# A Review Paper on Wireless Sensor Networks: Applications and System

Amitoj Kaur [#1], Gursimrat Singh[#2]

[#]*Student, M.Tech, Computer Engineering, Punjabi University*
*Patiala, Punjab, India*

[1]amitoj.kaur09@gmail.com

[2]gursimratsinghvirk@gmail.com

*Abstract*— **Wireless sensor network are a group of sensors linked by a wireless medium. This paper gives the introduction to these wireless sensor nodes and the areas in which they are implemented and also the various systems in which they are used now a days. There are numerous applications and areas in which they are used and are very useful in reducing the human effort. They are used to monitor physical conditions as well as environment conditions. There are various standards for implementing them. In this paper you will get a simple introduction in section1, followed by its applications and then in section3 we have the system that uses them.**

*Keywords*— **Wireless sensor networks, nodes, WINS**

## I. INTRODUCTION

A Wireless Sensor Networks (WSN) consists of spatially distributed sensor to monitor physical or environmental condition [1]. A sensor network is a computer network composed of a large number of sensor nodes [2]. The increasing interest in wireless sensor networks can be promptly understood simply by thinking about what they essentially are: a large number of small sensing self-powered nodes which gather information or detect special events and communicate in a wireless fashion, with the end goal of handing their processed data to a base station. Sensing, processing and communication are three key elements whose combination in one tiny device gives rise to a vast number of applications [3], [4].

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 [1].

### A. Characteristics

The number of sensor nodes in a sensor network can be several orders of magnitude higher than the nodes in an ad hoc network.

- Sensor nodes are densely deployed.
- Sensor nodes are prone to failures.
- The topology of a sensor network changes very frequently.
- Sensor nodes mainly use broadcast communication paradigm whereas most ad hoc networks are based on point-to-point communications.
- Sensor nodes are limited in power, computational capacities, and memory.
- Sensor nodes may not have global identification (ID) because of the large amount of overhead and large number of sensors [6].

## II. APPLICATIONS

Possible applications of sensor networks are of interest to the most diverse fields. Environmental monitoring, warfare, child education, surveillance, micro-surgery, and agriculture are only a few examples [7].

Sensor networks may consist of many different types of sensors such as seismic, low sampling rate magnetic, thermal, visual, infrared, acoustic and radar, which are able to monitor a wide variety of ambient conditions that include the following [5]:

- Temperature,
- Humidity,
- Vehicular movement,
- Lightning condition,
- Pressure,
- Soil makeup,
- Noise levels,
- The presence or absence of certain kinds of objects,
- Mechanical stress levels on attached objects, and
- The current characteristics such as speed, direction, and size of an object.

*A. Military Applications*

Wireless sensor networks can be an integral part of military *Command*, *Control*, *Communications*, *Computing*, *Intelligence*, *Surveillance*, *Reconnaissance and Targeting (C4ISRT)* systems. The rapid deployment, self-organization and fault tolerance characteristics of sensor networks make them a very promising sensing technique for military C4ISRT. Since sensor networks are based on the dense deployment of disposable and low-cost sensor nodes, destruction of some nodes by hostile actions does not affect a military operation as much as the destruction of a traditional sensor which makes sensor networks concept a better approach for battlefields. Some of the military applications of sensor networks are monitoring friendly forces, equipment and ammunition; battlefield surveillance; reconnaissance of opposing forces and terrain; targeting; battle damage assessment; and nuclear, biological and chemical (NBC) attack detection and reconnaissance.

***Monitoring friendly forces, equipment and ammunition***: Leaders and commanders can constantly monitor the status of friendly troops, the condition and the availability of the equipment and the ammunition in a battlefield by the use of sensor networks. Every troop, vehicle, equipment and critical ammunition can be attached with small sensors that report the status. These reports are gathered in sink nodes and sent to the troop leaders. The data can also be forwarded to the upper levels of the command hierarchy while being aggregated with the data from other units at each level.

