Strategy Model in Bus Tracking and Information Application (BTA) Towards Smart Mobility in Urban Spaces

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***Abstract*—Smart city can be defined as an urban space with complete and advanced infrastructure, intelligent networks and platforms, with millions of sensors among which people themselves and their mobile devices. Urban mobility is one of the global smart city project which offers traffic management in real-time, management of passenger transport means, tracking applications and logistics, car sharing services, car park management and more smart mobility services. Due to the frustrating waiting time for the arrival of buses and the difficulty of accessing shuttle bus-related information in a one-stop centre, bus tracking and information application (BTA) is one the proposed solutions to solve the traffic problems in urban spaces. This paper is aimed to design and develop a bus tracking and information application in a selected city in Selangor state, Malaysia. Next, this application also provides an alternative to design public transport tracking and information application for the urban places in Malaysia. Furthermore, the application also provides a smart solution for the management of public infrastructures and urban facilities in Malaysia in future. Finally, the smart mobility model will be presented to uncover the extent on how BTA provide smart solutions in urban spaces which focus on informative, interactive, assistive and green mobility.**

***Index Terms*—Smart City; Urban Mobility; Bus Tracking and Information Application.**

I. INTRODUCTION

Smart city, an advanced technology intensive and territory to connect people, information and city elements by using new technology and create a sustainable, greener city, competitive and innovative commerce and a raised quality of life. It is a solution to innovative socio-technical and socio-economic aspects of growth. There are many definitions for the smart city and a range of conceptual variants to replace "smart", for example, "intelligent", "digital", "virtual" or "ubiquitous". Intelligent refers to the inclusion of complex analytics, modelling, optimisation and visualisation services to make a better operational decision [1]. Smart City is a term has been applied to two types of domains: hard and soft domains. Hard domains refer to buildings, energy grids, natural resources, water management, waste management, mobility and logistics, where Information and Communication Technology (ICT) play a decisive role in the functions of the systems. In contrast, soft domains refer to education, culture, policy innovations, social inclusion and government where the application of ICT is not decisive [1].

A smart city is a city which integrates six dimensions: economy, mobility, governance, people, living and environment. These six dimensions are integrated to address intelligent solutions which allow the modern city to enhance the quality of the services that provided to the citizens [1, 2]. There are diverse of innovative applications and services have been created to meet the variant demands of citizens and ensure sustainable development and quality of life in the city and urban area. These challenges may include maintain and upgrade infrastructure and establish efficient, effective, open and participative innovation, such as reduced public spending, increase efficiency and quality of services, provide support in decision-making, promotes innovation and provide information in real-time.

Urban mobility is one of the global smart city project which offers traffic management in real-time, management of passenger transport means, tracking applications and logistics, car sharing services, car park management and more smart mobility services [3]. Bus tracking and information application are one of the proposed solutions to solve the traffic problems in urban spaces. This paper is aimed to design and develop a bus tracking and information application in a selected city in Selangor state, Malaysia. Next, this application also provides an alternative to design public transport tracking and information application for the urban places in Malaysia. Thus, the application also provides a smart solution for the management of public infrastructures and urban facilities in Selangor state, Malaysia. This paper also provides the useful information on how to integrate the application and intelligent transportation system towards smart mobility to achieve smart city for Malaysia in future.

II. SMART MOBILITY IN URBAN SPACES IN MALAYSIA

The Klang Valley is the beating heart of economic growth in Malaysia. This region covers the city of Kuala Lumpur and nine other municipalities (can be categorised as urban cities), which are Ampang Jaya, Kajang, Petaling Jaya, Putrajaya, Selayang, Sepang, Shah Alam and Subang Jaya. Malaysia is recently shifting from an emerging market towards a developed market, and smart solutions are considered as the key point towards growth [4]. The government is proactive and ready to invest in smart initiatives that push these regions forward. For the smart mobility in Malaysia study, especially for the transportation system, the main challenges are high congestion during peak hours on rail and road, unreliable

transportation services, poor connectivity between modes, poor access to public transport services and high dependence on private transport [4]. Thus, it is a must to have the smart solutions in Malaysia context to provide an intelligent transport system to enhance citizens' travel experience in Malaysia and accelerate the national economy as well as promote sustainable development in Malaysia.

