IPASJ International Journal of Computer Science (IIJCS)
Web Site: http://www.ipasj.org/IIJCS/IIJCS.htm
A Publisher for Research Motivation ....
Email:editoriijcs@ipasj.org
Volume 6, Issue 4, April 2018
ISSN 2321-5992

IoT-based Collision Avoidance System for Railways using Fog Computing

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Abstract : ***Fog computing is an emerging distributed computing platform aimed at bringing computation close to its data sources, which can reduce the latency and cost of delivering data to a remote cloud. This feature and related advantages are desirable for many Internet-of-Things applications. The Internet of Things allows objects to be detected and controlled remotely over existing network, making open doors for more straightforward incorporation of the physical world into PC based frameworks, and bringing about enhanced system, exactness and economic advantage when IoT is expanded with sensors and actuators. To prevent train accidents, it is necessary to develop an advanced mechanism. This paper proposes a system for collision avoidance in railways using the Internet of things and fog computing technologies.***

Keywords: Fog computing, cloud, Internet of Things, sensors, actuators.

1. INTRODUCTION

It is estimated there are over a billion internet users and rapidly increasing. But there are more things on the internet than there are people on the internet. This is what we generally mean when we say internet of things. There are millions and millions of devices with sensors that are linked up together using networks that generate a sea of data. With the benefit of integrated information processing capacity, industrial products will take on smart capabilities. They may also take on electronic identities that can be queried remotely, or be equipped with sensors for detecting physical changes around them. Such developments will make the merely static objects of today dynamic ones - embedding intelligence in our environment and stimulating the creation of innovative products and new business opportunities. The Internet of Things will enable forms of collaboration and communication between people and things, and between things themselves, so far unknown and unimagined.

The Internet of things (IoT) is the inter-networking of physical devices, vehicles, buildings, and other items embedded with electronics, software, sensors, actuators, and network connectivity which enable these objects to collect and exchange data.

Fog computing [7] is a computing paradigm introduced by Cisco to tackle these challenges. Fog is “cloud closer to ground”. It is a novel architecture that extends the traditional cloud computing architecture to the edge of the network. With fog, the processing of some application components (e.g., latency-sensitive ones) can take place at the edge of the network, while others (e.g., delay-tolerant and computational intensive components) can happen in the cloud. Compute, storage, and networking services are the building blocks of the cloud and the fog that extends it. However, the fog provides additional advantages, such as low-latency, by allowing processing to take place at the network edge, near the end devices, by the so-called fog nodes and the ability to enable processing at specific locations. It also offers densely-distributed points for gathering data generated by the end devices

In this paper, we suggest a fog computing based system to detect collision in railways. Here, the Internet of things concept along with fog computing is utilized to develop the collision avoidance system

2. RELATED WORKS

The paper [1] introduced the multi sensor railway track geometry surveying system. Multiple sensors such as IR sensors and MEMS sensors used to check status of railway tracks. The crack detection is performed by LED-LDR combination. The object detection is done through IR sensors. The MEMS sensors are used for vibration detection.

K. Ajith Theja et. al. [2] focused on preventing skilled workers to operate the railway crossing and established a model to open and close railway gate automatically using Wireless Sensor network (WSN) and thus avoiding accidents caused by human errors.

Any M. Kottalil et. al. [3] proposed a tested circuit to control the opening and closing of railway gate precisely using ATMEGA 16 in order to reduce the problem of longer wait time for road passengers while waiting for passage of train.

In [4], the authors proposed a model which provides the means for real time inspection and automatic gate control using IR sensors which lessens the manual interference to avoid accidents occurring due to human negligence. Our paper also proposes this as a solution and adds more safety features with the inclusion of IOT.

Sheikh Shanawaz Mostafa et. al. [5] proposed a method for avoiding collision by using radio links in order to transfer identification, information of approaching and outgoing trains faster to avoid accidents at railway crossing.

