An Optimum Train Selection and Management Platform

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Abstract -Sri Lanka, as a developing country faces rapid urbanization, which leads to high mobility requirements. Due to increased traffic congestions during peak hours, people tend to select the railway system as their mode of transportation. As a considerable amount of people choose railway as their preferred platform in their daily routine, it is highly crucial to maintain an efficient and timely railway system. Unfortunately, the Sri Lankan Railway system is not known for its efficiency. As a result, considerable number of daily users of the system are affected in their daily routines. Increasing the efficiency of underlying infrastructure has been going on for decades, yet it has not been a solution for the inefficiency of the railway system itself. Hence, the only logical approach to address this issue is to introduce a common platform, which the users and Railway department can communicate, while maintaining a stand-alone system which can select optimum trains for the users. The objective of this research is to discuss the necessity of the proposed solution, ultimately providing a solution to the inefficiency of the railway system of Sri Lanka. The proposed platform will comprise of two parts; A web application for the railway department and an Android-based mobile Application for railway users. The web application will be powered by a ESP8266 and NRF-24 based hardware modules with a firebase Backend. A mobile application will gather required inputs via the hardware modules to provide users with an optimum train to travel at any given time of the day towards the required destination. System will be running using dynamic data acquired from the train stations with a dynamic train schedule. Users will have the opportunity to get notified about train delays, unavailability and breakdowns. The aim of this research is to provide a common communication platform to railway department and public, ultimately making railway platforms more efficient.

Keywords: railway transportation, Arduino, long-distance communication, public transportation, android applications

I. INTRODUCTION

Railway system was introduced to Sri Lanka in 19th century by British to bring the harvest from inland to the port located in Colombo. For few decades this was used as the main mode of transportation for both passengers and cargo. Introduction of road based public transportation led to drastic downfall of the railway transportation. Since then, Railway department has been trying to increase its revenue and to provide more efficient service towards the users.

Each year a considerable portion of employees, students and tourists use trains as their main transportation mode. Sri Lanka Railway department operates approximately 396 trains. This includes 67 Long distance trains, 16 Intercity trains. These trains carry around 3.72 million passengers daily ("Welcome to Sri Lanka Railways," n.d.) .As these figures depict, railway system plays a major role in the transportation sector of Sri Lanka. Increasing efficiency in such system will benefit major areas of the society.

Currently, Sri Lanka Railway system is overseen by Ministry of Transport. It is operated under three main operation regions namely, Colombo operation Region, Nawalapitiya operation region and Anuradhapura operation region. Colombo Region consists of 4 railway lines, Coastal line, Main line, Kelani valley line and Puttalam line. Among these railway lines, coastal line accommodates most of the passengers who are seeking to get to Colombo urban areas.

Due to numerous reasons trains experience delays. A Research by Vromans et al. has

introduced few measures to measure the punctuality/reliability of the trains (Vromans et al., 2006).

- Punctuality of trains at starting, ending and mid points
- Transfer punctuality
- Average train delays
- Average passenger delays
- Amount of cancelled trains

As these factors suggest punctuality is a complex measurement which has a considerable number of variables affecting it. Each variable has a considerate impact on the reliability of trains. A Delay at a transfer of trains will lead to a greater number of passengers getting in to the train, leading it to passenger delays at each station. These kinds of situations occur at a considerable rate in Sri Lanka.

According to research done by Pubudu Damsara and others focusing on the coastal railway line of Sri Lanka, it's noticeable that more than 92% of the trains are experiencing a delay during peak hours (Damsara, n.d.). A train delay at the starting station will result in a chain delay which will affect till the end of the train route. Since delay at one station will affect the arrival time of the next station. Due to this staggering number of delays observed during the peak hours of the country most of the workers and students who use railway as their mode of transportation disrupt their daily schedules. Hence people tend to use other modes of transportation to get to their destination during peak hours. This leads to unnecessary number of vehicles being pushed in to the urban areas during the peak hours, creating more congestions.