In a study of Intelligent Transportation System (ITS) in Singapore, there are three key strategies used by them: implement innovative and sustainable smart mobility solutions, develop and adopt ITS standard and establish close partnership and co-creation [5]. Among the initiatives and programmes, their focus still on four main elements, which are informative, interactive, assistive and green mobility. These elements are similar within Malaysia's context, with the rise of population, lack of physical space and infrastructure, our government, is promoting green technology and emphasises the use of public transportation. Furthermore, there is no real linkage between building, lack of access for physically challenged and elderly consumers, and poor continuity in Klang Valley area.

The previous study for the transportation system in Klang Valley also shown that an integration plan is needed for the various public transportation mode [6]. Besides that, the low ridership for the public transportation in Kuala Lumpur needs a further exploration to share modal for transportation and rethink the similarities and differences among Kuala Lumpur and other cities so that to determine the smart solutions are beneficial in Kuala Lumpur or not. The public transport, bus route map and schedule need to be analysed the current status of the terms of mobility and accessibility. Moreover, the information on low ridership of the public transportation system needs to be analysed for current demand too [6].

Public transport service, road data management and road network performance enable a good travel experience for the road consumers in Malaysia. Therefore, technology, mobility devices or tools, big data analytics are crucial to making the success of intelligent transportation system in Malaysia and towards smart mobility and smart city visions.

III. Bus Tracking and Information System Design

Some problems faced by the public transport system, which include frustrated waiting time for the arrival of buses and the difficulty of accessing shuttle bus-related information in a one-stop centre [7]. Thus, the proposed application will use existing in-vehicle GPS geolocation tracking devices to collect geo-locational data from all operational shuttle buses. The raw data is then processed and presented by the application to provide real-time bus location information to users, allowing them to monitor the status of the buses. Additionally, the application will serve as a one-stop centre where all bus information such as bus schedules and announcements can be accessed. Furthermore, the application also features an intelligent alert and notification modules that alerts users on important events such as bus arrivals.

Also, the proposed application will aggregate all the bus service related information to provide a one-stop centre for users to access shuttle bus service information such as bus schedules, bus routes and stops, as well as announcements. The two main end-users of the application are bus riders and the bus management. Bus riders will have access to the main functionalities of the application while the bus management will have access to additional features such as creating and managing announcements. The overall architecture of the system can be illustrated as a simple graphical representation as shown in Figure 1 that provides an overview of the system's linkage of different components regarding hardware, software and technology.

The system's architecture was proposed under the assumptions that the bus agency can provide the Static and Real-time Google Transit Feeds Specification (GTFS) Data Feed module for the system to work. Thus, the proposed system does not cover any bus tracking and bus times prediction mechanisms which need to be implemented on the bus agency's side. The reason to design the proposed system in such a way that the current bus agency already provided the bus service had a full-fledged fleet management system with the AVLs technology. Thus, the bus agency needs to share the data with the proposed system, so the information such as bus schedule, bus's service alert and bus's ETAs are available to the bus riders in the city. However, a protocol or standard should be defined in the data communication between the bus agency system and the proposed system.

