IJIREEICE
ISSN (Online) 2321 – 2004
ISSN (Print) 2321 – 5526
INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH IN ELECTRICAL, ELECTRONICS, INSTRUMENTATION AND CONTROL ENGINEERING
Vol. 4, Issue 4, April 2016

Condition Monitoring In Railway Industry

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Abstract: In recent years the range of sensing technologies has expanded rapidly, whereas sensor devices have become cheaper. This has led to a rapid expansion in condition monitoring of systems, structures, vehicles, and machinery using sensors. Key factors are the recent advances in networking technologies such as wireless communication and mobile ad hoc networking coupled with the technology to integrate devices. Wireless sensor networks (WSNs) can be used for monitoring the railway infrastructure such as bridges, rail tracks, track beds, and track equipment along with vehicle health monitoring such as chassis, bogies, wheels, and wagons. Condition monitoring reduces human inspection requirements through automated monitoring, reduces maintenance through detecting faults before they escalate, and improves safety and reliability. This is vital for the development, upgrading, and expansion of railway networks. This paper surveys these wireless sensors network technology for monitoring in the railway industry for analyzing systems, structures, vehicles, and machinery. This paper focuses on practical engineering solutions, principally, which sensor devices are used and what they are used for; and the identification of sensor configurations and network topologies. It identifies their respective motivations and distinguishes their advantages and disadvantages in a comparative review.

Keyword: Microcontroller, Sensors, Wireless communication modem, LCD displays, web application.

I. INTRODUCTION

Railways were introduced in INDIA as a medium of transportation for goods and people on April 16^{th} April1853.Since its induction Railways has played an important role for the development of INDIA and connecting the remote areas to the main commercial areas. Also a lot of accidents have been caused due to inappropriate security, which may be due to the bad railway tracks, poor quality of infrastructure. Thus our system involves the proper monitoring of the railway networks system using sensor networks. By sensor networks we mean Wireless Sensor Networks. We typically enhance sensors because sensor technology is rapidly increasing with advanced features to overcome any deficiency caused due to any other mode. Condition monitoring detects and identifies the deterioration and destruction before the actual damage is caused. In simple condition monitoring, sensors monitor the condition of a structure or machinery. If the sensor readings reach a predetermined limit or fault condition, then an alarm is activated. However, this simplistic approach may lead to a large number of false alarms and missed failures. It only provides local analysis but does not take advantage of the superior capabilities when the sensors are networked and their data processed collectively.

Integrated data processing allows an overall picture of an asset's condition to be achieved and overall condition trends to be determined in recent years, networking technologies such as wireless communication and mobile ad hoc networking coupled with the technology to integrate devices have rapidly developed. The new technologies allow vast numbers of distributed sensors to be networked to constantly monitor machines, systems, and environments. Wireless sensor networks (WSNs) are wireless networks of spatially distributed and autonomous devices. They use sensors to cooperatively monitor infrastructure, structures, and machinery.

Each sensor node generally has a radio transceiver, a small microcontroller, and an energy source, usually a battery. WSNs and data analytics allow the railways to turn data into intelligence. They provide decision support through continuous real-time data capture and analysis to identify faults. The data from distributed systems such as sensor networks are monitored using classification, prediction or anomaly detection to determine the current and future status of the distributed network. Lopez-Higuera developed a staircase of structural health monitoring, where the higher the level, the higher the complexity and functionality.

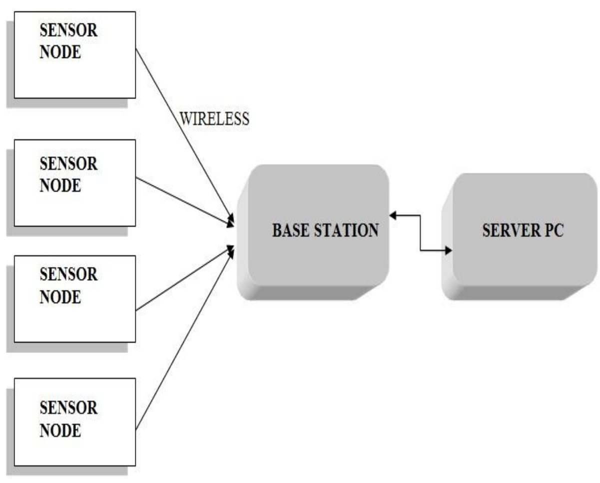

Fig.1. Figure shows a typical WSN setup for railway condition monitoring.