In [6], authors did a comparison of Level crossings used across the world and aimed to embed railway crossing with automated platform bridges in order to provide automatic level crossing and reducing the wait time which wastes due to opening and closing of gate irrespective of train arrival.

In [8], the authors proposed a solution encompassing GSM and GPS technologies to provide train tracking and pin pointing location of obstacles using GPS.

3. THE INTERNET OF THINGS

The Internet of Things (IoT) is a framework in which all things have a representation and a presence in the Internet. More specifically, the Internet of Things aims at offering new applications and services bridging the physical and virtual worlds, in which Machine-to-Machine (M2M) communications represents the baseline communication that enables the interactions between Things and applications in the cloud. [9]

The IoT will create a huge network of billions or trillions of “Things” communicating each other. The IoT is not subversive revolution over the existing technologies, it is comprehensive utilizations of existing technologies, and it is the creation of the new communication modes. The IoT blends the virtual world and the physical world by bringing different concepts and technical components together: pervasive networks, miniaturization of devices, mobile communication, and new ecosystem. In IoT, applications, services, middleware components, networks, and end nodes will be structurally organized and used in entire new ways.

IoT offers a means to look into complex processes and relationships. The IoT implies a symbiotic interaction between the real/physical and the digital/virtual worlds: physical entities have digital counterparts and virtual representation; things become context aware and they can sense, communicate, interact, and exchange data, information, and knowledge. New opportunities will meet business requirements, and new services will be created based on real-time physical world data.

4. FOG COMPUTING

Fog computing is known to be a system level architecture which builds on the basic capabilities of the cloud. The main element of this type of architecture is called the fog node. These nodes are connected within a network using different connection media: wired and wireless. The architecture of the nodes can be further investigated by considering two categories: hardware architecture and software architecture. While the connection media may be different, the connections rely on the IPv6 protocol because of its wide range of addresses. It should be pointed out that Ethernet is also an option for the connection.

Fog computing—which seamlessly integrates edge devices and cloud resources— helps overcome these limitations. It avoids resource contention at the edge by leveraging cloud resources and coordinating the use of geographically distributed edge devices.

Fog computing is a distributed paradigm that provides cloud-like services to the network edge. It leverages cloud and edge resources along with its own infrastructure, as Figure 1 shows. In essence, the technology deals with IoT data locally by utilizing clients or edge devices near users to carry out a substantial amount of storage, communication, control, configuration, and management. The approach benefits from edge devices' close proximity to sensors, while leveraging the on-demand scalability of cloud resources.