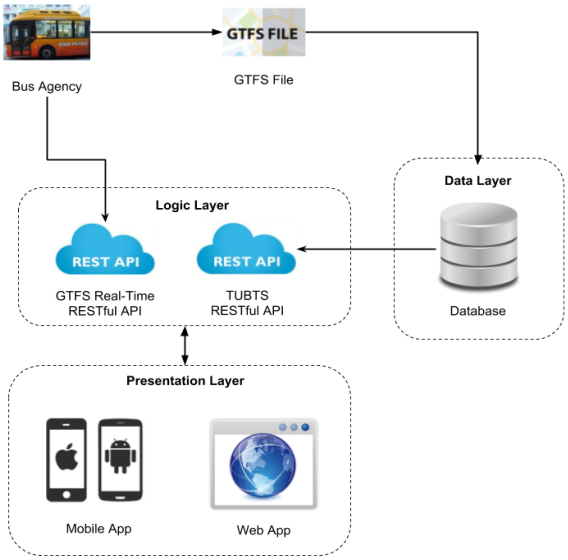


Figure 1: The simple overview of the overall architecture view of Bus Tracking and Information System (BTA)

As a result, the proposed system will use the available global transit data standard provided by Google which known as GTFS & GTFS-RT as the standard of defining the data's format to communicate with the bus's agency system easily. Some scripts were expected to be written and execute on a daily basis on the bus's agency side to make the data recorded in the database to be available for the proposed system.

The GTFS file provided by the bus agency that consists of the information such as bus schedule, bus trips, bus stops, bus routes will be manually converted and store into the bus system database. The relational database is necessary to optimise the data retrieval from the web and mobile app with the execution of SQL statements through the RESTful API. This procedure allows the optimisation of network resources with an only request for the data from a database that required by the users at that moment. Besides that, the database will also use store the announcements and accounts' data that is important in executing the administrator's functions such as create, edit and delete announcements.

The logic layer is the central core of the proposed system's backend as the service layer is responsible in exposing the

data available to the user information such as ETAs, service alerts and announcements that can be consumed by either the mobile client or web client. The reason the proposed system is going to API design approach can help internally structure the architecture for easy maintenance and develop more efficiently [8]. There is two RESTful API service is required to be deployed for the mobile and web app to retrieve the bus static and real-time information which then display to the users. The bus agency will have required to implement and deploy a RESTful API service to expose the real-time bus data that follows the GTFS-RT protocol. Another RESTful API service is part of the TUBTS system which is responsible for exposing the data resides in the database for the information such as bus routes, bus stops, bus announcements and account data.

Lastly, the mobile and web app in the presentation layer will consume both the GTFS Real-Time and TUBTS RESTful API service to display the bus information such as the Estimated Arrival Time (ETA), bus location, bus schedules, bus routes, bus stops and bus announcements to the bus riders. However, the ETA and bus locations might be extrapolated according to the scheduled arrival time according to the bus schedules if the GTFS-RT RESTful API provided by the bus agency experienced an interruption to ensure the continuous service of the system.

In summary, the proposed system will implement both mobile and web app for the users as well as the database and a TUBTS RESTful API service. However, the proposed system would not cover the implementation of the GTFS-RT RESTful API which supposed to be implemented and deployed by the bus's agency side as well as the management of the GTFS files.

A. Use Case Model

Figure 2 described further about the user's behaviour under the proposed application context to understand what and how the user can interact with the application. There are two main actors which the mobile client and web client are involved and able to interact with the application with the given features. These two main actors are differentiated according to one of the project's requirements which is a multi-platform deployment in web and mobile. The differentiation of between two different platform's client are important as some of the features such as receive bus event's push notifications is yet supportable with the current web technology.

A brief use case descriptions are given for each use case shown in Figure 2 are as follows:

- View Bus Static Information
  Both the mobile and web client users can access the bus static information which are the bus schedules, bus routes, bus stops and bus announcements in the application. The mobile users are offered the given filter choices to choose and filter the information that only needs to be displayed on the interface at a time. By default, the web users will get the default displays that shows all the bus static information as soon as the users launched the application.

- View Bus Real Time Information
  Both the mobile and web client users can access the bus real-time information which is the estimated arrival times, vehicle positions, service alerts and trip updates. Again, the mobile users are offered the given filter choices to choose and filter the information that only needs to be displayed on the interface at a time. By default, the web users will get the default displays that shows all the bus static information as soon as the users launched the application.

