MINIMIZING PASSENGER CONGESTION IN TRAIN STATIONS THROUGH RADIO FREQUENCY IDENTIFICATION (RFID) COUPLED WITH DATABASE MONITORING SYSTEM

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ABSTRACT

This study is about the implementation of an automated transportation system through Radio Frequency Identification and Database Management which can be used for the Philippine's Manila Rail Transit (MRT) system. The group would focus on two major tasks and that is for the interface of the RFID reader to the PC and creating simulation that has a database that would store, sort and retrieve data according to the needs of the system. The input module for the simulation system is done in two methods first is coming from the user input and the other one is with the use of RFID tags to be read and checked by the reader before sending it to the database system for recording and classification of data. The system has also been made in accordance to the current situation of the MRT. With the use different formulas and equations created by the group, would then determine the train's scheduling depending on the number of RFID tags per station. This would also determine the number of passengers that would enter the train station, and could possibly reduce people congestion inside the train. This paper has been able to produce an algorithm to aid in the queuing of the MRT System to ease congestion.

Keywords: train optimization algorithm, database management, RFID, transportation management.

1. INTRODUCTION

Rapid transits are considered to be one of the most efficient and fastest modes of transportation today [1]. It is a high capacity public transport that provides safe, fast and reliable transport services for the people. Unlike cars, buses and other means of transportation, rapid transits operate on grade separated tunnels in order to operate at a faster pace [2]. The world's first rapid transit system opened in 1863, the Metropolitan Railway (also known as MET) located in London, England. Since then, its development has vastly improved and has been adopted in different areas of the world [3].

The Manila Metro Rail Transit System Line 3 of the Philippines, popularly known as MRT, much like MET is a rapid transit system that operates in Metro Manila. Opened in 1999, MRT is the country's third rapid transit line; MRT 3 is operated by the Metro Rail Transit Corporation (MRTC), a private company in partnership with the Department of Transportation and Communications (DOTC) under a Build-Operate-Transfer (BOT) agreement. MRT 3 is composed of 13 stations along over 16.9 Kilometers of line, from North avenue station (Quezon City) and ends at Taft avenue station (Pasay City) [4].

MRT is the main of solution of DOTC on trying to resolve and lessen the chronic traffic congestion among Epifanio de los Santos Avenue (EDSA). It was designed to carry around 23,000 passengers per hour, per direction, and is expandable to accommodate 48,000 passengers per hour, per direction. It operates around 17.5 hours a day that runs from 5:30 AM up to 11 PM. However, due to the continuing increase of commuters around Metro Manila, the trains are forced to accommodate more people than their usual limit causing more wear and tear to the trains and its track [5]. They are forced to do manual scheduling for the flow of trains, these type of scheduling however is not as efficient as automated scheduling system because they could not respond to immediate changes in number of people, these manual scheduling of trains results in longer queues for the people. With the development of computers and technologies, it would be more efficient to implement an automated train scheduling algorithm in order to calculate and monitor the best possible way for train operations [6].

1.1 Statement of the Problem

The Metro Rail Transit (MRT) is a common means of transportation for the public, going to school, going to work, or going to their respective businesses. Because of the increasing population, there is a corresponding increase in the demand of the usage of the MRT. Some of the accidents and machine breakdowns brings inefficiency to the system. The Metro Rail Transit, no longer serves its purpose as effective as before. According to philstar.com, the current system of the queues for the MRT only limits 500 persons to queue for the actual ride. This has left the masses a challenge to ride in order to go to their respective businesses and also bringing congestion to the MRT stations.

1.2 General objective

- To develop a train control system through database management that will provide an effective monitoring entry of passengers per station and scheduling process.