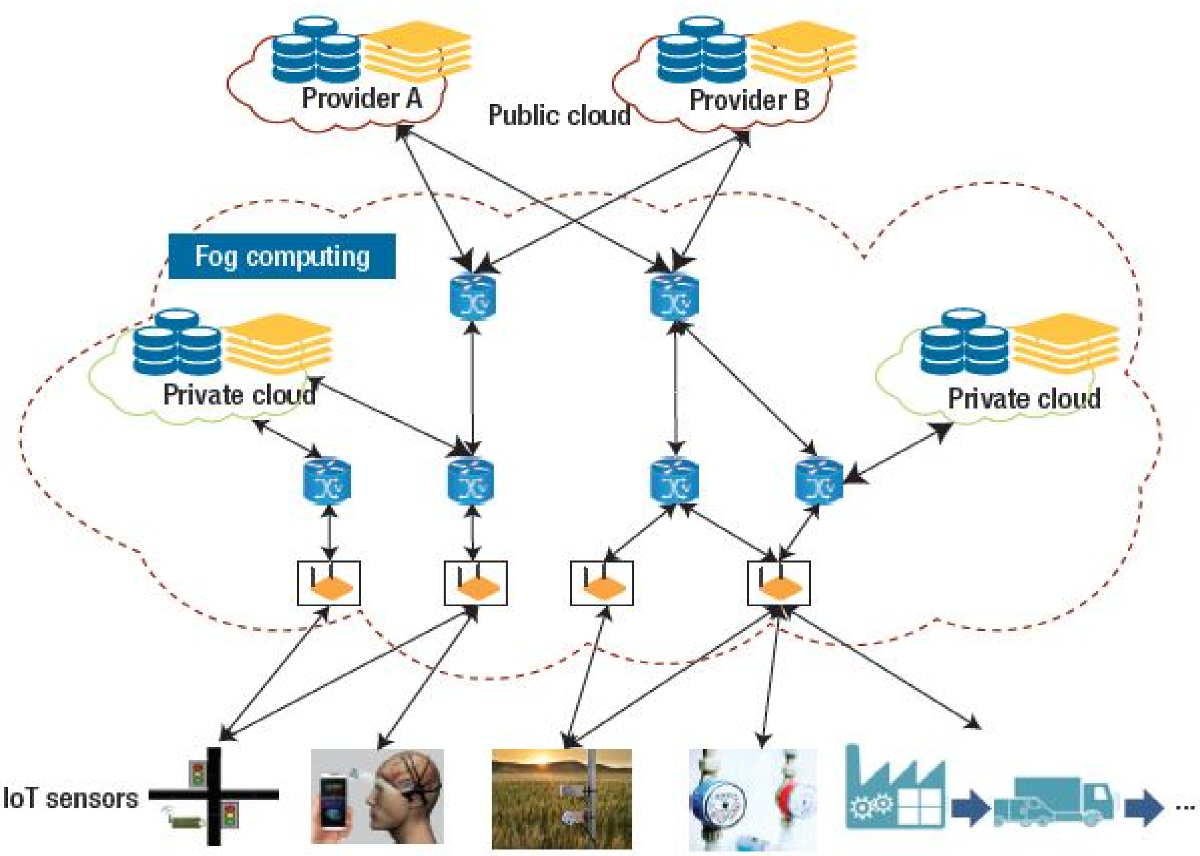

Figure 1: Distributed data processing in fog computing

Fog computing involves the components of data-processing or analytics applications running in distributed cloud and edge devices. It also facilitates the management and programming of computing, networking, and storage services between data centers and end devices. In addition, it supports user mobility, resource and interface heterogeneity, and distributed data analytics to address the requirements of widely distributed applications that need low latency.

5. METHODOLOGY

Fog computing is usually suitable for latency-sensitive applications. Traffic management is one of the major application areas of the internet of things and fog computing technologies. There is a need of introducing a system to reduce the loss of life due to train accidents. To overcome the drawback of existing system, we suggest a new system in which there is an automatic detection of accident through the Internet of Things oriented model using fog computing. The collision avoidance system is implemented using Raspberry Pi kit, Ultrasonic sensors and other devices.

Here we use a Python code to check whether the Echo input of the ultrasonic sensor is high or not. If the input is 1, it indicates that there is an obstacle and the distance is to be computed to prevent collision. The echo input remains zero as long as there is no obstacle found. The Figure 2 shows the required Python code.

```
TRIG = 23

ECHO = 24

while GPIO.input(ECHO)==0:

      pulse_start=time.time()

while GPIO.input(ECHO)==1:

      pulse_end=time.time()

      pulse_duration=pulse_end-pulse_start

      distance=pulse_duration*17150

      distance=round(distance, 2)
```

Figure 2: Python code to detect obstacle

6. IMPLEMENTATION

The IoT-based collision avoidance system to prevent train accident is implemented using Raspberry Pi kit and Ultrasonic sensors. Figure 3 depicts the interfacing of ultrasonic sensor with Raspberry Pi kit.

A system on a chip (SoC) is a single microchip or integrated circuit (IC) that contains all the components needed for a system. SoCs are typically found on cell phones and embedded devices. For the Raspberry Pi, the SoC contains both an ARM processor for application processing and a Graphics Processing g Unit (GPU) for video processing.

