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Enhancement of the Conventional Sri Lankan National Fuel Pass to a Comprehensive Fuel Station Application

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ABSTRACT

Due to the economic crisis in Sri Lanka. There was a fuel supply problem because of the lack of foreign currency. Even though the government tried to supply the fuel demand, it was unsuccessful due to refueling the fuel since all people were trying full tank their vehicles. Therefore, the government took a new approach by creating a simple QR code scanning application. Even though the application was developed, the features were minimal. To give good insight and emotions to the users, improve their user experience, and maximize user usability Fuel Station App was developed. This is capable of viewing, Downloading, Regenerating the QR, Managing and altering the user profiles, and calculating the fuel consumption of the user vehicle. After the development phase, the app was tested, and the results were collected from the study. The survey confirmed that the users prefer the proposed solution to pump fuel and get good insights from the application.

Keywords— Fuel Station, Fuel Consumption, QR(Quick Response), UX (User Experience), Fuel Availability

I. INTRODUCTION

During the past few months, Sri Lanka was suffered a lot with an economic crisis due to the foreign currency problem. As a result, a fuel shortage occurred in the fuel stations. Therefore, long queues were formed near the fuel stations. Even though the government proposed a different solution to supply the fuel, it was unsuccessful due to people were trying to make their vehicles full tank since people cannot waste their time in long queues. So, everyone tried to make their vehicles fuel full. Due to foreign currency issues, the government failed to supply the required fuel on demand. Then the government proposed a new solution with IT support. The solution was a QR-based application to supply the fuel. The application was created to supply fuel based on a quota. In the preliminary stage, the app only supports providing fuel according to the vehicle assigned fuel quota, and one customer can register with one vehicle. As time went by the government updated the application to supply fuel for household items such as generators and grass cutters. To address all these issues, the application was not feasible. The app was able to manage only a fuel quota. It does not provide any insights about the other parameters. For an instance, the fuel quantity available in the fuel stations, the nearest fuel station to pump fuel, and fuel types. Even the fuel stations cannot measure their ongoing fuel quantity.

The purpose of the newly created fuel app is to provide complete detail to the customer. Rather than giving the QR code, the customer could regenerate the QR code if the customer had lost or stolen the QR. Also, compared to the previous app the user profile can be updated according to the user preferences. The previous application supported only the mobile number. But with the provided solution, we can send the OTP to both email and to mobile. Also, customers can view the nearest fuel station based on the fuel type and fuel availability. Customers can get a good insight into the fuel availability, fuel supply per hour, next fuel availability, and vehicle count based on the fuel availability.

The application provides the fuel availability for the respective fuel types. Then it provides a real-time fuel supply per hour. If any fuel station has a low fuel supply per hour, then the customer can decide that the fuel station has a low queue. The app also provides real-time data about vehicle availability for fuel. It shows how many vehicles are currently available for the fuel pump. If any vehicle type has a large number. The customer can decide whether he/she can exactly pump the fuel from that fuel station.

This paper is structured as follows. First, our solution is introduced in detail. In sections II, III, IV, V, and VI the background for conducting this research, research methodology, proposed solution, discussion, and conclusion are discussed respectively.

II. LITERATURE REVIEW

Management systems can provide numerous benefits to businesses in all industries. Petroleum stations are the structure of the executive. For instance, the management system quarterly progresses to identify and