II. DESCRIPTION

1. Block Diagram Description
This system can be represented using block diagram as given below.

DOI 10.17148/IJIREEICE.2016.4468

IJIREEICE

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Vol. 4, Issue 4, April 2016

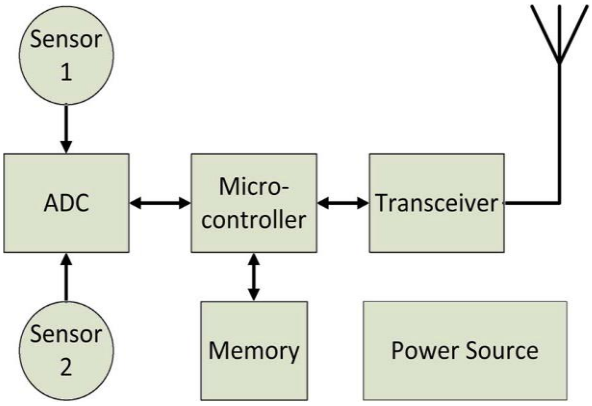

Fig.2. Diagram of the composition of a typical sensor node

Sensor devices are mounted on boards. The boards form a platform combining mobile computing and wireless communication (media access control (MAC), routing and error detection) with sensor devices as shown in Fig. 2. Many sensor nodes are moving toward enabling data interrogation and autonomous data processing to identify anomalies in situation. Hence, many data processing algorithms have also been embedded in wireless sensor nodes for autonomous execution. The boards generally comprise one or more wireless sensors, a microcontroller, transceiver, data storage (memory), and a power source. If the data sampling rate is low, for example, when monitoring the growth of a crack over a period of time, then the microcontroller, memory, and transceiver power can all be low. However, for frequent sampling such as monitoring the temperature of a mechanical bearing every second, then the microcontroller, memory, and transceiver must be more powerful.

A. Base Station:

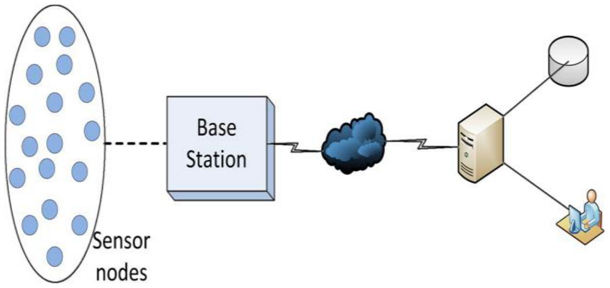

Fig.3 Diagram of the composition of a typical base station node

The base station controls the sensor nodes and acts as a gateway for data transmission to a remote server. The sensor nodes use short-range communication such as Wi-Fi or Bluetooth to transmit data to the base station. The base station uses long range communication such as GPRS or satellite to transmit collated data back to a server at a control centre. It has a more powerful processor and more memory than the sensor nodes to allow it to collate data from multiple sensors. Hence, the base station requires more power. For example, train monitoring systems have battery-powered sensor nodes in the carriages but place the base station in the locomotive, where more power is available from the train engine.

III. HARDWARE USED

1. Sensor Nodes

Sensor devices are mounted on boards. The boards form a platform combining mobile computing and wireless communication (media access control (MAC), routing and error detection) with sensor devices. Many sensor nodes are moving toward enabling data interrogation and autonomous data processing to identify anomalies in situ. Hence, many data processing algorithms have also been embedded in wireless sensor nodes for autonomous execution. The boards generally comprise one or more wireless sensors, a microcontroller, transceiver, data storage (memory), and a power source. If the data sampling rate is low, for example, when monitoring the growth of a crack over a period of time, then the microcontroller, memory, and transceiver power can all be low. However, for frequent sampling such as monitoring the temperature of a mechanical bearing every second, then the microcontroller, memory, and transceiver must be more powerful. Lynch and Loh provided a thorough overview of sensor boards for WSNs.

2. Power supply unit- On-board 12V rechargeable battery is use to drive relay. To drive ATMEL 16 and for various sensors we require 5V. So to do this we will have to build variable power supply unit using voltage divider circuit and regulator IC like LM7805.

3. Sensor Power- Sensor nodes often use batteries as their energy source. Batteries have a finite life. The batteries in an accelerometer monitoring a train pantograph only lasted 20 days. Chebrolu et al. were able to extend battery life to 1.5 years for 4 AA batteries by only waking their sensors when required and sleeping otherwise. However, even with extended life, fitting and replacing batteries is not always possible in remote and inaccessible railway locations. The nodes may also be embedded in the monitored structure or mechanics of a train, where no access to batteries or wired connection is possible. Hence, authors have considered alternative energy sources for nodes. These need to be reliable to allow the WSN to function for long periods of time with no human involvement and able to generate sufficient power.. Piezoelectric materials can produce electricity as a response to mechanical strain such as the strain exerted on the track or sleepers by a passing train. Piezoelectric materials are robust, able to withstand harsh environmental conditions, and can deliver a large amount of energy. Investigation reported that piezoelectric vibration harvesters that derive energy from the vertical displacement or vibration of tracks, ties, and sleepers.

