A Survey on Wireless Sensor Network Technique for Secure Railway Operation

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Abstract – Railways are large infrastructures and are considered as safest mode of transportation. In present scenario, inspectors walking the track lines and train cars instrumented with accelerometers along with ultrasonic sensors are the methods to detect the wear of the rail and breakages. Near about 10,000 accidents has been occurred in last eight years. Thus, a proper maintenance strategy is required to govern optimization of inspection frequency and/or improvement in skill and efficiency. This paper deals with the surveys which is associated with various technologies available in wireless sensor networks. Eventually, which could be used to prevent accidents and ultimately safety and security of railway transportation can be achieved.

Index Terms – Wireless Sensor Networks, Fuzzy Data Aggregation, Railway Safety.

1. INTRODUCTION

Railways comprise a large infrastructure and are an important mode of transportation in many countries. The poor maintenance of the railways can lead to accidents. Accidents involving railroad assets including: train collisions, train derailment, and fatalities due to people being struck by trains in motion either along the track or at crossings. However, train collisions and derailments do still occur. Rail transportation requires more safetysince the number of trains running along the same existing tracks gets increasing. The number of collisions occurring world-wide shows increasing tendency year by year. In order to achieve safety, new technologies have to be incorporated with railways. Indian Railways lack in existing infrastructure. With the same available number of tracks, number of trains and their speed are increasing year by year. By using WSNs, a system can be established to monitor a rail line and harmful areas could be quickly identified so as to prevent a massive loss of lives. Recent advances in wireless communications and electronics have enabled the development of low-cost, low-power, small-size, and multi-functional sensor nodes. These sensors consists of a microprocessor, a few kilobyte of RAM, a short-range radio transmitter, a small power source (e.g., a battery), and a few sensors to interact with the environment. Such tiny sensor nodes, which cooperate on sensing different physical phenomenon, have led to the appearance of wireless sensor networks (WSN). Sensor networks hold the promise of revolutionizing sensing in a wide range of application domains because of their reliability, accuracy, flexibility, cost-effectiveness, and ease of deployment. The most important feature of the WSNs is being multi-layered i.e. starts at the lowest layer and continues to the next higher layer. Government of India ministry of Railways in mentioned about the statistics of Train accidents. It is also mentioned that in order to achieve safety, new technologies have to be incorporated with railways. Indian Railways lack in existing infrastructure. With the same available number of tracks for many years, they are increasing the number of trains and speed which leads to accidents.

The main objectives of our this paper are to generate innovative solutions for a number of the issues facing the railroad community include finding new approaches to reduce the occurrence rate of accidents and improving the efficiency of railroad maintenance activities.

2. RELATED WORK

The current state of the art in detecting immediate and long-term track problems involves both inspectors walking the track lines and train cars instrumented with accelerometers and ultrasonic sensors that are capable of detecting wear of the rail and breakages. Additionally, a widespread practice of sensing rail continuity by using the tracks to complete simple circuits is in place.

TECHNIQUES FOR INSPECTING CRACKS IN RAILWAY TRACKS

2.1: Long Range Ultrasonic Testing (LRUT)

Long Range Ultrasonic Testing (LRUT) technique is proposed as a complimentary inspection technique to examine the foot of rails, especially in track regions where corrosion and associated

fatigue cracking is likely, such as at level crossings. LRUT technique is found to be suitable for examining inaccessible areas of railway tracks such as areas where corrosion occurs and susceptible areas of fatigue cracking. In different parts of the rail section (such as head, web and foot) properties of guided waves are used and are examined for their capability to detect defects in each part.

2.2: Ground-penetrating radar (GPR)

A technique based on Ground-penetrating radar (GPR) [7] is used for obtaining quantitative information about the depth and degree of deterioration of the track. This paper aims at automating the processing and interpretation of data to the extent whereby on-site interpretations may be achieved with minimal intervention of the expert. This is done through the development of new image and signal processing tools specifically for GPR data and the range of anomalies found on the track bed.

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3. LITERATURE REVIEW

Wireless Sensor Network [WSN] for Railways Sandeep Patalay gave a basic approach of how the sensor network could be utilized in railways. Use of sensor nodes with a special node called driving node at the locomotive engine, Gateway node and a Base station could achieve an architecture needed for this scenario.

The sensor nodes could detect the events occurring and could be triggered. The sensor node reports the events to the base station which could further take actions that depends on the applications. For e.g. In closing of railway gates automatically once arrival of train is detected. In this scenario the event is the arrival of train and a vibration sensor which was laid in the track could detect this event and could report it to the nearby base station which then sends commands to do the action which is here the closure of gates.

This basic approach can be applied in two ways:

1) On Signalling:

- To detect the presence of trains
- To detect the strength of the signal
- To detect the presence of vehicles at crossing gates

2) On Engines:

- To monitor different parameters such as:
- Brake pressure
- Speed of the engine

The sensor nodes are fitted to the carriages at a distance of four hundred meters apart which communicates to the driver node at the Engine which then transmits the information to the Gateway node. A wired backend could serve as the communication medium for the communication between the gateway node and the Base station. The base station can then send back the commands to the driver node.

Zeinab Sam Daliri, et.al., have given the method for providing security in railways through wireless sensor networks based on Fuzzy Logic which acquired the basic sensor network architecture and multi-layer routing from that of paper and includes ultrasonic broken flaw detecting system. This system includes a transmitter which sends out high energy waves in two directions at estimated intervals. The break in rails will be indicated by the change in the amplitude of the waves. It has a system for tracking any materials in tracks which employs either image processing by analysing the images captured by the cameras or leaky cable method for areas where there are possibility of landslides.