report improved Management System utilization strategies for achieving corporate objectives. In 2013, Peter et al. proposed Management Systems can be used as a Management by Objectives tool to create factual reports and analyze data. [1] Management by Objectives is a management technique where subordinates agree on a series of goals to achieve within a given time. In 2012, Muhamad and Kodrat studied gas station inventory management. Their research aimed to create an inventory system. They built a system to handle gas ordering and inventories. [2] In 2014, Maheshwari et al studied a resource planning system for gas stations to automate the manual process of keeping daily records on one computer. This study established an easy approach for supervisors to keep daily records. [3] Ali et al. (2015) developed an automated gas station fuel management system. This technology creates a receipt after each transaction and can trace via the internet. This framework can store database data to generate daily, weekly, monthly, and yearly report business reports. In 2017, Areeg et al. focused on a system to track and analyze gas station changes. Their study highlighted how important a remote monitoring and data collection system is for petrol tank storage. [4]. Kaushik et al. designed and constructed an automated fuel station management system. This study led to cashless transactions and a regulated mechanism to increase the country's finances. Increasingly, gasoline is needed. [5] In 2018, Tynchenko et al. studied how to automate a conveyor shop's oil pumping station. The automatic system collects numbers to predict alarming scenarios. Failure-causing platform pieces are tracked. [6]. Alberto et al. focused on the oil risk management system based on high resolution hazards. The study was novel and accurate to improve decision makers' routines and crisis reaction in management. The technology delivers the end user oil disaster updates. [7] In 2016, Okemiri et al. (2016) described MIS as an integrated system that supports managerial operations, analysis, and decision making. A MIS uses technology, software, databases, and models for analysis, control, planning, and decision making.

III. METHODOLOGY

This solution contains a single-page application that will help work as a single system to give the information that the user request for the application. The UI and the service are separated and communicate through REST API calls. The methodology will be broken into three main sections to ease the description process.

A. User Interface

The app is developed using angular. Angular is a single-page application framework. It provides high-performance app functionality. In addition, angular use additional libraries for this application, such as apex charts, for the reports. Bootstrap 5 is used for styling, and box icons as the primary set of icons in the application. Also, google map is used to deliver a good insight into the customer, and google fonts were used to make the app more attractive. The user interface is mobile responsive. Therefore, a need of a separate mobile application is not required. UI has different logic for reordering the existing data. The interfaces are consisting of only two-tone colours to make it simple for the user interaction without warming up eyes on the application. It has a collapsible side navigation bar to use a large space for the content. The respective UI components are consisting of a few buttons and essential functionalities for ease of use. All functionalities are separated with meaningful tabs which are navigated by the navigation bar.

B. Backend Service

The back end is developed using spring boot. Spring has less coding. The application needs to consider more on the business services and remove the overhead from the controller and the database connections. This is a lightweight framework rather than pure Java EE. All configurations are configured within the framework. This has a well-organized layered architecture and no need to consider the dependency injection. All logical operations are implemented in the service layer. The service and the UI are communicating through the controller. Spring boot has a separate repository layer to contact the database with the hibernate framework. The application has the ability to change the data layer later by changing the repository layer without affecting to the service or the controller layers.

C. Database

The database is developed using MySQL. This is a relational database. According to the flow of the data, a relational database is the best solution for the database approach. Since every end user is interconnected with each other. The spring boot provides the spring JPA and Hibernate to access and work with the database. So, the developer will not need any complex coding for database operations. Hibernate provides an object-oriented database approach to the application.

The UI and the Server communicate through REST communication. When the UI request any data from the server, the UI sends a request to the server, and the server process the request along with the database and responds to the UI. So, the UI and the server are independent of each other at the REST level.

Figure 1 is describing the overall architectural diagram.

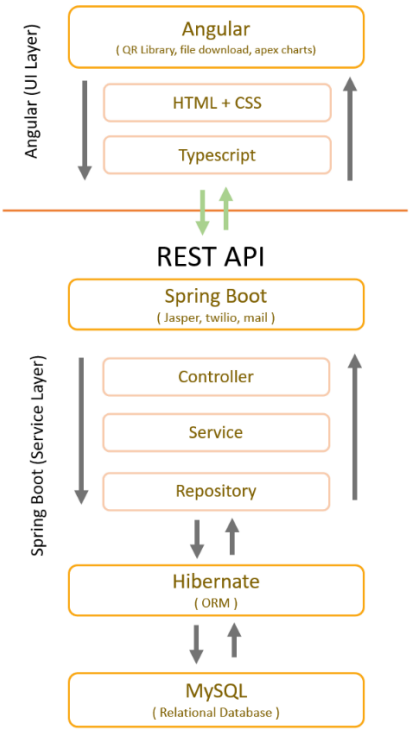


Figure 1: Architectural Diagram

IV. PROPOSED SOLUTION

This app contains various features to provide the user with the entire experience and provide the user in getting aware of fuel availability and the nearest location. This app includes a variety of features.

