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Real Time Design of Wireless Sensor Network for Monitoring ionized Radiation using Raspberry Pi

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Abstract: Early detection of ionized radiation using intelligent technology will minimize the number of casualties when radiation disasters occur. The objective of this paper is to design sensors network using Raspberry pi technology able to detect any leakage of radiation. The design used the internet of things (IoT) to provide easy and safe monitoring in everywhere. This design calculates the radiation quantity in real time and provides both sound and LED alerts. Geiger-Mueller (GM) counter was used for sensing the ionizing radiation such as gamma rays. An application web was designed to ensure the facility of monitoring radiation everywhere. A daily report of radiation amount over the day can be obtained easily. Each radiation power level was represented by a set of LEDs with different colours. The structures contain sub-nodes, main node and raspberry pi node. XBEE used to connect between sub-nodes and the main node then Ethernet module is used to connect the main node to raspberry pi unit.

Keywords: *Index Terms— Ionized radiation, Geiger-Mueller, WSN, Raspberry pi.*

1. INTRODUCTION

Radiaition has an invisible nature which explains how dangrous that it can affect the human body. Radiation surround us every where and it results from different sources such as sun radiation,soil and rocks which provide low level of radiation often considerd as safe radiation, but some types of radiation such as ionizing radiation can be harmful to the human body. The dangrous degree of radiation depends on the type of radiation and the amount of radiation that the human body has been exposed to. Medium and high levels of radiation cause damage to the cells in the body. Expert new modern technology becomes a necessity to avoid increasing the number of lost ones if any disaster happens [1]. Early detection of radiation leakage is important to save lives because time is an important factor when dealing with radiation danger to avoid getting in complex situations that lead to more difficulties of evacuating people. Intelligent monitoring and management systems are the most effective solutions to achieve quick detection of radiation leakage. Usually this technology depends on the usage of network of embedded devices. In this paper a design that provides multilevel warning detection of radiation using raspberry pi device is proposed.

2. Geiger Mueller Tube

Geiger counter is the basic instrument of measuring any form of energy related to Radiation. Mainly radiation energy is one of three forms; alpha, beta and gamma radiation. Gamma radiation as shown in Fig.1 is the most dangerous form due to its high penetration power to pass through human body [2]. GM Structure consists of cathode usually of cylindrical shape of thin metal surrounding the GM in the middle where there is an anode. Radiation energy enters the GM through mica surface which enables wide range of radiation to pass even those of low penetration power. The ability of GM to give an efficient metering of radiation power effects is influenced by:

- *The type of radiation.*
- *The amount of radiation energy .*
- *The direction of the source relative to the instrument detector active area.*

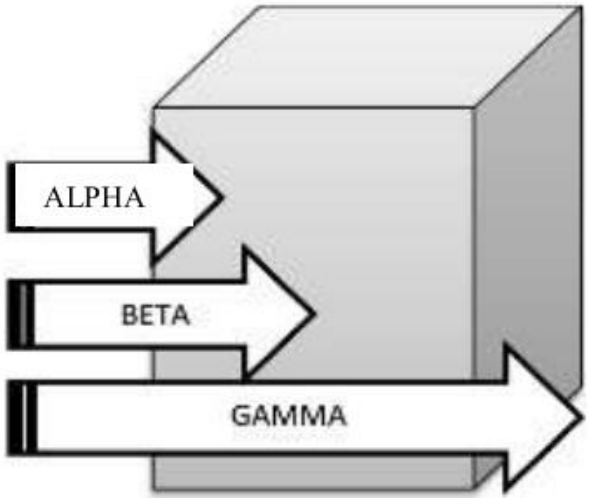

Fig .1. Penetration Strength

3. Related Works

There are a lot of researches published recently that attempts to develop an efficient technology of early radiations detectors. Unlike all works discussed in this section this paper offers the use of advance technology of raspberry pi and it differs in the term of using several levels with different colors to monitor the status of radiation everywhere which saves more time to alert of danger. The survey meters in Islam et al[4] requires sensitive electronics to amplify the signal, which makes them fairly expensive and delicate. Okeyode et al [5] used smart phone to provide radiation monitoring via Bluetooth technology using GM which have certain range. Altayeb et al [6] also shows GSM radiation detection and did not use Raspberry Pi controller. Hua [7] in his

design used a TI CC2530 chip which has high sensitivity and short life. Ghuge[8] used pic microcontroller and LCD to obtain digital output display of the GM. Ros[9] summarized the solid state of detectors used in neutron diagnostic, the original data may be lost or interfered because of its processing and inefficiency through multiple units from source to destination. Abbas et al.[10] used (WCDMA) with absence of high frequencies (above 11700), absence of frequencies with horizontal polarization or vice versa.