1.3 Specific objectives

- To use RFID only for counting the number of passengers that will enter the train stations.
- To determine the optimal location of RFID readers.
- To construct a simulated system that mimics the current trains system in Manila using 6 stations.
- To create a database program that will monitor the passenger count for each station.
- To compute for the optional number of passengers allowed in each station.
- To simulate the environment and process monitoring system that will imitate train queuing using database system.
- To use actual data from one of the train stations in Manila for the simulation.
- To achieve 90% reliability in system rate response for the RFID Reader.
- To limit the number of allowable passengers per train to its recommended capacity (387 per train).
- To assume that the MRT simulated system will not experience any breakdowns or failures.

1.4 Scope and delimitation

The scope of the study is for the MRT crowd control implemented by the Metro Rail Transit Corporation (MRTC). The study will include the people who use the MRT every day in going to their respective businesses. It will also include the people that use it for their convenience in travelling to their respective destinations. It is focused in monitoring the number of people entering through the premises and the leftover quantity that each stations holds. The group will also be determining the time that the train needs to be at the station due to the fact that the number of people is continuously increasing.

The group will only be presenting the thesis prototype as a PC simulation of the MRT system and the hardware product is with the integration of the RFID reader during the time when a passenger enters the premises. This is done due to the fact that the group will not be allowed to take repetitive testing on the MRT station because it is frequently used by the public. This study will only include the 6 stations of the MRT, starting from EDSA (Taft Avenue) station until Boni station to the purpose of reliable of the data analysis since the simulation is flexible enough to handle a feasible amount of computing. And it is assume that the first 6 stations are the most congested stations since these are located in one of the busiest area in the National Capital Region.

Also, this study does not cover Light Rail Transit (LRT) lines 1, 2 and Philippine National Railways (PNR) for the reason that the group will be unable to conduct its methodology and testing of the train lines. The group assumed that there will be no skip trains therefore it will accommodate all 6 stations of the MRT. And that the train flow of the simulation will only be a one-way route. Lastly, the researchers will not be designing the RFID readers since it is commercially available in the market.

1.5 Description of the project

The group aims to minimize the congestion problem on the train stations by developing a comparable division of passengers per train and a scheduling system by using recommended train intervals. The project is basically made up of two parts, the hardware section and the software section.

The hardware part focuses on the sensor (RFID reader) that would read and receive the input (RFID Cards) per station and transmits the signal into the database. The software part, on the other hand focuses on the database and the scheduling through the use of Visual Studio and MySQL database. In the study, the software would determine when to send the train to the next station depending on the number of people are there in each station. The software would then compare the number of people per station in determining the priority for a train scheduling; a maximum amount of people per station would also be enforced in order to prevent overloading of the train on a specific train station. The system would be programmed to prioritize certain stations that would exceed their allowable queue limit per hour in order to avoid longer queues for stations that have more anticipated passengers compared to other stations.

The software part, would also implement the train scheduling for each train, each train would be allocated a fix number of time per station in order to have a continuous flow and avoid unnecessary stops per station. The simulation system would ask for the number of passengers per station and process it to show the train flow recommended through different kinds of intervals. The system would also be designed to adopt to uncontrolled changes in the transit line such as accidents or train malfunction, under these circumstances, the system would then adjust in order to accommodate the problem, and decide on a new schedule for the transit system to continue its operation despite of the circumstances.

2. THEORETICAL CONSIDERATION

2.1 RFID Standards

RFID or Radio Frequency Identification, the primary technology that will be applied in this study describes a system that is able to communicate and transmit data containing information about people and/or objects wirelessly through the usage of radio waves [7].

The reader is also responsible for detecting the tags through matching activation signals. As for its dual purpose, the writer component of such device is used to imprint data to the tag. Upon regarding and consequently encoding the data previously written in the tag's integrated circuit, the data is passed to a host computer where it will be processed and possibly stored in a database [8].

For this study, the group made use of Passive RFID Tags primarily for their efficiency and affordability. Passive RFID tags are generally encoded with data that is read-only, and thus cannot be modified by the user in the event that a change in a certain field is to be made [9]. On the other hand, an active RFID tag has internal batteries that act as the only source of power for the device. These types of RFID tag also contain data that can be modified, in contrast to the other type of RFID tag. Its complex structure also enables transmission of data cover a long distance possible, though it has a limited lifespan [10].

