Wireless Sensor Networks for Industrial Process

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***Abstract* — Wireless sensor networks have gained more space with the evolution of transistor, sensor, Mems, and microprocessor technologies. The networks are formed by sensor nodes that have reduced physical characteristics allowed to be applied in the most diverse areas, such as monitoring of risk areas, environmental parks, historical monuments, military, domestic, hospital and industrial environments. Wireless sensor network technologies are supported by simulators that allow the analysis of the best deposition, communication, energy consumption and performance, as well as physical structures that allow to establish better practices of production and maintenance. This work aims at the analysis of the wireless sensor networks for the monitoring of industrial processes, thus allowing the association with the reliability of processes and the reduction of risks.**

Keywords — Sensor Networks, Monitoring Condition, Industrial Processes.

I. INTRODUCTION

Wireless sensor networks are being used in a wide range of areas, such as military, tourism, education, inventory control, monitoring of hazardous areas, environmental parks, historic ruins, military, domestic, hospital and industrial environments. A wireless sensor network is used in situations where it is not possible to use cables and wires. In industrial processes wireless sensor networks can be used with several objectives when associated with reliability techniques, predictive maintenance, and support for preventive and corrective maintenance processes. Wireless sensor networks can be applied to reliability processes, which aim to achieve a certain operational campaign in a certain period without failures. Monitoring of critical conditions indicated in the processes may allow increased reliability. When applied to the Rcm technique, Reliability Centered Maintenance, hidden fault detection can employ sensors and eliminate the root cause of failure. Wireless sensor networks in relation to their physical characteristics are formed by many devices, which have the capacity for sensing, processing, actuation, and communication. The main characteristics of a sensory network are sensor, observer, and phenomenon. The sensor is the device that makes the wireless sensor networks are being used in the most military, tourism, education, inventory control, risk areas monitoring, environmental parks, historical ruins, military, domestic, hospital and industrial environments. A wireless sensor network is used in situations where it is not possible to use cables and wires. In industrial processes, wireless sensor networks can be used with several objectives when associated with reliability techniques, predictive maintenance, and support for preventive and corrective maintenance processes. The main characteristics of a sensory network are sensor, observer, and phenomenon. The sensor is the device that makes the monitors the magnitude or phenomenon being analyzed. The element of sensor, processor, radio, and battery form its basic

TABLE I. MAINTENANCE AND APPLICATION TECHNIQUES

Techniques	*Application*
Preventive: technique based on time or condition	Monitoring parameters of filters, collectors, cameras, supporting decision-making for anticipation or postponement of campaigns.
Predictive: technique based on resulting analysis	Vibration, temperature, and noise monitoring. Allows support for investigation of hidden failures.

structure. The information collected are sent to the observer. The observer is the user who wishes to obtain data about the phenomenon monitored. The phenomenon is the greatness or object of study of the observer. Among the limiting and critical factors for wireless sensor networks is the question of substitution due to consumption. Wireless sensor networks are being used in a wide range of areas, such as military, tourism, education, inventory control, monitoring of hazardous areas, environmental parks, historical ruins, military, domestic, hospital and industrial environments. A wireless sensor network is used in situations where it is not possible to use cables and wires. In industrial processes wireless sensor networks can be used with several objectives when associated with reliability techniques, predictive maintenance, and support for preventive and corrective maintenance processes. Wireless sensor networks can be applied to reliability processes, which aim to achieve a certain operational campaign in a certain period without failures. Monitoring of critical conditions indicated in the processes may allow increased reliability. When applied to the Rcm technique, Reliability Centered Maintenance, hidden fault detection can employ sensors and eliminate the root cause of failure. Wireless

sensor networks in relation to their physical characteristics are formed by many devices, which have the capacity for sensing, processing, actuation, and communication. The main characteristics of a sensory network are sensor, observer, and phenomenon. The sensor is the device that monitors the magnitude or phenomenon being analyzed. The element of sensor, processor, radio, and battery form its basic structure. The information collected are sent to the observer. The observer is the user who wishes to obtain data about the phenomenon monitored. The phenomenon is the greatness or object of study of the observer. Among the limiting and critical factors for wireless sensor networks is the question of substitution due to consumption. Thus, the establishment of efficient protocols can allow the prolongation of the useful life of the system. The main metrics for evaluating the protocols are energy efficiency, latency, precision, fault tolerance, scalability, and sensor exposure. Important requirements for receiving and transmitting data securely are defined as data confidentiality, data authentication, data integrity, and data being recent.

