Adaptation of Wireless Sensor Network in Industries and Their Architecture, Standards and Applications

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Abstract: Wireless Sensor Networks (WSN) is a rising technology that proves enormous assurance in various applications. The combination of communication processing and sensing technology provides profitable low cost and efficient environment for different systems. The small nodes constrained capabilities to collect, process, sense and disseminate data for applications. The intent of this paper is to investigate the architecture of traditional sensor and components. Further, discuss standards and applications, which are used in industrial zone, discuss some technologies of industrial applications such as Zigbee, wirelessHART, ISA 100 and compare with each other. We shed some light on the future trends as well.

Key words: Industrial wireless sensor network (IWSN) · Wireless HART · Zig Bee · Sensor · Standard

INTRODUCTION

The Industrial sector focuses on improvement, proficiency and profitability and thinks about their financial objective and enhancement in productivity. They are looking for low cost and intelligent system for automation system. Previous systems based on wired network with highly maintenance requirement and difficulties in installation. New technologies and their smartness in various fields change the shape and boost up overall scenario. Now the industries use many technologies for monitoring and controlling the operations for intelligent automation systems. The mutual nature of industrial wireless sensor networks (IWSNs) carry several advantages over previous wired base industrial monitoring systems. In the IWSNs system, the nodes are self-organize and have intelligent processing capabilities. They are reliable and rapidly deploy in industrial environments. The low cost wireless tiny sensors nodes sense the temperature, pressure, vibration of machines and process depend with nature of work and application. The collected data transmitted through wireless technology to the sink node for analyzing. The analyzed data check the performance of all equipments and notified to plant personnel. For the base of analyzed data the plant personnel take a decision, he will repair or change the equipment for services and for better production [1]. The sensor network also use for long pipe lines in oil field for leakage checking and flow measurement. Transportation industries use WSN network for production process and tiny sensors are install on robots for welding, spraying and handling the parts etc. In the paper, we discuss open issues for adopting these technologies and standards or applications specially design for industries need and compare these technologies on the base of throughput, power consumption and range.

Open Issues: Wireless Sensor network are use in various fields and applications such as health, transportation, environment, home automation, military and industrial applications. Transportation sector use low cost sensors, health and home automation use sensor compactness and wireless, while Industries use WSN for motion control, discrete automation, process control and for plants. Different equipment need specific application for the system and requires Quality-of-service (QoS) and accuracy. The functions of different application depend on the field or the system. The Industrial wireless sensor network faces various open issues such as energy conservation, processing and memory storage, transmission,
application design. Sensor is a tiny device and it has limited battery for energy supply and limited computational capabilities. Compare with other fields the industrial environment is cruel because of noise pollution, vibration and highly caustic environment. Dynamic topology in this situation is a major open issue. Synchronization and time is also very important factor for monitoring the industrial machines and for decision-making. Data redundancy and packet errors and variable link capacity, high bit rate interference are open issues in industrial wireless sensor networks (IWSN). Security should be an essential part of designing the system of IWSN [1]. The industrial applications faces various circumstances such as electromagnetic field in heavy motors, welding plants, smelting furnaces and the impact of these on transmission quality [2]. Sensor nodes deployed in unsympathetic environment in industries where the random noise and channel fading affected on the radio signal and packet losses. These problems are directly effective on production operations of equipments [3]. Research has been going on for the solution for these issues.

**Sensor Architecture:** Wireless sensor nodes are normally low-cost and low power, data processing and wireless communication capabilities examples are microchip, RFID etc. The WSNs (Wireless sensor networks) have a large number of sensor nodes represent a significant efficiency over traditional sensors [4]. Sensor technologies designs for dissimilar scenarios in industrial wireless sensor network. Industrial Wireless Sensor network (IWSN) use various applications and devices such as pressure transmitters, flow meters, temperature transmitters, level transmitter and so on. In WSN the sensors or nodes, which are deployed for data gathering and one or more sink nodes connected through different long range connections like Zig Bee, wireless HART etc. A sensor node base on four main components: Power Unit, transceiver, Sensing and processing unit. Sensor node has an additional unit for application called location finding system and a power generator, mobilizer. Further sensing unit is dividing into sensors and analog to digital converters (ADCs). The sensors are very small like a matchbox. Below table shows the functions of all components of sensor [5].

**Table 1: Sensor components with functions**

<table>
<thead>
<tr>
<th>No</th>
<th>Components</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Power Unit</td>
<td>It has a solar cells for power</td>
</tr>
<tr>
<td>2</td>
<td>ADC( Analog to Digital Converters)</td>
<td>It converts the analog signal into digital signal and fed into the processing unit</td>
</tr>
<tr>
<td>3</td>
<td>Processing Unit</td>
<td>It is a small storage unit, manage the procedures for collaborate with nodes</td>
</tr>
<tr>
<td>4</td>
<td>Transceiver</td>
<td>For Networking</td>
</tr>
<tr>
<td>5</td>
<td>Other sub units</td>
<td>Application dependent</td>
</tr>
</tbody>
</table>

**Fig. 1: Wireless Sensor Network In Industries**

![Wireless Sensor Network Diagram](image-url)
Standards and Technologies in IWSN: Standard family for industrial wireless sensor networks application is IEEE802.15 standard group. The group consists of Personal Area Network standards for short distance wireless networks (10 m). These standards are also used in various mobile and computing devices for instant pager, mobile, personal digital assistance (PDAs), consumer electronics etc. The Wireless Personal Area Networks (WPAN) working group was firstly focused on IEEE 802.15.1 standards for Physical layer and Medium Access Control layers based on Bluetooth technology. In 1999, the group formed two more subgroups, IEEE 802.15.3 and WPAN. In 2000 IEEE 802.15.4 WPAN for low rate introduced [6]. For long range wireless communication and Wi-Fi is used for industrial zone. Standards summary is shown below in figure 2.