2.2 Serial port

The main communication of the computer and the RFID Reader is a serial cable. A serial cable is a computer accessory that is used to communicate between two devices that use a serial communication protocol. This item was part of the RFID reader that is used to connect to communicate to the program of the RFID reader, which in turn is used to register the RFID cards through the program [11].

2.3 Universal serial bus to serial adaptor

This adaptor is a converter that makes serial communication possible to devices that does not have a port for serial communication [12].

3. DESIGN CONSIDERATIONS

For the system to be able to process the data, formulas and equations are essential for the operation. The following figures to be shown in this section will summarize the step by step process that the program will do once the simulation starts. The equations below show the variables that would act as inputs to our system from 6 different MRT stations (from Taft Avenue to Boni Station).

3.1 Formulas and equations

For the system to be able to process the data, formulas and equations are essential for the operation of the simulation program. The following equations are used by the group in order to have a systematic approach on how the prototype will be able to decide and to choose which functions are to be used in order to come up with a proper execution.

For the time interval formula to be used, the following equation has been formulated according to the needs of the simulation program:

$$t = 60\ x \left[\frac{T_M + \sum_{F=1}^{6} E_F}{T_P + \sum_{i=1}^{6} Q_i}\right]$$

Where:

t = Time in minutes.

TM = Maximum number of passengers a train can accommodate

TP = Total amount of passengers on queue

Qi = Initial queue of passengers where:

- Q_1 = 40% of the input value in Taft Station
- Q_2 = 40% of the input value in Magallanes Station
- Q_3 = 40% of the input value in Ayala Station
- Q_4 = 40% of the input value in Buendia Station
- Q_5 = 40% of the input value in Guadalupe Station
- Q_6 = 40% of the input value in Boni Station

EF = Fixed entry of passengers into the queue where:

- E_1 = 5% of the input value in Taft Station
- E_2= 5% of the input value in Magallanes Station
- E_3 = 5% of the input value in Ayala Station
- E_4 = 5% of the input value in Buendia Station
- E_5= 5% of the input value in Guadalupe Station
- E_6 = 5% of the input value in Boni Station

When the output of the equation is be less than or equal to 7.5 minutes, the program will choose the 5 minute interval for the process of simulating the graphs. When the output of the equation is be greater than 7.5 minutes but less than or equal to 12, the program will choose the 10 minute interval for the process of simulating the graphs. Finally, when the output of the equation will be greater than 12, then the program will choose the 15 minute interval for the process of simulating the graphs.

The initial queuing of the passengers are done by taking the 40% of the input value and as the simulation goes on with its 1 hour processing of data, the train flow is considered to be in continuous flow since the entry and exit of passengers are also manipulated. The passenger entry is being chosen randomly according to the priority level of each station. For example, the Taft Avenue station has a 60-70% random entry of passenger since it is the starting station. Since there is no actual data of passenger exit then the “Poisson Distribution” [13] is responsible on the number of passengers being held on each station. Furthermore, it was also used in this study since the simulation deals with the queuing. This type of distribution is highly recommended in order to understand the behavior of the passenger flow.

$$f(x) = \frac{\lambda^x * e^{-\lambda}}{x!}$$

The manipulations of the leftover passengers are divided according to the needs of the intervals to be used in the simulation. The group decided to have a constant timing of five (5) minutes and it is considered as the maximum number of waiting of the passengers in each station. The program will then simulate and shows a graph of the leftover queue of each station in order to show their current situations. It will adjust according to the total amount of the passenger input in each station.

3.2 Database management

The enhancement of this study is by organizing and improving the crowd control scheme implemented by the MRT management. With the help of the implementation of the database management system, tag numbers, destination of the congested passengers per station, time of arrival of the trains, it will maintain the smooth flow of passengers through the 6 stations will be monitored at all costs and instances.

