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Wireless sensor network for structural health monitoring using RFID based data mules

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Abstract. The wireless system did the huge cost-cutting in monitoring the structure so, now it can be used permanently as an integral part of the system as a smart infrastructure that will give them real-time information the structure. The wireless devices transmit the collected data about cracks, displacement, and excess vibration in slab-tracks. The train which will collect the data and train will be used as a data mule in this paper which will upload the information to a remote-control centre. The data which will be collected stored in the database and to know the status of the track a query will be fired from an application. In this paper, many design for communication systems are proposed which are efficient, with fine accuracy, and most importantly it is a low-cost system.

Keywords: RFID, WSN, sensor node, communication technology.

1. Introduction

To know the condition or health of the infrastructure such as railway industry, civil engineering, aerospace we have to do some process which is known as Infrastructure health monitoring (IHM). In context to view there are mainly two types of challenges or we can say aim to achieve, to improve public safety with a cost-effective manner in installation as well as maintenance and repair [1]. To know the damages on the surface of material and too known properties we will do a Non-destructive test which gives us results or Evaluation that can be done without any damages. Wireless sensor networks are being used almost in all areas because of their accuracy as well as cost-effectiveness. Nowadays wireless sensors are widely used as critical infrastructure protection (CIP). The national critical infrastructure i.e., nuclear power plants, railways, water distribution and management, power station. These infrastructures can implement wireless sensor networks at their place to know the health of these critical structures and awareness towards any kind of failure [2]. In this paper the architecture presented has mainly focused

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on railway Infrastructure using slab track [3]. We installed a permanent monitoring system and for transferring a large amount of data we will install sensor node along with the track in a triangulation way which will take a periodic reading and transferred to the trains which will pass through the nodes, and this is used as data mules which have great advantage i.e. it doesn't require the direct internet connectivity for the WSNs [4].

The data after that stored in the database and through the help of an application, we can fire a query and get the data and can check or predict any kind of failure or damages. Along with this the rest of the paper is arranged in a way i.e., work related to paper, how the system works, how the communication will be managed, approach towards optimization of energy consumption, map of the overall system, evaluation of bad nodes, also for finding bad nodes and at last conclusion [5].

2. Related work

There are several demonstrators that monitor critical infrastructure which depends on wireless sensor networks, but this paper will cover majorly rail-road structures. The use of a train bridge is presented in the study of the Bischof wireless sensor network is dependent on the Tmotesky node and it will detect deformation in the structure when the moving train came across it. The sensor which is placed on the track (accelerometer) will become active or in on-mode when the train came nearby too and start collecting the data and become turn-off automatically after processing the data to save power [6]. After collecting the data, it will be sent to remote centre [7]. Once the data collected it will be sent to the base station using a wireless sensor or we can say with the help of the routing feature. Now to send the data to control Centre this paper includes the technology used in mobile communication. When we integrate some devices such as ultrasonic sensors with an accelerometer it will provide us information about any damages in the track such as gap at some point in the track, crack in the track [8]. This system also includes image detection and any kind of hazardous things on the rail track. With the help of wireless sensors, we can monitor the rail track in less money because wired devices are more expensive than wireless ones. If we use a tree type structure or hierarchical system, we can also increase efficiency and reliability to their highest possible levels. The control centre will receive the data collected by the nodes via GPRS (General Pocket Radio Service) [9].

2.1. Sensor node architecture

The main parts of WSN node are Control device, Universal communication device, Wireless devices, Memory, Power Backup [10]. The architecture is given in Figure 1.

