Chapter 9
An Intelligent Alarm System to Detect and Control Railroad Crossings Using Wireless Sensor Networks: RailAlarm

N. G. Nageswari Amma
Muslim Arts College, Thiruvithancode, India

N. G. Bhuvaneswari Amma
https://orcid.org/0000-0003-3660-380X
Vellore Institute of Technology, Chennai, India

ABSTRACT

In India, although train accidents and derailments have come down, there has been a considerable increase in the number of accidents on unmanned railway level crossings in rural or remote areas. In this study, an intelligent railroad crossing alarm system (RailAlarm) is proposed using wireless sensor networks (WSN) to avert accidents at unmanned level crossings. The design of RailAlarm has three contributions: Firstly, a train detection mechanism has been built that triggers data in response to an approaching train. A second feature of RailAlarm is that a simple, stateless data transfer mechanism is used to forward the data to a sink and balance the power consumption. Thirdly, a novel sleep wakeup mechanism to conserve power has been designed which is a crucial feature in WSN. Based on a study of the model, the current RailAlarm design can be deployed with a maintenance interval of about

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once every 5 months, implying that all sensors are replaced only after 5 months with AA Batteries of 2500 mAh, after the expiry of their lifetime.

1. INTRODUCTION

India's railway network transports 24 million passengers and 203 million tonnes of freight daily (Arha et al., 2024). The Indian Government strives hard to eliminate all the unmanned level crossings. But still, rural areas are experiencing an increase in accidents at level crossings (Selvan et al., 2021). It is not uncommon to witness a major accident every year due to a vehicle head-on collision with a train. In 2005, one major accident occurred at Nagpur (Central India) and cost the life of 55 passengers. In October 2006, 17 persons were killed. In April 2007, 11 persons were killed in Vellore District, Tamil Nadu (Southern India) by a speeding train. In August 2012, an accident at an unmanned level crossing (ULC) in the Varanasi division of North Eastern Railway killed six persons. In April 2019, 13 school children were killed at a ULC in Kushinagar, near Gorakhpur in Uttar Pradesh. A school van driver was crossing the railway track when the vehicle was hit by a train. Train accidents occur though the unmanned level crossings are equipped with passive crossing devices such as stop signs, railroad warning signs, and pavement markings. These signs still do not ensure the safety of the public. The magnitude of the loss, both of life and property and the trauma it causes to the bereaved families are very high. An automated approach to keep track of gates closing and opening is thus of utmost importance. In this study, we present the design of *RailAlarm*, a system for controlling gates with the help of actuators using WSN. Data transfer will not be possible at the remote location without wide area network coverage such as GPRS. It is not easy to set up long-distance wireless links (such as 802.16), which adds to maintenance overhead. It is too expensive to connect by satellite.

The Indian Railways have estimated that the cost of manning unmanned level-crossings is approximately USD 1 billion as capital cost, USD 175 million per annum as maintenance and operation cost, and USD 2 billion for manning with interlocked signals. A conventional wired sensor network cannot be used because providing a power supply to these sensors in remote areas is tedious. In contrast, wireless sensor networks offer a very attractive and practical alternative (Potdar et al., 2017). As wireless communications and electronics have advanced, low-cost, low-power, small-size, and multifunctional sensor nodes have been developed. Because sensor networks are reliable, accurate, flexible, cost-effective, and easy to deploy, they have great promise for transforming sensing applications in a variety of domains (Xu, 2002). We built our system based on battery-operated wireless sensor nodes to facilitate deployment. Solar panels are not only costly, but they

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Ruay-Shiung Changand Shuo-Hung Wang (2010). *Handbook of Research on Developments and Trends in Wireless Sensor Networks: From Principle to Practice (pp. 20-37).*

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