The key for the success of the integration of the different subsystems of this study is a database management system that contains programs that enable creation and modification of information in database files, as well as storing and accessing that information when it is needed. With an organized and systematized way of managing data, sorting and searching among thousands of entries is possible and will later on be advantageous with regards to keeping track of hundreds and thousands of vital information. Though implementing the database management system proves to be costly and needs intricate security measures to guard against unwanted access to private and confidential user information, its benefits are numerous.

3.3 Operations for the interface

The Admin Panel Interface is composed of the actual user entries that will be collected such as the passenger status of the train stations, the number of trains that the user wants to use for the simulation and the calculation for the estimated travel time for the passenger. In this interface it will also show the total number of card inputs that has been read by the RFID Reader and the total number of passenger count after the user has entered the data into each station.

The RFID Configuration Form is the main interface to manipulate the RFID Reader and to edit the RFID Tags based on what kind of data is to be read. Before using this interface, the group makes sure that the necessary driver needed for the RFID Reader is installed in the computer. The driver that the group used is called PL303 Prolific Driver Installer v1.7.0. The group installed the 2008 version of this driver since it is compatible for the system being used for testing [14].

The three (3) Interval Forms namely the Five, Ten and Fifteen will be responsible on showing the passenger flow for each station.

3.4 Hardware prototype

The hardware prototype is built according to the dimension needed by the RFID Reader. The height of the stand to be used for the prototype is 2.5 meters. The angle of placement of the reader is 90 degrees perpendicular to the ground. The range of the reader in terms of its length and width is 5.5 meters and 3 meters respectively. A limit of 8 meters is also included for the design.

3.5 Flowchart

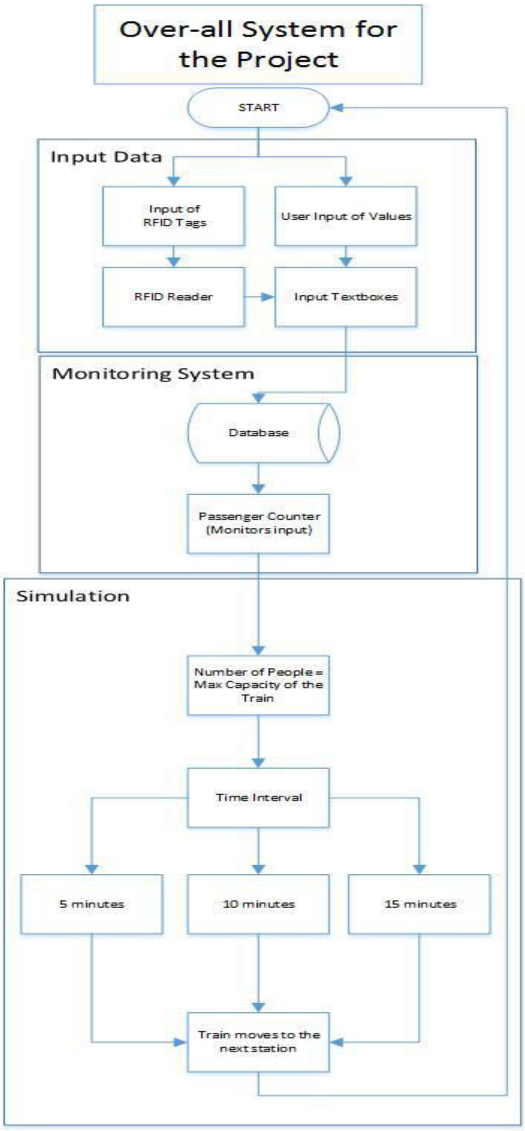

Figure-1. The over-all project is shown in this diagram was in the software and the hardware part are already integrated.

The system works initially with the use of the user inputs of the bulk value of each station and RFID tags. The passengers would tap the tags into the reader before entering the train station. The reader would then analyze and read the tag before sending it to the database system. The database system, would then check the tag number in order to determine whether or not the tag has already been read or analyzed, this is done in order to prevent having multiple inputs for a single tag, with each tag only amounting to one input to the database regardless of how many times it was tapped through the RFID reader. After checking, the database system would either accept or reject the tag, once accepted, the tag would be recorded into the database and would serve as an input for the simulation.

