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On Wireless Sensor Networks: Architectures,Information Dissemination Protocols,Applications

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Abstract. In recent years, many research in fields of data dissemination protocol to mobile sinks for wireless sensor networks have been published. The communication or message passing process must be designed to conserve the limited energy resources of the sensors.Clustering in mobile ad hoc networks (MANETs) and wireless sensor networks (WSNs) is an important method to ease topology management and routing in such networks. Once the clusters are formed, the leaders (coordinators) of the clusters may be used to form a backbone for efficient routing and communication purposes. A set of clusters may also provide the underlying physical structure for multicast communication for a higher level group communication module which may effectively be used for fault tolerance and key management for security purposes. Clustering sensors into groups, so that sensors communicate information only to clusterheads and then the clusterheads communicate the aggregated information to the processing center, may save energy.

Keywords: WSN,Architectures,Information Dissemination,Applications

1. Introduction

A wireless sensor network (WSN) is a wireless network of many autonomous low-power, low-cost, and small-size sensor nodes that are self-organized and use sensors to co-operatively monitor complex physical or environmental conditions, such as motion, temperature, sound etc. Such sensors are generally equipped with data processing and communication capabilities and are deployed in indoor scenarios e.g.-the home and office, or outdoor scenarios like the natural, military and embedded environments. These nodes communicate with each other, sharing data collected or other vital information to monitor a specific environment.

A wireless 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.

The ideal wireless sensor is networked and scalable, 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[1][2].

2. Applications

Sensor networks are applied in a wide range of areas, such as military applications, public safety, medical, surveillances,environmental monitoring, commercial applications, habitat and tracking. In general, sensor networks will be ubiquitous in the near future, since they support new opportunities for the interaction between humans and their physical world. In addition, sensor networks are expected to contribute significantly to pervasive computing and space exploration in the next decade. Deploying sensor nodes in an unattended environment will give much more possibilities for the exploration of new applications in the real world. In this context, we will look briefly at some of these applications. The idea behind these applications is that; densely deploying sensor nodes with capabilities of sensing, wireless communications, and computation in an unattended environment, will assist in measuring its ambient conditions, and obtaining the characteristics about phenomenon of interest surrounding these sensors; by transforming these sensed/gathered data into electrical signals that can be processed. Moreover, other applications for wireless sensor networks can be seen in environmental monitoring and control field (e.g., robot control), high-security smart homes, tracking, and identifications and personalization[1] .Areas of probable usages of WSNs are :

- **Military**
    - Sensing intruders on basis.
    - Detection of enemy unit movements on land and sea.
    - Battle field surveillances.
    - Monitoring inimical forces
    - Monitoring friendly forces and equipment
    - Military-theater or battlefield surveillance
    - Targeting
    - Battle damage assessment
    - Nuclear, biological, and chemical attack detection
- **Emergency situations**
    - Disaster management.
    - Fire/water detectors.
    - Hazardous chemical level and fires
- **Physical World**
    - Environmental monitoring of water and soil.
    - Habitual monitoring.
    - Observation of biological and artificial systems.
- **Medical and Health**
    - Sensors for blood flow, respiratory rate
    - ECG(electrocardiogram)
    - Remote monitoring of physiological data
    - Tracking and monitoring doctors and patients inside a hospital
    - Drug administration
    - Elderly assistance
- **Industrial Factory process control and industrial automation**
- **Home Networks**
    - Home appliances,
    - Location awareness.
    - Person locator

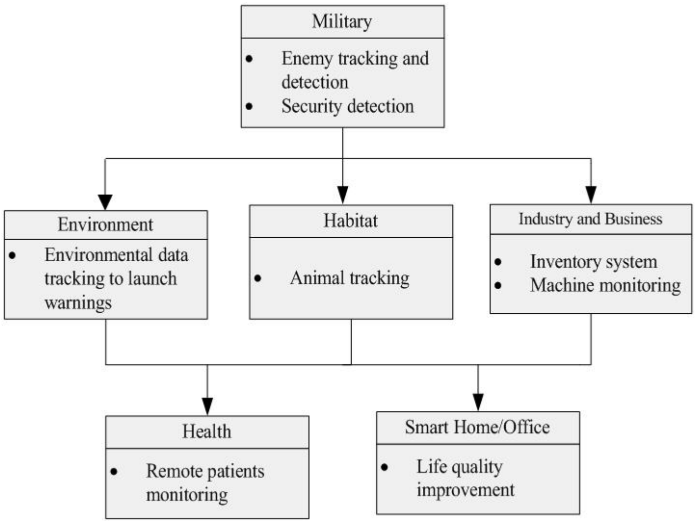

Figure 1 : Sensor Network Applications Development

For example in figure 1:

Military applications, such as environment monitoring, tracking and surveillance applications. Sensor nodes that from sensor network are dropped to the field of interest (e.g., behind the hostile forces, spy, etc), and remotely controlled by user who is situated far from them. User may assign new tasks to be performed by these sensor nodes.

