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Wireless Sensor Network for Industry 4.0

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Abstract: This paper provides a sneak view on the scope of wireless sensor network in industry 4.0. These networks have got a vital role in future industries in terms its monitoring, safety and thus the productivity in the factory. Many small embedded sensors capable of acquiring information from the surrounding are deployed at different parts of the industrial equipment. These sensors continuously monitor the technical parameters and communicate with a centralized base station which is linked with the cloud system. The type of sensor network to be implemented is based upon the industrial environment.

Keywords: Wireless Senor Network, Base Station, Sensor Node, Industry 4.0, Internet of Things.

I. INTRODUCTION

Wireless Sensor Networks (WSN) are tiny embedded systems capable of acquiring data from its surroundings and send it to the nearby base station. Such a sensor-based system consists of subsystems used for measuring various parameters like temperature, pressure, vibration, humidity, flow rate etc. Different types of sensors are used based upon the requirement and the industrial environment. The major constituents of a sensor network include an assembly of distributed sensors, a wireless based network system, and a centralized computing resource [1]. The applications of WSN are so wide that it is spread into a variety of fields including climate monitoring, pollution monitoring, forest fire detection, under water surveillance, industrial monitoring, land slide detection etc. Normally the system consists of many numbers of sensor nodes in the order of hundreds or thousands and this depends on the field of application. The wireless media can be of any protocol including ZigBee/IEEE 802.15.4, IEEE 802.15.1 PAN/Bluetooth, IEEE 802.15.3, Ultrawideband, IEEE 802.16 WiMax or Wi-Fi. The power required for the tiny sensor nodes are taken from the battery within each Sensor Node (SN). The efficiency of this battery has a vital role in wireless sensor network since the lifetime of the SN mainly depends upon the energy utilization [2].

One among the major pillars of the industry 4.0 is internet of things in which many devices are interconnected to each other or controlled by a centralized cloud system. This technology can be implemented in many areas including home appliances, offices and in industries. Most of the devices or systems used in the sophisticated industries will be equipped with the state-of-the-art embedded units which can control, monitor and process data and this industry automation will increase the productivity, safety and accountability. The sensor nodes kept at different points in a specific system will acquire data to monitor the status of the system and can send these data to a Base Station (BS) which is connected to internet [3]. The wireless links used in WSN based industry automation will avoid wired communication cables inside the industry which require frequent physical maintenance and also reduce the cost of communication systems.

A. Architecture of a Sensor Node

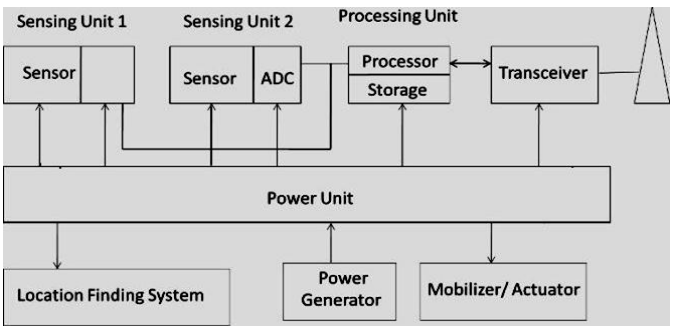

Fig.1 Architecture of a Sensor Node

A typical wireless sensor network consists of (i) sensor unit, (ii) processing unit, (iii) transceiver unit, and (iv) power unit as shown in Fig.1. The sensor unit includes the required parameter transducers like temperature sensor, vibration sensor, pressure sensor, humidity sensor, or flow rate sensor. An Analog to Digital Converter (ADC) is always required since the data acquired using sensors are analog in nature and the next level processing units are in digital domain. There can be many sensors with in a single sensor node and there can be many such sensor nodes in a WSN system.

