# PROSPECTIVE APPLICATIONS OF WIRELESS SENSOR NODE AND WIRELESS SENSOR NETWORK

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**Abstract**
**The most well-liked principle for distributed clustering methodology is to choose cluster heads with more residual energy and to rotate them occasionally. Sensors at very heavy traffic locations rapidly deplete their energy resources and die in advance, before the network to collapse. The use of these sensors and the probability of organizing them into networks have discovered many research issues and have highlighted innovative ways to cope with certain problems. Here, the view of distributed clustering mechanism has been elaborated elegantly and different areas where such distributed clustering methodology could be put to use in emerging real world wireless sensor network applications have been compiled and discussed.**

**Index Terms: Wireless sensor network, sensor node, distributed clustering, energy utilization, real world applications.**

## I. INTRODUCTION

Wireless sensor networks (WSN), sometimes called wireless sensor and actuator networks (WSAN) are spatially distributed autonomous sensors to monitor physical or environmental conditions, such as temperature, sound, pressure, etc. and to cooperatively pass their data through the network to a main location. The more modern networks are bi-directional, also enabling control of sensor activity. The development of wireless sensor networks was motivated by military applications such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control, machine health monitoring, and so on. The WSN is built of "nodes" – from a few to several hundreds or even thousands, 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 routing or flooding.

Wireless sensor network (WSN) is a collection of enormous number of small, low-power and low-cost electronic devices called as the sensor nodes. Each sensor node consists of four key blocks namely sensing, processing, power and communication unit and they are responsible for sensing, processing and wireless communication (figure 1 and figure 2). These sensor nodes bring together the relevant data from the environment and then forward the gathered data to the base station (BS). Since WSNs has numerous advantages like self organization, infrastructure-less, fault-tolerance and locality, they have an extensive variety of potential applications like border security and surveillance, environmental monitoring and forecasting, wildlife animal protection and home automation, disaster supervision and control. Considering that sensor nodes are normally installed in remote locations, it is impractical to recharge their batteries. Therefore, ways to make use of the limited energy resource wisely to extend the lifetime [1-4] of sensor networks is a very demanding research concern for these sensor networks. Clustering is an efficient topology control approach [13], which can extend the lifetime and raise the measurability of these sensor networks. The well-liked principle for clustering method [5] is to select a cluster head (CH) with higher residual energy and to spin them periodically. Distributed clustering has no fixed central CH and this keeps on shifting from node to node based on some pre-assigned parameters, for instance residual energy. If a centralized architecture is used in a WSN and when the central node fails, the entire network will collapse and hence there is no guarantee for the reliability.

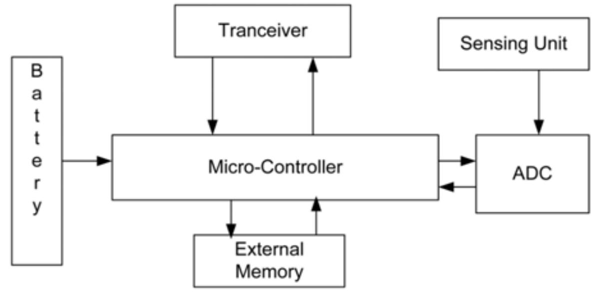


Figure 1: Components of a wireless sensor node

Hence, the reliability of a WSN can be enhanced by using distributed architecture [6, 7, 8]. Distributed architecture is used in WSNs for some explicit reasons like sensor nodes prone to failure, improved collection of data and provide backup in case of breakdown of the central node. Also, nodes sensing and forwarding [11] the redundant information can be reduced. Since there in no centralized body to allot the resources, they should be capable of self-organization.