- Set Bus Arrival Reminders
  The mobile client's user selects the certain bus and bus stops to be reminded that are available in the application. The user is also given a choice to set the reminder to be repeatable for certain days in a week. A reminder entry was created for the specified bus stop, and a pop-up sound notification will trigger once the bus almost arrives at the destination.

- Receive Bus Event's Push Notifications
  As a default, the app will be automatically run at the startup, but the user might force to close and disable the app to be run on startup. Thus, the user needs to launch the mobile app to receive the push notifications being a push by the server on the events like news and announcements. Then, the user also able to look for the notification details which redirect the user to the respective interface for the event that specified in the app.

- Administer Bus Announcements
  The admin needs to login in the web client before the admin can access the admin panel that allows the admin to create, edit and delete a bus service-wide announcement. The admin type in the text content to create the announcements. An announcement entry is created and recorded inside the app, and a notification was automatically created to be pushed to the mobile's client.

- Accounts Authentication
  The admin enters the valid username and password in the login form of the web client. An account verification was done with the account's records in the database once the admin executed the login action. Then, the admin will be redirected to the admin panel where the place to manage the bus service's announcements. This use case is compulsory to be carried out first before the execution of the "Administer Bus Announcements" use case.

The users in the proposed application can view the bus real-time information which are the bus schedules, bus routes, bus stops and bus static information which are the estimated arrival times (ETAs), vehicles positions and service alerts in both mobile and web clients. An admin management interface was proposed for the Bus Service Administrator to easily make announcements in the application and publish on the web and mobile platforms which are available to the public.

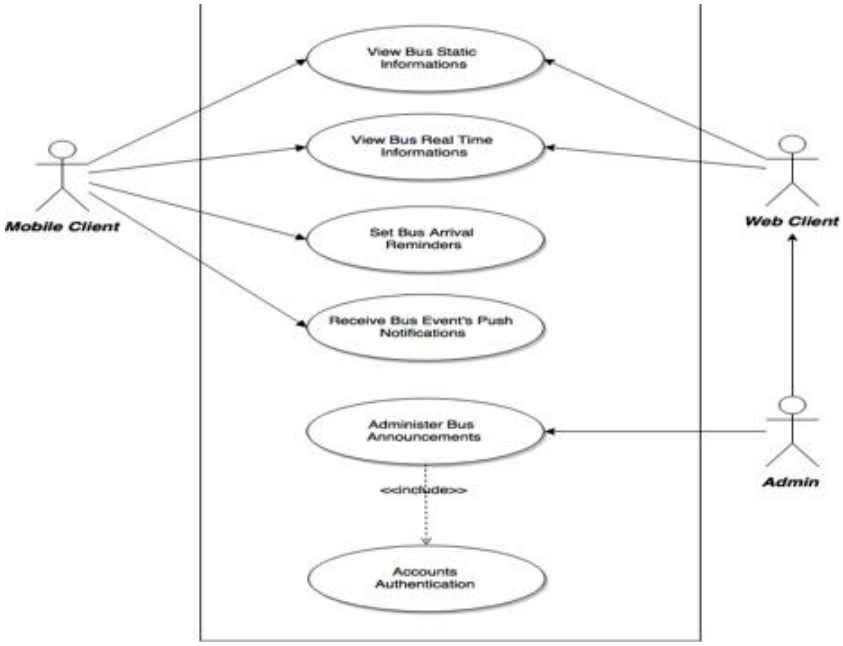


Figure 2: The use case diagram for Bus Tracking and Information App.

