Environmental Radiation And CO_2 Monitoring Using Wireless Sensor Network Based on IoT

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Abstract- *All nuclear power plants mandatorily enlists environmental monitoring procedures to guarantee that there are no negative effects from plant operations. Technicians and operators enrolled by nuclear power plants continuously need to sample air in different, strategic locations near the plants to determine if dangerous releases of pollutants are detectable in the environment outside the operating site . Even at the end of the power plant life cycle, the procedure of decommissioning includes a general and complete cleanup of radioactivity and progressive dismantling of the plant, together with a permanent control of the surrounding areas. To this aim, several works have been presented in the literature based on sensors networks, data acquisition systems and digital signal processing to provide real-time information on the radioactive risk. Best solutions are even characterized by wireless screens capable of provide real-time results to technicians on field.*

***Keywords*-** Sensors Network, Environmental Radiological Monitoring, CO2 monitoring, IoT.

I. INTRODUCTION

Electromagnetic radiation is emitted by many natural and man-made sources and is a fundamental aspect of our lives. RF fields are produced by many man-made sources including cellular (mobile) phones and base stations, television and radio broadcasting facilities as well as other electronic devices within our environments. A number of biological effects and established adverse health effects from acute exposure to RF fields have been documented. Absorption rate of RF energy depend on frequency, strength and orientation of the incident fields and its electrical properties. Absorption of RF energy is commonly described in terms of the specific absorption rate (SAR), which is measure of the rate of energy deposition per unit mass of body tissue. The risks related to radioactive element is referred as “Radiological Threat” or as a malicious release of radiation at nuclear power plants or research facilities. Collateral damages associated with radiological pollution can be associated with loss of economic activity during cleanup and by frightened public refusing to visit the affected area. A system based on a traditional Wireless Sensor Networks (WSNs) to monitor environmental conditions has been showed. According to evolution of the state of the art, the authors started with the implementation of a cost effective wireless sensors network for monitoring of environmental radioactive pollution. The intensive use of IoT oriented software like NoSQL Redis database and Node.js could greatly enhance the lightweight, long-range and non-contact detection of radioactive materials combining wireless sensor networks.

II. EXISTING SYSTEM

The methods for radioactive source detection are elaborations upon those yielding estimates of source parameters i.e., tackling an inverse problem. Herein, network nodes are stationary and the source is mobile. The nodes are equipped with a radiation sensor which records counts – such as a Geiger–Müller counter. For detection, one could implement a (background dependent) threshold on the summed counts, but for this approach to be effective, the source’s trajectory must, in essence, be known, and here we explore more general methods, effective for considerable “universes” of possible trajectories.

Disadvantages of Existing System:

- ✓ It is expensive.
- ✓ There will be more power consumption.
- ✓ Critical issue of detection of nuclear materials

III. PROPOSED SYSTEM

Technicians and operators enrolled by nuclear power plants continuously need to sample air in different, strategic locations near the plants to determine if dangerous releases of pollutants are detectable in the environment outside the operating site using Bayesian approaches, the implementation of a cost effective network for monitoring of environmental radioactive pollution. To this aim, the innovative paradigm of Internet ofThings (IoT) will be adopted in order to design and implement a new WSN capable of taking advantage of the provided features.

IV. WORKING PRINCIPLE

As stated above, the final goal of the research activity will be an IoT implementation of a WSN for environmental radiological risk monitoring, particularly addressed for dismissed nuclear plant. In the following, a first hybrid prototype, mandated to define and tests nodes and some issues of the final network, is preliminarily presented. The chosen preliminary system architecture requires the presence of a central server with which the sensor nodes are connected. The server receives and saves the data acquired through a local sensors network in order to carry out radiological monitoring. The network has, currently, a star topology, with individual nodes that can register themselves and communicate with the central server, while remaining independent from one another. The area covered by a sensor is strictly dependent on the specific probe characteristics. Nodes are easily accessible, so node lifetime is not a real issue. Configuration and monitoring messages, which are exchanged between nodes and server, present a simple structure and a frequency of repetition (tens of minutes during regular operation) which does not provide a throughput requiring ad hoc solutions.