A. View, Download, and Regenerate the QR

The user will not require to login into the app again and again. They can print and hold the QR as in the previous app. But the new app has a most required feature which, if any customer had lost the QR, the customer can regenerate a QR, then the system will invalidate the previous QR codes for the user. The QR is generated for a user specific unique code. The QR is the identity to identify the vehicle at every fuel station.

B. Registering and altering the user profiles

The user can only manage only one vehicle per user. Since this app is to limit the fuel quota per vehicle. If the system provides multiple vehicles for one customer. The customer will tend to pump fuel for all use or non-use vehicles and misuse the fuel quota. When a new user is getting registered to the system. The user has to enter an OTP to validate the user and then allows to enter the vehicle. The system sends the OTP to both email and mobile number. After the login, if the user wants to change the vehicle, the user can alter the user profile. If the user profile is deleted, the system only removes the customer details and it will not remove the vehicle. Since the system needs vehicle data to manage the ongoing data entire the application. The system maintains the vehicle information for further reports. When updating a user profile, if any vehicle was previously registered with the system. The user has no need to enter the vehicle again. The system will automatically add the vehicle to the user. (Figure 2)

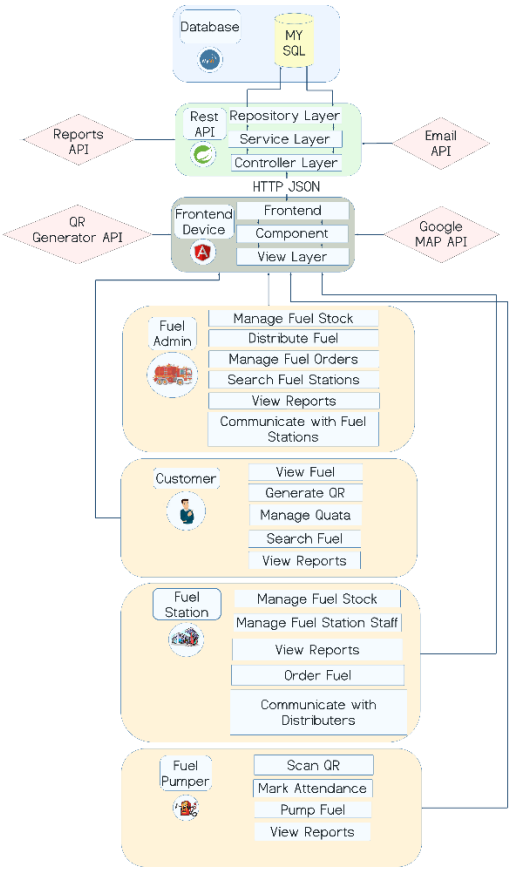


Figure 2: System Overview Diagram

C. Calculate the fuel consumption of the user vehicle

According to Equation (1) If any customer's last two consecutive fuel pumps are fully tanked, the user can add the trip and calculate the latest fuel consumption, and can measure the fuel efficiency. Also, customers can only add the trips and calculate the consumed fuel for every trip. Customers can save the trip with calculated consumption. They have the ability to save only trips without calculating the consumption until the next two consecutive full tanks to calculate again the latest fuel consumption. By adding only trips without calculating the consumption. Based on the last fuel consumption, the customer can calculate the consumed fuel for every trip he/she entered (2). This application will provide the total fuel pumped, fuel consumption, and the remaining fuel quota for the respective weeks on the graphs. So, the customer has the ability to get a graphical view and get insights about the fuel consumption patterns during the last four weeks.

Figure 3 is describing the flowchart of which all data are categorized into respective fuel stations and the fuel types.