In Abddala [11] the sensor alert is received if the sensor values exceed the specified or normal value so that the alarm can be exceeded before the specified value. Record [12] used arduino ATMeqa so that Arduino UNO is the best in terms of speed but it has less features than Raspberry Pi such as WI –Fi technology without adding new device. The results in Burnett et al.[13] were rounded by a standard logarithm distribution, and the radiation was not measured in real time.

4. Methodology

Mainly this paper presents a design of wireless embedded system used for monitoring the radiation in certain predefined areas. The design is divided into two parts hardware and software. The software implementation is concerned with writing the code and programming of the arduino. This wireless embedded system design consists of three Nodes (Node1, Node2, and Node3).

The schematic diagram and the basic block diagram are shown in Fig.2 respectively, each node of the system is represented as independent embedded system that can be located in different places for measuring and detecting any possible radiation at any time.

Each of the sub nodes as shown in Fig.3 consists of a battery and radiation sensor, which are interfaced to the Arduino board. The Arduino board reads the sensor's values then sends these values via the XBee wireless communication module based on the IEEE 802.15.4/ZigBee standards connection.

The server (Raspberry Pi) receives the data from the main node via the Ethernet module based on the IEEE 802.3 standards. The server will provide the ability to monitor and store the data in the database, and finally display the readings on the monitoring system. The monitoring system is a web application (HTML, PHP, MySQL, CSS, JS) hosted in the server accessed via web browser.

The data is collected by Geiger-Mueller GM tube and for the simulation purpose the mechanism of how the GM can measure the radiation amount the following equation is used [3].

$$R.A = (CPM) \times C.F \quad (1)$$

Where:

R.A: the radiation

C.F: is the conversion factor which equal to 00812.

CPM: refers to the Count per minute and it can be given by:

$$CPM = (R.A \times 1000) / CF \quad (2)$$

Where the R.A in equation 2 is measured by mSv unit.

In this paper three levels of power radiation are specified, namely, danger level, risk level and safe level and each level is divided to several sublevels. Table. 1 illustrates the specified levels classified in this implementation depending on the radiation dose.

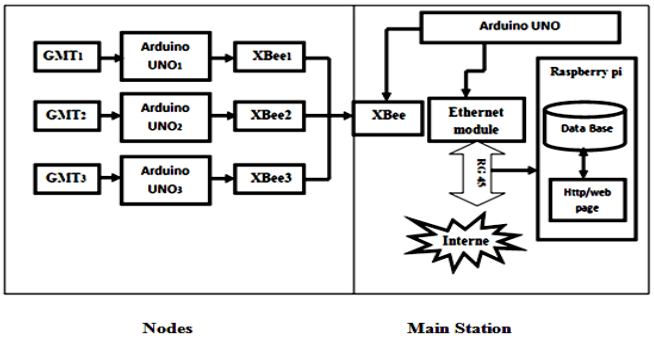

Fig .2. Blockdigram

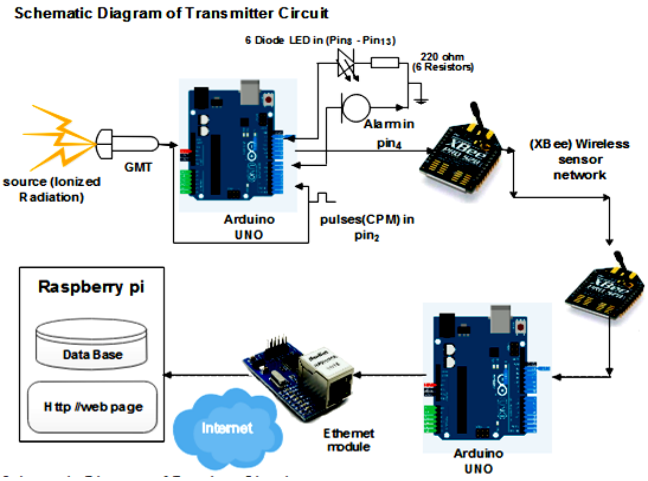

Fig .3. Diagram Schematic

Table 1. Radiation levels

level	uSv per H	CPM	No of LEDs	Condition
Danger	10.0000	1231527	Red 2	Value>=
Danger	1.0000	123152.7	Red 2	1231
Danger	0.0200	2463.054	Red 2	
Danger	0.0100	1231.527	Red 1	value >= 246 and value < 1231
Risk	0.0050	615.7635	yellow 2	value >= 123
Risk	0.0020	246.3054	yellow 2	and value < 246
Safe	0.0010	123.1527	yellow 1	value >= 61 and value < 123
Safe	0.0005	61.57635	green 2	value >= 24 and value < 61
Safe	0.0002	24.63054	green 1	value < 24

Sublevels are divided according to the degree of radiation effects; for example the level of 0.001 is safe but for short time, while the level be long time.

