

Wireless sensors essay

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Wireless Sensor Technologies are becoming increasingly popular and useful to varying sectors of the economy. Numerous innovations have been made possible through the use of wireless sensors. Features of wireless sensors that have made them readily acceptable include their efficiency, small size and ease of deployment. They are however faced with critical challenges that need to be addressed through continued research and collaboration. This study examines the concept of wireless sensors, areas of application, accompanying advantages, theoretical studies, the various approaches to deployment and what the future is likely to hold in the field of wireless technologies.

Introduction The popularity of wireless sensors has recently increased as indicated by their widespread use for the development of modern technological applications.

Present trend shows that there are embedded sensors in most recent electronic devices manufactured today. The world of technology is beginning to record a high demand for miniature sensors that are capable of performing data communication with servers and other intelligent devices. Designing sensors that meet varying user requirements often involves a lot of research, design and integration of best practices applicable to such systems. Wireless sensor designs are usually multi-layered and involve front-end sensor technology, aerial design, subsequent implementation and application of effective design principles of wireless technology.

Wireless Sensor Networks Smart data usually depends on sensory data from the environment that is channeled through sensors located in different target places. Smart environments need information about their surroundings in order to function effectively. This information is provided through the use of

distributed wireless sensor networks. Wireless sensor networks typically comprise a data acquisition network and a data distribution network that are monitored by a management center (Lewis, 2004).

Wireless sensors are being increasingly utilized especially in fields of observing environmental conditions and increasing the interaction between both the physical and virtual worlds. A wireless sensor network is one that contains small nodes that are able to compute, communicate and sense different symptoms and changes within the environment. Major areas of application include monitoring of seismic activities, architectures, soil management, tracking herds of animals, monitoring the habitat, traffic monitoring (this is commonly used in the deployment of military systems), and the management of supply chain processes.

Wireless Sensor Networks are widely incorporated into the development of smart systems. They are different from everyday systems because they are usually installed in close proximity with the devices and objects they are built to monitor (Romer, Kasten, & Mattern, n. d.

). Wireless sensors have penetrated a wide variety of applications and systems that have varying requirements and features (Romer & Mattern, 2004). US-based research projects once defined wireless sensor networks as “ a large-scale ad-hoc, multi-hop, single network of small, static sensor nodes that are deployed in specific locations of interest” (Romer & Mattern, 2004). Wireless sensors may be utilized in networks that contain different types of sensors, topographies, and infrastructures. The uses of wireless sensors are becoming increasingly diversified (Romer & Mattern, 2004).

Wireless technologies provide easier and more cost-effective ways and methods of operating manufacturing plants. They can be used to monitor equipment, production processes and they also provide a platform for making real-time decisions. This can lead to a massive reduction in industry and manufacturing costs associated with maintenance and production delays.

Wireless Sensors and Moore's Law Gordon E. Moore, one of the co-founders of Intel mentioned in a 1965 paper that since the introduction of the integration circuit in 1958, the number of transistors that can exist on an integrated circuit has been increasing and doubles almost every two years. In recent times, capabilities of digital devices have been strongly linked to Moore's law especially in areas of memory, processing speed and related features. These features are also expanding exponentially. Moore's law seeks to describe the innovation and trends involved in the development of wireless sensor devices which are becoming increasingly smaller with time.

Most experts believe that Moore's law will hold true at least for the next two decades (Webopedia, 2009). Other schools of thought interpret Moore's Law as the assertion that the number of transistors on a chip would increase to twice its number every 24 months. In affirmation of this Moore's law, technological trends are now generally inclined towards the production of faster, smaller and more efficient technologies (BBC, 2005). Advantages of Wireless Sensor Technology Wireless sensors will continue to have a huge impact that will be beneficial to the environment, says Chuck Mc. Parland, a Computer Scientist at the Lawrence Berkeley National Labs who sees

wireless sensor systems as an effective way of monitoring energy usage and controlling environmental pollution. It will help to promote data center operations.

A major advantage of wireless sensor applications is their flexibility and ease of deployment. The use of wireless sensors in manufacturing and testing can lead to significant improvements in quality, savings and adaptability of equipment. It also allows for greater connectivity, control and less inefficiency as is the case with wired systems. Energy and process efficiency are improved with wireless sensors and most customers are usually satisfied with the services rendered by concerned industries, which is the basic objective of any business. With most businesses and economic sectors having a high turnover of overhead and opportunity costs, a wireless sensor application that is flexible, easy to deploy and maintain, seems to be the clear cut solution to adopt. Through wireless technology, quality is enhanced, downtime is minimized, operational efficiency is sustained and resources are utilized optimally. Most importantly, revenue and productivity are determined by the effectiveness of the most critical equipment. More advantages of wireless sensors include the following: 1) they are cost-effective and energy-efficient; this means that wireless sensor nodes are usually cheap and require little power to function 2) They are small in size; wireless sensors are extremely portable and can send signals across a wide area quite effectively.