4. OVERVIEW OF SYSTEM

Figure.4.1 depicts a wireless sensor network deployed along a railway track. The network consists of one or more control centres (sink nodes) connected through a wire lined connection, and many wireless sensor nodes scattered across a sensing site (railway track). Each of these scattered sensor nodes are capable to collect the necessary data and to forward the data back to the sink. The data will be delivered to the monitoring system at the remote site through networked connections between the different sink nodes (base stations).

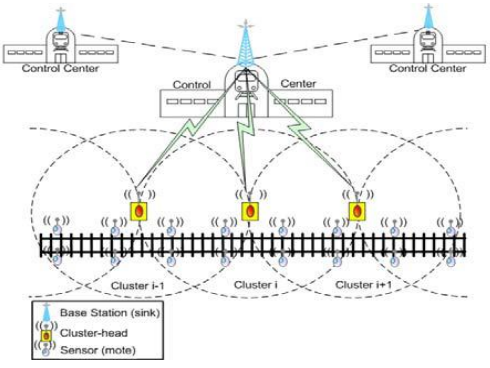

Figure 4: Safe railway system with wireless sensor nodes and control centers (base stations).

Multi-homing is a widely deployed scheme to improve the reliability of Internet by connecting to the Internet through multiple service providers. Given the broadcast communication characteristic of wireless sensor network, it is nature and energy efficient to apply multi-homing technique for fault tolerance since no extra transmission energy will be consumed to send multiple copies of the information to multiple homes. The multi-homing technique to be utilized inour proposed system will allow every node in the network to be associated with two "homes". The landmark nodes will be acting as the "head of the home" (HoH).

The occupants of each home are a group of sensors defined by their vicinity to the HoH. Each HoH will work as a gateway that forwards traffic from one home to the other or to the main base station for processing. Multi homing adds the following features to our system:

• Better identification of the area that has an anomalous condition, by narrowing it down to the overlapped region of the homes.

• Increase the robustness of the system so that the system can function in the presence of node failure, link failure, or misbehaving nodes.

5. MULTILAYER ROUTING

Sensor nodes are placed in and around the tracks forming different layers as shown in fig.5. Sensor nodes which are fitted to the tracks at regular intervals form layer 2 and at a fixed distance another layer(Layer 1) is formed .Each node in Layer 2 sends its sensed information to layer 1. Layer 1 sends this obtained information to the corresponding Cluster head which aggregates the sensor values from two of its layer 1 nodes and sends this to the base station which further takes appropriate action or sends it to sink nodes.

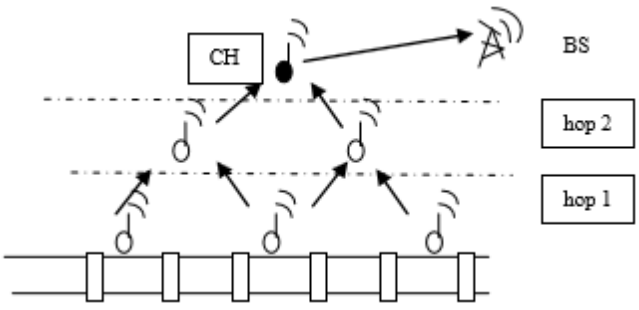

Figure 5. Multi-layered routing tree

6. AGGREGATION TECHNIQUE BASED ON FUZZY LOGIC

The proposed aggregation technique in our system is based on fuzzy logic to maximize information gain of the readings from the sensors while minimizing resource usage and minimizing false alarms. Fuzzy logic allows for approximate aggregation that is fault tolerant and scalable. Readings measured by sensors and transmitted using the wireless network ingrain imprecision or fuzziness. For handling and tackling such kinds of imprecision or vagueness in the received readings, it is not hard to imagine that the conventional aggregation approaches are not the best approaches to be applied. In addition, fuzzy logic allows us to represent the sensors readings as linguistic variables with the benefit of decreasing the space required to store their values and hence decreasing the amount of the bits to be transmitted by each node in the WSN.

6.1 Application Message Format

The application layer in our WSN will communicate using our Fuzzy Logic–based Data Aggregation message (the FLoDA message). The FLoDA message has the preliminary format shown in Figure 6.1

ID	Area (Start,End)	Type	F	μ_F	Time

Figure 6.1: FloDA message format.

The following are the definitions of the fields of the FLoDA message:

• ID: The location-based identity of the sending node.

• Area: The coordination (start and end) of the area which is covered by this message.

• Type: It is the code of the phenomena being reported in this message (e.g., temperature). The size of this field in bits will be ≥ log2P where P is the number of phenomena to be measured.

• F: The Fuzzy set that describes the value of the phenomena being reported (e.g., Freezing). The size of this field in bits will be ≥ log2S where S is the number of fuzzy sets associated to the phenomena to be measured.

• μF: The grade of membership (a value between 0 and 1), of the measured phenomena in the reported area, to the Fuzzy set F.

• Time: It is used to synchronize the clock of the nodes in the WSN. It will be utilized by the Fuzzy inference system in the aggregation process. In WSN, the power consumption of each sensor node tends to be dominated by the cost of transmitting and receiving messages. From the above description of the FLoDA message, it is clear that fuzzy logic contributes in decreasing the size of the messages to be transmitted and received.

7. CONCLUSION

This paper presents a survey on various technologies for providing security in railways and a fundamentally different approach that utilizes wireless sensor network (WSN) to

improve the current practices in railway operations. There is certain need of advanced and robust techniques that can not only prevent these accidents but also eradicate all possibilities of their occurrence. In this paper we presented the model of our safe railway system with its different components including the wireless sensor nodes along with the control centers. Several techniques from each paper could be integrated to be used along with the existing railways infrastructure since entire replacement of existing techniques in railways is not possible.

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