Figure 2: Wireless sensor node

The growing interest in wireless sensor networks can be quickly understood simply by thinking about what they basically are: a large number of small sensing self-powered nodes which collect information or detect special events and communicate in a wireless manner, with the end objective of handing their processed data to a base station [10]. Sensing, processing and communication are three key essentials whose combination in one tiny device gives rise to a vast number of exclusive applications. The advances in Micro Electro-Mechanical Systems (MEMS) are nearing enough towards networks of tiny distributed sensors and actuators. Possible real world applications of sensor networks are of attention to the most diverse fields. Environmental monitoring, warfare, surveillance, micro-surgery, and agriculture are only a few examples. Since habitat monitoring is rather sensitive to human presence, the exploitation of a sensor network provides a noninvasive approach and an extraordinary degree of granularity in data acquisition [9].

Since the network is intended to operate in an infrastructure-free environment, peer-to-peer swaps of information are used to create redundant databases so that researchers only have to meet a few zebras in order to collect the data. Sensor networks can also be used to observe and study natural phenomena which intrinsically discourage human presence like hurricanes and forest fires. Wireless Vineyard is an excellent example of using ubiquitous computing for agricultural monitoring. In this application, the network is anticipated not only to collect and interpret the data, but also to use such data to make decisions aimed at detecting the presence of parasites and enabling the use of the appropriate class of insecticide. Data collection relies on data mules, small devices carried out by people or dogs that communicate with the nodes and collect the data. In this project, the concentration is shifted from reliable information collection to active decision making based on the acquired data. Medical research and healthcare can really benefit from sensor networks: vital sign monitoring and accident recognition are the most ordinary applications [20]. An important issue is the care of the elderly, especially if they are affected by cognitive turn down: a network of sensors and actuators might monitor them and even assist them in their daily schedule. Smart appliances could help them systematize their lives by reminding them of their meals and medications. Sensors can be used to capture some vital signs from patients in real-time and relay the data to handheld computers carried by the medical personnel and wearable sensor nodes can stock up patient data such as identification, history, and further treatments.

An attractive application to civil engineering is the idea of Smart Buildings: wireless sensor and actuator networks incorporated within buildings could allow distributed monitoring and control, civilizing living conditions and reducing the energy consumption, for example by controlling temperature and air flow.

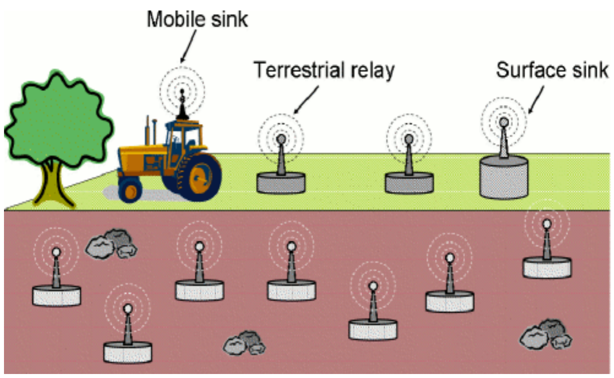


Figure 3: Military Application

## II. POTENTIAL APPLICATION AREAS

Military applications (figure 3) are very intimately related to the perception of wireless sensor networks. In fact, it is very hard to say for sure whether motes 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 [14], the area of attention extents from information collection, generally, to enemy tracking or battlefield surveillance. For example, mines may be regarded as unsafe and obsolete in the future and may be replaced by thousands of detached motes that will detect an intrusion of unreceptive units. Then, 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 eventual objective was the tracking and classification of moving objects with major metallic content and specifically the tracking of vehicles and weapon-carrying soldiers. Other civilians were ignored by the system. The purpose is to coordinate a number of this class of sensors in order to keep sensing the track of a preferred moving object minimizing any information gaps about the track that could occur.

Peacetime applications of wireless sensor networks such as homeland security, property protection and surveillance, border patrol, etc. are the activities that possibly in future sensors networks will take on. Since the wireless sensor nodes are deployed in remote areas, whole network collapses when some or many of the sensor nodes die. Hence, by efficiently clustering these nodes using distributed clustering mechanism the potential applications of wireless sensor network in military applications could be enhanced.