The simulation system would then accept and manage all inputs from different stations. The system would then decide based on the number of total passenger

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and the system would recommend the number of trains and the time interval of the trains in order to accommodate the number of people on queue. The system would then send back the output to the database system in order for it to be used and implemented on the station.

4. ANALYSIS OF DATA AND RESULTS

The analysis of the group according to the gathered results are divided into several sections according to their function. The following graphs and explanations shows that the objectives are meet particularly the 90% reliability of the system and the train simulation shows the train flow and the passenger queue.

4.1 Reliability of the RFID scanning

In order for the group to test the reliability of the RFID reader and passive tags, the groups come up with a series of testing. Fifty (50) pieces of RFID cards are used in each testing. The distance between the reader and the cars are measured in “30 cm” and “70 cm”. There are four (4) setups that are done the first and second setup is that the RFID cards are not covered with respect with the given range of distance. The third and the fourth have the same range but the RFID Cards are being inserted into a leather wallet. As the results stated, the first and second reading has no difficulty but the third and fourth had some problems since the reader produced a delay in reader the cards. But nevertheless, the RFIDs are indeed reliable above the 90% limit based on the objectives.

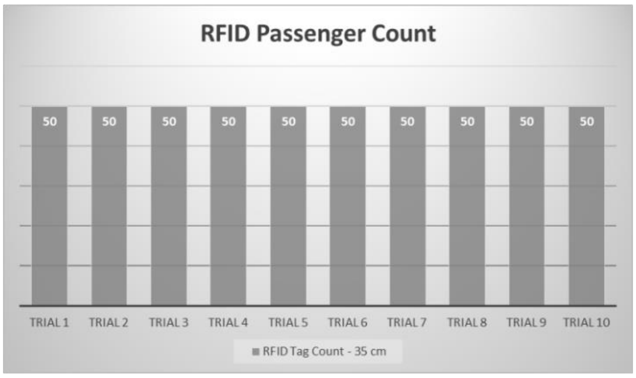

Figure-2. 35 cm distance RFID test

Figure-2 shows the RFID test from a distance of 35 cm. All trials for Setup 1 got a result of 50/50 for a 100% reliability rate, also, in this setup; the reader could read the tags with ease.

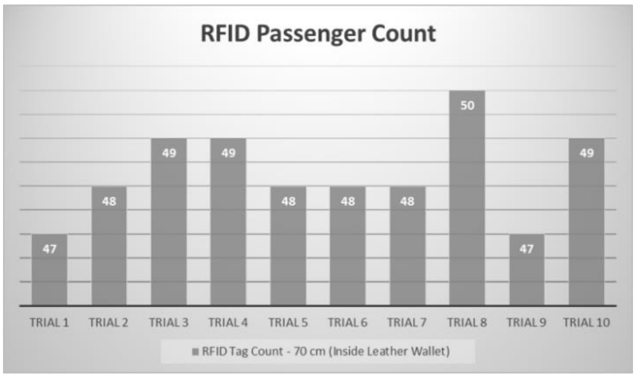

Figure-3. 70 cm distance RFID test inside a leather wallet.

Figure-3 shows the setup when the RFID is inside a leather wallet. Unlike With this setup, the reader have difficulties in reading the tags and wasn’t able to achieve 100% reliability. Although the discrepancy in the reliability wasn’t that high, 90% reliability was still achieved from the results of the trials.

4.2 Interval decision

Initially, the system would ask the user to enter the number of passengers on queue for each of the six stations, the system would then divide the entered value into portions to make the system dynamic just like on real life situations. Based on the total number of passengers, the system would then use the group’s formula for time interval in order to get the required time interval for the system.