Radiological and other data (node status, last measurement, historical measures, alarm etc.) are stored in a database on the server. The network server has been implemented on a traditional personal computer (PC), whose specification has been chosen according to the expected load burden. It is worth noting that the adoption of an embedded platform will allow to straightforwardly moving towards the final IoT implementation by suitably changing some specific hardware and software sketches. As an example, the communication stack between sensor nodes and the cloud can be changed to LoRaWAN and the Message Queuing Telemetry Transport (MQTT) can be exploited for low-power communications in order to assure extended reliable operations.

V. BLOCK DIAGRAM

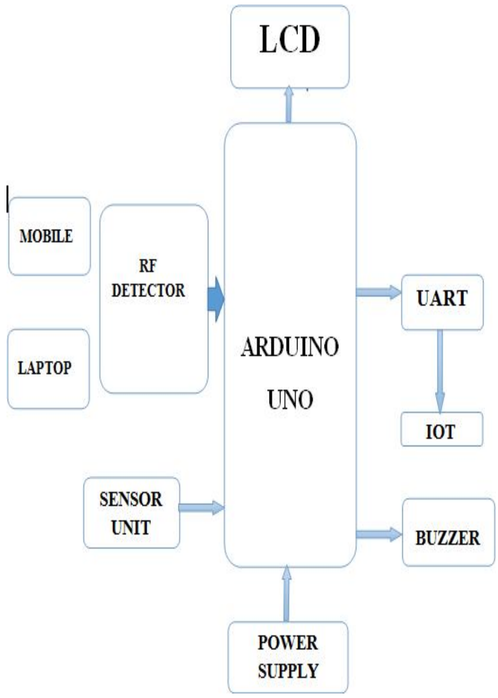

Fig.1 Transmitter Section

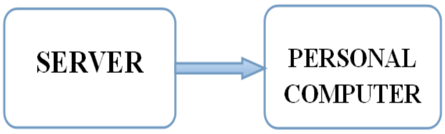

Fig.2 Receiver Section

Software Tool and Hardware Architecture

In the following, some details about the current tools, both software and hardware, adopted for the preliminary implementation of the IoT platform for radiation monitoring are given. All the presented solutions are intended to be adopted and even improved in the final network. In Fig.1 and 2, the block diagram of the architecture is shown. The PC server mainly executes the final-user application (WebApp), an ntp server and the Redis database. On the other side, the sensor node acts as client of the server PC with regard to the ntp synchronization and Redis database; the node acts also as ZeroMQ server for the PC web application, by accepting configuration and control requests.

Selection of Software Environment for Monitoring Algorithm Implementation

The selected environment has to be already included in IoT platform and grant the secure communication among the cloud and the single sensor node of the network, in order to allow the realization of a secure hub IoT. Node.js uses an I/O model of non-blocking type and has an event-driven architecture capable of asynchronous I/O. Moreover, it is lightweight and efficient, especially in the client-server type applications. Therefore, it allows building fast, scalable network applications capable of handling a huge number of simultaneous connections with high throughput. Node.js is a platform specifically tailored for cloud computing that focuses on micro-services and container architectures, turning out to be the ideal solution for the required implementation of sensors network. It also presents a wide range of libraries, such as those for the management of REDIS database. Node.js package manager keeps packages isolated from other projects, avoiding version conflicts.

Selection of Hardware Architecture

The hardware architecture of the sensor network node consists of three main components: the microcontroller board, the radiation sensor interface, and the sensor. In particular, the microcontroller board deals with the communication with the local network communication and processes the measures provided by the interface sensor. The interface instead controls and manipulates the sensor output signal. The sensor interface has been realized as daughter board to be connected on the top of the Beagle Bone board.

Preliminary tests have been carried out in order to assess the feasibility of the WSN; in particular, a set of three sensor nodes have been deployed throughout the department spaces in order to measure the radiation noise floor during a monitoring period of one month.

