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Review Article

The Impact of Clustering Mechanism in Dense Wireless Sensor Network

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Abstract: A sensor is a miniature component which gauges physical parameters from the environment. A sensor measures the physical parameters and transmits them either by wired or wireless means. In wireless medium the sensor and its allied components are called as node. A wireless sensor node is self-assured by a processor, local memory, sensors, radio, battery and a base station accountable for receiving and processing data collected by the nodes. The incorporation of multiple types of sensors such as seismic, acoustic, optical, etc., in a single network platform and the evaluation of the overall coverage of the system also presents numerous interesting challenges. The sensor-based military applications involves intrusion detection, perimeter monitoring, information gathering and smart logistics support in an unknown deployed area, sensor-based personal health monitoring, location detection with sensor network and movement detection using wireless sensor network. This paper gives a detailed description about the impact of clustering mechanism in dense wireless sensor network.
Keywords: Sensor, sensor nodes, wireless sensor network (WSN), distributed clustering, dense wireless sensor network..

INTRODUCTION

Recent leading research topic that has been emerging is the wireless sensor network. They have enormous long-term economic potential, ability to transform lives and pose many novel system-building challenges. They also create a number of new conceptual and optimization problems such as location, deployment and tracking. The rest of this paper has been organized as follows. An introduction to wireless sensor network, wireless sensor node and its components has been elaborated in section II. The mechanism of clustering and the manner by which the cluster head gets elected have been discussed in section III. The challenges and design issues for wireless sensor network have been enumerated in section IV. Real-world applications of wireless sensor network with their constraints have been detailed in section V. Finally the last section concludes the paper.

WIRELESS SENSOR NETWORK

Wireless Sensor Network (WSN) consists of a group of spatially distributed sensor nodes which are interconnected without using wires as worked out by [1]. Wireless sensor network has been originally motivated for the use in military applications like border monitoring. In recent years, it is mainly focused on civilian applications such as environment monitoring, object tracking and biomedical applications. Figure 1 depicts a typical wireless sensor network. Unlike centralized systems, the sensor network is subjected to a set of resource restrictions like finite on-board battery power and restricted communication bandwidth.

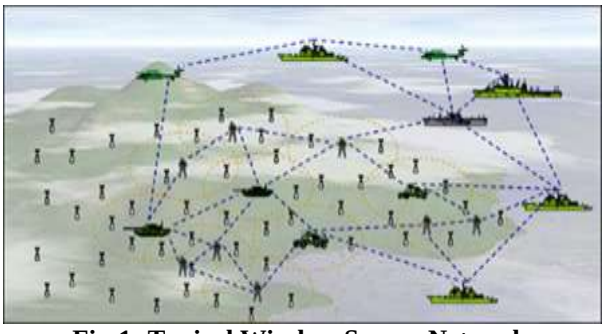

Fig-1: Typical Wireless Sensor Network

Sensor network inter-networks with an Internet Protocol (IP) core network via a number of gateways. A gateway routes queries or commands to appropriate nodes within a sensor network. It also routes sensor data, at times aggregated and summarized to users who have requested it or are expected to utilize the information. A data repository or storage service is

available at the gateway, in addition to data logging at each sensor. The repository may serve as an intermediary between the users and sensors thereby providing persistent data storage. Additionally, one or more data storage devices are attached to the IP network to archive the sensor data from a number of edge sensor networks.

One of the major advantages of wireless sensor network is their ability to operate in unattended, harsh environments in which existing human-in-the-loop monitoring schemes are uncertain, inefficient and sometimes impossible. Therefore, wireless sensors are expected to be deployed randomly in the predetermined area of interest by a relatively uncontrolled manner.

Given the huge area to be covered, the short lifespan of the battery-operated wireless sensors and the possibility of having damaged sensor nodes during deployment, large population of sensors are expected in the majority of wireless sensor applications.