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The transceiver system performs both data transmission and reception. The amount of data transmission will be normally more than data reception. This unit utilizes the major portion of energy utilization [4]. If we can reduce the energy consumption in this unit, then we can reduce the overall power utilization and thus to increase the life of the sensor node. Depending upon the application area, additional subsystems like Location Finding System, and mobilizer unit can also be included in a SN. The location finding system will help in providing the details regarding the place or point from which the node has activated and the mobilizer will help in giving mobility to the sensor node so that it can move within the predetermined area to acquire required information [5]. This will reduce the communication distance between SN and the Base Station (BS).

B. Types of Wireless Sensor Networks

Based upon the implemented network topologies WSN can be classified into (i) Bus, (ii) Star, (iii) Ring, (iv) Tree, (v) Circular, (vi) Mesh and (vii) Grid topologies. In Bus topology, the data send from one SN will be of broadcast type and will receive at all other nodes. The data congestion and single path communication nature of this topology made this less preferable. Each of these topologies has got its on advantage and disadvantage. Therefore the topology selection is purely based on the application scenario. Mesh type is commonly used in most of the wireless sensor network applications.

Another way of classification of WSN is based on the data routing protocol used. Different types of routing algorithms have been proposed by the researchers for efficient and effective data packet transmission from node to node and node to base station. The classification includes (i) Data Centric, (ii) Hierarchical (iii) Location Based, and (iv) QoS Oriented. For accomplishing efficient routing schemes, different clustering algorithms have been evolved in the last decade. Here the sensor field is partitioned into different clusters and one among many SNs in a cluster is selected as Cluster Head (CH) based on different protocols as shown in Fig.2.

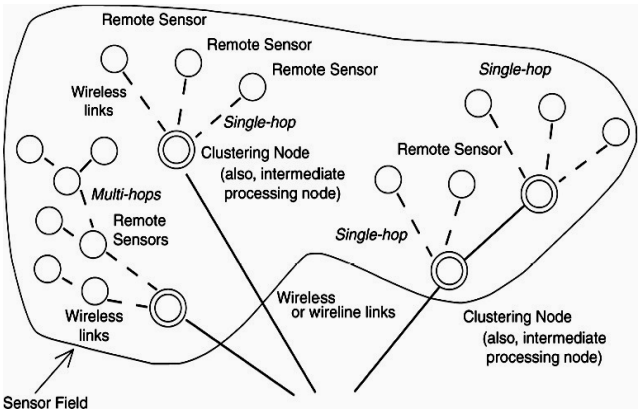

Fig.2. A Wireless Sensor Network field

C. Industry 4.0

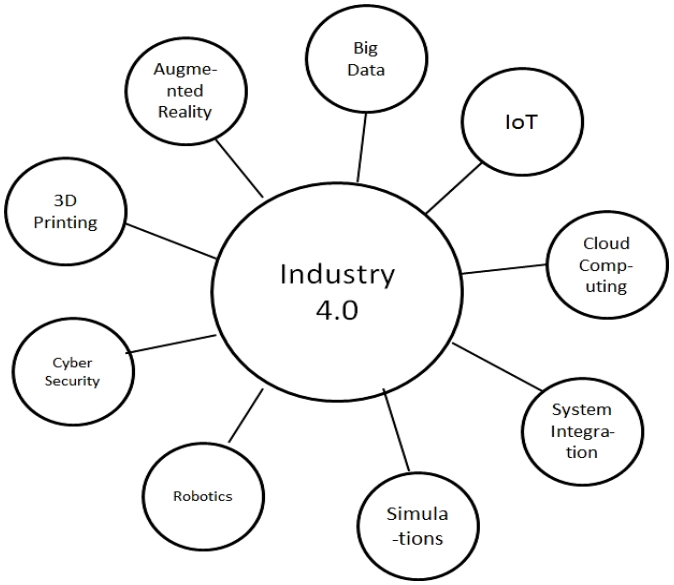

Fig.3. Nine Pillars of Industry 4.0

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Industry 4.0 is a strategic initiative make known to the industrial community in Germany around ten years back and presently spread through the world. The basic concept is the extension of industrial revolution phases. The first industrial revolution began in early 18th century was based on mechanization of factories through steam and water power. The second phase began with the enactment of electricity in industries and the third one came along with electronics and information technology. The new born fourth industrial revolution is based on cyber physical systems in which the classical hierarchical industrial automation is replaced by self- organizing robotic and cyber systems [3]. This will increase the productivity and also simplify the customization of the products.