3) They can be easily installed and moved around if the need arises (Curry, n. d.).

ARC's prediction regarding wireless technology is very positive. The market for wireless technology is expected to reach a billion dollars by 2010.

According to Harry Forbes of ARC, manufacturers have seen the benefits of using wireless technologies to reduce overall costs of production. They agree that wireless technology is a driver of business processes that is less expensive, more transparent and definitely more reliable than current manufacturing tools and methods. Theoretical Studies behind Wireless sensors With the application of Moore's law, wireless sensors are becoming smaller and less expensive even though they are just as powerful as some of the huge mechanisms developed today. Building wireless sensors involves the use of technologies from different fields of research.

These include sensing, communication and computing (algorithms, hardware and software). Research needs to be conducted in each of these areas to ensure that sensor networks are developed accurately. Thus, combined and separate advancements in each of these areas have driven research in wireless sensor areas. Manufacturers can also employ the use of semiconductor materials and techniques to build devices that react to fields and different types of forces. Most of the research projects that have been conducted into wireless sensor networks were initiated by military applications funded by DARPA. Examples of these projects include Smart dust and NEST. These two projects are usually regarded as the foundation of wireless sensor research.

Apart from the military, other applications of wireless sensors have been developed amongst the civilian population such as in areas of environmental

and species monitoring, healthcare, production and delivery, agriculture and so on (Romer ; Mattern, 2004). Design of Wireless Sensors. After the initial deployment, sensor nodes often change their locations. They may be attached to mobile entities with automotive features. The mobile tendency of wireless sensors implies that they are prone to being adversely affected by environmental factors such as wind, water and other natural elements.

Mobility could be an incidental occurrence or a built-in feature of the equipment. It is an area that demands intensive research and consideration in the field of wireless sensors because it influences the design of networking protocols and distributed algorithms (Romer ; Mattern, 2004). Wireless sensors can be designed in various shapes and sizes. Individual sensors can be as huge as a shoe box or as miniature as a tiny particle. The price of the wireless sensor also varies and depends on its size and strength. Devices that contain wireless sensors may obtain their power from their environments, for example, they may be solar-powered or obtain their power from batteries (Romer ; Mattern, 2004).

Earlier research into the design of wireless sensors had anticipated that sensor devices would contain homogenous sensors. However today, it is evident that sensor networks contain a variety of devices and heterogeneous nodes that perform different functions. For example in a typical sensor network, some nodes may be capable of collecting, processing and routing sensory data, while some are equipped with Global Positioning Systems (GPS) to act as beacons for indicating the positions of other nodes.

Some other wireless sensors may act as routers for long distance data communication networks such as Satellite networks, Global System for Mobile Communications (GSM) networks and even the internet (Romer ; Mattern, 2004). The range of sensors attached to a sensor node is also of extreme importance in the design of wireless sensor systems. With dense coverage, the distance covered by the wireless sensors is increased. High level of coverage of wireless sensors is needed to build robust and effective wireless systems and applications.

Redundant nodes may also be included in the design to ensure that a power-saving mode exists as a failover if an active node develops a fault. The number of sensor nodes is usually determined by the amount of connectivity and coverage that's needed within a network (Romer ; Mattern, 2004).

Methods used in Deploying Wireless Sensors The deployment of wireless sensors is a very important aspect of designing and implementing solutions that require wireless sensors because the type of deployment implemented affects the most crucial properties of the wireless sensor application which include node locations, density, and degree of network dynamics (Romer ; Mattern, 2004). There are different ways of deploying wireless sensors across diverse technological applications. They may be deployed to target locations randomly, for example, sensors could be dropped randomly from an aircraft or installed at specific spots in order to obtain optimal advantages. Deployment may be achieved once, as is the case of a one-time installation or it could become a continuous activity, with the number of sensor nodes continually increased, as is the case with expanding networks. Under the latter arrangement, it's common to replace failed sensor nodes

with new ones or to increase and strengthen the area of coverage of wireless sensors with extra nodes (Romer ; Mattern, 2004). The deployment of wireless sensor networks is in some cases, a continuous process that has to be monitored and maintained throughout its existence.