5. DESIGN ARCHITECTURE

The radiation amount collected by each node will be sent wirelessly in a frame format to the main node via XBee wireless technology then to the raspberry pi node via ethernet module as shown in Fig.4.

The operation step of each node is shown in Fig.5. When the system is switched on, it will run in auto mode. All XBees modules scan their channel to connect with main station.

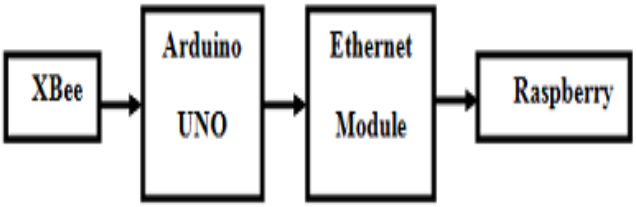

Fig .4. Node block diagram

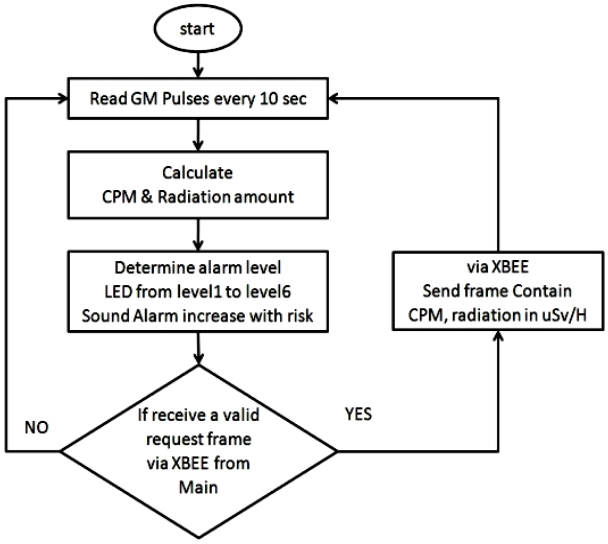

Fig .5. Node Algorithm

The node frame as shown in Fig.6 includes the information such as identity number of node, radiation value in addition to the start and end bytes of frame.

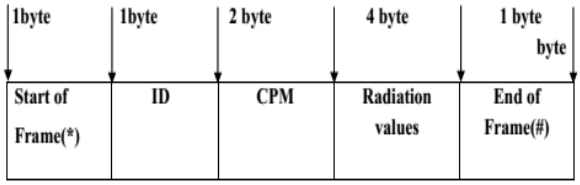

Fig .6. Transmitted frame

The main node algorithm operates as shown in the following chart depicted in Fig.7.

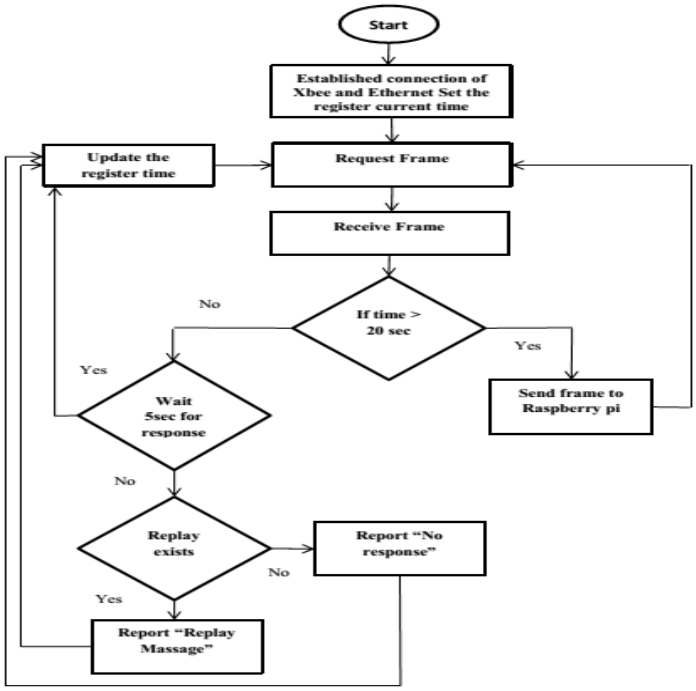

Fig .7. Main Node Algorithm

Time that will be considered for timing then a request frame containing node number will be sent to the node which will respond with a frame containing CPM and radiation value. After that the status is checked every 20 seconds. The Raspberry Pi algorithm is illustrated in Fig.8. On page load refers to a function accomplished in the code aimed to check if the password is not NULL and match with the given password on the server side .When the main node request for radiation saving page (addrad.php) two parameters will be sent namely ;the password and the frame values. The password used for authentication and the radiation values holds the node ID, CPM and radiation value in uSv/h.