***Battlefield surveillance*:** Critical terrains, approach routes, paths and straits can be rapidly covered with sensor networks and closely watched for the activities of the opposing forces. As the operations evolve and new operational plans are prepared, new sensor networks can be deployed anytime for battlefield surveillance.

***Reconnaissance of opposing forces and terrain*** Sensor networks can be deployed in critical terrains, and some valuable, detailed, and timely intelligence about the opposing forces and terrain can be gathered within minutes before the opposing forces can intercept them.

***Targeting*:** Sensor networks can be incorporated into guidance systems of the intelligent ammunition.

***Battle damage assessment*:** Just before or after attacks, sensor networks can be deployed in the target area to gather the battle damage assessment data.

***Nuclear, biological and chemical attack detection and reconnaissance*:** In chemical and biological warfare, being close to ground zero is important for timely and accurate detection of the agents. Sensor networks deployed in the friendly region and used as a chemical or biological warning system can provide the friendly forces with critical reaction time, which drops casualties drastically. We can also use sensor networks for detailed reconnaissance after an NBC attack is detected. For instance, we can make a nuclear reconnaissance without exposing a recce team to nuclear radiation.[6]

*B. Area Monitoring*

Area monitoring is a common application of WSNs. In area monitoring, the WSN is deployed over a region where some phenomenon is to be monitored. A military example is the use of sensors to detect enemy intrusion; a civilian example is the geo-fencing of gas or oil pipelines. When the sensors detect the event being monitored (heat, pressure), the event is reported to one of the base stations, which then takes appropriate action (e.g., send a message on the Internet or to a satellite). Similarly, wireless sensor networks can use a range of sensors to detect the presence of vehicles ranging from motorcycles to train cars [1].

*C. Environment Monitoring*

The term Environmental Sensor Networks, has evolved to cover many applications of WSNs to earth science research. This includes sensing volcanoes, oceans, glaciers, forests, etc. Some environmental applications of sensor networks include tracking the movements of birds, small animals, and insects; monitoring environmental conditions that affect crops and livestock; irrigation; macro instruments for large-scale Earth monitoring and planetary exploration; chemical/biological detection; precision agriculture; biological, Earth, and environmental monitoring in marine, soil, and atmospheric contexts; forest fire detection; meteorological or geophysical research; flood detection; bio-complexity mapping of the environment; and pollution study [1],[6].

***Air quality monitoring:*** To protect humans and the environment from damage by air pollution, it is of the utmost importance to measure the levels of pollutants in the air. Real time monitoring of dangerous gases is particularly interesting in hazardous areas, as the conditions can change dramatically very quickly, with serious consequences.

**Environmental magnitudes**: Temperature, Humidity, Light

**Gas & particle concentration**: O2, CO, CO2, SO2, H2S, NO, NO2, NH3, CH4, PM-10, TVOC

**Ambient monitoring**: Rainfall, Wind speed, Wind direction, UV levels, Atmospheric pressure [1].

**Interior monitoring:** The measurement of gas levels at hazardous environments requires the use of robust and trustworthy equipment that meets industrial regulations.

**Exterior monitoring**: Outdoor monitoring of air quality requires the use not only of accurate sensors, but also rain & wind resistant housing, as well as the use of energy harvesting techniques that ensure extended autonomy to equipment which will most probably have difficult access [1].

***Air pollution monitoring:*** Wireless sensor networks have been deployed in several cities (Stockholm, London or

Brisbane) to monitor the concentration of dangerous gases for citizens. These can take advantage of the ad-hoc wireless links rather than wired installations, which also make them more mobile for testing readings in different areas. There are various architectures that can be used for such applications as well as different kinds of data analysis and data mining that can be conducted [1].

***Forest fire detection:*** A network of Sensor Nodes can be installed in a forest to detect when a fire has started. The nodes can be equipped with sensors to measure temperature, humidity and gases which are produced by fire in the trees or vegetation. The early detection is crucial for a successful action of the fire-fighters; thanks to Wireless Sensor Networks, the fire brigade will be able to know when a fire is started and how it is spreading [1].