Wireless sensor nodes need to be replaced when their batteries have been depleted or destroyed due to environmental agents. Deployment involves associating sensor nodes with objects, animals and locations so that they can process a variety of sensory information. It may involve a one-to-one relationship amongst sensors, cover a specific target area or be done by throwing nodes from an aircraft or a high location to the target area of interest. Nodes are usually left to perform their functions after they have been deployed. Once the number of nodes in a particular location is sufficient, it can then be used to perform the activity it was built to perform. A PDA or an internet-enabled device may be used to issue these tasks (Romer, Kasten, ; Mattern, n. d.).

There are some existing sensor networks that are programmed to fulfill certain sensing tasks that produce results that affect actuator nodes. In more sophisticated architectures, the sensing results are used to trigger an in-depth observation of a phenomenon or occurrence. For example, a wireless sensor system could be designed to report the size, speed and direction of any motor vehicle that moves load above a specified limit through a specified area. Individual sensor nodes, on the other hand, provide very basic functionality like motion detection at a certain place. To achieve a more comprehensive and optimal result, multiple sensor nodes need to be

deployed and the tasks split between the nodes. Sometimes, the results or outputs of different sensors have to be merged to obtain an effective sensing result (Romer, Kasten, ; Mattern, n. .).

Ad hoc networks of wireless sensor nodes are usually deployed using aircraft or ships. These networks are able to organize themselves for communication and positioning. Nodes are able to detect each other and form a communication network. This kind of technology is common with mobile phones. Surveillance sensor networks need information on the positioning of these nodes in order to report data on detected targets (Lewis, 2004).

Wireless sensor networks may range from tens to thousands of nodes, arranged sparsely, densely or redundantly.

They may have a lifespan of hours to years. One important thing however, is that the Wireless Sensor Network should not halt because some nodes are spoilt. Sensors Prototypes Wireless technologies can be used with wireless access points, sensors, computers, dongles, industrial PCs and so many other devices. A wireless sensor prototype would comprise a large number of sensory nodes, also known as motes that are deployed in varying quantities.

Motes are electronic gadgets capable of recognizing different variations in light, radiation, humidity, temperature, and seismic vibrations. They can also detect the presence of living organisms and different types of computer data. These motes have to be combined to achieve optimal results because they have inherent constraints which include bandwidth, storage and processing speed. The practical prototype of wireless sensors can be seen in the field of Telecommunications. With infrastructure-based prototypes,

sensor nodes are used to communicate with base station devices. When sensor nodes communicate with each other, signals have to pass through the base station. If there is more than one base station in an area, individual base stations must be able to communicate with each other effectively. The area covered by sensor nodes and their range of communication will determine the number of base stations that are needed within a particular area.

Wireless sensors can help in the building of smart systems that can tell people when something is wrong. Intelligent systems are the future of most existing technologies we see today. The types of sensing that a machine can decipher include vibration, temperature, magnetic fields, force, pressure, and so on. They are used in the development of health monitoring applications (Bocko, 2001). Wireless sensor networks are currently being used in the field of animal study on an experimental basis. The areas of application of these devices are currently under study and are being improved upon.

A little bird known as Leach's Storm Petrel is presently under observation at the Great Duck Island in Maine, USA. A wireless sensor network can be used to monitor and document the breeding habits of the bird since it is quite sensitive to human presence. Wireless Sensor Networks (WSN) is capable of monitoring environmental conditions, variations among breeding locations, and the features of available breeding sites. Sensor nodes can be found on burrows and even on surfaces of different materials.

These nodes are capable of measuring temperature, humidity, pressure and light. They work by forming a network where every cluster operates by using its antenna to connect to a central base station system. The computer at the base station is connected to a central database through a satellite link. All signals are transmitted to the database back-end system (Romer ; Mattern, 2004). The behavior of animals within a spacious area can also be monitored through the use of wireless sensor networks. Zebras, lions and wild horses are presently being studied in Kenya at the Mpala Research Center. Animal Behaviours that are of interest include grazing patterns, interactions within a particular species, and the effects of human development on species over an expansive mass of land (Romer ; Mattern, 2004).

Sensor nodes are placed on target animals together with an in-built GPS receiver that can continually indicate the position of the animals at all times. These nodes are capable of logging their readings. At regular intervals, a mobile base station such as a car or plane, moves through the observation area and collects all the required data. A WSN is also being used to implement virtual fences which contribute significantly to reducing the overheads of installing physical fences to restrict the movement of animals. Each animal is equipped with a sensor node that comprises a GPS receiver, Wireless Local Area Network (WLAN) card and a loudspeaker (Romer ; Mattern, 2004).

