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Survey on Deployment of WSN in Radiation Monitoring

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Abstract: ***Wireless Sensor networks (WSN) have been efficiently used in various industrial applications. Many protocols have been deployed in order to provide a more robust and efficient network. Deployment of WSN has covered various areas in concern[8] in the past including agriculture, military, environment monitoring, industrial and home automation and other detection and surveillance areas. Radiation monitoring is on such vulnerable area that has been considered when coming to industrial applications [4]. This paper includes the analysis of requirements for radiation monitoring, the designing challenges and current deployment strategies and future works.***

Keywords: Deployment of WSN, various applications, analysis of requirements, challenges, current deployment strategies for radiation monitoring

1. Introduction

Radiation monitoring is a process of measuring radiation dose or any radionuclide contamination for the purpose of controlling the exposure to radiation or radioactive substances [2].The basic radiation monitoring systems are highly on demand due to the potential vulnerabilities like nuclear terrorism threat in the nuclear power plant. The global radiation monitoring, detection and safety assessment is mainly done on the basis of composition, application and region of exposures. The permanently installed (stationary) and portable radiation monitoring systems and equipment are used to ensure the radiation safety of a nuclear power plant and its environment. Their purpose is to measure the radiation dose rates and radiation exposures within the plant as well as to monitor the concentrations of radioactive materials in the systems and the radioactive releases.

The measurements conducted at a nuclear power plant include dose rate measurements of external radiation, surface contamination measurements, air activity concentration measurements and workers' dosimeters and determination of internal radioactivity (whole body counting). The purpose of radiation measurements of the systems is to monitor the transport of radioactive materials in the liquid and gas process systems inside the plant.

The alarm and control functions of radiation measurements depend on the safety systems of the nuclear power plant. The control functions may include the reactor protection function or the process control (for example, purification control or closing of the release line). However, the measurements also have an immediate control function linked with radiation safety of the area concerned, and therefore all the radiation monitoring systems and equipment of a nuclear power plant are required to be of high quality and to operate reliably.

The monitoring device [2] may be placed in the areas including.

- The reactor containment building.
- The reactor hall.
- The spent fuel stores and the fuel handling machine.
- The radioactive waste treatment and storage facilities.

2. Radiation Monitoring Requirements

2.1 Based on the Environmental Conditions

The measuring systems should ensure their operability under the conditions and stresses in which they have been designed to function [5]. In assessing their operation, at least the following factors shall be taken into account:

- Temperature
- Pressure
- Humidity
- Mechanical vibrations
- Effects of radiation
- Chemical effects
- Changes in the operating voltage
- Electrical and magnetic disturbances.

Stabilizing these factors enhances better monitoring there by providing more robustness in physical security of the plant. Radiation monitoring not only on the radiation levels alone but also requires the balanced effects of all the above mentioned parameters.

Separate sensing and evaluating units may be included within the network to review the environmental conditions to a higher degree [7].

2.2 Basic Network Requirements

The basic nuclear radiation monitoring process basically requires Low-Power Embedded Technologies including proper industrial utility protocol implementations including ZigbeePRO, WirelessHART[9] etc. and low power consumption, low cost, distributed and self-organization network structure.

The basic component of a WSN includes the end or field devices(sensors/actuators)-that records and sends the sensed data, routers-that forwards the data, gateway-interfaces with the host, coordinators if required, the host application and any interface say GPRS but preferably the Internet. The basic architecture and the arrangement of the components is described in Fig 1.

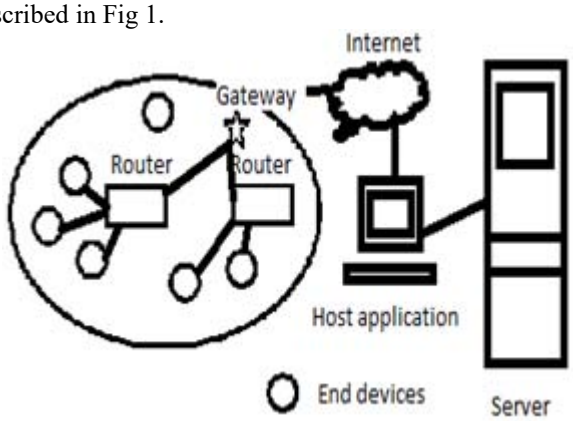

Figure 1: Overall basic architecture of WSN for radiation monitoring

3. Zigbee For Radiation Monitoring

The current implementation of nuclear detection in industries is done using the Zigbee technology. Zigbee provides low complexity, low cost, low power consumption, low data rate transmissions. It is based on the standard seven layer Open System Interconnect Reference Model (OSI)[3]. The IEEE 802.15.4 Working Group designed the standardization of two bottom layers of ISO/OSI protocol stack: the Medium Access Control (MAC) sub-layer and Physical Layer (PHY). The Zigbee standard adopted them and developed by the Zigbee Alliance which specified the Application Layer (APL) and the Network Layer (NWK).The overall is arranged as mentioned in Fig 2. The Application Layer is usually a GUI which provides an ease access to control and manage the network.