Time	Train Nos.	From/To	No. of delays (%)
5.00-5.30	8302	IDA/FOT	73%
5.30-6.00	8304	ALT/FOT	68%
6.00-6.30	8309	ALT/FOT	89%
	8309.1	ALT/FOT	94%
6.30-7.00	8311	GLE/MDA	90%
7.00-7.30	8310	PND/MDA	91%
7.30-8.00	8313	PND/FOT	96%
	8316	PND/MDA	93%
	8320	GLE/MDA	82%
	8321	GLE/MDA	83%
	8327	GLE/MDA	100%
8.00-8.30	8324	ALT/MDA	100%
	8326	KTS/FOT	100%
	8324.1	ALT/MDA	92%
	8328	PND/FOT	100%
8.30-9.00	8325	MRT/MDA	97%
	8331	MRT/MDA	95%
	8333	KTS/FOT	100%
	8334	KTS/FOT	100%
	8334.1	KTS/FOT	100%
9.00-9.30	8330	RML/MDA	98%
	8335	PND/MDA	94%
9.30-10.00	8341	MRT/MDA	98%

Figure 1: Train delays during peak hours

People who depend on the railway system is overwhelmed as most of the trains are not being arrived at stations according to schedules. This leads to peoples' daily routines being disruptive completely. Workers might be late to work, students will be late to school and numerous people might lose their appointments and schedules.

Ensuring having an efficient railway system will benefit the society in numerous ways. Starting from traffic congestions during peak hours to employees' productivity. By making sure railway system is efficient, people will be attracted to using public railways rather than their own personal vehicles. Reducing traffic congestions will benefit every sector of the society.

II. LITERATURE REVIEW

Researchers have developed various techniques and products which can be used to monitor and track the trains. These systems are developed in a way which they communicate with a central server, providing data towards the government body. It's noticeable that systems are not developed in a user centered manner. Most of the existing systems are developed to ensure the data collected are centralized and authorities can make the necessary decisions after analyzing data collected through the systems. As a result, users of the railway system are not benefited directly, rather in an indirect manner. Systems have been deployed using a variety of technologies including Global System for Mobile Communications (GSM), Global Positioning System (GPS) and Ethernet.

This section of the study focuses on identifying existing systems and their perspectives on the problem. It can be later analyzed through the efficiency, productivity and the technologies they have used to deploy their systems. By identifying these existing systems' literature, we can dive into more insights and approaches which can be inherited or removed by comparing their performances.

A. Existing Systems

Stated below are some of the of the systems which were researched and developed by researchers. Each system has its own pros and

cons depending on the hardware, platform and other technologies used to deploy the system.

Train tracking and monitoring system was developed by Poornima Mashesh and others. Trains are equipped with a GPS module ensuring a high accuracy and transfers GPS data towards a central system using a GSM module (Mahesh et al., n.d.). Realtime data availability makes sure that the train controller can take accurate decisions. Using positioning data with train speed, controllers can identify possible safety issues which might occur and react to them before any issue occurs within the railway and trains. Multisensory system was used to inform the monitoring system about any existence of obstacles. Obstacle monitoring system was built using infrared and ultrasonic sensors. Proposed system is aimed at building a management structure based on performance evaluation using the monitoring data. System is able to generate time-distance graphs which can be used to plan train movements. It functions as a monitoring and warning system as well. Warning system is equipped to send alerts to train drivers on possible collisions and derailments.