To better understand the earth's climate and varying weather conditions, wireless sensor nodes are being used to monitor glacier environments in Norway. The nodes are drilled into glacier ice and they are sensitive to

pressure and temperature and are also able to communicate with a base station located on top of the ice. Despite the fact that radio communication between ice and water is difficult to accomplish, significant progress has been recorded through the use of differential Global Positioning System (GPS) and GSM technologies (Romer ; Mattern, 2004). Sensor nodes can be installed on ocean beds by scattering them at strategic locations on a ship. Each sensor node is connected through a cable to a buoy on the surface of the ocean that contains radio and GPS features because communication under water is difficult to achieve.

These nodes are able to measure current, conductivity, turbidity, pressure and numerous natural elements (Romer ; Mattern, 2004). An Oceanic Monitoring Project known as the ARGO project employs wireless sensors to measure salinity, temperature and the current status of the upper ocean. The basic aim of the project is to come to a definite description of the condition of the upper layers of the ocean, climate variability, weather shifts and so on. Sensor nodes that can respond to salinity and temperature are employed to record significant data. In this case, the nodes are also dropped from ships or planes, and they cycle to approximately 2000m every 11 days. The data collected during the cycles are transmitted via satellite while the nodes are on the surface. The nodes may last for about four or five years after which it may become necessary to replace them (Romer ; Mattern, 2004).

A WSN is currently used in Oregon to measure the effects of humidity, light and temperature across a vineyard in Oregon, USA (Romer ; Mattern, 2004).

Application of Wireless Sensors Wireless sensors are constantly employed by industrial manufacturers because they are extremely affordable. They can be used in the production of equipments which are resistant to chemical attack, electrical interference, vibration and adverse temperatures. The sensors can measure variations in temperature, pressure, humidity and other process indices relevant to the subject under study (Wireless Sensors Inc. 2005).

There are numerous fields that engage wireless sensors and they are listed as follows: scientific, military, environment, agricultural, commercial, industrial, health care, home automation, surveillance and numerous monitoring systems to mention a few. Wireless sensors are also being used in the development of cyber-physical systems, agricultural construction systems and numerous systems that involve the use of temperature sensors; body sensing, and so on (Wireless Sensors Inc. , 2005). Over time, sensor manufacturers have been using wireless technologies to produce sensor devices. Radio devices, formerly used to manufacture sensors, are not so popular anymore due to the costs associated with installing, testing, maintaining and upgrading such equipment. Even the Federal Aviation Administration of the United States of America stated that aircraft wiring could no longer be seen as a fault-free technology. Wireless systems are becoming generally more acceptable and practical for most organizations (Allgood, Manges, ; Smith, 1999).

There are numerous areas of application of Wireless and most of these areas are summarized below: 1. They can be used as a research instrument, for example a ' macroscope' can be used as a device for habitat monitoring and

environmental monitoring. 2. It can be used as a diagnostic system for monitoring and observing body functions.

It may also be used as a surveillance system for home monitoring, exploration and goods monitoring. Goods like parcels, containers and vehicles can be equipped with wireless sensors which can make tracking of these goods easy to accomplish (Kutylowski, 2006). 3. Wireless sensors can also be used in health monitoring systems and relaying information especially in mission-critical situations like firefighting. The vital signs of patients can be monitored with the use of wireless sensors. This system consists of four different parts and they are: patient identifier; this contains information of the patient; a display device through which patient data and vital signs can be inspected; Medical sensors, for example, an electrocardiogram; and a setup pen, used by medical administrators to establish and remove associations between various devices (Kutylowski, 2006).

. A WSN is employed in locating the buried victims of avalanches. Rescuers are provided with additional information on the state of victims based on respiration activity, heart rate and consciousness level. This is the reason why snowboarders, hikers and skiers carry sensor nodes that are equipped with oximeters. Oximeters are sensor nodes that are capable of measuring the level of oxygen in the blood.

They can also be used to measure heart rate and respiration activity of the body. Rescue teams are able to receive sensory data from victims through PDAs (Romer ; Mattern, 2004). . Tracking Military vehicles has become easier

through the use of hidden wireless sensors which are difficult to destroy. Magnetometer sensors are usually attached to these nodes so that the closeness of tanks can be easily detected. The existing nodes collaborate to determine the path and velocity of the vehicle that is being tracked. The results of the tracking exercise are sent to an unmanned aerial vehicle. In the Military, it can also be used to locate snipers and the angle of bullets by implementing a multi-hop adhoc network (Romer ; Mattern, 2004).

Recent innovations in the field of wireless sensors are authentication, use of cryptography, and numerous mechanisms for conserving data integrity that are being used for the secure deployment of wireless sensors. Innovations that involve the application of real-time technology are also being explored. One major setback is however, the environment in which most wireless sensors are built.