***Landslide detection:*** A landslide detection system makes use of a wireless sensor network to detect the slight movements of soil and changes in various parameters that may occur before or during a landslide. And through the data gathered it may be possible to know the occurrence of landslides long before it actually happens [1].

***Water quality monitoring:*** Water quality monitoring involves analysing water properties in dams, rivers, lakes & oceans, as well as underground water reserves. The use of many wireless distributed sensors enables the creation of a more accurate map of the water status, and allows the permanent deployment of monitoring stations in locations of difficult access, without the need of manual data retrieval [1].

***Natural disaster prevention:*** Wireless sensor networks can effectively act to prevent the consequences of natural disasters, like floods. Wireless nodes have successfully been deployed in rivers where changes of the water levels have to be monitored in real time [1].

*D. Health Applications*

Some of the health applications for sensor networks are providing interfaces for the disabled; integrated patient monitoring; diagnostics; drug administration in hospitals; monitoring the movements and internal processes of insects or other small animals; telemonitoring of human physiological data; and tracking and monitoring doctors and patients inside a hospital [6], [8],[9], 10], [11] and [12].

***Telemonitoring of human physiological data*:** The physiological data collected by the sensor networks can be stored for a long period of time, and can be used for medical exploration. The installed sensor networks can also monitor and detect elderly people's behavior, e.g., a fall. These small sensor nodes allow the subject a greater freedom of movement and allow doctors to identify pre-defined symptoms earlier. Also, they facilitate a higher quality of life for the subjects compared to the treatment centers [6].

***Tracking and monitoring doctors and patients inside a hospital*:** Each patient has small and light weight sensor nodes attached to them. Each sensor node has its specific task. For example, one sensor node may be detecting the heart rate while another is detecting the blood pressure. Doctors may also carry a sensor node, which allows other doctors to locate them within the hospital [6].

***Drug administration in hospitals*:** If sensor node can be attached to medications, the chance of getting and prescribing the wrong medication to patients can be minimized because patients will have sensor nodes that identify their allergies and required medications. Computerized systems as described in have shown that they can help minimize adverse drug events [1].

*E. Agriculture*

Using wireless sensor networks within the agricultural industry is increasingly common; using a wireless network frees the farmer from the maintenance of wiring in a difficult environment. Gravity feed water systems can be monitored using pressure transmitters to monitor water tank levels, pumps can be controlled using wireless I/O devices and water use can be measured and wirelessly transmitted back to a central control center for billing. Irrigation automation enables more efficient water use and reduces waste.

***Greenhouse monitoring****:* Wireless sensor networks are also used to control the temperature and humidity levels inside commercial greenhouses. When the temperature and humidity drops below specific levels, the greenhouse manager must be notified via e-mail or cell phone text message, or host systems can trigger misting systems, open vents, turn on fans, or control a wide variety of system responses.

*F. Home Applications*

***Home automation*:** As technology advances, smart sensor nodes and actuators can be buried in appliances, such as vacuum cleaners, micro-wave ovens, refrigerators, and VCRs [13]. These sensor nodes inside the domestic devices can interact with each other and with the external network via the Internet or Satellite. They allow end users to manage home devices locally and remotely more easily [6].

***Smart environment*:** The design of smart environment can have two different perspectives, i.e., human-centered and technology-centered [14]. For human-centered, a smart environment has to adapt to the needs of the end users in terms of input/output capabilities. For technology-centered, new hardware technologies, networking solutions, and middleware services have to be developed. A scenario of how sensor nodes can be used to create a smart environment is described in [15]. The sensor nodes can be embedded into furniture and appliances, and they can communicate with each other and the room server. The room server can also communicate with other room servers to learn about the services they offered, e.g., printing, scanning, and faxing [6]. These room servers and sensor nodes can be integrated with existing embedded devices to become self-organizing, self-regulated, and adaptive systems based on control theory models as described in [15]. Another example of smart environment is the "Residential Laboratory" at Georgia Institute of Technology [16]. The computing and sensing in this environment has to be reliable, persistent, and transparent [6].