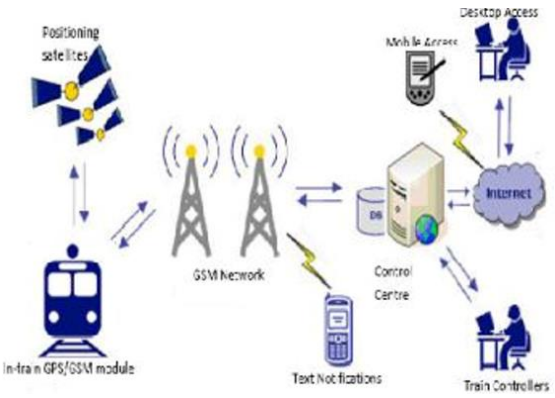

Figure 2: High Level Architecture

GPS and Ethernet based Realtime train tracking system was developed by R.Immanuel Rajkumar and others. (Rajkumar et al., 2013) System was focused on ensuring the safety of the train while alerting the driver about any shortcomings in the system. The system reports to a central controller which provides the ability to the controller to provide necessary instructions to the train driver. System communication was made available using 3 modes namely, periodic, query based and event driven. First mode periodically reads the sensor data and location data and reports it to central command. Query driven mode is used to receive data matching a certain criteria and event driven mode is triggered when a pre-defined event is triggered by the sensors. System is comprised of 5 main components, Arduino Microcontroller, Ethernet shield, GPS Shield, Router and USB dongle and Sensors (Alcohol sensor, Force sensing resistor - FSR) . System was able to provide real-time data to a Web Interface which was deployed at the central command displaying Train position, train speed and driver health status.

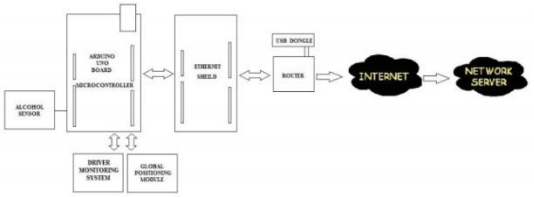

Figure 3: System Block Diagram

A Realtime train track tracking system is introduced by Shreya Mathur and others.(Mathur, n.d.) In their research they have focused on providing a solution for the existing problem of railway track maintenance. Openlayer-2 is used to implement the dynamic map of the rail tracks and to show outline and vector information from any required source. Researchers has developed a simple algorithm to find inspected tracks and uninspected tracks. In the proposed system, user will enter values towards 2km from his current location. That data is compared to values stored in a central railway database and it will notify in green if the track is inspected, otherwise in red, requiring inspection of the track. As the researchers point out, the cost of automating track identification is cost effective than the manual method of inspecting each track. Proposed system provides detailed information about tracks and it can be used for future references in upcoming developments and inspections.

Figure 4: Representation of track slots

III. METHODOLOGY

A. Data Gathering

To gather required data, interviews, questionnaires, yearly statistics and documentary reviews were used. The main purpose was to identify the correct objective and the critical drawbacks of the existing system. Finally to deliver a useful product with the sole purpose of making railway system more effective and efficient.

B. Data Analysis

Collected data was analyzed to identify the critical problems and requirements. For analyzing purposes, the collected data was represented through visual means such as charts. And through this it was concluded the exact requirements and critical issues which the system needs to address. This helped authors to provide required features towards the system.

C. Approach

Main users of this system are categorized into two parts, namely train users and administrators. Inputs to the system will be administered using the Hardware modules deployed in trains, stations and notification handling will be done by System administrators; Railway department. In order to increase the reach of the user-base android platform was selected.

D. Technology Adapted

Web application will be implemented using HTML, CSS, JavaScript, Firebase and Google Cloud Platform. These technologies and platforms were selected after analyzing the requirements of the system. Technologies were selected in a criteria which provides the best performance while being cost effective.

Proposed system will be consist of three parts, hardware modules, a mobile application and a web application. Development will be done locally and hosted in Google cloud platform. REST-APIs will be hosted on Heroku, a Pipeline service provider. Since communication between system modules were critical Google Push notification system was introduced to provide minimum latency to the system. High Priority messaging was used within google push notification system to ensure all notifications to be delivered to users almost instantly ("About FCM messages," n.d.).

E. Proposed Design

The proposed system comprises of hardware and software modules. The hardware of the proposed system comprises of the following components.

- ESP12-F WiFi module
- nRF24L01+ Transceiver module
- Arduino Nano

Hardware modules of the system are connected as follows. Two modules, one module equipped in the train to communicate towards the module in the station and one module equipped in train stations to receive data from the train and sync with the cloud database. The system block diagram is as follows. Web Application and the mobile application will be responding according to data received from the hardware modules deployed in the train stations. Collected data via the hardware modules in stations will be synced throughout the System via Google Cloud platform.