An ultrasonic sensor is a device that can measure the distance to an object by using sound waves. It measures distance by sending out a sound wave at a specific frequency and listening for that sound wave to bounce back. By recording the elapsed time between the sound wave being generated and the sound wave bouncing back, it is possible to calculate the distance between the sonar sensor and the object. The working of the ultrasonic sensor has been illustrated in Figure 4.

Since it is known that sound travels through air at about 343 meters per second, we can take the time for the sound wave to return and multiply it by 343 meters to find the total round-trip distance of the sound wave. Round-trip means that the sound wave traveled 2 times the distance to the object before it was detected by the sensor; it includes the 'trip' from the sonar sensor to the object and the 'trip' from the object to the Ultrasonic sensor (after the sound wave bounced off the object). To find the distance to the object, simply divide the round-trip distance in half. The formula to find the distance between the obstacle and the IoT device is given below:

$$Distance = \frac{speed\ of\ sound \times time\ taken}{2}$$

$$Distance = \frac{34300 \times time\ taken}{2}$$

$$Distance = 17150 \times time\ taken$$

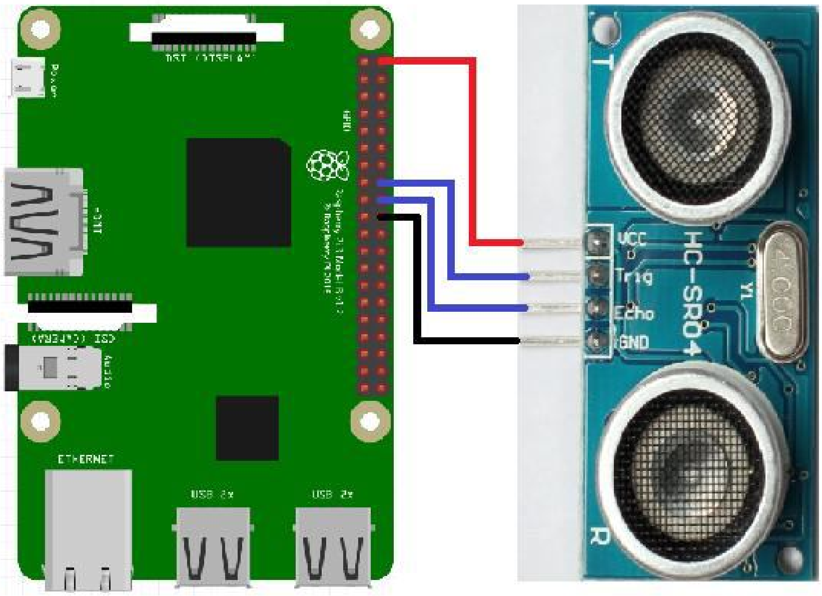

Figure 3: Interfacing of the ultrasonic sensor with Raspberry Pi kit

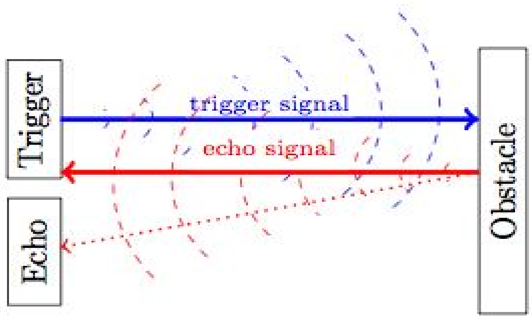

Figure 4: Functioning of the ultrasonic sensor

7. CONCLUSION

The proposed model aims to make railways a more reliable source of transport by replacing existing systems with an automatic collision avoidance system with the help of IoT and fog computing technologies. This prevents fatal accidents occurred near level crossings caused by human errors. The features include train collision detection which notifies train drivers and the nearest station about the presence of another train on track which may cause collision. This not only helps in avoiding an accident but can also help in providing faster assistance.

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