The capability of a wireless sensor node to sense temperature, light, air streams and indoor air pollution can be used in indoor and outdoor environmental monitoring [12, 17, 18] applications (figure 4). Consider a former case: A major wastage of energy occurs through unnecessary heating or cooling of buildings. Motes (sensor nodes) can aid in using heaters, fans and other relevant equipment at a practical and economic way, leading to a healthier environment and superior level of comfort for residents. Other indoor applications can be lessening of fire and earthquake damages. Fire and smoke detection is something universal nowadays in buildings and in most countries it is imposed by relevant regulations. The subsistence also, of light-signals indicating exits is, usually, mandatory in big buildings. However, these two systems do not help in case of a fire. The setting up of sensor networks in buildings can lead to the incorporation of these two systems. So, the accountability of a sensor network is to direct the trapped residents through the safest path and save their lives. Sensor networks may also be supportive after an earthquake. In addition to systems like the ones described above for fires, civil engineering research has shown that the examination of structures based on vibrations is achievable. Based on this examination, the incorporation of wireless sensors inside cement blocks during construction or their addition to structural units makes sense. The recording of vibrations throughout the life of a building can function as the identity of the building. The inspection of a building after an earthquake by the use of this scheme will not be limited to evaluation of cracks and damages, but will be accompanied by real statistics. Computation of average and maximum values of vibrations maybe done by every mote, so the inspection can be done sooner and the determination for any repairs can be more accurate.

Figure 4: Environmental Monitoring

Outdoor monitoring (figure 4) is another cosmic area for applications of sensors networks. One of the most delegate examples is the deployment of sensor nodes on Great Duck Island (GDI). This sensor network was used for habitat monitoring. The sensor nodes that were used were able to sense temperature, barometric pressure and humidity. In addition, passive infrared sensors and photo resistors were employed. The plan was to monitor the natural environment of a bird and its activities according to climatic changes. For that reason, some motes were installed inside birds' burrows, to spot out the bird's presence, while the rest were deployed in the neighboring areas. Data are aggregated by the use of sensor nodes and are passed through to a gateway. The function of the gateway is to transmit data using a higher-level network to a local base station.

The database is reachable through the internet and is replicated to another remote location for security. This application provides an example for monitoring using a heterogeneous multi-level sensor network. The nodes that have been used all through these experiments are not size optimized and they control acoustic signals. Either in indoor or outdoor applications, the damaged sensor nodes are merely impossible to be replaced. Mainly in outdoor applications, these sensor nodes are deployed in hilly areas to monitor temperature or rainfall using a helicopter. Once deployed, these sensor nodes organize themselves in to clusters and the cluster heads send the aggregated data to the base station. When majority of the sensor nodes die due to long distance communication, the network ceases functioning completely. One method to prolong the network lifetime of these sensor nodes is by clustering the wireless sensor network by distributive mechanism.

Management of valuable assets like equipment, machinery, different types of stock or products can be a predicament [15]. The trouble is highly distributed, as these companies enlarge all over the world. A gifted way to achieve asset tracking and cope with this problem is believed to be with the use of wireless sensor networks. The application of wireless sensors in petroleum bunks and chemical warehouses refers to warehouses and storage supervision of barrels. The concept is that motes attached to barrels will be able to locate nearby objects (other barrels), detecting their content and alerting in case of inappropriateness with their own, aging effects of the enclosure etc. This will enhance the wellbeing and guarantee the product eminence. Tracing of lorries (figure 5) and tracking of parameters regarding carried goods is probable through motes and the GPS system. So telemetry and wireless sensing can be united together to build smart objects.