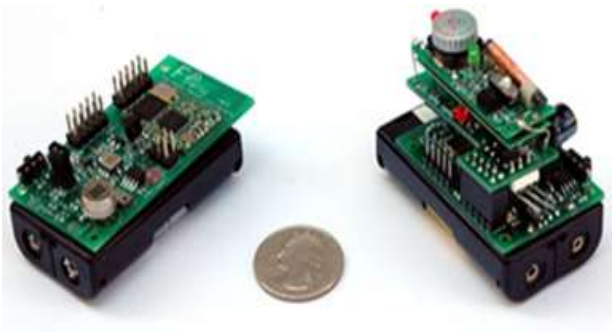

Fig-2: Wireless sensor node

The sensed data is collected, processed and then routed back to the desired end user through a designated sink point, referred as the base station (BS). It has become feasible to construct multifunctional sensor nodes with advanced capabilities. Such sensor nodes are relatively of smaller size, lower cost and lesser power consumption.

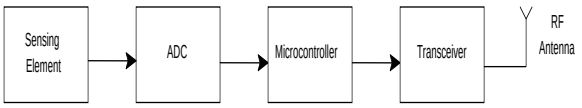

Fig-3: Internal Components of a Wireless Sensor Node

Figure 2 demonstrates a typical wireless sensor node. Figure 3 shows the internal components of a wireless sensor node. A typical sensor node consists of a sensing element, analog to digital convertor (ADC), microcontroller and a transceiver. The sensing element converts the physical parameters such as temperature, humidity, etc., to an equivalent electrical signal. The analog signal is then converted to an equivalent digital signal using the analog to digital convertor.

The processing of the digital signal is done by the microcontroller. The processed signal is transmitted or received using a transceiver. The Radio Frequency (RF) antenna is used at the transceiver to transmit the processed signal, thus minimizing the amount and range of communication as much as possible.

CLUSTERING IN WIRELESS SENSOR NETWORK

Grouping of sensor nodes into clusters have been widely pursued by the research community in order to achieve the network scalability objective as formulated by [2-7]. Every cluster has a leader, often referred to as the cluster head (CH). A cluster head may be elected by the sensors in a cluster or pre-assigned by the network designer.

A cluster head may also be just one of the sensor nodes that are rich in resources. The cluster membership might be fixed or variable. Cluster heads form a second tier network or just ship the data to the base station or sink node. Figure 4 represents the basic clustering mechanism in wireless sensor network. In addition to network scalability, clustering has numerous advantages.

Clustering localizes the route setup within the cluster and thus reduces the size of routing table stored at the individual node. Clustering conserves communication bandwidth as it limits the scope of inter-cluster interactions to the cluster heads and evades redundant exchange of messages among the sensor nodes. Moreover, clustering stabilizes the network topology at the level of sensors and thus cuts down the topology maintenance overhead.

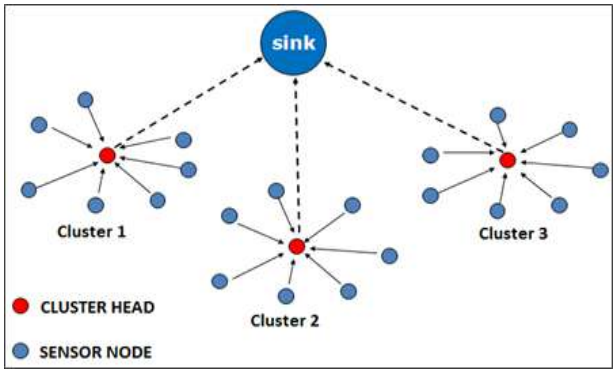

Fig-4: Clustering mechanism in Wireless Sensor Network

The cluster head implements optimized management strategies to further enhance the network operation and to prolong the battery life of the individual sensors. A cluster head schedules activities in the cluster so that nodes can switch to the low-power

sleep mode most of the time and thus reduce the rate of energy consumption. Furthermore, cluster head aggregates the data collected by the sensors in its respective cluster by the process of data aggregation and thus decreases the number of data packets.

DESIGN ISSUES IN WIRELESS SENSOR NETWORK

The major technical issues and challenges for realization of wireless sensor network could be summarized as follows as given[8,9].