Environmental monitoring, such as animals tracking, forest detection and flood detection, and weather prediction and forecasting. Commercial applications: such as seismic activities monitoring and prediction, and smart environment applications.

Health applications, such as tracking and monitoring of doctors and patients in or out the hospitals by providing them with sensors.

Automation and control , such as robotics control.

3. Basic Sensor Network Architectural Elements

In this section we briefly highlight the basic elements and design focus of sensor networks. The node has communication interfaces, typically wireless links, to neighboring domains. The sensor node also often has location and positioning knowledge that is acquired through a global positioning system (GPS) or local positioning algorithm .(Note, however, that GPS-based mechanisms may sometimes be too costly and/or the equipment may be too bulky.) Sensor nodes are scattered in a special domain called a sensor field. Each of the distributed sensor nodes typically has the capability to collect data, analyze them, and route them to a (designated) sink point. Figure 2 depicts a typical WSN arrangement. Although in many environments all WSNs are assumed to have similar functionality, there are cases where one finds a heterogeneous environment in regard to the sensor functionality[2].

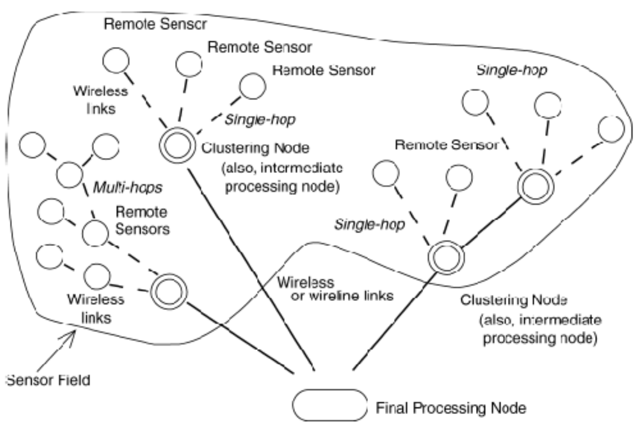

Figure 2: Typical sensor network arrangement

4. Data Dissemination

Data Dissemination is the process by which queries or data are routed in the sensor network. The data collected by sensor nodes has to communicated to the BS or to any other node interested in the data. The node that generates data is called a source and the information to be reported is called an event. A node which is interested in an event and seeks information about it is called a sink. Traffic models have been developed for sensor networks such as the data collection and data dissemination (diffusion) models. In the data collection model , the source sends the data it collects to a collection entity such as the BS . This could be periodic or on demand. The data is processed in the central collection entity.In WSNs, the sensor nodes deployed produce data. The data sensed need to be transmitted to some special node or a sink for further analysis, management, and control. Therefore, a data dissemination protocol is required to provide effective data transmission from sensor nodes to the sink. Data dissemination protocols have a certain relation to the routing protocols. The routing protocols are general and are designed to find a path between the source and destination nodes. On the other hand, data dissemination protocols should guarantee successful transmission from nodes to the sink. Data dissemination protocols consist of at least two phases:

- The initial phase of triggering data transmission, often initiated by the sink, by sending out a query to inform sensor nodes of its intent. The query contains information to guide data transmission from the node to the sink, the frequency of data reporting, the duration of interval in which data reporting should take place, and so on.
- The data transmission phase, sensor nodes report data to the sink. Data dissemination protocols need to indicate whether the data are to be transmitted in broadcast or unicast mode. Routing protocols and other techniques, such as data replication and cache, may also be used for performance optimization[3].

The Hierarchical Cluster-based Data Dissemination protocol defines a hierarchical cluster architecture to keep the location of mobile sinks and find paths for the data dissemination from the sensors to the sink. Each cluster is composed by a cluster head, several gateways and ordinary sensors.When a mobile sink crosses the network, it registers itself to the nearest cluster head. A notification message is then propagated to all cluster heads. During this procedure, each cluster head records the sink ID and its sender such that future data reports transmission can be easily performed from sources to sink.LEACH (Low Energy Adaptive Clustering Hierarchy) is a self-organizing, adaptive clustering-based protocol that uses randomized rotation of cluster-heads to evenly distribute the energy load among the sensor nodes in the network.

