Survey on Applications and Challenges of Wireless Sensor Network in Industries

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Abstract

Recent advancement in wireless communications and electronics has enabled the development of Wireless Sensor Network (WSN). These networks promise to revolutionize sensing in a wide range of application domains. One of them is industrial automation, which is necessary for competing globally. Industrial automation from component assemblies to data integrated manufacturing execution systems are available to achieve greater precision, improves quality and enhances control over the whole process. Another one is industrial and environmental safety. The aim of this paper is to analyze the possibilities of applying WSN technology in industrial platforms from the use of simple detector; complex analyzers to latest MEMS (Micro Electro Mechanical System) based system, machine vision system with their advantages and implementation challenges.

1. Introduction

Although computer-based instrumentation has existed for a long time, the density of instrumentation made possible by a shift to mass-produced intelligent sensors. WSN gives a new kind of scope that can be applied to a wide range of uses. In industrial processes such as assembly, manufacturing, instrumentation, packaging and communications, data is continuously being monitored through sensors, digitized, analyzed, collected and stored.

Despite the impoverishment, pollution, health and environmental problems created, the government (people) believes that industrialization at any cost is the way for advancement and it is impossible to avoid industrialization. But the environmental assessment concerned with identifying, predicting and evaluating pollution both beneficial to people and development of a country is necessary. To make the world a better place to live, there is a need to wise in managing our resources, and take positive action towards preventing any forms of pollution to the environment.

In this paper, WSN application in industrial area is viewed in two directions namely, intelligent industrial management and secure industrial management.

2. Industrial Sensor and Sensor Network

A sensor should be selected depending on the application in mind. Sensors are of two types. Some sensors simply detect the presence of a stimulus (Fig 1). These are called detectors. A sound sensor that detects the presence of a sound. Other sensors can actually discern relative values of a stimulus. These are called analyzers that can do qualitative and quantitative analysis of measuring element. A sound sensor that detects the number of decibels in a sound.

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**Figure 1. Examples of Stimulus**

Booth are important to the society such as analysis of industrial samples (steel, mining ores, plastics), pharmacological samples (drugs and medicines), food samples (agriculture) and environmental samples (quality of air, water, soil and biological materials).

The WSN has enabled new classes of applications that benefit an industrial sector and industrial
automation. The implementation of these applications in industrial automation sector is increasing the graph of productivity in marketplaces [1]. According to survey result, the leading application for industrial networks (both wired and wireless) is Supervisory Control And Data Acquisition (SCADA).

The major classifications of WSN in industrial automation are found in the literature are [2]

- **Rare event detection**- Sensors are used to detect rare, random and ephemeral events such as fault detection, notification system and alarm warnings due to uncertainty in machines and in plants [3].

- **Periodic data collection** - Data collection from unreachable terrain and then transmit the information to the sink is a fundamental task in periodic sensor networks, [4]

- **Real-time data Detection, acquisition** - Leakage detection and location is one of the paramount concerns of pipeline operators all over the world. A timely evaluation and response to a leakage, allows proper management of the consequences and an effective risk minimization [5]. Other real-time applications are monitoring hazardous chemical levels and fire detection.

- **System Control and monitoring** - Several industrial organizations, such as WINA and ZigBee, have been advocating the application of wireless technologies in industrial control. Weaving machinery monitoring and control system displays real time state of weaving machines status and gives information about the number of picks and warp, weft and mechanical halts and stops of weaving machine [6].

- **Industrial mobile robots** - Sensors will flow through pipelines, emitting data on leakages and bursts. Faults can be remotely monitored. Intra pipe inspection (inside the pipe) and between pipes, already applied to nuclear power plants using a MEMS based mini robot [7].

3. Applications of WSN in industries

Industrial automation system can be defined as the use of computers and sensors to control machines and processes. There is the obvious benefit of automation; it dares to work where humans do not, such as oil refineries, manufacturing certain hazardous chemicals, welding nuclear reactors etc. Autonomous machine controlled through WSN are more effective in such areas than a scared human worker. WSN application in industrial area is viewed in two directions namely, intelligent industrial management and secure industrial management.