IEEE 802.15.4/ZigBee: IEEE 802.15.4/ZigBee is a low cost (less than 5 $), low data rate (250 Kb/s) and consume low electricity standard of wireless sensor network. ZigBee transmits the data 10-75 meters, depend on environment and application and will operate in the unlicensed RF worldwide (2.4GHz global, 915MHz Americas or 868 MHz Europe). The life of ZigBee network is six to two years on just two AA batteries. The standard connects thousand of sensors in a factory for transfer sampled process data to control systems. The new wireless solution for industries decreases the cabling cost and maintenance overhead. ZigBee standard defines the application and network layer behavior. The topologies of ZigBee are tree, mesh, or star and it depend on the application and operation. ZigBee protocol is a secure and provide authentication on MAC and network layers.

Wireless HART: WirelessHART (Highway Addressable Remote Transducer Protocol) is an industrial standard of wireless technology. WirelessHART worked since 2007 officially. It is a low cost and low speed solution for plants in industries operations. It is a physical layer technology when we compare with WLAN-IEEE802.11. The data-rate of WirelessHART is 250 kb/s and use 2.4 GHz ISM radio band with 15 channels and adopt IEEE 802.15.4-2006
standard. The architecture is centralized and devices are access points (field devices), adaptors and handheld gadgets. The features of this technology are security, synchronization between communication, TDMA (Time division multiple access) mechanism for supporting channel hopping, fault-redundancy and mesh routing [8]. WirelessHART field devices are sensors and actuators and the adaptors make a connection with wired HART devices for communication. The personnel carrying devices are connect wirelessly for configuration and debugging. The gateways nodes are connecting with wireless network for to the rest of the automation system.

**ISA.100**: ISA-100 is a family of standard for industrial automation and control applications base on wireless sensor technologies. The architecture of ISA-100 system includes thousands of devices cover in the range of 1 Km in a plant. It has a network enhance functionality. This standard supports channel hopping to avoid interference from RF devices operating in the same band. ISA-100 is a fully redundant and self-healing and support end-to-end network reliability.

**Wi-Fi-IEEE802.11**: WiFi-IEEE802.11 standard is for local area networks and use in various environments in offices, home, industries and educational sector. The Wi-Fi access points are available for industries in market. This technology provides MAC or physical, network layer services. It is a high speed, moderate range Ip data transfers in local area networks. Wi-Fi devices are power efficient and sensors have multi-year battery life. Wi-Fi also provides the security mechanism and well proven in encryption, authentication and end-to-end security.

**Bluetooth**: Bluetooth wireless technology is for short distance and low power radio communication. This technology is very popular in portable devices such as mobile phones etc. Usage of Bluetooth in industries for connoting the devices with each other like sensors, actuators, controllers and allow them to connect with laptop or hand device. It is best for critical infrastructure in industries.

**UWB**: UWB (Ultra-Wideband) technology is a short-range wireless communication. The various attractive
advantages it has such as low power consumption, enormous bandwidth, robustness against multipath fading because of these advantages it is suitable for high data rate communication. UWB is emerging solution for the IEEE 802.15.3a standard. The data rate must be 100 Mb/s to satisfy the industrial use. This standard also provide the QoS (Quality of services) [9].

Applications: The Wireless Sensor Network has enabled new classes of applications that benefit an industrial sector and industrial automation. The implimitation of these applications in industrial automation sector is increasing the graph of productivity in marketplaces [10]. WSN based Application for industries collect the real time data acquisition, rare event detection, controlling, industrial robots, periodic data collection. 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. Sensors are also use for monitoring controlling the machinery and plants. The adoption of these applications the cost of labor is low and decrease human errors and enhances the efficiency in production. The multiple network technologies working play a role with different aspects in industries. Various short and long-range technologies work together [11].

The robots are equipped with sensors in industries use for delicate, risky, repetitive tasks. They are perform with efficiently in assembling, welding, loading the parts etc [12]. The wireless sensors are install on robots and connected with laptop or servers for obtaining the information for analyzing and monitoring. These types of robots also use in outdoor field for collecting the data for many sensors. Wireless sensor applications use in inventory management system where the inventory and asset could be monitored in real time for raw materials. Wireless sensor network is used for monitor the industrial customer for supply the demand especially in Gas and oil fields. Tracking system for monitoring the inventory, assembling the cars, visibility of materials and equipments, increase supply chain etc. These applications are use for continuously monitoring the temperature,
pressure, vibrations and power usage in industries. This technology provides many solutions for leakage detection, climate reporting, radiation check, intrusion notification etc. Below table shows some application with features.

**CONCLUSION**

Wireless Sensor Network system use for monitoring and controlling the equipments and plants and play an excellent performance in the shape of reliability, capability, flexibility and cost effectiveness. An integrated WSN access achieved in this realization offered a capability of delivering data, concentrated management and real time monitoring in industrial automation. However, the realization and the application of the WSN in industrial still need much more experiment and test. But all of the characteristics have shown that the WSN will have a vast range of prospects. This paper presented several industrial technologies and applications with standards. It highlighted the open issues of WSN based industrial systems for designers to evaluate carefully the right technology for their system.

**REFERENCES**