Some important hardware components used in our system are follows:

- ❖ Arduino UNO
- ❖ IoT
- ❖ RF Detector
- ❖ Sensor Unit
- ❖ Buzzer
- ❖ Power Supply

1. Arduino UNO

It is a microcontroller board based on ATmega328. It provides everything in need to support the microcontroller. Simply connect it to a computer with a USB cable or power it with AC-to-DC adapter or battery to get started.

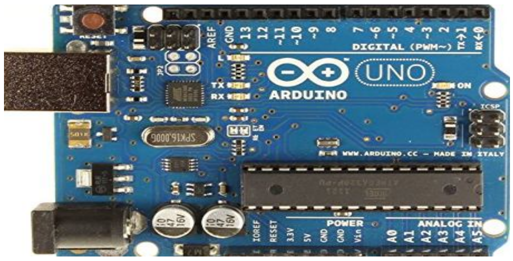

Fig.3 Arduino UNO

It gives facilities for communicating with a computer, another Arduino, or other microcontrollers through UART. It provides UART TTL serial communication, which is available on digital pins 0 (RX) and 1 (TX). It also provides serial communication over USB and appears as a virtual com port to software on the computer. The Receiver and Transmitter LEDs on the board will start to flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer. The Arduino Uno can be programmed with the Arduino software by just installing it in computers.

2. Internet of Things

The Internet Of Things (Iot) Is – At Its Most Profound Levels – About Creating Digital Representations Of Real-World Objects. It Is A Phenomenon That Draws On Rapid Developments Within It, Ict And Telecommunications To Spark Insights And To Help Companies Create Entirely New Types Of Services And Business Areas.

The improved next generation connectivity can be giving using IoT to devices, systems, and services that goes above machine-to-machine (M2M) communications and can able to cover different types of protocols, domains, and applications. In coming days, it may be a non-deterministic and open network in which auto- intelligent entities, cause able to act independently depending on the context, circumstances or environments.

Collection and reasoning of context information and objects ability to detect changes in the environment, faults affecting sensors and introduce suitable mitigation measures constitute a major research trend, we must provide credibility to the IoT technology for its autonomous approach.

Nowadays, It has wide variety of technologies to support such context-aware automation, but still even more forms of intelligence are required to sensor units to be deployed in environmental tasks.

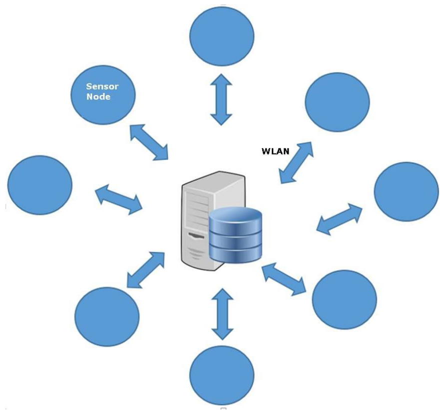

Fig.4 Connecting Sensor nodes through IoT

3. RF detector

This device monitors the output of an RF circuit and from that result, develops a dc output voltage proportional to the power at that point. These are used primarily to measure and control RF power in wireless systems. Signal strength is the key factor in maintaining reliable communications in reception side. Then, amount of power transmitted is very critical due to guidelines on transmission side. To maintain the range and reliability of the radio link, detectors are very important. In most RF and wireless applications, the power can be expressed in terms of dBm or decibels related to 1mW, is given by,

The equation shows the relationship between absolute power and dBm. This unit of measurement is usually referenced to an impedance of 50 Ω. Transmitter output power measurement is its primary application. It is essential to know the RF output power because the application specifies it in most cases. Measurement of power is done, then it is compared to point level in the feedback control circuit. So that power can be adjusted as per the requirement. Measurement of power is referred as the received signal strength indicator in receiver section. The RSSI signal is used to control the gain of the RF/IF signal chain with an automatic gain control or automatic level control circuit to maintain a constant signal level.

There are two basic types: the logarithmic type and the rms type. The input RF power is converted to dc voltage in proportion to the log of the input, making the output directly related to decibels in log type. The next type, rms detector produces dc output in proportion to rms value of the reference signal.