There many future technologies which can act as the backbone of industry 4.0, and thus named as nine pillars of industry 4.0. They are (i) Big Data and Analytics, (ii) Simulation, (iii) Horizontal and Vertical system integration, (iv) The Industrial Internet of Things, (v) Automated Robots, (vi) Cyber Security, (vii) The Cloud, (viii) Additive Manufacturing, and (ix) Augmented Reality as shown in Fig.3. Wireless Sensor Networks have an important role in many of these technologies especially in Industrial Internet of Things and Automated Robots.

II. RELATED WORKS

There are many scientific researches depicted on the effective implementation of wireless sensor networks in different fields in which industrial automation is significantly addressed. Gang Zhao in [6] have identified different areas where WSN can be implemented in industries to control and monitor various industrial parameters and thus to increase its efficiency and therefore the productivity. The scope of implementation of WSN in different areas of industries has been described and its difficulties in operation are identified. The need for advancement in sensor network technology for improving the energy efficiency, smart routing, self-healing ability, responsiveness and reliability is also mentioned.

In [7], Chun-Tai Yen et.al has mentioned the role of Cloud Platform in industrial automation through Wireless Sensor Networks. Storage of data from sensor nodes, data sharing, and cloud computing have been distinguished. The production efficiency can be improved much through sharing of data resources in a centralised manner through a Cloud platform. The use of cyber physical systems (CPS) in various areas in the industry like monitoring, controlling, and error correction has been detailed.

The Preventive Maintenance applications of wireless sensors in industry has been discussed in [8] by Donato et.al. and the Condition Based Maintenance (CBM) for Industry 4.0 is specifically mentioned. Many protocols and technologies has been analyzed and their compatibility for the upcoming cyber physical system revolution has been discussed. Many off-the-shelf sensor nodes for monitoring parameters like humidity, temperature, vibration and acoustics have been tabulated along with the latest sensor manufacturing firms.

For increasing the life span of the network, the energy consumption within each sensor node is to be decreased as described by Metin et.al in [9]. A Q learning assisted energy efficient model model has been demonstrated and its simulation outcomes showed that it has increased the energy efficiency of the system. The real time data acquisition and monitoring capability of sensor nodes in harsh environment like industries is discussed along with the advantages of wireless network compared with wired connections.

The deterministic scheduling method suggested in [10] by Heng Wang et.al tries to overcome the difficulties faced in real time data communication in industrial wireless sensor networks. Time slots and channel allocations are introduced to provide the deadline constraints to ensure that the transmitted data from sensor nodes reach the destination with minimum delay. Two scheduling algorithms have been proposed namely branch and bound based on link conflict classification, and least conflict degree first. The optimal schedulable ratio is obtained by building a search tree and espousing necessary conditions of scheduling. The second method dynamically adapts the arranging order to distribute channels in a empirical manner.

III. IMPLIMENTATION OF WIRELESS SENSOR NETWORK IN INDUSTRY

Industrial environment is normally considered to be a harsh atmosphere for data acquisition and monitoring the surrounding. Any variation in the equipment parameters like temperature, vibration, pressure or humidity can adversely affect the entire system and there by the product. A real time monitoring and quick responsive system is required to overcome these unpleasant situations. Wireless Sensor Networks can perform the task of real-time monitoring system in an efficient way. Many tiny sensors deployed at different locations can detect different parameter variations and communicate it to the cloud based controlling system through a base station as shown in Fig.4. The selection of data routing algorithm is purely based on the industrial environment.

