SLR Navigator

K.G.Nishadi Lakshika, S.D.H.S.Wikramarathna
G.T.I. Karunarathna, Dr.J.C. Balasuriya, Prof. A.S.Karunananda

Faculty of Information Technology, University of Moratuwa, Sri Lanka
Email: harshisd@gmail.com, nlakshika@gmail.com

Abstract: **SLR Navigator which is an acronym for Sri Lankan Railway Navigator is a multi agent system which has been designed to handle the train delays and avoid unpredictable train crashes in a dynamic situation as a human thinkable train scheduling system. The system has been implemented to overcome the current issues in the manual train scheduling system. SLR Navigator consists of two modules; In Motion Train Tracking System (module 1) and Intelligent Train Control System (module 2).**

The system has been implemented as a Multi Agent System so that it can have all the strengths provided by MAS technologies. Each and every agent can have an idea about the overall situation by reading the message space continuously. They can then contribute to the decision making process when necessary. A two way communication will be established among trains and signal towers as trains may also need to pass messages to the control agent in a panic situation. The ultimate output of the system will be a proper train scheduling process which can smoothly handle train delays and avoid train crashes.

1.0 INTRODUCTION

Sri Lankan Railway is providing travelling services to their customers and it is one of the major infrastructures which directly affects the development process of Sri Lanka. A major part of the work force of the country is using the Railway for their traveling purposes and it highlights the need of efficient and effective service from the railway [12]. Therefore, to improve the service, they need to have a good decision making system and also they should maintain a proper communication with the trains which are on the move. In the existing system of the railway department, these functions are done manually. They maintain traveling information in large excel sheets and take decisions according to those information [12]. The decision making process is highly centralized and as a result it is very difficult to react accurately in an emergency. There is no method to have a direct communication with the train in between stations. Therefore, the maintenance of this system is so difficult and can depend on incorrect information.

The project SLR Navigator gives solutions to these problems by replacing both traditional communicating system and the decision making system of the Railway with newly created two modules of In Motion Train Tracking System and Intelligent Train Controlling System. The target of the module one is to track the current location and the speed of ongoing trains and to establish a proper communication with them. Module two will take needed information from module one and will take necessary decisions about delayed and unscheduled trains. Those decisions will be passed to the train through the established communicating method.

The module 1 uses Radio Frequency Identification (RFID) technology to detect trains and their speeds at signal towers [3]. Then it will use Global System for Mobile (GSM) technology [4] to send this information to module 2 which use them as the inputs. And also Module 1 communicates with trains and passes messages to the trains regarding their speeds. An LCD display will be fixed to the trains where these messages can be displayed to the drivers. The module 2 maintains the message space which all the agents in the system read and write. The controller agent, which is the heart of the Multi Agent System (MAS) [7] analyzes the train behaviors and takes necessary decisions to manage the critical situations with the aid of Fuzzy Logic [8].

2.0 LITERATURE REVIEW

Doing a literature survey to identify the similar approaches to the problem area was one of the first steps taken in this project. When doing a survey, several approaches using RFID and GSM technology to track the vehicles were found. And also there were several applications which have been developed using Multi Agent Systems and Fuzzy Logic.

2.1 Vehicle Tracking Applications

The focus was directed to some main applications regarding the vehicle tracking. The first one is Falcon EVR (Electronic Vehicle Registration) system. It enables vehicle remote monitoring and centralized fleet management using the radio frequency technology to electronically identify vehicles and validate the identity, status, and authenticity of vehicle data [3].

Next studies have been done on a vehicle tracking method proposed by Savoie and Boulay[11]. This system utilizes the cellular network to locate vehicles by paging a cellular transceiver, which is installed on the vehicle, to identify which cell sites are near the vehicle [11].

There are some projects which used Global Positioning Systems (GPS) technology to track the vehicles. The solution proposed by Annett and Swarbeick is one such project using GPS to track vehicles [11]. GPS has valuable features, such as the ability to track a vehicle's location continuously, even off-route, and the ability to use that information to determine its speed and direction. However, GPS systems are both expensive and hard to set up for vehicles on a set route.

In Turkey, the municipality of Pendik deployed the vehicle tracking system using RFID to control access to an employee-only lot within a large parking area, and to restrict unauthorized vehicles from entering [10]. There are similar types of projects developed to track vehicles using RFID technology [2**]**. One of them is a vehicle tracking system implemented in Venis to recognize the vehicle by using its RFID tag [15].

2.2 MAS Applications related to Train Controlling Systems

In this literature review, it has been studied about several MAS approaches for train controlling. A logic programming based environment for MAS prototyping has been adopted for the management of freight train traffic along the railway line between two Italian stations [1]. The research has successfully demonstrated the advantages of the MAS approach to this field of application.

Railway Intelligent Transportation System (RITS) [5] is also another good example for the related works. It is an intelligent transportation system which aims at the guarantee of safety, the increase of transportation efficiency, the improvement of management, the enhancement of the service quality through optimized deploitation of the RT-related mobile, fixed, spatial, temporal and human resources on basis of information collecting, transferring, processing and sharing.