To measure power, output of the coupler be attenuated down to 0-dB crossover point of RF detector. Then, output is digitized using analog-to-digital converter and sent it to controller, which calculates the power level based on comparing with previously stored calibration coefficients. After that, the power level is compared to a set point value. If the measured value is higher or lower than the set point, the controller uses a digital to analog converter (DAC) to control the gain of a variable gain amplifier (VGA). This results in a change in the output power at the Power Amplifier.

4. Gas Sensor Unit

A sensor is a technological device that senses a signal, physical condition and chemical compounds. It is also defined as any device that converts a signal from one form to another. Sensors are mostly electrical or electronic. Gas sensor measures the concentration of gas in its vicinity. Gas sensor interacts with a gas to measure its concentration. Every gas has an individual breakdown voltage, the field at which it gets ionized. Sensor identifies gases by measuring these voltages. The concentration of the gas can be determined by measuring the current discharge in the device.

Fig.5 Gas Sensor

Carbon dioxide (CO_2) gas sensor: CO_2 absorbs infrared light therefore CO_2 sensor consists of a tube containing an infrared source at one end and an infrared detector at the other end. The infrared detector detects the infrared light which is not absorbed by CO_2 between source and detector. Infrared radiation which is not being absorbed by CO_2 produces heat so the temperature will increase. The infrared detector measures the temperature. A voltage is produced due to the temperature increase in the infrared sensor. We can read amplified voltage into the data logger.

5. Buzzer

Generally, buzzer is a signalling device used in automobiles, household appliances, etc. More number of switches connected to a control unit inside the circuit, which helps to determine which button was pushed and usually illuminates a light on button, and gives sound as a warning like beeping sound. Implementing a circuit to make the AC current into noise loud enough to drive a loudspeaker and in cheap 8-ohm speaker can also possible. Nowadays, ceramicbased piezoelectric sounder which makes a high-pitched tone is more popular.

Fig.6 Buzzer

The Piezo buzzers are made with two conductors, which are separated by Piezo crystals. When a voltage is applied to these crystals, they push on one conductor and pull on the other. The result of this push and pull is a sound wave. These buzzers can be used for many things, like signaling when a period of time is up or making a sound when a particular button has been pushed.

6. Power Supply

A device, which is the source of electrical power and supplies electrical energy to load is called power supply unit. It is most commonly applied to electrical energy supplies.
To perform our function, a 230v, 50Hz Single phase AC power supply is given to a step down transformer to get 12v supply. After that, this voltage is converted to DC voltage using a rectifier. The converted voltage is given to 7805 regulator to get constant 5v supply as output. This is given to all the components in our system. To discharge all the capacitors quickly, RC time constant circuit is added. A LED is connected for indication purpose to ensure the power supply.

VI. RESULTS

Our proposed system can be utilized as effective means to identify the environmental radiation and Co_2 Monitoring Using Wireless Sensor Network based on IOT.

VII. ADVANTAGES

- No negative effects from plant operations.
- Overcome the side effects from RF waves.

VIII. APPLICATIONS

- Used in health department.
- Human welfare
- It is used to monitor industrial radiation levels.

IX. ACKNOWLEDGEMENT

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X. CONCLUSION

The paper highlighted the possibility of greatly reducing costs of environmental radiological monitoring through the innovative approach that makes use of cheap Linux based development platform and open source software tools. In particular, it described the architecture of an inexpensive wide area sensors network. Preliminary performance assessment showed the feasibility of the proposed sensors network. Ongoing activities are mainly focused on the execution of tests in actual measurement conditions and carrying out comparisons with other solutions already available in the literature or on the market. Particular attention will be paid to other proposals based on the IoT paradigm or exploiting well-settled frameworks as Node-Red. To further reduce the costs and enhance the flexibility of the sensor node, in order to increase the range of possible measures, authors are working on a revised hardware version, which is capable of mounting a different detector, based on silicon technology, which is cheaper. Cloud computing integration solves more issues of WSN, like storage capacity of collected data using sensor nodes together by processing these data. Cloud computing has a huge storage capacity and processing capabilities. The use of IoT-based predictive analytics technologies to monitor connected machines and to predict machine degradation can further prevent potential failures.