Among thousands of sensor nodes, some are selected as cluster head based upon a cluster head selection algorithm like Particle Swarm Optimization (PSO), Variable Length Genetic Algorithm (VLGA), Bee Colony Inspired Clustering Protocol, Fuzzy Inference System with Mobile Sink [10], etc.

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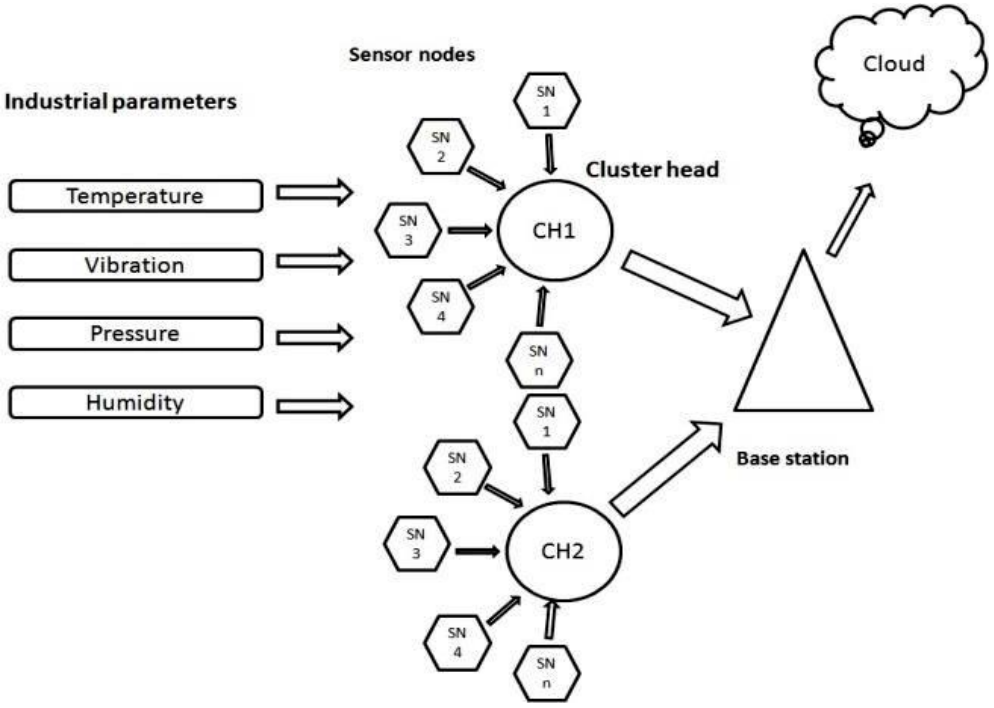

Fig.4. Wireless Sensor Network in Industry

Most of these techniques are aimed at reducing the power consumption. The cluster head once selected will change based upon the protocol implemented. Fuzzy Logic Based clustering algorithm with three CH selection parameters is a better option in industrial wireless sensor network [11].

The shift from wired network to wireless network can be beneficial only if we ensure the better efficiency of the system in terms of accuracy, integrity, and speed of data acquisition and transmission. Since the sensor nodes are battery operated and cannot be charged once deployed, its energy conservation is of much importance. There are many parameters to be considered while designing a wireless sensor network for industries. Sensing parameter, network technology, and communication protocol shown in Table 1 are of primary importance while designing a WSN for industry.

Industry 4.0 has got many challenges like reliable interconnection between different systems or modules, immediate problem solution, real time data acquisition etc. Implementation of wireless sensor network can overcome many of these challenges.