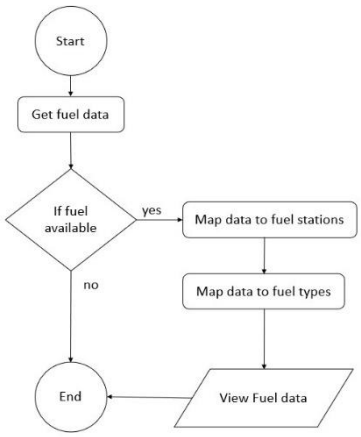


Figure 3: Flowchart of the algorithm used to view fuel data

$$Fc = \{ \sum \left(B_{ft} + C_{ft} \right) \} / Tv \quad (1)$$

The variable Fc is the fuel consumption and the Tv is the trip value. B_{ft} is the last fuel pumped amount and the C_{ft} is the amount before the last fuel pumped. Both fuel pumps must be a full tanked amount to calculate the fuel consumption.

$$Fu = Tv / Fc \quad (2)$$

The variable Fu is the fuel consumed and the Fc is the fuel consumption. The Tv is the trip value. The consumed amount is calculated by the last fuel consumption.

D. View the available fuel stocks, fuel supply per hour, fuel availability

Customers can view fuel availability for the respective fuel types, the fuel supply per hour, and how many vehicles are available for the fuel pump (5). The fuel supply per hour provides the hourly fuel supply rate to the vehicles (6). Then it shows how many vehicles can pump fuel, based on the remaining fuel stock for the respective fuel types. So, the Customer can decide where they go to pump fuel. This component provides well comprehensive information to the customer. The component has features to order the information to easily get the required information. It has a user-friendly way to easily do that. Any customer can select their region and select the place under the region where he/she wants to know about fuel stations. Then the customer can filter the fuel type and select the fuel availability or fuel supply. If any customer is outstation, they do not know about the fuel stations. The customer can select the region and select the place where he/she is. Even if do not know anything about fuel stations in the place, the app provides the all required information including the map. The map is also powered by google maps and the customer can expand the map view and search the directions to the selected fuel station. If the customer is required for a selected fuel type, the app can filter those available fuel stations easily.

$$A(V) = (|count(h,t)|) / h \quad (3)$$

The variable A(V) is the average vehicle count and the t is the vehicle type. The h is defined as hours and if the system has plenty of data the h variable can be a large number for the more accurate average value

$$A(FS) = (\sum_{x=1}^{q} PumpedAmount(F_x, h, t)) / t \quad (4)$$

The variable A(FS) is the average fuel supply and the t is the vehicle type. The h is defined as hours and if the system has plenty of data the h variable can be a large number for a more accurate average value. The q is defined as the total fuel quota, the x is defined as the starting amount and the F is defined as the fuel amount

$$R = A(V) * \{ T / \sum (A(V) * A(FS)) \} \quad (5)$$

The variable R is the remaining vehicle count for the next fuel pump. A(V) is defined as the average vehicle count for the vehicle type previously calculated (3), A(FS) is defined as the average fuel supply for a vehicle type previously calculated (4). The T is defined as the total fuel quantity

$$Fsh = Fs_t / h \quad (6)$$

The variable Fsh is defined as the fuel supply per hour for a fuel type. The variable Fs_t is defined as the fuel supply for a fuel type and the h is defined as hours. If the system has plenty of data the h variable can be a large number for the more accurate average value

E. Reorder the information according to the requirement

When the customer searches the selected criteria. The UI component reorders the fuel stations in descending order and takes the highest requirement to the top of the list. In addition, it also informs about the next fuel availability and the map shows the location of the listed fuel stations. Then all the UI components have the ability to reorder the data to the selected data column in descending order. The customer can view the data as the highest one on the top of the list. They can reorder according to date, any character values, or any other numerical column values. The UI does not contact the service again to do the reordering process. Only the UI component does by itself from the available data set which previously loaded from the service.

F. Fuel stations can manage the fuel orders and the available fuel stock

The existing application does not have options to manage fuel stations. But the proposed new system can manage the fuel stations and the fuel quantity. The fuel stations are subscribed with fuel distributors. The fuel stations are adding their fuel pumping employees to the system. The fuel pumpers cannot directly register with the system. They are allowed only to register through the fuel station login. Fuel stations can request a fuel order and accept it after receiving the order. After accepting the order, the fuel quantity is added to the main fuel stock. The fuel station administrators can monitor the real-time fuel in and out by viewing graphical graphs.

G. The fuel stations can provide the information about next fuel availability to the customers

The fuel stations can update the next fuel availability for the respective fuel types to the customers.