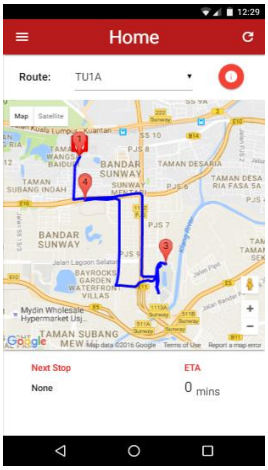
IV. BTA: TOWARDS SMART MOBILITY

At the end of the implementation of this module, users can view that the stops that are being plotted on a map along with the route in Android device as shown in Figure 3(a) and Figure 3(b). Besides that, the users are also able to view the routes' service days and stop's picture along with the name that retrieved from the database as shown in Figure 3(c). Furthermore, the user also able to select which route to be displayed on the page to avoid confusion of overlapping routes such as TU1A and TU1C routes consist of overlapping routes and stops to each other. The refresh feature is shown in Figure 3(d) is provided in the app as an additional feature after the consideration that the users might want to get the updated route info without restarting or quitting the app.

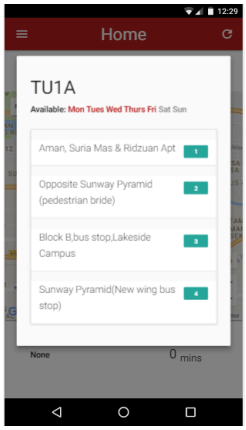
Besides that, bus announcement module provides the user with the bus service announcements that are posted by the administrator through the web app. The implementation of this module allows the users to view all the announcements posted or created by the admin in Android Smartphone. Furthermore, the announcements are always up to date as the data are retrieved from the PostgreSQL Database through the API with GET Method so the users can view the past and latest announcements that are stored in the database. Figure 4 has shown the announcements scene in the app.

Push notification module in the android is responsible for receiving the push notification of the newly posted and a created announcement from the web app. The implementation of this module will allow the users to receive the push notifications in the event of new announcements made from the Web App in the Android Smartphone as shown in Figure 5. Furthermore, the app will also redirect the user to the announcement page that was updated with the new announcements after the user clicked the push notification.

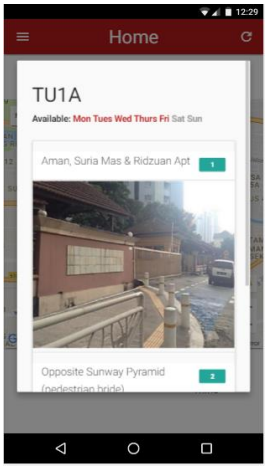
The BTA reliability and the road network performance affect the consumer travel experience. By having this app, transport operators will be better equipped to fasten solve any unexpected abnormal situations. The integration between public transport information and road operations allows a holistic visualisation and enhance operational efficiency via coordinated response to crises or incidents [5]. Through BTA, bus arrival time at bus stops can be improved and reduces bus bunching. Furthermore, public transportation can be promoted as the alternative way to reduce the carbon emissions, sustain transport system, reduce health risks and social cost. Figure 6 presents the strategies that embedded in BTA which are a focus on informative, interactive, assistive and green mobility and bring towards smart mobility for Klang Valley region.



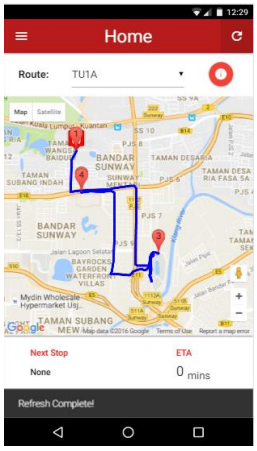
(a) Stops are plotted on a map along with the route



(b) A route's details that include the route name and bus stop name.



(c) Stop's name with pictures



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(d) User able to refresh the route info with the updated data from the database

Figure 3: The features available for the users after the implementation of bus static info module in Android Smartphone.