Table 1. WSN parameters for industries

No.	Parameter	Different Types
1	Sensing parameter	Pressure, Level measurement Temperature, Flow rate, Vibration
2	Network Technology	Star Point to Point Communication, Mesh Network, Star Mesh Network
3	Communication Protocol	Frequency Hopping Spread Spectrum (FHSS), 2.4 GHz Direct Sequence Spread Spectrum (DSSS), Bluetooth, ZigBee, Wireless HART, RFID Passive
4	Gateway Interface	Modbus, 802.11 Wi-Fi, Ethernet.
5	Companies with industrial WSN products	Accutech, Honeywell, Emerson, Rockwell, Intel etc..
6	Commercially available CBM Solutions	iQunet, OneProd EAGLE, EastWay, Sensor Works, ZetLab, ABB Ability

IV. CONCLUSION

Industry 4.0 is the future manufacturing environment based upon the nine technological pillars which are not just aimed at the bulk product manufacturing but also includes a value chain from industries to costumers. Wireless Sensor Network has got a visible role while appreciating the advanced technologies like Internet of Things and Robotics with a Cloud Platform for centralized control and monitoring. Industrial parameters like temperature, vibration, pressure, and humidity can be sensed and communicated to the cloud platform by the help of many tiny self-organizing sensor nodes. With wireless data communication capability, it can overcome many of the upcoming challenges in industry 4.0.

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REFERENCES

[1] Kazem Sohraby, Daniel Minoli, and Taieb Znati, Wireless Sensor Networks: Technology, Protocols, and Applications, 2007 John Wiley & Sons, Inc.
[2] Hoon Kim, and Sang-wook Han, "An Efficient Sensor Deployment Scheme for Large-Scale Wireless Sensor Networks", IEEE Communications Letters, Vol. 19, No. 1, pp. 98-101, 2015.
[3] Xingfa Shen , Zhi Wang, and Youxian Sun, "Wireless Sensor Networks for Industrial Applications", 5Ih World Congress on Intelligent Control and Automation, pp. 3636-3640, 2004.
[4] Aniji John, K. Vinoth Babu, "Two Phase Dynamic Method for Cluster Head Selection in Wireless Sensor Network for Internet of Things Applications", IEEE WiSPNET 2017 conference., pp.1228-1232, 2017.
[5] Y. Gu, F. Ren, Y. Ji and J. Li, "The evolution of sink mobility management in wireless sensor networks: A survey", IEEE Communications Surveys Tutorials, vol. 18, pp. 507-524, Firstquarter 2016.
[6] Gang Zhao, "Wireless Sensor Networks for Industrial Process Monitoring and Control: A Survey", Network Protocols and Algorithms ISSN 1943-3581, Vol. 3, pp. 46-63, 2011.
[7] Chun-Tai Yen, Yu-Chi Liu, Chih-Chieh Lin, Chih-Chiang Kao, Wen-Bin Wang , Yu-Rong Hsu, "Advanced Manufacturing Solution to Industry 4.0 trend through Sensing Network and Cloud Computing Technologies", 2014 IEEE International Conference on Automation Science and Engineering, pp.1150-1152, 2014.
[8] Donato Catenazz, Brendan O' Flynn, Michael Walsh, "On the use of Wireless Sensor Networks in Preventative Maintenance for Industry 4.0", Twelfth International Conference on Sensing Technology, pp.256-262,2018.
[9] Metin Ozturk, Mona Jaber , Muhammad A. Imran, "Life-span Extension for Sensor Networks in the Industry", Wireless Automation as an Enabler forthe Next IndustrialRevolution, pp.19-45.
[10] Heng Wang, Shuai Tan, Yuanjie Zhu, and Min Li, "Deterministic Scheduling With Optimization of Average Transmission Delays in Industrial Wireless Sensor Networks", Digital Object Identifier 10.1109/IEEE Access
.2968491, volume 8 pp. 18852-18862, 2020.
[11] Vinod K, Kanika Sharma, "A Review on Different Cluster Head Selection Methods for Improving the Lifetime of Wireless Sensor Network", ICRMTCEE, pp.1-5,2020.
[12] Vinod K, Kanika Sharma, "Routing Algorithm using Fuzzy Logic Based Clustering with Mobile Sink for Wireless Sensor Network", International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8 Issue-4, November 2019.

BIOGRAPHIES

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