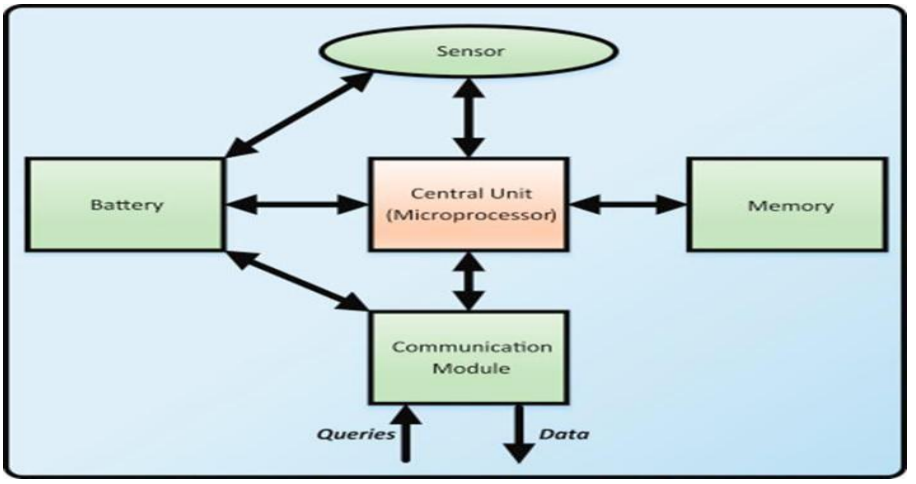

Figure 1. Sensor node architecture.

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In the segments of this paper, it will conclude the communication technology. As we all know railway trains will move in all areas which include some remote areas where communication between these portions is very crucial as there is no internet connectivity, as well as no power backup, exist [11]. The sensor platform which was installed will be collected the data such as vibration, frequency, slope, and these data must be collected and reached to the control-Centre to analyse. The power backup problems the WSNs is installed with solar backup and sensor which will make active the WSNs while any train approaching towards it and become of when no movements will be there for communication, the connectivity issue will be solved if the WSNs node used railway train as data mules to collect and transmit the data to the Control Centre. The train will collect the data on its movements basis and all data, at last, will be stored in the database at the Control Centre. The steps for transmitting the data are shown below:

- *Step1.* Every WSNs store the data in a triangulation form of acceleration when movements of trains occur.
- *Step2.* Acceleration information is changed into the frequency area utilising the "Fast Fourier Transform" (FFT) for every window.
- *Step3.* The peak acceleration frequency area will be noted in each window.
- *Step4.* The three top acceleration that relates to the primary frequency at which vibrate the late then and there comparing timestamps are sent to the following train the movement from and to the train to control-Centre (Fig 2).

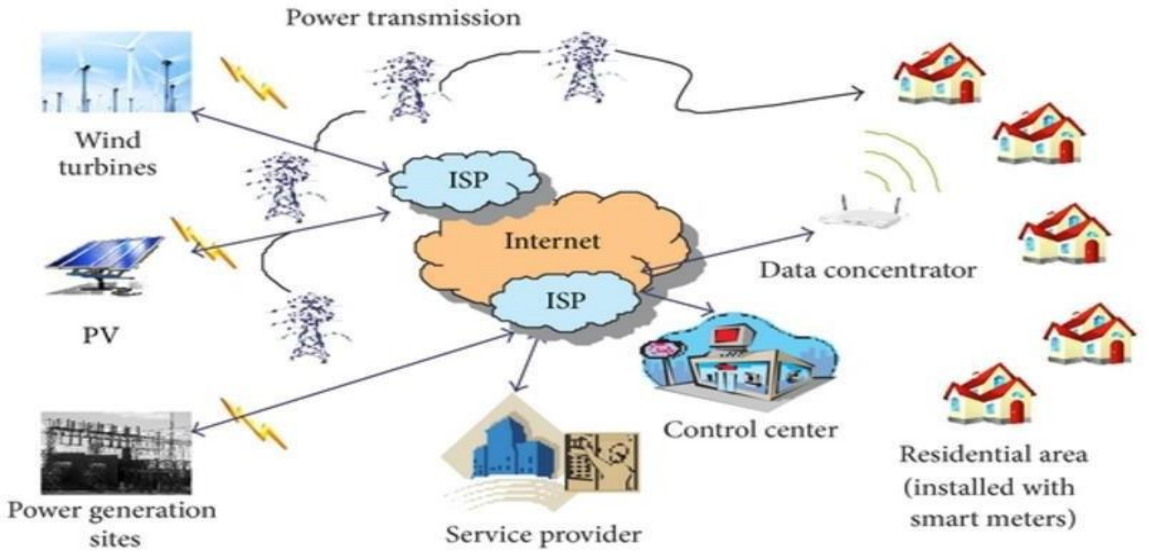

Figure 2. Example of Architecture Communication in smart greed [5].