REFERENCES

[1] Ding F, Song G, Yin K, Li J, Song A (2009) A GPS-enabled wireless sensor network for monitoring radioactive materials. Sens Actuat A Phys 155:210–215.

[2] Charles D. FERGUSON , Michelle M. SMITH, Assessing Radiological Weapons: Attack Methods and Estimated Effects Defence Against Terrorism Review, Vol. 2, No. 2, 2009, pp. 15-34 Copyright © COE-DAT ISSN: 1307-9190.

[3] Acton, James M., M. Brooke Rogers, and Peter D. Zimmerman, Beyond the Dirty Bomb: Re-thinking Radiological Terror," Survival, vol.49, no.3, 2007, pp. 151-16.

[4] Vax, E., Sarusi, B., Sheinfeld, M., Levinson, S., Brandys, I., Marcus, E.,& Cohen, Y. (2009, October). An integrated approach for multi purpose fast deployment Environmental Radiation Monitoring System. In Nuclear Science Symposium Conference Record (NSS/MIC), 2009 IEEE (pp. 912-913). IEEE.

[5] Gomaa, R. I., Shohdy, I. A., Sharshar, K. A., Al-Kabbani, A. S., & Ragai, H. F. (2014). Real-time radiological monitoring of nuclear facilities using ZigBee technology. IEEE Sensors Journal, 14(11), 4007-4013.

[6] S. Brennan, A. Mielke, D. Torney, and B. Maccabe, "Radiation detection with distributed sensor networks," Comput., vol. 37, pp. 57–59, 2004.

[7] S. M. Brennan, A. M. Mielke and D. C. Torney, "Radioactive source detection by sensor networks," in IEEE Transactions on Nuclear Science, vol. 52, no. 3, pp. 813-819, June 2005. doi: 10.1109/TNS.2005.850487

[8] R. Lubis and A. Sagala, "Multi-thread performance on a single thread in-memory database," 2015 7th International Conference on Information Technology and Electrical Engineering (ICITEE), Chiang Mai, 2015, pp. 571-575.doi: 10.1109/ICITEED.2015.7409012

[9] Jing Han, Haihong E, Guan Le and Jian Du, "Survey on NoSQL database," Pervasive Computing and Applications (ICPCA), 2011 6th International Conference on, Port Elizabeth, 2011, pp. 363-366.doi: 10.1109/ICPCA.2011.6106531

[10] Moniruzzaman, A. B. M., and Syed Akhter Hossain. "Nosql database: New era of databases for big data analytics-classification, characteristics and comparison." arXiv preprint arXiv:1307.0191 (2013).

[11] Tilkov and S. Vinoski, "Node.js: Using JavaScript to Build High-Performance Network Programs," in IEEE Internet Computing, vol. 14, no. 6, pp. 80-83, Nov.-Dec. 2010. doi: 10.1109/MIC.2010.145

[12] Lukas, W. A. Tanumihardja and E. Gunawan, "On the application of IoT: Monitoring of troughs water level using WSN," 2015 IEEE Conference on Wireless Sensors (ICWiSe), Melaka, 2015, pp. 58-62. doi: 10.1109/ICWISE.2015.7380354

[13] Allan Liska, NTP Security, Apress, 2017

[14] J. L. Carlson, Redis in Action, Hanning, 2013

[15] Faruk Akgul, ZeroMQ, Packt Publishing,2013

[16] REDIS Documentation[Online]Available: https://redis.io/documentation

[17] Kim Spilker, Free ebook: Microsoft Azure Essentials: Fundamentals of Azure, Second Edition, Microsoft Press blog, 2016

[18] BeagleBone Black Wireless description [Online] Available: https://beagleboard.org/black-wireless

[19] Clifford K. Ho, Alex Robinson, David R. Miller and Mary J. Davis Overview of Sensors and Needs for Environmental Monitoring, Sensors, volume 5, 2005, pp. pp.4–37