Other new areas in which wireless sensors are being explored for use include nuclear reactor control, automation of buildings and disaster prevention. The latter concept of disaster prevention involves being able to tell from natural phenomena when harmful occurrences like earthquakes, land slides or floods are about to occur and building protective and proactive mechanisms of tackling them. Challenges of Wireless Sensors Existing research into sensor networks use the principles of distributed computer networks on a large scale. There are however, certain challenges of sensor networks that need to be addressed due to their specialized nature, diverse power and sensitivity. Wireless sensors should always be manufactured with adaptability in mind since they are usually employed in different devices and under different

environmental conditions and physical locations. The importance of a middleware is very important in the deployment of a WSN. Sensors are small in size and are therefore restricted in the amount of energy they can obtain from their environment.

These nodes are also easily affected by battery depletion and environmental impacts. This imposes limitations on the resources available like CPU performance, range and communication bandwidth. Topology changes and movements also have a high impact on sensor nodes. Communication paths of sensor nodes may experience delay in the flow of information, and communication may be unidirectional. Another basic problem of Wireless sensors is heterogeneity.

WSNs may comprise a large number of different nodes that have varying computing power and memory. The large number of sensors deployed at any specific location increases scalability but also promotes redundancy. Most nodes operate with little or no supervision since they are sometimes located in inaccessible locations (Romer, Kasten, ; Mattern, n. .

). Wireless sensor networks are sometimes used in protecting sensitive information that is vulnerable to manipulation, fraud, or sensor destruction. Important data such as data that involves environmental information, pollution, and security details need to be guarded effectively.

Security solutions tailored to fulfilling the needs of wireless sensors need to be developed. An EU Project known as FRONTS (Foundations of Adaptive Networked Societies of Tiny Artifacts) is one of the major projects that

examine ways of incorporating wireless sensors in an effective manner. Even without the cryptographic technology used to improve the level of security of wireless sensor systems, effective security solutions can still be incorporated. Data along sensor networks are routed by using hops. The disadvantage in this is that an attacker can gain control of intermediary nodes. Additional security measures include sending information over a double path.

This architecture involves hiding transmission routes so that the attacker is unable to identify the traffic coming from each node (Klonowski, Koza, ; Kutylowski, 2009). Solutions to Challenges In order to deal with the characteristics and challenges stated above, some principles have been proposed for the design and implementation of WSN and they are discussed below: 1. Localized algorithms: These are distributed algorithms whose main objective is to communicate with nodes within the vicinity only. These algorithms work more effectively with an increased network size, partitions and node failures. Adaptive fidelity algorithms, on the other hand, allow a trade between result quality and resource utilization. They help to increase the overall efficiency of WSN.

There are different algorithms that are available to people and there should be options in choosing which particular algorithm is needed in achieving the best quality and utilization of resources. 2. Data-centric communication is a form of node addressing that focuses on the data produced by nodes. Middleware is usually installed between an operating system and the

application. It is still unclear which direction the implementation of the middleware will follow and current research focuses on resolving this.

Middleware performs these two functions: 1) it supports the development, deployment, and maintenance of sensor-based applications. 2) It helps in formulating high level sensing tasks, communicating these tasks to the WSN and coordinating sensor nodes in order to split the tasks and distribute them evenly to individual sensor nodes. A high level result is obtained and reported back to the task-issuer (Romer, Kasten, ; Mattern, n. d.).

Future of Wireless Technology.

In the near future, scientists believe that there will be better algorithms, systems and architectures. It is necessary in the interim, to identify what is missing in sensor networks to make them applicable for everyday equipment and utilization. Most businesses are going to use them to satisfy their increasing business needs and expanding process objectives. Wireless sensor nodes that are commonly utilized today include Bluetooth kits. Wireless sensor technology will eventually catch up with existing technologies and possibly replace them.

Research Methodology.

Throughout the period of research, News Publications, Research Journals, Documents from the Internet and other trusted sources of information were used in gaining further insight into the wide concept of wireless technologies. Focus was placed specifically on information that highlighted the benefits, scope and examples of how wireless sensors can be used both now and in the future.

Discussions were also held with some experts and professors in the field of wireless sensors. Through the use of questionnaires, interviews and analysis of surveys, a comprehensive dissertation has been developed. Areas of further research that would shed light on new innovations include:

Conclusion It is now apparent that wireless sensors have been embraced by the world of technology and its users. This is hardly surprising because these sensors offer numerous advantages and opportunities in an extremely seamless and effective manner. This technology has come to stay.

Researchers and experts should continue to seek and promote innovative ways of expanding the reach of wireless sensors to ensure that they are utilized in the most optimal and beneficial fashion for the benefit of all.