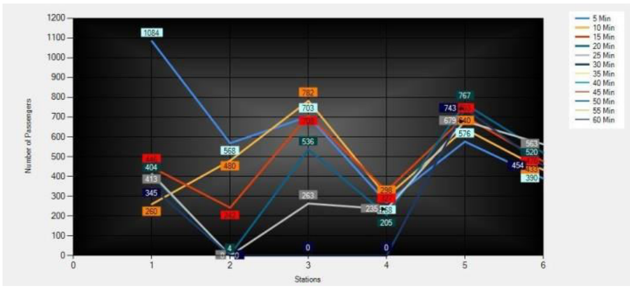

Figure-4. Time interval of the simulation.

Figure-4 shows the initial value of passengers on queue decreases simultaneously after applying the recommended time intervals for the computed required number of trains. The time interval being chosen by the simulation is the 5 minute interval due to the fact that the bulk value of the initial queuing is considered as a congested situation.

5. CONCLUSIONS

The group was able to fulfill and accomplish all their objectives such as creating a simulation system that successfully mimics the MRT queuing system, to attain the 90% reliability of the RFID reader and to suggest the approximate number of trains to accommodate the total number of passengers entering the stations. The group also determined the ideal location for the RFID reader for it to maximize its capabilities according to the group's objective. The simulation system was able to handle and manipulate different inputs according to different queuing situations.

For the hardware module of the prototype, the transferring of data between the simulation interface and the RFID reader has been stable using the USB to Serial Port communication. Its accuracy has been tested through the trials being presented in Chapter 5 in order to justify that the system is reliably enough to be use. On the other hand, the software part of the prototype had experience constant changes in the codes regarding the computation for the equal division of stations in terms of the allowable passengers. This is done so that the representation of data per train and per station would be handled properly by giving priorities to those stations that have more passengers. The group only used 6 stations as basis for the simulation, because the system is expandable and flexible through the use of the RFID reader, also, the six stations that the group used were the most congested stations southbound to northbound track of the MRT system.

Furthermore, the prototype for the train simulation system made by the group is able to present a visual representation of the actual situation on each train stations. As shown on the graphs for the simulation, the state of people on queue did not experience congestion. During peak hours of the MRT system, the solution of the DOTC to accommodate passenger congestions was to implement a manual crowd control system. They line up their passengers resulting into long lines of queue with an estimation of about 30 minutes to an hour of waiting time with a train interval of about 10-15 minutes during rush hours. On our simulation system, with the use of RFID readers as the input device for the passenger on the system, we simulated the same of amount of passengers of about 19-20 thousand total passengers on queue for the six stations from Taft station to Boni station, of that number there were only about less than two thousand passengers left after simulation. The system was able to reduce the number of passengers on queue to about 75-85% as the simulation was able to show successfully on how it will manipulate and handle train process depending on the number of people on queue in order to lessen their queue/ waiting time by about 5-10 minutes per train to prevent further congestions. Also, the system would maximize the number of trains to be used for each situation, as the system would only release the required number of trains that would accommodate the total passengers on queue to maximize profit and avoid waste of resources for the system.

Based on the data and graphs above, The group can conclude that the study would be applicable to and helpful to the Metro Rail Transit Administration because their current manual crowd control will be optimized by providing them with a more systematic calculation for the recommended number of trains to be used and with their respective time intervals that would be adaptive to the total number of passengers on queue in order to reduce actual passenger congestions to maximize their resources. And also improve their service rate to the passengers by providing them a systematic approach on train management because it would lessen their waiting time to about 5-10 minutes per train depending on the number of passengers on queue. Based on a per hour simulation results, the group can conclude that based on the findings of the simulation, the recommended interval of 5 minutes per train that was chosen based from the formula would prevent or lessen train and station congestions by about 75-85% on a per hour basis. Also, based on the group's results. The intervals vary adaptively depending on the number of passenger on queue from each station, as the number of people increase, the value for the interval of the simulation will decrease since it would require sending more trains at a faster pace. Therefore the group's simulation program can be used as a basis for testing train management as an effective and efficient tool for the MRT Administration for it to provide better transportation service to the public masses. Since the program can provide visual representation of the possible situation of the actual situation within the MRT stations.

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