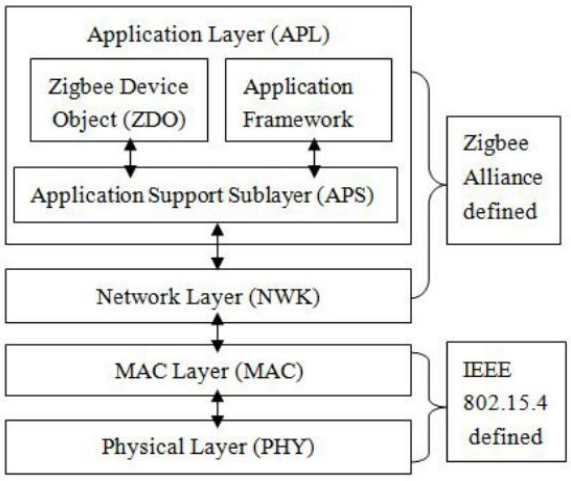

Figure 2: Zigbee Stack Architecture

There are three kinds of Zigbee devices: the coordinator, the router and the end device which play different roles in the WSN[1]. The coordinator aims at establishing and maintaining the wireless network. The router is optional to support the network and relay the wireless message when necessary. The coordinator, router and end device may establish three kinds of Zigbee network topologies: star network, mesh network and mesh-tree network. Fig 3.represents the different topological arrangements.

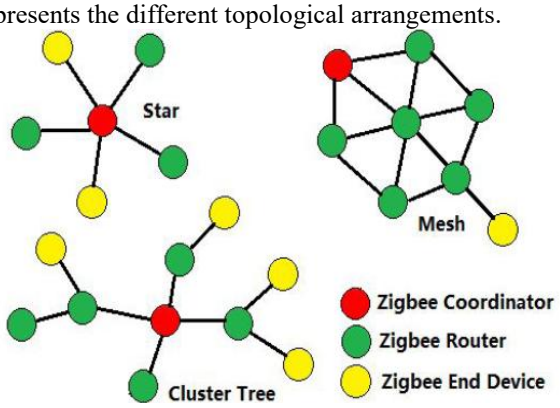

Figure 3: Zigbee Topologies

In Zigbee,once a path fails, the nodes would find a new path by connecting the surrounding other nodes as it exhibits a self-healing function. That makes Zigbee become a very robust solution.

3.1 Hardware Implementation

ZigBee wireless sensing adopts peer to peer communicationin which a permanent link between two pointsis established. The ZigBee End Devices (ZED)[6] which are the field devices, consists of the RF module equippedwith the radiation sensor; it senses the radiation levels in thesurrounding environment and communicates the informationgathered from the monitored field through the wireless link.

The data is forwarded to remote points; where a ZigBeeCoordinator (ZC) or sink node is interfaced to a PC in the controlcentre via a serial converter[1]. Fig 4.Illustrates the basic communication hierarchy between the devices.A specially developedGUI “Wireless Data Monitor” installed on the control centerPC processes and displays the data to the operator. We keepthe minimum possible size of the prototype while ensuringall functions of sensing, calculation, and communication.

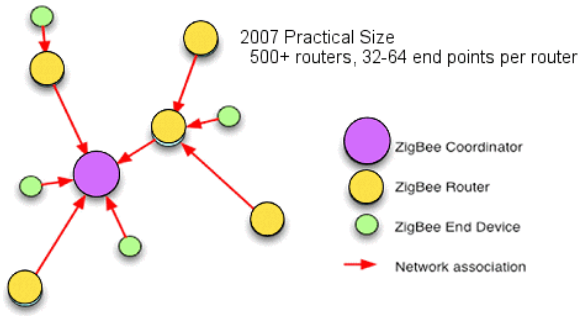

Figure 4: Zigbee architecture.

For radiation monitoring using Zigbee the field devices usually adapted are Giegermullertubes (GMT)sensors.

3.2 Results and Evaluations

A monitor program is developed with Microsoft Visual Studio as a GUI for the operator, it reads all data parsed on

the connected serial pin of ZC and displays them on the GUI[4]. Buttons to control and select the required COM port for communication are located at the upper right corner. At the upper middle, a record for the radiation dose levels is displayed. At the left of the GUI, a box appears with an alert message each time the radiation level exceeds the preidentified levels as the visual part of the alarming system. The bottom box represents the monitored radiation raw data levels on real time scale. Recording capability of the "Wireless Data Monitor" is provided for the raw date to ensure tractability of all the previous date for evaluation and analysis. The visual and audible alarming system has six warning grades.

A separate database is used to store the recent rrecording.Fig 5 illustrates thehost application screen shot results referenced from [3].

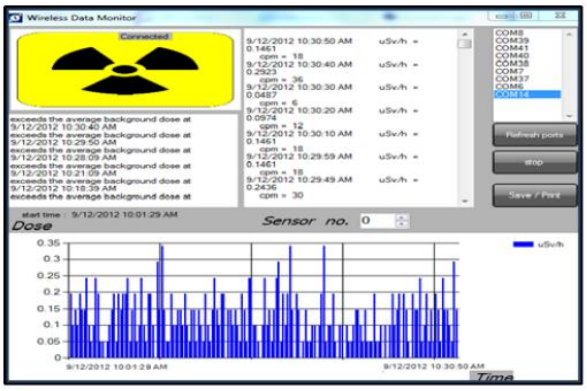

Figure 5: Wireless Data Monitor Screen shot

4. Conclusion

This paper includes all the basic concepts of Radiation monitoring, the key aspects to be considered while monitoring and the current techniques used for radiation monitoring- the Zigbee protocol implementation.

5. Future Work

The future works include designing a much robust network structure for radiation monitoring using various other technologies in field. This includes getting a wider knowledge in current techniques thereby analyzing all the feasible solutions to make the network functionality broader and more efficient.

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