LEACH nodes use a code-division multiple access–based scheme for communication.

Low-energy adaptive clustering hierarchy (LEACH) is a routing algorithm modeled to gather and transmit data to a sink. The fundamental aims of LEACH are to reduced energy consumption by each sensor node in network, to reduce the number of messages using data aggregation, to increase the network lifetime.

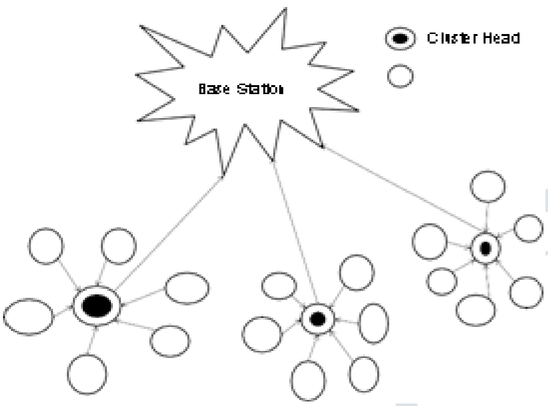


Figure 3.1 LEACH Network Model

The fundamental functions of LEACH are managed in two different phases. These phases are illustrated in Figure 3.2. The setup phase is the first phase. It is divided in two parts: -cluster-head selection and cluster formation. The steady-state phase is the second phase. Its main roles are data gathering, aggregation, and transmission to the sink. To reduce the protocol overhead, the duration of the setup phase is considered to be comparably smaller than the steady-state phase.

A round of cluster-head selection starts at the beginning of the setup phase. The cluster-head election process [45] confirms that this role moves among sensor nodes. As a result, assigning energy consumption is equally across all sensor nodes. To identify if a node is going to become a cluster head, the node n, produce a random number v, between 0 and 1. And compares "v" to the cluster-head selection threshold T(n). The node becomes a cluster head if its threshold value "T(n)" is greater than produced value "v". The cluster-head selection threshold is modeled to ensure with high probability, at each round, cluster heads is elected by a predetermined fraction of nodes P. Further, the threshold ensures that nodes which served in the last 1/P rounds are not elected in the current round.

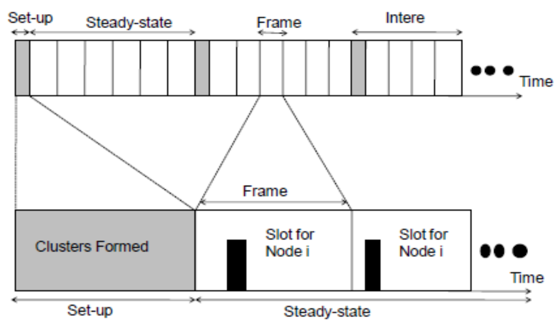


Figure 3.2 LEACH Phases

To meet these requirements [45], the threshold T(n) of a competing node n can be represented as follows:

$$T(n) = \begin{cases} 0 & if\ n \notin G \\ \frac{P}{1-P(r\ mod(1/P))} & \forall n \in G \end{cases}$$

"P" represents the cluster-head probability. It is clear that if a node has served as a cluster head in the last 1/P rounds, it will not be selected in this round. "r" represents the current round. And the variable "G" is the set of nodes that have not been elected to become cluster heads in the last 1/P rounds.

After finishing the cluster-head selection process, every node that was selected to become a cluster head announces its new role to the rest of the network. Now each remaining node selects a cluster to join the group upon finding the cluster-head announcements. To become a member of the cluster, the nodes then inform their selected cluster head. The selection criteria may be based on the received signal strength among other factors.

Each cluster head makes and assigns the TDMA Schedule after cluster formation. TDMA specifies the time slots allotted for each member of the cluster. A CDMA code is also selected by each cluster head, which is then assigned to all members of its cluster. To reduce intercluster interference, code is selected carefully. After the termination of the setup phase, there is the starting of the steady- state phase. In this phase, nodes gather information and use their allotted slots to transmit the collected data to the cluster head. This method of data gathering is accomplished repeatedly.

In simulation results, it shows that LEACH [45] gains pertinent energy savings. These savings depend basically on the data aggregation ratio acquired by the cluster heads. In spite of these advantages, LEACH experiences various limitations. The supposition that all nodes can arrive at the base station in single hop may not be feasible. Because of powers and energy caches of the nodes may change over time from node to node. Moreover, to acquiring the energy reduction necessary to offset the overhead caused by the cluster selection process, the length of the steady- state period is significant. A short steady-state period raises the protocol's overhead. Whereas a long period may lead to cluster head energy reduction. Various algorithms have been presented to direct these limitations. The extended LEACH (XLEACH) protocol takes into consideration the node's energy level in the cluster-head selection process. The resulting threshold cluster-head selection T(n), used by n to determine if it will be a cluster head in the current round is defined as:

$$T(n) = \frac{P}{1-P(r\ mod(1/P))}\left[\frac{E_{n,current}}{E_{n,max}} + \left(r_{n,s}\ div\frac{1}{P}\right)\left(1 - \frac{E_{n,current}}{E_{n,max}}\right)\right]$$

In above equation, En , max is the initial energy and En , current is the current energy of the sensor node. The variable, rn,s , is the number of consecutive rounds in which a node has not been a cluster head. Here rn,s is set to 0 when a node becomes a cluster head. When the value of, rn,s ,accessed 1/P, the threshold T(n) is reset to the value it had before, the addition of the residual energy onto the threshold equation.

LEACH presents various features which allow the protocol to minimize energy consumption. All sensor nodes imagine the cluster head role in a round-robin fashion based on their residual energy. Energy demand in LEACH is shared across all sensor nodes. LEACH is a completely distributed algorithm; they need no control information from the sink. The cluster management is obtained locally which eradicate the requirement for global network knowledge. Moreover, since nodes are no longer need to transmit their information directly to the base station, so data aggregation by the cluster also donates greatly to energy saving. Using simulation, it has been shown that LEACH outperforms traditional routing protocols, including static clustering–based routing, direct transmission and multi-hop routing, minimum-transmission energy routing algorithms.

4. CONCLUSION

In this research work, a survey on wireless sensor networks and their technologies and standards was carried out. Some of the most relevant environmental monitoring projects with real deployments were analyzed and the conclusions used to identify the clustering in wireless sensor network.

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