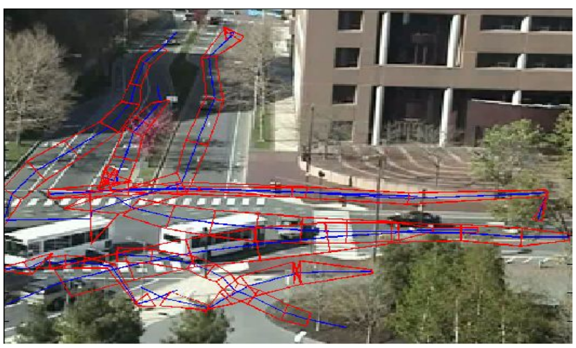

Figure 5: Smart Transportation

Other industries are also fascinated in wireless sensors. For example, Intel research deployed a network of this type to observe the needed conditions of semiconductor fabrication equipments. Motes in this case are dedicated to sense the vibrations. More specifically, the plan is to make viable the detection of faulty parts which need revamp or changing, by analyzing their vibration. Another industrial case study was carried out by Helsinki University of Technology, which deals with the use of motes to the progression of paper production. The sensors are fixed into the rolls used in the paper drying stage. The role of the motes is to compute temperature in order to manage the heating rolls. The integration of a mote to a part of the equipment that firemen wear, not only makes the management of fire extinguishing easier and more effective but can also act as a additional safety measure by enlightening the exact location of each fireman. In case of an accident, the rescue crews can act more successfully. Delivery and distribution systems are an added area of application for wireless sensors. In all these applications, the prolonged lifetime can be attained by integrating the distributed clustering mechanism to these real world applications.

Health science and the health care system can also profit from the use of wireless sensors. Applications in this category include telemonitoring human physiological data remotely, tracking and monitoring of doctors and patients within a hospital, drug administrator in hospitals, etc. In Smart Sensors [16], retina prosthesis chip consisting of 100 micro sensors are built and fixed within human eye. This allows patients with restricted vision to see at an adequate level. Cognitive disorders, which possibly lead to Alzheimer's, can be monitored and controlled at their early stages, with wireless sensors. The nodes can be used to trace recent actions and thus remind senior citizens, point out the person's real behavior or detect a budding problem. A similar approach employs RFID tags to inspect patient behavior and customs by recording the frequency with which they touch certain things. The application includes a display, which will aid the caregiver extract information about the indisposed person inconspicuously and without hurting their feelings. Sensor motes can also be used in order to learn the behavior of young children.

For example, analyzing children activities by monitoring sensors enclosed inside toys. Another crucial medical application refers to human vision restoration by retina prosthesis. Sensors are implanted to human organs to support a task and they need the capability to communicate wirelessly with an external computer system which carries out further processing. Energy restrictions do not allow this computing to be carried out on-board the sensors. Some other analogous applications include Glucose level monitoring, Organ monitoring, Cancer detectors and General health monitoring.

The design of embedding wireless biomedical sensors inside human body is promising, although many added challenges exist: the system must be safe and reliable, require least maintenance and energy-harnessing from body heat. Other applications of wireless sensors to healthcare that have been projected include tracking and monitoring doctors and patients or tracking drug practice inside hospitals. Wireless communication is necessary to suit the need for feedback control, image recognition and corroboration. The communication model is deterministic and periodic, so TDMA slots are incorporated in this application to serve the purpose of energy conservation. Two group communication methods are investigated: LEACH protocol based cluster head selection and tree-based distributed clustering approaches.

Robotic applications (figure 6) already implemented are the discovery of level sets of scalar fields using mobile sensor networks and imitation of the function of bacteria for seeking and discovering dissipative gradient sources. The tracking of a light source is done with some of the simplified algorithms. In addition, an answer to the coverage problem by robots and motes is accomplished for dense measurements over a broad area. The collaboration of both static and mobile networks is accomplished with the help of mobile robots, which explore the environment and deploy motes that act as beacons. The beacons assist the robots to describe the directions. The mobile robots can perform as gateways into wireless sensor networks. Examples of such tasks are: sustaining the energy resources of the wireless sensor network indefinitely, maintaining and configuring the hardware, detecting sensor breakdown and appropriate deployment for connectivity amid nodes. This approach tries to answer the problem of unifying a network that is divided because of disconnected groups of sensor clusters. In all these cases robots are the integral parts of the sensor network. In the range between robotics and medical applications is the virtual keyboard, which is an arrangement of wearable motes sensing acceleration. Motes are attached to a glove, one for every finger and one at the there have been 4,387 and 52,943 forest fires in Canada and the United States for every year on an average. Preventing a tiny fraction of these fires would account to significant savings in natural and human resources. In all these techniques under the roof of robotic applications of wireless sensor networks, distributed clustering could be employed to avoid the WSN failure in time-critical robotic applications.