Resource constraints

The implementation of sensor networks is mainly inhibited by resources like energy, memory and processing. Constrained by limited physical size, the sensor nodes have restricted battery energy. Similarly, their memories are also limited and have restricted quantity of computational capabilities.

Dynamic topologies

The topology and connectivity of the sensor network might vary due to link failure and sensor node failure. Furthermore, sensors may also be subjected to interference, highly corrosive environments, large humidity levels, vibrations, dust or other situations that confront their performance. These inconsiderate environmental conditions and dynamic network topologies cause a portion of the sensor nodes to get broken down.

Quality-of-service (QoS) requirements

A variety of applications visualized on wireless sensor network will have dissimilar quality of service requirements. The quality of service offered by these sensor networks refers to the accuracy between the data reported to the sink node and what is really happening in the sensing atmosphere.

Data redundancy

Because of the high solidity in the network topology, sensor interpretations are seriously correlated in space domain. Additionally, the nature of physical happenings constitutes the temporal correlation between the consecutive observations of the sensor node.

Packet errors and variable-link capacity

Compared with wired networks, wireless sensor network have the attainable capacity of each wireless links that depends on the interference level perceived at the receiver. Moreover, wireless links display widely changing characteristics over time and space due to noisy environments, thereby making quality of service provisioning to be a demanding task.

Security

Security is an essential feature in the design of sensor networks, to make the communication safe from external denial-of-service (DoS) attacks and intrusion. Passive attacks happen by eavesdropping on transmissions including traffic analysis or exposure of the message contents. Active attacks constitute modification, fabrication and interruption which might include node capturing, routing attacks or flooding. In military applications, security plays a vital role during data communication.

Large-scale deployment and ad-hoc architecture

Many sensor network have a multitude of sensor nodes (hundreds to thousands or even more), which might be spread arbitrarily over the deployment field. Furthermore, the lack of predetermined network infrastructure demands these networks to setup connections and upholds the network connectivity autonomously.

Integration with Internet and other networks

It is of fundamental importance for the commercial development of sensor networks to provide services that permit the querying of the network to retrieve useful information. For this reason, these networks should be remotely accessible from the Internet and hence needed to be integrated with the IP architecture. The current sensor network platforms use gateways for integration between sensor network and the Internet.

REAL WORLD APPLICATIONS OF WSN

Although the implementations of wireless sensors are enormous, there are few strange applications of WSNs which could be categorized under: military applications, ecological monitoring, profit-making or human centric applications and in robotics as documented by [10-18].

Military and Surveillance Applications

Military applications are very intimately related to the perception of sensor networks. In detail, it is very tough to say whether motes (nodes) were developed because of military and air defense needs or whether they were invented autonomously and were subsequently applied to army services. Regarding military applications, the area of attention ranges from information collection, generally to the enemy tracking or battlefield surveillance. The avoidance of intrusion will be the answer of the defense system. One example project is “A line in the Sand” and refers to the deployment of several nodes which are gifted for detecting metallic objects. The ultimate goal was the tracking and categorization of moving items with metallic content, and specially the tracking of vehicles and weapon-carrying soldiers. Other civilians were uncared by the system. The principle here is to coordinate with a number of this category of sensors in order to keep sensing the moving object, thereby diminishing any information gaps about the track that could arise. Peacetime applications of wireless sensor networks like homeland security, possession-protection,

surveillance, border patrol, etc., are the actions that possibly the future sensor network will be taking on.

Environmental Monitoring Applications

The ability of a wireless sensor node to sense temperature, light and indoor air pollution could be employed for indoor and outdoor environmental monitoring applications. A chief wastage of energy takes place through needless heating or cooling of buildings. Sensor nodes could be integrated with heaters, fans and other related equipment at an economic way, leading to healthier environment and greater level of comfort for the residents. Other environmental applications are the lessening of fire and earthquake damages. Fire and smoke detections are something widespread today in buildings, and in many countries it is forced by relevant regulations.