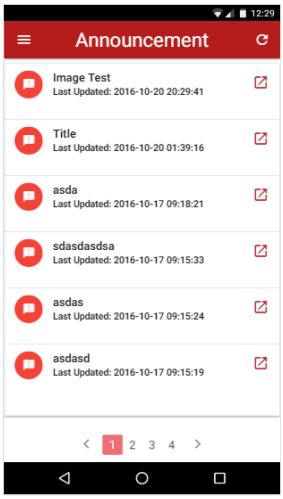

Figure 4: Announcement's listing that able to shows the new and past announcements

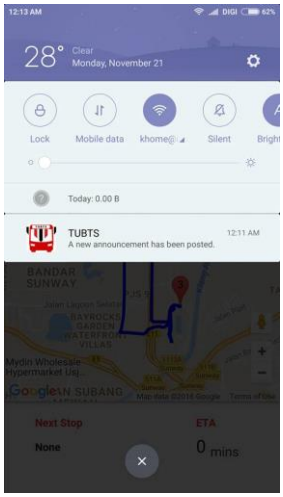

Figure 5: A push notification was received in the event of the new announcement posted.

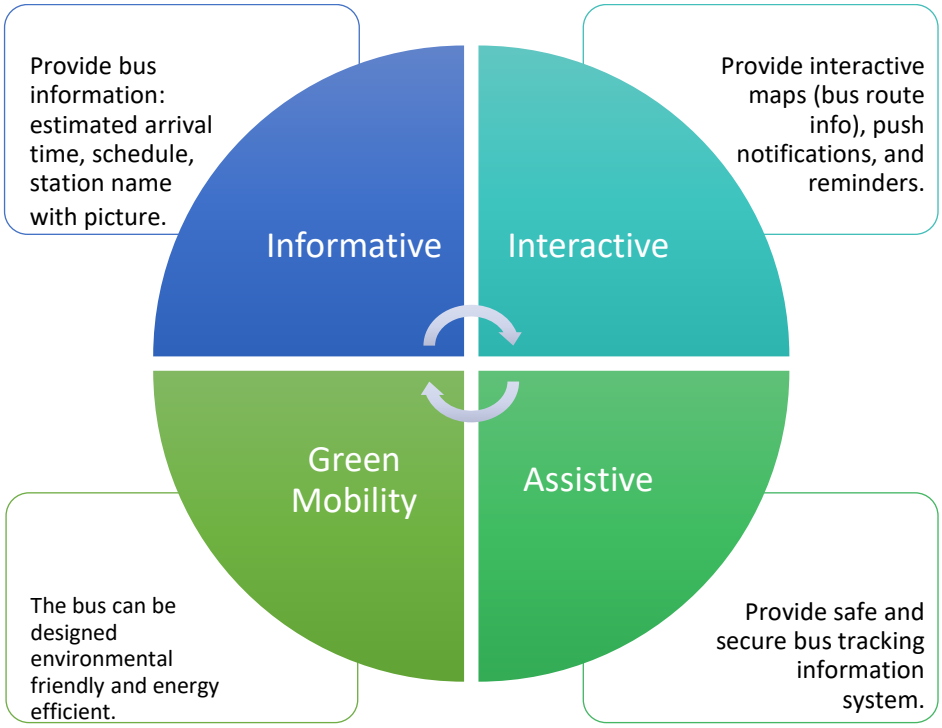

Figure 6. The embedded strategies in BTA and bring towards smart mobility in Klang Valley region.

IV. Conclusion

The BTA had considered fulfilling all the objectives that specified in the app design. One of the modules in the systems requires the enhancement is the bus real-time info module that provides the bus's location and the estimated arrival time (ETA) in real time. The original plan of this project is to incorporate the real-time data provides by the bus agency. However, this takes a considerably huge amount of time for the bus company to identify a way in the existing system to provide the necessary data. As for now, the bus real-time info is provided in such a way that the bus location is being extrapolated along the route and the arrival time is estimated under the consideration of the average time durations in traffic. Thus, the accuracy of the bus real-time info can be further enhanced by providing a GPS tracker device on the bus, but this implementation is going to be a long-term cost. The crowd-sourcing approach is a great and cost-efficient alternative to improve the accuracy of the bus real-time info. It is imperative and in the authors' interest that the public transportation tracking application is designed to be energy efficient and sustainable. The application will provide a smart solution for the management of public infrastructures and urban facilities in Malaysia in future.

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