After receiving the fuel stock, the fuel station updates the fuel stock and makes the next fuel availability as available. Also, the fuel station end user main dashboard provides comprehensive information about ongoing fuel supply, fuel pumping rate per hour, and pumped vehicle count.

H. Fuel stations can manage their employees through the app

Every fuel station can manage its employees. Mark attendance, view the availability, and the employee who is fuel pumped. If any customer made any complaint, the system has a complete record of the fuel pump including the pumped fuel station and the employee details. If any employee leaves the fuel station, the owner can remove the employee's information from the system. But it does not remove any record beyond the employee from the system. Since the system needs every record for further reports.

I. The fuel distributors can control the complete fuel supply through the application

Fuel distributors can supply fuel for the requested fuel stations and maintain comprehensive reports. The distributors can manage all the fuel stations. The fuel distributors can reorder the fuel orders by the date to the highest priority. Then they can distribute fuel on demand without any delay. The system users can monitor the daily, monthly, and weekly fuel distributions through bar graphs. In addition, they can monitor the overall fuel supply island wide or countrywide. According to the fuel distributors' information, the system can provide insights of the complete fuel distribution. The government or any higher management can gather accurate information for further decisions.

J. The fuel pumpers can stack the vehicles by scanning QR codes in the queue

The existing application can only scan a vehicle's QR and pump the fuel to the vehicle and then again scan the next vehicle. If a queue was there, the pumper had to scan the QR, pump the fuel, and mark it as pumped. Then he has permission to scan another vehicle and pump fuel. But the proposed solution can stack all the QR codes in the queue and then pump fuel. One or more employees can stack all the vehicles in the queue into the QR scanning component. Then the fuel pumper can only pump fuel and mark the entered amount according to the first come first serve basis in the vehicle list. Then the system will record the fuel pumped amount including the information about the fuel station and the employee who pumped fuel for the vehicle. In addition, they can mark their attendance using the application. If any fuel pumper made any mistake, they can reset the fuel pump and again add the correct amount.

K. Provides weekly, or four weeks reports in multiple graphs

The end users can view the previous week's fuel availability and consumption. The reports provide the last four-week analysis rather than providing daily analytics. On the customer end, the fuel consumption report shows the last four weeks fuel pumps, fuel consumption, and the remaining fuel. Then the customer can get an idea of how much fuel is pumped, and how much is consumed. Then they can decide how to save more fuel in the upcoming weeks

V. DISCUSSION

After creating the proposed application, the evaluation was carried out to test the proposed and the existing solution's results. A random sample was selected with 27 individuals to give and use the current and the newly developed Fuel Station Application. Both applications were tested concerning different parameters. The parameters are the User Experience while using both the applications, features of the applications, and awareness for the user and the reports. Finally, how the testing of the developed app is carried out is discussed.

A. User Interface and User Experience

According to the analysis, out of the 27 users, 23 users marked that the User interfaces and the user experience are plentiful in the newly proposed Fuel Station Application. The existing application 4 stated that the current interface and user experience are good. Some users are not much concerned about the application, since they only need fuel for their transport. Some of them were lack of IT literacy. So, they do not tend to rely on the application. Most people have liked it since the app has no large number of complex interfaces. It has only a few user interfaces with essential features. According to the user experience, this app is not focused on one aspect of society. The app is used by every aspect of people. Educated, uneducated and different levels in IT literacy. The app is designed to self-learn easily for every user. Some people do not have smart devices, but the application's main functionality can be used even without using a smart device. Those people can download the QR with the help of any other person.

B. Features

Regarding the app features, 25 people stated that the newly proposed application contains more features than the ongoing QR application. But most people liked the features of the new application. Since they need to be aware of fuel consumption and fuel pumped amount for their vehicles. The most liked feature is calculating the fuel consumption. Every end user can get comprehensive information about fuel distribution and it is well organized. Customers can view their fuel pumps including dates, pumped fuel amount, and the fuel type. Then they can view the fuel stations according to the fuel availability and many more information and filtering options to be much more aware of that information. The fuel stations can always be aware of the real-time fuel in and out status. The fuel pumpers have the ability to quickly scan and supply fuel for the customers within a minimum number of times. The fuel distributors can be aware of the overall fuel supply country-wide.