Another MAS Approach to Train Delay Handling has been developed currently for the Swedish railway for calculating Estimated Time of Arrival – ETA [6]. The system mainly consists of two parts. A railway network simulator based on traditional simulation techniques and a multi-agent based simulator of the decision making actors.

The fuzzy logic control unit built by Hitachi Ltd of Tokyo in 1988 runs subway operations in Sendai, Japan [16]. This automatic train operations system regulates train speed more precisely than the best human motorman and serves as a showcase for fuzzy-logic gear. Fuzzy control computers accelerate and brake trains more smoothly than a human driver. In addition, they can help rearrange departure schedules to compensate delays.

According to the review there are a lot of applications which use these technologies. But it is hard to find any application which gathers the strengths of all these technologies. So the main objective of SLR Navigator is to integrate all these technologies for one better solution.

3.0 SLR NAVIGATOR

3.1 In motion Train Tracking System

In Motion Train Tracking System is the first module of this project. In order to take decisions regarding delayed and unscheduled trains it is essential to identify the trains uniquely. To do that RFID technology is used [2, 13]. There is a RFID reader in each and every signal tower and it is responsible for reading the radio frequency and transfering the information to a processing device, and to a RFID tag. There is a RFID tag inside each train. RFID reader located in every signal tower sends out a signal, which activates RFID tags in the train when it reaches that tower. The transponders then reply with an encoded message, which include the train ID and the speed of the train at that location. This message is received by the transceiver and it will decode it. Then it will be read by the signal tower agent located in that tower and the agent will connect to the message space located in the control room to write those information in it.

Connection between the signal tower agent and the control agent will be established through a GSM modem. GMS modems are located in every signal tower and signal tower agent can also be connected to the control agent though that modem. Because GSM technology[14] is basically made to send and receive data streams between two units like PC's or embedded devices it is the most suitable method to transfer data through the modem. By using this connection, the signal tower agent can write into the message space about the train which just passed that signal tower and also the speed of that train. It has the ability not only to write information into the message space but also to read the message space to learn about the train schedule and delayed trains, signal tower agent use that connection established through the GSM modem.

Decision sent to the train agent from signal tower should be displayed in the train because that should be easily seen by the train pilot. Therefore, embedded system was implemented and through the microcontroller that message will be displayed in the LCD display.

3.2 Intelligent Train Controlling System

The main objective of this module is to implement an Intelligent Train Control System with the aid of MAS technology to advise the trains in a situation where some of them are unable to reach the pre-defined time schedule or in a situation where there are delayed or broken trains on the route.

This module is based on multi agent systems technology. The control center maintains a message space which will be the heart of the system. At the beginning this message space displays the scheduled time table. Any train or signal tower agent can read this schedule and check whether there is any contradiction with the actual behavior. If so, they can alert the other agents by writing it in to message space. The signal tower agents are supposed to update the message space each time when a train passes across the tower. The train ID, speed, location and time will be include in this message. It can also add some more information like whether the train passes at the scheduled time or whether it is delayed. By reading the message space, the signal tower agent gets to know the time a particular train should pass the tower. Therefore, if the train did not pass the tower in the expected time the agent is supposed to alert the others about it. Another signal tower agent may read this message and update the message space saying that the particular train has reached him at this time. In this way a proper communication can be handled among agents and the most important thing is that the control agent can get the overall idea about the train behaviors by reading the message space.

The control agent can then take decisions about trains. For example, if a particular train is getting delayed due to some technical problem, the control agent can decide to reduce the speed of the train coming behind. The amount of speed which should be reduced depends on the speed of the front train and the distance between two trains. Fuzzy logic has been adopted to calculate the speed of the train coming behind. The inputs for the fuzzy system are the speed of the front train and the distance between the two trains. A set of fuzzy rules should be specified according to the user experience. Some experienced train drivers should be interviewed to define these rules. The output will be the speed of the second train. The decisions which are taken in this way are written in to message space. The control agent should follow a set of pre defined rules in the decision making process. These rules will specify how a train crossing should occur, how the train priority should be addressed, how early a train should be informed to stop, how breaking should be done according to the speed etc. And also it should refer to the ontology which should contain information like train time schedule, the priority list of trains etc. Since all agents are communicating through a common message space, all agents have a clear idea about the overall behavior of the system.

4.0 DESIGN OF SLR NAVIGATOR

In order to visualize the whole system at once, high level architecture of SLR Navigator was drawn.

The architecture diagram shown in Figure 1 consists of four major components named Signal Tower Agent, Train Agent, GSM modem and Control Agent. Inside the train agent there is a RFID tag which is used to identify a particular train and to track its speed. RFID reader was located in the GSM modem and when a train arrives at the signal tower, it reads the RFID tag after establishing a connection. Message space for this Multi Agent System is located in the control room where the control agent is resides. Functions of those identified components can be described as follows.

Signal Agent:

- Rread the message space
- Write message space when a train arrived. [contain the train ID, arrival time, whether it is delayed or not]
- Inform about trains which passed that tower in special situations.