## III. WINS

Rockwell Science Center has created a development environment for wireless integrated networked sensors (WINS) that include customizable, sensor-laden networked nodes and both mobile and internet-hosted user interfaces. The WINS development system allows examination of issues relative to design, deployment and usage of micro sensor networks. WINS nodes sense their environment via multiple sensors, process sensor data both autonomously and in cooperation with neighbouring nodes into information, and communicate this information to users via a variety of network topologies. WINS are self organizing in that they establish and maintain the network without user intervention. Minimizing power consumption is a primary driver in WINS development. Each node processes sensor data into *information,* thereby reducing power-hungry communications requirements. Power minimization also drives the design of integrated WINS hardware and the creation of new networking protocols specific to the needs of microsensor networks. Prototype WINS are being applied to area monitoring, surveillance, and physical security, to networking of personnel and physical assets over large areas, as well as to machinery and platform health and status monitoring.

Wireless distributed microsensor networks consist of a collection of communicating nodes, where each node incorporates: a) one or more sensors for measuring the environment b) processing capability in order to process sensor data into "high value" information and to accomplish local control and c) a radio to communicate information to/from neighboring nodes and eventually to external users. In the not-too-distant future, technology will advance to the point that miniature, ultralow- power CMOS chips, which integrate radios for communication, digital computing, and MEMS sensing components on a single die that will be produced in high volumes for low-cost. This will permit large numbers of wireless integrated networked sensors to be easily and rapidly deployed (e.g., airdropped into battlefields or deployed throughout an aircraft or space vehicle) to form highly redundant, self-configuring, ad hoc sensor networks. For ease of deployment, the nodes use wireless communications and are capable of establishing and operating their own network. To prolong battery life, all node and network functions are designed to consume minimal power. Highly capable and ultra-reliable systems will be built out of large numbers of such nodes that are individually inexpensive and use cooperation between nodes to produce highly reliable, high quality information.

The Rockwell Science Center, in collaboration with researchers at UCLA, has developed a prototype development platform for experimenting with microsensor networks under a number of government and industry sponsored programs. The prototype node, called "WINS 1", is based on an open, modular design using widely available commercial-off-the-shelf (COTS) technology. To date more than one hundred units of the latest version of wireless microsensor nodes have been built. These nodes combine sensing capabilities (such as seismic, acoustic, and magnetic) with a commercial digital cordless telephone radio and an embedded commercial RISC microprocessor in a small package. As these networks are designed for low power, embedded signal processing is performed in order to reduce communication requirements [18].

### *A. Applications of WINS*

Rockwell is developing a series of potential military, aerospace, industrial, and consumer applications for WINS [18].

***Condition-based Maintenance of Machinery and Systems:*** Rockwell is developing WINS systems specifically tailored to the requirements for monitoring complex machinery and processes. WINS are presently deployed inside factories and on board U.S. Navy ships for continuous health monitoring of equipment. WINS are also being explored for use on aircraft, rotorcraft, and spacecraft as part of an overall integrated vehicle health management system. The primary driver in these applications is to reduce the requirement for human monitoring of equipment and provide detailed and continuous knowledge on the operating state of equipment such that costly, unanticipated downtime is avoided and logistics activities are optimized. The cost savings that can be achieved with on-line equipment monitoring are dramatic [17].WINS are enabling in these applications because they eliminate the exorbitant costs (e.g., economic, size, and weight) associated with wireline networks [18].

Rockwell is also actively developing the ability for distributed collections of WINS nodes located on machine components and/or throughout a process to provide information on the overall machine and/or process on which they are deployed. This is a primary advantage of a distributed sensing system in that it enables inferences from individual component data to be used to provide diagnostics for aspects of the system that are not directly being sensed. For example, monitoring bearing vibrations or motor currents can provide information on not only the bearing health, but also the inception and severity of pump cavitation. Pump cavitation, in turn, can provide information on the state of valves located throughout a pumping process. The heart of this capability is model-based diagnostics and Rockwell is a leader in the development of tools and applications for model-based diagnostics.