3.1. Intelligent industrial management

The application of WSN satisfies the business objectives to enable a broad spectrum industry to significantly increase productivity, quality, safety while reducing cost and time to market for new products. This will be accomplished by the improved control of industrial operations via the introduction of industrial control systems. Significant developments are taking place in industries with the upgrading technology and the incorporation of information technology.

Some of the modern applications in industries are

- **Machine vision system** – application of computer vision to factory automation. Just as human inspectors working on assembly lines visually inspect parts to judge the quality of workmanship. Machine vision systems use digital cameras and image processing software to perform similar inspections. Manufacturers favor machine vision systems for visual inspections that require high-speed, high-magnification, 24-hour operation, and repeatability of measurements. This may be installed at the end of production lines, to inspect for flawed products [8,9, 10]

- **Automated assembly** – Automated assembly of devices using robots - commands for aligning the parts were automatically calculated based on the sensor data and executed. [11]

- **Intelligent system** – Real-time process diagnostics and abnormal condition management [12]

- **Smart transmitters** – In refineries, chemical plants, paper mills and power generating plants to measure and report fluid flows, temperatures, pressures tank levels and valve positions at specific points in the process to the host computer [13]

- **Managing inventory control** - Monitoring the inventory product conditions and environment [14]

- **Vibration analysis**- industrial wireless sensor network (IWSN) for industrial machine condition monitoring and fault diagnosis. For example induction motor may be monitored due to its wide use in industrial processes. Motor stator current and vibration signals are measured for further processing and analysis. Mainly used to detect the faulty parts, which need repair or changing by analyzing their vibration signature [15].

- **Process monitoring** - in process monitoring and control, process data such as pressure,
3.2. Recent trends in industrial automation

As the reasons to automate increase day by day and as companies begin to realize this need, opportunities for technology solution provides in this space are also increasing proportionately [19]. With the increasing need for quality and flexibility, the following new trends are introduced in industries.

### 3.2.1. MEMS based sensors and actuators

The widespread use of MEMS technology has increasingly optimized the performance, size, and cost of sensing systems. "Key innovations in MEMS-based sensors and actuators are taking place in many associated industrial applications such as Heating, Ventilation, and Air-Conditioning (HVAC) applications, industrial safety, processing, and control, networked health monitoring of devices. The research and development focus is also shifting toward a large array or a network of MEMS sensors rather than just single MEMS devices. MEMS Technology Can Enable Industrial Automation Achieve Higher Standards [20]."

### 3.2.2. Chemical sensors

Chemical sensors (detectors/transducers) covers a wide category of devices used to monitor, measure, test, analyze data as generated due to changes in a measured norm. Some system-connected detectors also alert a monitoring service that can dispatch emergency services if necessary. Varieties of chemical sensors such as, Opto-Chemical, Biomimetic, Electrochemical, Semiconductor and their applications are endless [21].

#### 3.2.3. Ultrasonic sensors

Ultrasound ID (USID) is a real-time locating system technology used to automatically track and identify the location of objects in real-time using simple, inexpensive nodes attached to – or embedded into – objects and devices that transmit an ultrasound signal to communicate location to microphone sensors. Ultrasonic sensors are used to detect the existence of objects (digital) and distance (analog) in factory automation and processing.

Applications include positioning systems, asset tracking, workflow and locating personnel in mines [22].

#### 3.2.4. Electronic sensing

The expression "electronic sensing" refers to the capability of reproducing human senses using sensor arrays and pattern recognition systems. Since 1982, research has been conducted to develop technologies, commonly referred to as electronic noses that could detect and recognize odors and flavors. Till now online communication involved only two of our senses. Sense of sight, Sense of hearing. A new technology targets on sense of smell. Digital Scent Technology intends to change the interactive entertainment experience. It is possible to sense, transmit and receive smell through internet. Electronic Tongue is specially designed for taste analysis in R and D, formulation, food product Development, and food process improvement applications. It has got several applications in various industrial areas: The pharmaceutical industry, food and beverage sector, etc. It can be used to: identify toxic substances. Search for drugs, explosive. Searching for chemical/biological weapon, Detect trace amounts of organic substances [23, 24].