Figure 6: Sensor Based Robotics

Landslide detection (figure 7) employs distributed sensor system for predicting the happening of the landslides [19]. The idea of predicting landslides by means of wireless sensor networks arose out of a must to mitigate the damage caused by landslides to human lives and to the railway networks. A combination of techniques from earth sciences, signal processing, distributed systems and fault-tolerance is used. One unique trait of these systems is that it combines several distributed systems techniques to deal with the complexities of a distributed sensor network environment where connectivity is poor and power budgets are very constrained, while fulfilling real-world requirements of safety and protection. Generally these methods use a collection of inexpensive single-axis strain gauges coupled to cheap nodes, each with a CPU, battery and unique wireless transmitter block. These sensors make point measurements at various parts of a rock but formulate no effort at measuring the relative motion between the rocks. The strategy is based on the straightforward observation that rock slides occur because of increased strain in the rocks. Thus, by measuring the origin of the landslide, one can envisage landslides as easily as if one would be measuring the incipient relative movement of rocks. Also, wireless sensor technology can be used to provide advance warning of an impending landslide disaster, facilitating emigration and disaster management. Generally distributed clustering algorithms are employed for effectively clustering the wireless sensor nodes in these hilly areas.

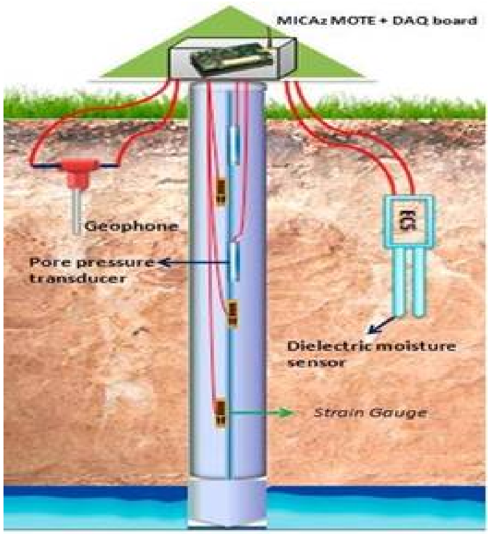


Figure 7: Landslide Detection

Forest fires, also identified as wild fires are wild fires occurring in wild areas and cause major damage to natural and human resources. Forest fires wipes out forests, burn the infrastructure and may result in high human death toll closer to urban areas. Common causes of forest fires include lightning, human carelessness and disclosure of fuel to extreme heat and aridity. It is known that in few cases fires are part of the forest ecosystem and they are significant to the life cycle of indigenous habitats. However in most cases, the spoil caused by fires to public safety and natural resources is intolerable and premature detection and suppression of fires deem crucial. For example, a forest fire originated by a lightning strike in the Okanagan Mountain Park in the Province of British Columbia, Canada. The fire was spread by the burly wind and within a few days it turned into a firestorm. The fire enforced the evacuation of 45,000 residents and burned out 239 homes. Most of the trees in the Okanagan Mountain Park were burned and the park was bunged. The condition of forest fires is even worse if we look at the national level. Over the past ten years