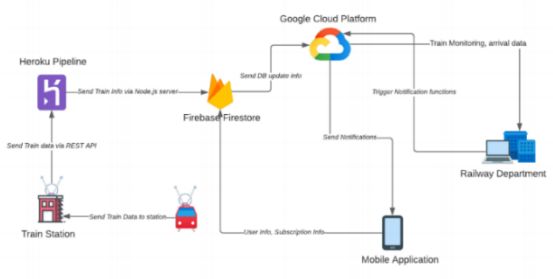

Figure 5: Proposed System Block Diagram

IV. IMPLEMENTATION

Web Application plays the role of notifying train unavailability, breakdowns, updating and modifying train schedules and sending alerts to mobile application. Web application can be used to generate performance graphs regarding the trains' individual performance. Mobile Application is presented to users which they can use to find the optimum and most efficient train to travel to their destination. Upon selecting the destination station, user will be provided with an optimum train to travel from his/her location. Following parameters are considered when calculating and selecting the optimum train,

- User Location

- Current Time
- Mode of transportation towards train station
- Destination Station
- Train Delays, unavailability
- Train arrival time to destination

Parameters are run through a tailor-made algorithm to detect the optimum train for the user to travel, even with any delays or unavailability of existing trains. When a train arrives at a certain station, modules at station and on the train will communicate with each other. The data received from the train module will be synced to the cloud database via the module installed at the train station. It will dynamically update the train schedules rather than prevailing static schedules. Basic information regarding hardware modules are as follows.

A. ESP 12-F WiFi module

ESP 12-F is developed by AI-Thinker team with a core processor ESP8266, with clock speeds of 80MHz, 160MHz and supports Real-time operating system (RTOS). This model supports standard IEEE802.11 b/g/n, complete TCP/IP protocol stack with 2.4GHz -2.5GHz frequency range ("esp8266-module-family [ESP8266 Support WIKI]," n.d.). ESP 12-F provides the ability to embed the WiFi-Capabilities in the proposed system, which will be used to sync data with the cloud. ESP-12F supports SPI/SDIO or I2C/UART interface for the communication with computer for data exchange or configuration tasks. ESP-12F can act as a standalone system at the lowest cost and minimal space requirement which makes it the best candidate for this system.

B. .nRF24L01+ Transceiver module

nRF24L01+ module is operating in 2.4GHz frequency using GFSK modulation for data transmission. Even though Operating voltage stands at 1.9-3.6V, logic pins are 5V tolerant making the transceiver compatible with ESP-12F. nRF24L01+ uses Enhanced ShockBurst packet structure ("In-Depth," 2018). Which ensures the acknowledgements to be received with each packet on arrival. Due to availability of Automatic Packet Handling, it ensures re-transmittance of packets which does not arrive within Auto Retransmit Delay (ARD) ensuring packet loss at a minimum. Range of nRF24L01 can be increased using PA LNA Wireless transceiver module with External Antenna, which will be deployed with this project to ensure the highest transmission range with minimum packet loss. Range variates from 500m – 1000m depending on structural architecture of the buildings, which falls within perfect range of this project.

C. Arduino Nano

Arduino nano is powered with ATmega 328 with 32KB memory. It's equipped with 14 digital pins which operate at 5V and specialized function pins which acts as Serial I/O (RX-TX), External interrupts, PWM and SPI. Arduino nano supports UART TTL serial communication ("Arduino - ArduinoBoardNano," n.d.). RX – TX ports in the Arduino nano will be used to ensure communication of nRF24L01+ module which will be equipped in the trains. Arduino nano runs with 5V external power supply to pin 27 or via Mini-B USB Connection, which in this project will be using a regulated external power supply.