### 3.3. Secure industrial management

In addition to the process automation other area of using WSN in industry is secure industry and environment management. Security and safety compliance vary from industry to industry. Fire alarm, Smoke detection, leak detection, Protect sensitive or restricted areas, Protect valuable assets, Detect unauthorized vehicles, Suspicious individual detection are some common applications, nowadays, in buildings, industries and in most countries it is imposed by relevant laws [5, 8, 25].

One important application of WSN is monitoring indoor and outdoor air pollution through industrial sources. The environmental assessment concerned with identifying, predicting and evaluating pollution both beneficial to people and development of a country is necessary. The first step is to do continuous air
pollution monitoring round the clock and online reporting [26]. The latest technology is Electronic Tongue to monitor agriculture and industrial pollution of air and water. Industrialization is for growth of the people, at the same time that must assure the secure lifetime of the people. Therefore there is a need to increase implementation of WSN in this direction also.

4. WSN Challenges in industrial environment

Even though there are so many advantages in using WSN in industries, there was a serious debate over whether or not WSNs and wireless communication in general were a technology suitable for industrial applications. To create robust network architecture, it is crucial to know the differences among all the wireless standards.

From industrial point of view, ISA SP100 workgroup introduces the following six classes (Class 5 – Class 0) for wireless communications based on analysis of industrial, inter-device wireless communication applications [27].

Class 5
* items related to monitoring without immediate operational consequences.
* without strong timeliness requirements
* reliability requirements may vary

Class 4
* monitoring with short-term operational consequences
* high-limit and low-limit alarms and other information
* require further checking or involvement of a maintenance technician. Timeliness of information in this class is typically low (slow)

Class 3
* open loop control applications, in which an operator, rather than a controller, “closes the loop” between input and output.
* The time horizon for this class is in a human scale, measured in seconds and minutes.
* an operator could take a unit offline, if required.

Class 2
* consists of closed loop supervisory control, and applications usually have long time constants
* with the time scale measured in seconds to minutes

Class 1
* closed loop regulatory control, includes motor and axis control as well as primary flow and pressure control.
* The timeliness of information in this class is often critical.

Class 0
* emergency actions related to safety, which are always critical to both personnel and the plant.

*Most safety functions are, and will be, carried out by dedicated wired networks in order to limit both failure modes and vulnerability to external events or attacks. Examples in this category are safety interlock, emergency shutdown, and fire control.

There are number of challenges in migrating from a wired to WSN implementation [28].

* Coverage area of the network may suffer in the industrial environment due to various interferences.
* The reliability and the signal strength may get affected due to the reflection from the walls, interference from other devices or machines and interference from the environment itself.
* Time delay through the network from sensor to monitoring site.
* Balance between battery life and data update rates.
* Power management and harvesting technologies
* Wireless network advances like ISA 100 and wirelessHART make WSN a more viable possibility in traditional manufacturing environments, but the challenge of latency remains.
* WSN protocol requirements, network architecture that is suitable topology
* Suitable wireless standards, bandwidth, dropped packets rate, throughput tradeoffs
* Special computers called PLCs are used to automatically interpret the data collected from sensors and events on a continuous basis and use this output to trigger certain actuators and events.
* Co-ordination between several technologies ranging from information systems to computer controlled machinery.
* As wireless is the best way for disparate, dispersed automation, wireless networks should be capable of integrating with standard plant and office networks [29]
* With so many network and volume of communication, security is a critical aspect.
* Longevity – lifetime of a sensor and sensor network
* Standard in data access specification
* Data access specification in Multi model arrays of sensors to capture a complex scene.
* Method to convert raw data from sensor to useful information and data redundancy
* Instead of passing large volume of data from WSN to destination, other option is better data aggregation
* QOS requirements

5. Conclusion

The industrial wireless business and use of WSN continues to grow fast every year. At the same time challenges are also there and depend on application and industrial environment. There is a need to concentrate on areas where the challenges and apply WSN to get
information and run processes more effectively and improve safety and production.

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