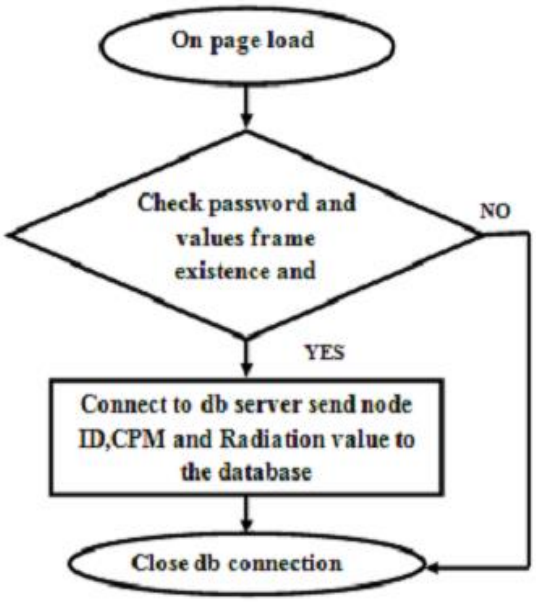

Fig .8. Rasspberry Pi Algorithm

6. RESULTS AND DISCUSSION

The results shown in this paper are carried out randomly using pulse generator function which is used to simulate the operation of GM as discussed in equation1 and equation2 above. Fig .9 shows the screen monitor of the system. As shown it uses colours to demonstrate the status of nodes. It shows last values spotted from the nodes. Green colour indicates safe values, yellow colour indicates risky values, and red indicates danger values.

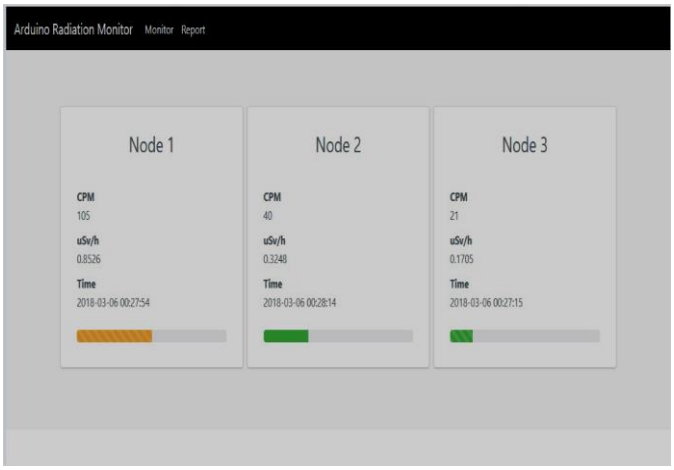

Fig .9. Node Status

The data base reports as shown in Fig.10 contain simplified (Min, Max, mean and median) statistics on the left. The values appeared on the right of statistics column with selectors to determine a node or level of danger to be represented.

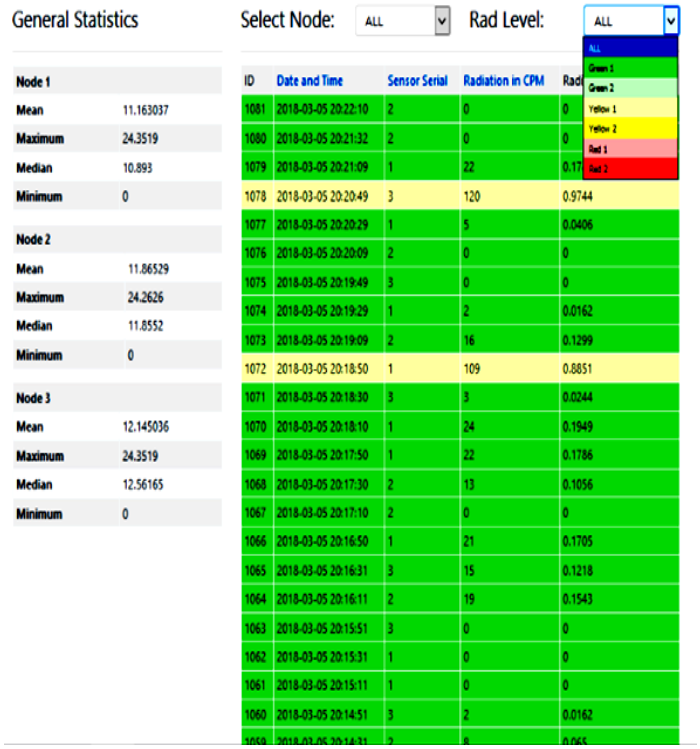

Fig .10. Represent report page

7. CONCLUSION

This paper presented WSN design aimed to detect the leakage of radiation. The design is based on raspberry pi technology .The design used indicator colours (green , yellow and red) to display the risk levels normal, medium and dangerous respectively .The overall results ensured that the design has performed very well and hence can be used in real environment.

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