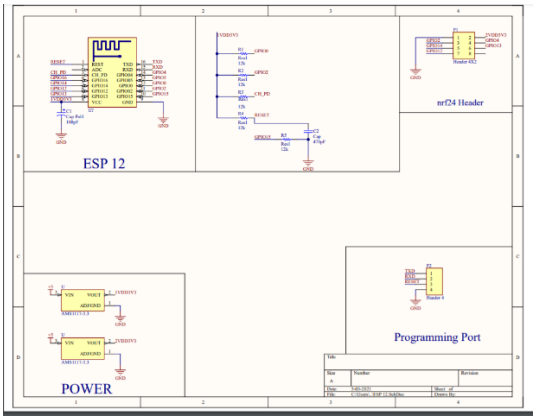

Figure 6: System Circuit Design

Data received through the Hardware modules will be synced with the Firebase Firestore database via a Heroku pipeline which is used to deploy representational state transfer (REST API) to collect incoming data from the ESP-12F. Upon arrival of a train to a train station, train id, train station and time is passed via the hardware module towards the Firestore database. This process takes up to ±10ms with an average WiFi connection. Upon updating of Firestore database, Web Application administrators can view data and trigger notifications towards mobile application if deemed necessary. Furthermore, if

train schedules need adjustments or train unavailability are notified to the Railway department, web administrator can broadcast notifications towards users. Users can find the optimum train to travel by selecting their destination station and the mode of transportation towards the railway station. Algorithm will calculate the optimum train to travel, alongside the optimum nearest railway station.

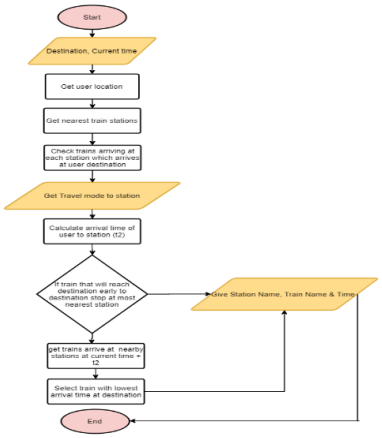

Figure 7: Train Selection criteria

Train delays and unavailability are automatically taken into consideration when the algorithm is processing user inputs, hence user will have a better understanding of the estimated arrival at his/her destination. If the arrival time is not up to users' satisfaction they can select another mode of transportation, rather disrupting their daily schedules due to train delays. Users can view the dynamically updating train schedules and train unavailability beforehand and plan their activities accordingly. Tourists can easily find their trains, and visit their destinations without any hassle.

V. DISCUSSION

Train delays and unavailability in developing countries such as Sri Lanka is a common sight. Even though a majority of the society is impacted by this issue a viable solution to reduce delays or completely eradicate them has not been provided. The remaining logical solution is giving power to the people who use the Railway system to adjust their activities accordingly. Therefore, a common communication platform, equipped with features to find the optimum train to travel towards user destination; will in fact make an impact on people who are using the public railway system. People will not have to deal with uncertainty of train delays or unavailability and start planning without visiting a railway station.

Arduino based hardware modules provide the cheapest and most reliable solution of synchronizing train data with the server while the whole system being at low cost and low maintenance rather than a typical GPS system, which monthly costs would occur and require maintenance. nRF24L01+ will ensure the communication between trains and the station without any delays or disturbance due to enhancement with PA LNA Wireless transceiver module to extend the range and bandwidth. Data update process merely take 10ms which ensures that the end-users get the updated data almost instantly. Dynamic train schedules will help the public to check on train delays and plan their activities accordingly.

This platform will be ensuring communication between railway department and public instantaneous while the public can get their optimized train selected with the mobile application itself.

VI. CONCLUSION AND FUTURE WORK

Main purpose of this research is to propose a solution to battle the train delays which people experience on a daily basis. Even though this has been going on for years, no official body has taken action to remedy the situation, leading the public to experience delays wasting their valuable time.

This article suggests a Introduction of a platform which they can communicate, as well as find their optimum train to a selected destination will give public a great relief and encouragement to use public railway transportation system.

This system has further development avenues depending on the public engagement on the system itself. Experiencing a high number of users in the system would make the system to be moved in to a cloud platform with scalable resources, such as Amazon Web Services, providing users with less latency. Increasing of accuracy of the system can be done by adding GPS based tracking to each train which will be subjected to more implementation cost and monthly maintenance cost as well. Drawbacks of the current system include the inability to track

the trains in Realtime, rather by station-to-station basis.

From the research gathered during this project, we can conclude that implementing this system will benefit each avenue of the society indirectly while reducing the time wastage of people using public railway system.

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