The dynamically reconfigurable nature of WINS is being exploited in an application of WINS to space vehicle health monitoring in collaboration with the Boeing Company. WINS will be deployed throughout space vehicles and will perform different missions during the different phases of the space flight. For example, during the launch phase, WINS located on various critical components of the spacecraft will monitor vibration levels for out of compliance signals. During flight and re-entry, the WINS network will monitor structural disturbances caused by the significant temperature gradients encountered as different portions of the vehicle are alternately exposed and shadowed from the sun and atmosphere. This will be accomplished via coherent collection and processing of vibration and strain data. Upon landing, critical components will once again be monitored for out of compliance signals. These data will be used to determine those components needing post-flight maintenance or replacement, thus enabling faster turnaround for the space vehicle and thereby dramatically lowering costs.

***WINS in Space:*** WINS have recently been applied in an experiment demonstrating the ease with which ultra-low-cost "picosatellites" can be deployed and communicated with. In collaboration with the Aerospace Corporation, WINS-based picosatellites will be launched on two space vehicles in late 1999 and early 2000. WINS communications and processor modules form the heart of an experiment in which multiple satellites will be deployed from a "mother-satellite." These satellites will communicate both with each other and with a ground station. The cost of the WINS-based picosatellites is less than $5K and they are slightly larger than a deck of playing cards. A network of micro electro mechanical (MEMS) switches will serve as the satellite payload demonstrating the efficacy of MEMS in space. We expect these initial demonstrations to be the first in a series of experiments demonstrating modular ultra-low-cost satellite networks that have ever-increasing functionality [18].

***Area Monitoring:*** For military users, a primary focus has been area monitoring. WINS will replace single high-value sensor assets with large arrays of distributed sensors for both security and surveillance applications. WINS 1 is smaller and more capable than sensor assets presently in the inventory. The added feature of robust, self-organizing networking makes WINS deployable by untrained troops in essentially any situation. Distributed sensing has the further advantages of being able to provide redundant and hence highly reliable information on threats as well as the ability to localize threats by both coherent and incoherent processing among the distributed sensor nodes. WINS will be used in traditional sensor network applications for large area and perimeter monitoring and will ultimately enable every platoon, squad, and soldier to deploy sensor networks to accomplish a myriad of mission and self-protection goals. The Rockwell WINS team has been very active in working with the U.S. Marine Corps and the U.S. Army to test and continuously refine WINS performance in desert, forest, and urban terrain. For the urban terrain, WINS will dramatically improve troop safety as they clear and monitor intersections, buildings, and rooftops by providing continuous vigilance for unknown troop and vehicle activity [18].

## IV. CONCLUSIONS

Many new applications can be created by using the efficiency, low- cost, high processing, fault tolerance and other characteristics of the sensor nodes. We can use the wireless sensor nodes in the area where human presence is not possible or not feasible, like the areas having very low temperatures, forests, etc. WSN can also be used to reduce human effort and to alarm us if the conditions are not favourable. They are used in various application areas like area monitoring, forest fires detection and prevention, environment monitoring. Now a day they are also used in home applications and also the research work is done to make the mobile phones as the nodes. The nodes have a processor, a battery and internal antenna and a radio transceiver. The nodes communicate with each other and send data or useful information to the user. A sensor is developed by Rockwell Science Center known as WINS which is now being used in space, aircraft monitoring, area monitoring. Also there is more development being made in WINS by Rockwell Science Center. There is research being done to reduce the battery power consumption and to lower the cost of sensor nodes so as to make it more efficient. Low cost and low battery consumption are the major challenges and issues for WSN.

## ACKNOWLEDGMENT

We would like to thanks all who helped me with this work.