Data diffusion on the other hand , consists of a two-step process of interest propagation and data propagation . An interest is a descriptor for a particular kind of data or event that a node is interested in , such as temperature, intrusion, or presence of bio-agents. For every event that a sink is interested in , it broadcasts its interest to its neighbors and periodically refreshes its interest. The interest is propagated across the network, and every node maintains an interest cache of all events to be reported . This is similar to a multicast tree formation , rooted at the sink. When an event is detected , it is reported to the interested nodes after refeering to the interest cache. Intermediate nodes maintain a data cache and can aggregate the data or modify the rate of reporting data. The paths used for data propagation are modified by preferring the shortest paths and deselecting the weaker or longer paths.The basic idea of diffusion is made efficient and intelligent by different algorithms for interest and data routing. Some protocols, such as directed diffusion (DD), consider WSN with only one sink. Later protocols, such as two-tier data dissemination (TTDD) and sinks accessing data from environments (SAFE), consider multiple sinks. In DD, the query is flooded. The initial data are also broadcast to all neighbors to set up a reinforced path, but subsequent data are transmitted only on the reinforced path. TTDD proposes two-tier grid architecture for data dissemination. In TTDD, sensor nodes need to announce the process to build a grid structure. Then the query is flooded only in an area smaller than a grid cell in order to find a nearby dissemination node. The dissemination node is defined as the node closest to the crossing point of the grid. SAFE attempts to share and compress the data dissemination if there is the same part from a source node to the multiple sinks. In this way it avoids duplicate data and therefore conserves energy. Data Compression Communication components consume most of the energy in WSNs. Computation uses less. Therefore, it becomes attractive to deploy data compression techniques, which might increase computational energy somewhat, but decrease the number of packet transmissions[4][5]. Several features of WSNs make it possible to implement effective data compression protocols:

- Usually, the data collected in neighboring sensor nodes are correlated, especially when the deployment of sensor nodes is quite dense in the network.
- due to the treelike logical topology of most WSNs, the correlation may become more apparent on the path from the sensor nodes to the sink.
- the occurrence of an event may be assimilated with a continuous-time but random process, and sampling of the random processes helps extract information content from the process.
- the application semantic may enable data aggregation or data fusion.
- the tolerance of applications for possible errors in data may make it possible to reduce data reading and reporting frequencies.

4.1 ROUTING PROTOCOLS IN WIRELESS SENSOR NETWORKS

The communication between the nodes of a WSN must be governed by a set of rules (protocols) in order for them to function properly. And the data or information that they share amongst them can be tampered with by an outside intruder (adversary) for its own benefit jeopardizing the operations of the network. Thus the protocol used must provide confidentiality of the data shared among the sensor nodes in order to carry out an intended operation in the selected environment successfully.Due to the difference of wireless sensor networks from other contemporary communication and wireless ad hoc networks routing is a very challenging task in WSNs. For the deployed sheer number of sensor nodes it is impractical to build a global scheme for them. IP-based protocols cannot be applied to these networks. All applications of sensor networks have the requirement of sending the sensed data from multiple points to a common destination called sink. Resource management is required in sensor nodes regarding transmission power, storage, on-board energy and processing capacity.

There are various routing protocols that have been proposed for routing data in wireless sensor networks due to such problems. The proposed mechanisms of routing consider the architecture and application requirements along with the characteristics of sensor nodes.

There are few distinct routing protocols that are based on quality of service awareness or network flow whereas all other routing protocols can be classified as hierarchical or location based and data centric. Presently quite a lot of WSN protocols are available using different techniques to ensure proper routing of authentic data; each protocol has its own advantages and disadvantages in design.

The challenge in core-based tree multicast protocols lies in finding a good core node. Once this node is determined, essentially the problem can be reformulated as a source-based tree protocol with the core node as the source (although better optimization is possible). An overview of such protocols and a performance comparison can be found in reference . further examples are contained in references .

To give an idea how such a core search could work, the “merge point formation” from reference is briefly described here. Assume there are a few sinks in a network to which data shall be distributed via a core-based multicast tree. A “merge point” for this tree is to be found. To do so, each sink broadcasts advertisement messages indicating its presence; each node in the network collects these advertisements along with sink identifier and number of hops that the advertisement took. After a certain time, each node that has received more than one sink advertisement broadcasts merge advertisement messages. These messages are only forwarded by nodes that have heard from fewer sinks or whose cumulative distance to all sinks is larger. Eventually, only one node (depending on network topology and timer values) will not have heard other merge advertisements overruling its own and will declare itself the merge point. This leader election result is then spread through the network.

5. Conclusions

Putting the data to be collected or disseminated in the focus of communication protocol design considerably changes the design paradigms. It is no longer possible or sensible to try to construct some form of routing structure in the network that is based on the identifiers of the nodes. Rather, the data as such has to guide the interaction of separate nodes in the network. In this paper we introduced the basic concept of

WSNs and supportive technologies.This paper has shown a couple of possible approaches. Many of them rest, in some form or another, on the notion of publishing named data and subscribing to certain names. This paradigm, in combination with data aggregation or other, advanced forms of in-network processing, admits crucial optimizations for wireless sensor networks.

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