Control Agent:

- Write the scheduled time table
- Read the message space continuously
- Identify delayed trains
- Take corrective decisions according to rules
- Display the decisions in message space

Train Agent:

- Read message space
- Execute decisions related to the agent
- Write in message space [reason for late, condition of the train, condition of the path, request for quick advise]

There are few constrains which have been identified in this design. The trains and signal towers communicate with the control agent through GSM modems. The GSM modems are placed in signal towers. The trains themselves do not contain GSM modems due to cost constrains. Therefore, the trains have to wait until they reach a signal tower to establish a connection. This will not be a serious issue to the system as signal towers themselves can inform the control agent about train delays. And also it can decrease the distance among two signal towers to avoid the train being disconnected for a long time.

The area which a GSM modem can cover, its signal strength, its ability to establish connections with moving trains and the noise disturbances are some other constrains related to the communication process which have to be considered. RFID tags are used to identify trains and their current speed. The distance it can cover is limited. The speed recognition RFID tags are more expensive. Therefore having one RFID tag per train and one RFID reader per signal tower will be less cost effective in practical implementation.

5.0 IMPLEMENTATION

The first step of implementation is to build the fuzzy inference system to calculate the train speeds. This fuzzy system is implemented to control the movement of two trains in one route. The system has been implemented using Math Lab software. If the train which is in front is getting slow or stoped and the distance between two trains is less, then the train behind should slow down or stop. To connect the fuzzy system to the SLR Navigator, JIntega tool has been used. Therefore, each time the control agent needs to take a decision, it connects to the fuzzy system and enters input values and gets the result. Then the control agent distributes these results to the signal tower agents.

The Multi agent system of SLR Navigator contains three types of agents. First one is the Control Agent. Only one agent of this type resides in the system. The next type is Signal Tower Agents. These agents are created and located at every signal tower. They have been named as 1, 2, and 3 according to the tower location. The other type of agent is the Train Agent. These agents are created and located in each train.

The control Agent is the heart of the SLR Navigator. It takes all the train information from signal towers and makes decisions about train movements. The agent periodically searches for available signal tower agents and asks all those signal tower agents to send information about the trains passed by. After getting the train location and speed information it connects to the fuzzy system and takes the appropriate decision. And then the decision will be sent to the signal tower which the particular train passes next. Then the message will be passed to the train when it is passing the signal tower. The train agent also can pass messages to the control agent in certain situations.

Signal tower agents are responsible for getting the train ID and speeding through the RFID when train reaches that tower and writing those into the message space. So establishing and maintaining the connection between control agent and the other agents through the GSM modem is also a responsibility of the signal tower agent. Not only that Signal tower agents will also read the message space continuously and learn about the train schedule and about the delayed trains and if it has some information about that delayed train that will be written in to the message space for control agents' consideration.

When train agent receives the message from the Signal Tower agent, that message will be displayed in the LCD display unit placed in front of the train pilot. So that train pilot can easily see the desired speed for that train so that he can drive in that speed. Implementation of that display unit was done by using microcontroller. 16f877a PIC was programmed and 16*2 LCD display was connected to display that message.

6.0 DISCUSSION

The project SLR navigator has been designed to handle the train delays and avoid unpredictable train crashes in a dynamic situation as a human thinkable train scheduling system. As railway is one of the major transportation services in Sri Lanka, increasing its efficiency and reliability will affect almost all Sri Lankans. SLR Navigator has the ability to identify the trains uniquely and advise them to behave in unexpected situations. RFID is used to identify the trains and to track its speed. That information will be written in to a message space of the Multi agent system. Connection between the control agent and the other agents is established through a GSM modem. Control agent will take some corrective decisions according to the rules using fuzzy inference system and those decisions will be written in to the message space too. Agents can execute decisions which are related to them and hence train crashes and other disasters will be avoided.

The major challenge of addressing this problem was that it is dealing with a real time system. The trains are used to carry a huge number of passengers. Therefore, if the generated speed results are inaccurate, then it will be a mess. The project's approach to address the train scheduling problem differs from the other approaches because it uses the strength of multiple technologies like MAS [7], fuzzy logic[8], RFID[9, 13] and GSM[14]. Hardly any system has used all these technologies to implement systems.

The project SLR Navigator was tested in laboratory using prototypes. It works accurately and all the expected performances were there. The
project will also be tested in VBS2 simulator which is a very rich simulation environment close to the real world. The system should be deployed in an existing railway system but a number of testing processes need to be carried out before the deployment of the project. A proper risk analysis also should be carried out before real time using.

There are some further enhancements which can be done to the SLR Navigator. The first one is to track the trains continuously. Currently the train is tracked when it reaches a signal tower only. The position of the train in between the signal towers is predicted by calculations. If the train can be continuously tracked by using some technology like GPS, then the system will be more accurate.

In this project train agents do not replace the human pilot of the train but it just displays the decisions to the pilot to manage train speed. But the system can be enhanced to give the whole responsibility to the train agent and automate the overall functionality of the Rail Way.

7.0 ACKNOWLEDGEMET

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