Apart from preventive measures, early discovery and suppression of fires is the only way to lessen the damage and casualties. Mechanisms for early detection of forest fires have evolved over the past decades based on sensor networks. Traditionally, forest fires have been detected using fire lookout towers situated at high points. A fire lookout tower houses an individual whose accountability is to look for fires using special devices such as Osborne fire finder. Osborne fire finder is comprised of a topographic map printed on a disk with a graduated rim. A pointer aimed at the fire decides the position and the direction of the fire. Once the fire position is determined, fire lookout alerts fire fighting team. Fire lookout towers are still in use in numerous countries around the world. Unreliability of human observations in addition to the hard life conditions for fire lookout personnel have led to the growth of automatic video surveillance systems which uses CCD cameras and Infrared detectors installed on the top of towers. CCD cameras use image sensors which enclose an array of light sensitive capacitors or photodiodes. In case of fire or smoke action, the system alerts the local fire departments, residents, and the industries.

The correctness of these systems is largely affected by weather conditions such as clouds, sunlight reflection and smoke resulting from industrial activities. Wireless sensor networks can potentially offer a good solution for problems of this kind. Recent advances in WSN supports the faith that they make a hopeful framework for building near real-time forest fire detection systems. Currently sensing modules can sense a diversity of phenomena including atmospheric temperature, relative humidity and smoke which are all helpful for fire detection systems. Sensor nodes can function for months on a pair of batteries to supply constant monitoring during the fire season. Moreover, modern protocols make sensor nodes proficient in organizing themselves into a self configuring network, thus eradicating the overhead of manual system. Large-scale wireless sensor networks can be effortlessly deployed using airplanes at a low cost compared to the damages and thrashing of properties caused by forest fires. In such type of large scale deployments, for proper cluster formation and prolonged battery utilization distributed clustering mechanism can be employed.


Figure 8: Forest Fire Detection

In environmental applications, it is possible to detect the earthquake and volcano explosion before its eruption by continuously monitoring them through the use of a number of different sensors like strain, light, image, sound, acceleration and barometer sensors. Through the Sensor-cloud infrastructure, the sensor instances occupied in environmental monitoring can be used in parallel with several other sensor instances, for example, by the healthcare division to shun any future casualty or with crop harvesting application services to evade the damage caused by bad weather conditions.

Sensor-clouds can be used for telematics, predestined to deploy the long distance transmission of the computerized or information to a system in continuum. It facilitates the smooth communication between system and devices devoid of any intervention.

Google health is a centralization service of Google that provides personal health information and serves as cloud health information storages. Google users are allowed to observe their health records by logging into their accounts at collaborated cloud health service providers into the Google health system. However, in a recent assertion Google has announced the discontinuation of this health service.

Microsoft Health Vault is developed by Microsoft to store and uphold health and fitness related information. Health Vault helps users to store, collect and share their health relevant information and its data can be acquired from several pharmacies, cloud providers, fitness employees, health laboratories, equipments and from the users itself.

Sensor-cloud can be used in the field of agriculture to watch the crop fields in order to upkeep it. For this, a field server has been developed that comprises of a camera sensor, air sensor, temperature sensor, CO2 concentration sensor, soil moisture and temperature sensor. These sensors constantly upload the field data via the Wi-Fi access point to the field owner to track the health of the crops, which can be used for harvesting itself.

## III. CONCLUSION

A sensor grid is developed for data gathering from various GPS stations to process, analyze, administer and visualize the data. This GPS data would then be uploaded onto the cloud for skillful monitoring, before-time warning and decision-making capability for critical situations like the volcanic eruptions, earthquakes, tsunamis and cyclones to the users all around the world. However, there are still plenty of hurdles needed to be overcome, among which essentially power reduction in communication links is the major subject of worry. Considerable efforts have been invested towards lowering the power consumption by improving sensor systems, including selectable power states, operating at low voltages, fine grained control of hardware and efficient usage of wireless broadcast medium. One best possible system is by adopting distributed clustering mechanisms to group the wireless sensor nodes in to clusters effectively. In this paper, possible integration of distributed clustering mechanism with the real world applications has been described creatively. However, these integration techniques can greatly lengthen the lifetime of the sensor nodes when used in remote and critical applications.

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