## REFERENCES

[1] http://en.wikipedia.org/wiki/Wireless_sensor_network

[2] http://en.wikipedia.org/wiki/Sensor_Networks

[3] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A survey on sensor networks," in IEEE Communications Magazine, pp. 102–114, Aug. 2002.

[4] L.B. Ruiz, L.H.A. Correia, L.F.M. Vieira, D.F. Macedo, E.F. Nakamura, C.M.S. Figueiredo, M.A.M. Vieira, E.H.B. Maia, D. Câmara, A.A.F. Loureiro, J.M.S. Nogueira, D.C. da Silva Jr., and A.O. Fernandes, "Architectures for wireless sensor networks (In Portuguese)," in Proceedings of the 22nd Brazilian Symposium on Computer Networks (SBRC'04), Gramado, Brazil, pp. 167–218, May 2004. Tutorial. ISBN: 85-88442-82-5.

[5] D. Estrin, R. Govindan, J. Heidemann, S. Kumar, Next century challenges: scalable coordination in sensor networks , ACM MobiCom'99, Washingtion, USA, 1999, pp. 263–270

[6] I.F. Akyildiz, W. Su*, Y. Sankarasubramaniam, E. Cayirci, "Wireless Sensor Networks: A Survey", Elsevier Science B.V., December 2001

[7] M. Haenggi, "Opportunities and Challenges in Wireless Sensor Networks," in Handbook of Sensor Networks: Compact Wireless and Wired Sensing Systems, M. Ilyas and I. Mahgoub, eds., Boca Raton, FL, pp. 1.1–1.14, CRC Press, 2004.

[8] N. Bulusu, D. Estrin, L. Girod, J. Heidemann, Scalable coordination for wireless sensor networks: self-configuring localization systems, International Symposium on Communication Theory and Applications (ISCTA 2001), Ambleside, UK, July 2001

[9] J.M. Kahn, R.H. Katz, K.S.J. Pister, Next century challenges: mobile networking for smart dust, Proceedings of the ACM MobiCom'99, Washington, USA, 1999, pp. 271–278

[10] B. Warneke, B. Liebowitz, K.S.J. Pister **Smart dust: communicating with a cubic-millimeter computer** IEEE Computer (January 2001), pp. 2–9

[11] J.M. Rabaey, M.J. Ammer, J.L. da Silva Jr., D. Patel, S. Roundy, **PicoRadio supports ad hoc ultra-low power wireless networking**, IEEE Computer Magazine (2000), pp. 42–48

[12] With Glacier Park in Its Path, Fire Spreads to 40,000 Acres, New York Times, Vol. 150, Issue 51864, p. 24, 0p, 1 map, 4c, 9/2/2001.

[13] E.M. Petriu, N.D. Georganas, D.C. Petriu, D. Makrakis, V.Z. Groza, **Sensor-based information appliances,** IEEE Instrumentation and Measurement Magazine (December 2000), pp. 31–35

[14] G.D. Abowd, J.P.G. Sterbenz, **Final report on the inter-agency workshop on research issues for smart environments,** IEEE Personal Communications (October 2000), pp. 36–40

[15] C. Herring, S. Kaplan, Component-based software systems for smart environments, IEEE Personal Communications, October 2000, pp. 60–61

[16] I.A. Essa, **Ubiquitous sensing for smart and aware environments**, IEEE Personal Communications (October 2000), pp. 47–49

[17] K.C. Becker, C.S. Byington, N.A. Forbes, G.W. Nickerson, **Predicting and Preventing Machine Failures**, The Industrial Physicist, American Institute of Physics, 20-23, Dec., 1998.

[18] Henry O. Marcy, Jonathan R. Agre, Charles Chien, Loren P. Clare, Nikolai Romanov, and Allen Twarowski, **Wireless Sensor Networks for Area Monitoring and Integrated Vehicle Health Management Applications,** Rockwell Science Center, Thousand Oaks, CA 91360