II. HARDWARE AND COMPONENTS

Wireless sensor networks have a comprehensive and dynamic technology. The areas of operation allow the most diverse applications and there are technological advances for both hardware and software. The flexibility of network installation allows for the minimization of implementation costs of monitoring projects and the results can be quite significant when compared to other technologies given the ability to adapt the network. The network monitoring architecture uses the cluster concept, where tens or hundreds of nodes make up a network. [16]. In this type of architecture, we have three basic types of sensor nodes: slaves, masters, and sinks. The slave nodes perform basic operations of sensing and transmission of data, either transmit or otherwise detect information, establishing communication with the master node that is within the cluster. The master node within the cluster controls and monitors all slave nodes in addition to storing slave node addressing. Data merging is performed by the master node that will characterize network performance. The sink node establishes the connection between the external network and the wireless sensor network, receiving the information of the client applications promoting the actions of receiving and sending information within the network. Stopping the sink node provides the network application shutdown and consequently loss of network function. Its programming nature offers a huge potential for customization and programming tuning. The slave modules connect to the sensor nodes to increase the capacity of detection parameters. Gateways are required to connect sensor networks to a corporate, industrial, or custom network, or locally to a Pc. Multiple interfaces are supported, including Ethernet, Wifi, Usb and serial, to provide a base station for connecting an Iris or Mica sensor network. Any Mica or Iris Mote can function as a base station when coupled to the relevant interface card.

III. OPERATING SYSTEMS

The operating systems for sensor nodes must be structured in such a way as to allow for flexible configurations, considering the requirements of physical restrictions and memory limitation. Table II shows the main characteristics of the operating systems.

TABLE II. OPERATING SYSTEMS

System	***Characteristics***
TinyOS	Language: NesC Component-based architecture; Competition based on tasks and events; Operations divided in phase;
Contiki	Flexible dynamic loading system; Supports preemptive multithreading.
MantisOS	Multitasking based system; Supports preemptive multi-threading
SOS	Common kernel; Dynamic reconfiguration; Priority scheduling
Yatos	Event-driven system; Low memory on sensor node; Low energy consumption; Multitasking system based on priorities.

IV. APPLICATIONS OF WIRELESS SENSOR NETWORK

The technological advance has allowed the diagnosis of active equipment in relation to its operating condition and availability. The applications of the wireless sensor networks allow the analysis of conditions of temperature, vibration, pressure, among other magnitudes allowing the intervention in the equipment in a suitable time avoiding the breakage or loss of total function. Several works have used wireless sensor networks for process monitoring. The works are aimed at monitoring the processes with the objective of detecting the failure and guaranteeing the reliability of the process.

A. Areas of difficult acess

In this application it is proposed the use of a wireless sensor network for the formation of an autonomous collaborative network for the monitoring of scale in pipes, tank, and difficult access areas. The hardware used as well as the deposition of sensors for the measurement of Ph, proximity, pressure among other parameters are described in detail. Also described are the communication protocol and the algorithms used in the sensor nodes. [6]

B. 4.0 Industry

The activity has attracted interest in the use of wireless sensor networks. The applications aim to reduce energy consumption, increase economic benefits, and allow optimized, lean, and intelligent productions. There are important merits that should be included such as flexibility, absence of wiring, mobility that can allow the most diverse applications. Among the applications are also mentioned the differences between the traditional wireless sensor networks Wsn and the industrial wireless sensor networks Iwn such as latency, mobility, environment, and capacity. [17]

C. Machinery and equipment

The work proposes the use of accelerometers for the monitoring of vibrations in machines in and approaches the preventive maintenance based on condition. The linear relationship between surface finish, wear and vibration of machines and the use of monitoring equipment is demonstrated. [14]

D. Manufacturing

It is proposed to use wireless sensor networks to monitor the process of manufacturing crockery. The process steps are step-by-step detailed as well as the hardware employed for monitoring. Financial benefits of implementation are presented in relation to production costs. [6]

E. Environmental monitoring

The paper describes applications of wireless sensor networks for environmental monitoring and process safety conditions. The applications allow to detect conditions of pollution, danger, and security in the processes. [13]

F. Sustainable Operation

It is proposed to use wireless sensor networks for sustainable operation. The monitoring conditions, different types of sensor elements, the programming languages used as well as depositions are proposed in industrial equipment to produce fertilizers. [4]

G. Tankes and utilities

Describes the application of sensors in tank monitoring processes on oil and utilities platforms, pure water, in a semiconductor industry. The vibration analysis, one of the parameters of monitoring of assets used in predictive maintenance, were analyzed through networks of wire sensors. Two types of network platforms were implemented and compared, both in network performance as well as network implementation costs compared to traditional processes. [11].