Wildlife Maintenance and their Conservation

Maintaining the faunas in remote areas is one of the vital applications of wireless sensor network. Their lifestyle could be analyzed by placing wireless sensor nodes on their bodies. Their migration in the areas where human intervention is merely impossible could be analyzed and steps could be taken for their conservation. These sensor nodes will be grouped into dynamic clusters, and the collected information will be sent to the distantly located monitoring station.

Application in Logistics

Management of precious assets like equipment, machinery and diverse stock or products could be predicament. The difficulty is extremely distributed as these companies increase all over the globe. A gifted technique to achieve asset tracking and cope with this crisis is believed to be with the employment of wireless sensor network. The application of wireless sensors in petroleum bunks refer to the storage supervision of barrels. The concept is that, the sensor nodes attached to these barrels will be able to position the nearby objects, detecting their content and alerting in case of impropriety with their own, etc.

Healthcare Applications

Healthcare systems can also profit from the use of wireless sensors. Applications in this group comprise of tele-monitoring human physiological data, monitoring of patients within the hospital, monitoring drug administrator in hospitals, etc. Cognitive disorders possibly leading to Alzheimer's could be monitored and controlled at their premature stages with these wireless sensors. The nodes can be used to outline the recent actions, and thus remind the senior citizens, point out the person's real actions or detect a growing problem. A comparable approach employs Radio Frequency Identification (RFID) tags to examine the patient behaviour and customs by recording the frequency with which they touch particular objects. These applications include a display which will assist the care-giver with the exact information about the indisposed person unnoticeably and without hurting their mental feelings. Sensor nodes can also be used in order to study the behaviour of young children.

Robotic Applications

The association of both static and mobile networks is accomplished with the help of mobile robots, which discovers the environment and deploys motes that operate as beacons. The beacons help the robots to explain the directions. The mobile robots can act as gateways into wireless sensor network. Examples of such tasks are satisfying the energy resources of the wireless sensor network indefinitely, configuring the hardware, perceiving sensor breakdown and suitable deployment for connectivity amid the nodes. This approach strives to answer the difficulty of unifying a network that is separated because of detached groups of sensor clusters. In all these cases, robots are the essential part of the sensor network. In the choice between robotics and medical applications is the virtual keyboard, which is an arrangement of wearable motes capable of sensing the acceleration. Motes are attached with a glove for every finger and at the wrist which is capable of recognition. Applications could be a wireless wearable keyboard or a pointing device, hand motion and gesture recognition for the disabled.

Landslide Detection Applications

Landslide detection employs wireless sensors for forecasting the occurrences of landslides. One sole trait of these systems is that it combines numerous distributed techniques to contract with the complexities of a distributed sensor network environment where connectivity is deprived and power budgets are unnatural, while fulfilling the real-world safety requirements. These sensors prepare point measurements at different parts of the rock but formulate no effort in measuring the relative motion between the rocks. The approach is based on the uncomplicated observation that rock-slides takes place because of bigger strain in the rocks. Thus, by measuring the source of the landslide, the landslides could be foreseen as easily as if one would be measuring the budding relative movement of rocks.

Forest fire Detection Applications

Forest fires are wild fires happening in wild areas and become a reason for major damage to natural and human resources. Forest fires burns the infrastructure and might result in severe human death toll closer to urban areas. The universal causes of forest fires include lightning, human carelessness and disclosure of fuel to tremendous heat. It is known that in few of the cases, forest fires are part of the forest ecosystem and they are momentous to the life cycle of indigenous habitats. However, in many cases the losses caused by these fires to public safety and natural

resources is intolerable, thereby untimely detection and suppression of fires deem crucial.

Wireless Sensor-Cloud Applications

Sensor-Clouds could be used for health monitoring applications by means of merely available sensors like accelerometer sensor, proximity sensor, temperature sensor and so forth to gather patient's health-related data for tracking the sleep activity pattern, body temperature and other respiratory conditions. These wearable sensor devices have the support of wireless interface for streaming the data and are linked wirelessly to any smart phone through this interface.

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