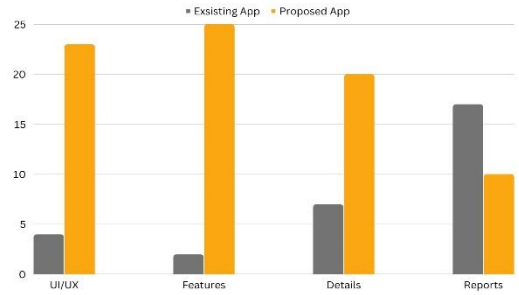
C. Details comparison

Regarding the details the user can get, 20 stated that the proposed app gives all the details that the user requires, while seven said that they are satisfied with the simple facts provided by the conventional application. Most of the people tend to only pump fuel for their vehicles and they do not have the time to explore more during the initial using of the application. In other situations, normally people do not have any idea about newly proposed systems. After few months, they are having some idea about system and the features since they explored more about the application during their free time. Most of the people mostly needed that information introduced by the proposed system, since they can easily find locations of fuel stations, details about fuel obtained, and the fuel consumptions. In case of rising fuel prices, people more tend to save fuel more. So, they are having those most needed features inside the app

D. Reports Feature

Regarding the report feature, 17 people stated that the report's part does not interest them and that the traditional application details will be sufficient for them. But ten number people commented that the generated reports are good with the provided details. Most people do not have good knowledge to read a bar graph or judge the bar heights. So, the customers only see a comparison between bars and get an idea about weekly fuel consumption. Most people tend to use the fuel consumption bar graph and fuel consumption tab since customers are keenly interested on save money for fuel. Fuel stations are used to calculate their daily income by viewing recorded information on fuel quantity in and out. The fuel pumpers or the employees provide the information. Fuel distributors can view overall fuel distribution through graphs and make decisions further. The Fuel Station application provides user-friendly and user-readable graphs for all users since it emphasizes their required fuel information well detail. The graphs can be read even if any user does not know graphs. The system always tries to provide an overall user-understandable graphical view to the user. (Figure 4)

Figure 4: Comparison between the standard application and new application



E. Testing

Selenium web tool was used to test each functionality. It provides automated features to make testing easier. First, the selenium needs to study the process, and then it does the testing by itself. With the help of that tool, the system is fully tested and validated. After that, the code was optimized using the sonar cube. The system is designed to easily do any upgrade for future releases. The system implementation should be easily understandable and clean code for other developers for further development. The sonar cube validates the source code according to the best coding standard in this system. The next testing method is user-end testing. In the preliminary stage, the system was tested with a minimum number of people and gathered the bugs and fixed those issues found.

VI. CONCLUSION

Due to the current economic situation in the country. The government planned to limit the fuel supply through an app. The newly proposed app has a number of enhancements for the end users to let them aware of the fuel supply and the fuel consumption. This study introduces a fuel application called Fuel Station. This solution includes a newly designed and developed fuel application that will give the ability to View, Download, and Regenerate the QR codes, manage and alter the user profiles, calculate the fuel consumption of the user vehicle, and much more for other end users. The initial evaluation shows that having a modern, resourceful fuel application will help the users to use the app and get the full service and the user experience via the Fuel Station app. Rather than other applications, researching the user experience is a must on this application, since this app must be easy to use by different knowledge levels of people and must reach different technology levels. So, this app is designed to reach the maximum level of the approach. The analysis showed that the developed app was preferred over the existing fuel app in Sri Lanka because the previous QR application's features were minimal. So, this application can replace the previously developed conventional application. The app not only provides solutions for the fuel crisis, but it also provides more information for the end users even if there is no fuel crisis in the country. Due to that, the system can be implemented in other countries and function the application continuously without any end date. Any government or private authority can make long-term decisions with the comprehensive information from this app. Saving fuel in a country save foreign currency and reduce carbon emission. In addition, it can reduce CO2 emissions and reduce other poisonous gases in the country. If any higher management needs to limit the CO2 emission in some areas, the experts can measure how much should be the fossil fuel supply in the area. So, they can maintain that fuel limit through this application.

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