4. LCD Display: A liquid-crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, except that arbitrary images are made up of a large number of small pixels, while other displays have larger elements.

5. USB to UART Bridge (CP2102): The CP2102 is a highly-integrated USB-to-UART bridge controller providing a simple solution for updating RS-232 designs to USB using a minimum of components and PCB space. Offering Baud rates aliasing and supporting additional data formats, the CP2102 is a pin-to-pin upgrade from CP2101. The CP2102 also includes a USB 2.0 full-speed function controller, USB transceiver, oscillator, EEPROM and asynchronous serial data bus (UART) with full modem control signals in a compact 5 x 5 mm MLP-28. No other external USB components are required.

IV. WORKING

As the name of our project condition monitoring in railway industry using zigbee this suggest that we can monitor in and around of bogie using various sensors. In this the sensor senses the physical parameters in and around the bogies as well as the rail tracks, bridges, train equipments such as train wheels, wagons, chassis etc.
The sensors and monitoring pc are the two parts connected each other by wireless connection. The sensor connected part is called as Sensor node and monitoring part is called as base station.

Sensor Node:
All the sensors connected on train track, train infrastructures, in the bogies come under the sensor node. All the sensors in the sensor node are connected to the microcontroller for the controlling part as well as to send the data to the base station.

Base Station:
The base station act as the intermediate between the monitoring station and sensor nodes. Base station collects the data from the various sensor nodes and collectively sends the data to the monitoring station.

V. ADVANTAGES

1. Maintain process.
2. Verify and protect machine, systems and process stability
3. Minimize manpower
4. Prevent failures and save businesses money and time

VI. APPLICATIONS

1. Detect maintenance requirements
2. It is used to monitor real time conditions.
3. Request maintenance based on the prediction of failure rather than maintenance running to a standard schedule or being requested following an actual failure.

VII. CONCLUSION

This paper has reviewed the range of WSNs used for condition monitoring in the railway industry. The emphasis is on the practical engineering solutions, principally which sensors devices are used and what they are used for; and, identification of sensor node configurations and network topologies.
The paper divides railway condition monitoring into fixed monitoring for immobile infrastructures such as bridges, tunnels, tracks and associated equipment, and movable monitoring for vehicles and their mechanics. Fixed monitoring uses sensors to monitor vibrations, stresses and sound waves passed through structures (acoustics) caused by passing trains (short-term monitoring) and also changes in stresses, pressures and sound waves passed through structures over the longer term (long-term monitoring). One of the key issues for fixed monitoring is network topology. The topology is constrained by the requirements of the
Monitoring and by the physical environment. Sensor nodes can be arranged in either an ad hoc or a preplanned configuration. Determining the optimum node placement is a complex task and often requires a tradeoff. The network configuration can be optimized against a number of different constraints. A network may minimize relay nodes, may need to ensure a minimum level of service (include a certain level of redundancy), minimize energy usage to preserve battery life, or may need to ensure accessibility of the nodes. The communication mechanisms, for example, Bluetooth, Wi-Fi, GSM, or satellite also need to be evaluated to ensure coverage and reliability and the routing protocol to ensure data is successfully transmitted from sensor node to base station to control center. Another issue is powering the sensors as fixed monitoring often requires placing sensor nodes in inaccessible locations, for example, in tunnels, on bridge trusses, or in rail track beds. Many sensors use batteries but replacing batteries in inaccessible locations may not be possible. Authors have considered ambient energy harvesting such as converting vibrations caused by passing trains into energy or using solar power. These energy harvesters may be accompanied with energy storage such as capacitors Authors have also reduced sensor energy usage using event detection where a single cheap sensor detects approaching trains and wakes a larger sensor network to commence taking measurements of a bridge structure.

VIII. FUTURE WORK

There are a number of promising directions for further research in condition monitoring in the railways. One future direction is a move toward holistic integrated systems which provide near real-time information and alerts. These approaches will integrate data from different sensor systems using sophisticated modeling techniques. They will also incorporate more contextual data into the modeling, including the ambient conditions, the route, the journey time, the weight of the train, and more. The models will use multistage data fusion. This fuses measurements from a variety of sources (sensors and contextual data) and over a range of time epochs to generate a consolidated state history of the object being monitored. The models will also mitigate data dependencies (physical dependencies) across the physical objects being monitored. An integrated multifaceted approach should improve prediction quality. For example, train monitoring data can be combined with route data and GPS data. If multiple trains detect a vibration fault at exactly the same GPS location, then the fault is more than likely in the rail infrastructure such as uneven track. However, if only one train identifies a vibration anomaly

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Vol. 4, Issue 4, April 2016

at a particular GPS location, then the fault is more likely to be in the rolling stock.

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DOI 10.17148/IJIREEICE.2016.4468