H. Pipes

Wireless sensor networks are applied for the monitoring of pipelines. The gains of the application are directed to the detection, location and quantification of ruptures, leaks, and other anomalies in water pipes. The work details the results and experiments of the actual deposition as well as the algorithms implemented in laboratory conditions. [9]

V. COMMERCIAL SOLUTION

Commercial solutions for wireless sensor networks. Wireless sensor networks have commercial solutions that allow the implementation and monitoring of quantities within industrial processes. Acquisition of data through sensors such as vibration, temperature, humidity, among others allow the processing of signals using signal conditioning software, tracing the diagnosis of equipment or process failures. Classifying the monitoring process in condition environmental, monitoring and automation conditions we can deploy process variants according to the need for detection. Commercial solutions for wireless sensor networks. Wireless sensor networks have commercial solutions that allow the implementation and monitoring of quantities within industrial processes. Acquisition of data through sensors such as vibration, temperature, humidity, among others allow the processing of signals using signal conditioning software, tracing the diagnosis of equipment or process failures. Classifying the monitoring process in condition environmental, monitoring and automation conditions we can deploy process variants according to the need for detection.

A. Environmental Detection

For environmental detection the sensors should be studied and implemented to withstand local conditions and deterioration caused by the medium. Sensors must be of adequate protection, prone to mechanical shock, wind, humidity, corrosion caused by the environment or even by animal feces. This robustness is one of the implementation challenges since it causes a significant increase in network cost. Buying this balance of costs with the implementation of the network, also allows the detection and prior preparation of resources, equipment, structures, or populations monitored. The environmental impact of the reliability processes can make business continuity unsustainable. Breaking environmental standards involves much more than productive losses, but fines, significant losses of the biome and socio-economic losses. Monitoring of hazardous, risk or safety conditions are variables that can be monitored by wireless sensor networks.

B. Condition monitoring

The condition monitoring of equipment and systems is one of the essential conditions of the reliability of processes. Reducing the rate of structural, mechanical, electrical, or electronic failures depends on the monitoring and the equipment degradation curve interval. The critical break point in the degradation curve is the element that should be avoided because it establishes the most cost to reestablish the line or process. The technology allows the establishment of sensors embedded or embedded in the equipment to monitor the operating conditions. The hardware and firmware solutions in sensors can establish the detection in real coding. The impact on productivity for industry 4.0 is one of the aspects favored by real-time detection, optimizing processes and especially addressing adverse conditions in equipment and processes.

C. Process automation

Wireless sensor networks can be established in conjunction with industrial process automation. The traditional design of automation seeks to establish homogeneous systems for the detection of production lines. The sensors, deposited previously or in an embedded way, allow to establish heterogeneous constructions and to establish the necessary detection to the process. The mobile applications for logistics, continuous

monitoring of energy processes, productive among others are examples of networks that can be established. The goal of an automation is to seek the reduction of human resources safely, reliably, using only the amount of resources required. Wireless sensor networks allow this iteration when associated with traditional formal detection processes in applications.

VI. Conclusion

Wireless sensor networks enable important contributions to the monitoring of industrial processes. The techniques of preventive and predictive maintenance can be followed by parameters such as temperature, vibration, pressure, among other magnitudes. The technology of the sensor nodes allows through different operating systems the integration of the monitored environment with efficient, lean production techniques and direct the internet applications of things. Several works have presented the advantages of network applications for monitoring environments hostile to conventional monitoring, as well as show substantial savings in deployment resources when compared to conventional networks. Quality parameters such as latency, mobility, implemented medium and transmission capacity are indicated as elements that indicate the quality of networks and are described as wireless industrial networks. Applications are described in industrial processes with the objective of monitoring environmental conditions, risk, and safety. The application of wireless sensor networks to monitor industrial processes can allow substantial gains to the reliability and physical integrity of existing processes.

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