2.2. Communication technology

The data created by nodes must be collected since trains will be utilised as data mules, as described. Therefore, it is crucial to research the many ways that a train acting as a data mule can interface with the WSNs that have been installed on the slab track. The overview of communication technologies will just highlight the key features of the above technologies according to our study [8-11] which are given below:

- Radio Frequency module doesn't need any Global positioning of the area.
- Zigbee technologies uses 2.4 GHz bandwidth which is mostly used as it is short range and low energy consumption method. So, it is cost effective technology.
- In the above group's method of transmission there is a direct connection between node as they will not superimposed on any wave (Figure 3).

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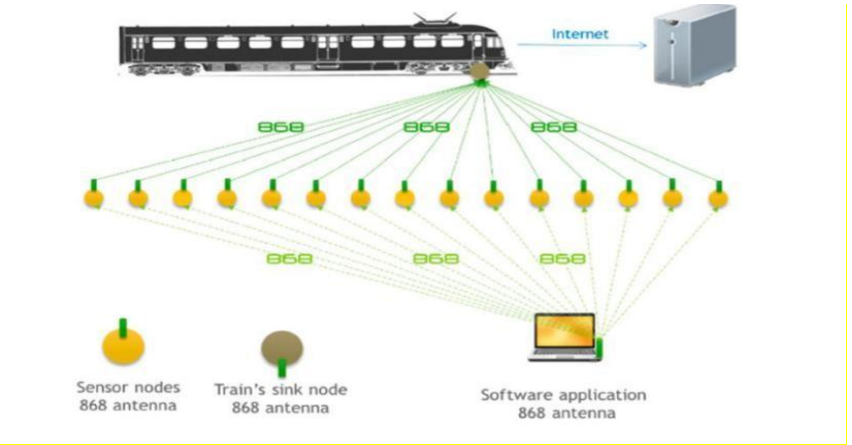

Figure 3. MHz radios without using groups.

2.3. Power consumption optimised design

The important points of power consumption optimised design are discussed in the Table 1

Table 1. WSN Power Management for Train Tracking.

Theory	• Power dissipation has a great role in this design, as all WSNs depend on power and if these WSNs dissipate their energy continuously then it will hard to collect the data. Therefore, these WSNs are designed to be like that when the train passes through it will be the inactive state after getting some vibration on the track and have to transmit the data to the next train.
Implementation	• To prevent the WSNs from being idle there is another inter-action being installed to awake the WSNs by giving the alert to the system. Accelerometers help in detecting: The accelerometers used in detecting the speed of the train and with the help of an accelerometer it is used to activate the WSNs system to store and transmit the data to the trains, which is used as a data mule.
Advantage	• Detection using time switching: To awake the WSNs inactive state there can be a program for a certain time to active the WSNs from off state. Therefore, the switching technique should be used here. It will be used for scanning the energy of the device. When the accelerators detect the vibrations.
Limitations	• The vibrating patterns for roll-track will be different therefore it is required to analyze the pattern of vibration. There will be some situations arise when some coordination between nodes gets disconnected than at that movement the Centre will be different.

3. Result and discussion

There is no interference between node to node and node to train communication. The architecture divides the nodes placed on the railway structure into different groups. The data generated in every group is collected by a coordinator node who are using ZigBee in 2.4 GHz band. Every time when a train passes, the coordinator of each group uses the 868 MHz band to send the data to a receiver node installed on that train. For receiving the data, we assumed that train has internet connectivity. The data is stored in

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database and be accessed from any system through its server which is deployed. Once the data has been collected it will be analysed and when the movement or peaks in the frequency area have been noticed, then this data will be sent to the coordinator of the monitoring group. At last, when the data mule train is detected, all the data will be sent to it. Finally, when the data is received by the radio module placed on the train, a connection opens to communicate with the database. This database can be accessed through a browser. When we collect sample of data from train and with the database we will and analyse the data and queried any data information from the database.

4. Conclusion and future work

This system can be used in a new project of bullet trains or high-speed trains. Many designs have been proposed from costly to pocket friendly and more reliable methods. These nodes will transmit the data to the train when it passes through it. In this paper, it also includes the detection of bad nodes if any nodes will be hacked or not in range the using algorithm, we got their information and action can be taken accordingly. Through all this work we hope to design a real monitoring system for not only railway structure as well as all critical structures. For analysing the large amount of data, we should work on Big Data analysis techniques such as Data fusion and data integration, Data mining etc.

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