Smart Bus Management System Architecture Using Mesh App and Service Architecture

Surachet Sangkhapan*, Panita Wannapiroon, Pachyanun Nilsook
The Division of Information and Communication Technology for Education, Faculty of Industrial Education, King Mongkut's University of Technology North Bangkok (KMUTNB), Thailand.

* Corresponding author. Tel.: +066818972515; email: surahetsungkhapan@gmail.com
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Abstract: Public transportation users in Thailand have faced the problem of wasting time waiting for the bus due to do not know when the bus will arrive, its location, number of passengers, and speed, etc. They are risky to injure and disability due to frequent accidents and have increased gradually each year. Therefore, this research aims to study smart bus management system architecture (SBMSA) using mesh app and service architecture (MASA), to synthesize SBMSA using MASA, and to evaluate the suitability of SBMSA by studying and analyzing related research on smart bus management system (SBMS) models. The researcher discovers a synthesized model of SBMSA using MASA which consists of 3 modules: IoT stack, GPS tracking system, and smart bus management system. Module 1 IoT stack consists of 5 subsystems: sensors devices and actuators, IoT gateway, communications network, cloud data management, and mesh app. Module 2 GPS tracking system to receive signals via satellite to specify bus location and route in real-time. Module 3 SBMS consists of 8 subsystems: smart tracking, smart gate attendance, smart camera, smart alert, smart estimate time of arrival, smart suggestions, smart accident center, and smart report. The suitability evaluation of SBMSA using MASA was at the highest level. The findings of this research will lead to the development of SBMS and help to solve problems of public transportation in the future.

Keywords: Smart bus management system, GPS tracking system, mesh app and service architecture.

1. Introduction

The public transportation users in Thailand have faced the problem of wasting time waiting for public transportation. Because they do not know when the bus will arrive, its location, number of passengers, and speed, etc. People have tried to use modern technology to solve problems. From studying related research, it is found that there are different researches related to real-time vehicle tracking systems. for example GPS, smart tracking technology to track the vehicle. There was also a program to schedule the bus and inquire in case the bus was canceled or stopped in the particular route including sending a notification to passengers via the server [1]. Ticket booking and passenger counting system in which users can search for bus locations on the map application via smartphone and check number of the passengers including the list of other bus routes available. RFID technology uses to count the number of passengers and GPS technology to find the current location of the bus through smartphone applications available on Android, IOS, and other operating systems [1]-[5]. The main motivation of this system is to provide good help for planning a traveling plan effectively and know the waiting time, the arrival time of the bus. From the study of the

related research leads to an ideal concept to develop SBMS in the future and motivates the researcher to design SBMSA using MASA.

The researcher chooses to study the school shuttle bus which has the same design concept with the public bus to design the system to track students' travel throughout the route from home to school and vice versa. The idea is to use a tracking device to track the current location of the bus and use the RFID card to check students' traveling with the bus from home to school and vice versa [2], [6]. The system will notify the real-time bus location and students' attendance information until the students arrive at school. Also, the system will notify the students' parents and advisors via smartphone application [3]. This concept helps parents reduce concern about the safety of the students when traveling on the school shuttle bus. Besides, the system can identify the location of the station that the bus had passed, which allows parents to calculate the time that the bus will arrive so they can prepare students to be on time and vice versa calculate the time when students will arrive home [7], [8]. The researcher uses MASA to support the increasing usage of smartphone applications for a large number of users in the future [9].

The researcher has an idea to develop the SBMS which include 1) GPS to notify current bus location in real-time, 2) sensor system to check students and count the total number of students on the bus, 3) IP camera system to record and monitor the students on the bus, 4) speed limit warning system, 5) notification system to notify when the bus out of the route 6) notification system to notify when the bus pass the students' pick-up point, 7) notification system to notify when the bus stops abnormally, 8) system to identify distance and calculate time to arrive at the pick-up point, and 9) temperature sensor system to warn when the temperature exceeds the limit. All components shall depend on hardware and software based on IoT technology such as sensors, GPS tracking, IP camera, RFID, MCU or MPU, etc.

2. Literature Review

2.1. Intelligent Transportation Systems (ITS)

Intelligent transportation systems (ITS) is an advance application which, without embodying intelligence such as, aim to provide innovative services related to different modes of transport and traffic management and enable various users to be better informed and make safer, more coordinated, and 'smarter' use of transport network [10].

2.2. Smart Bus Management System

Smart bus management system (SBMS) is the use of information and communication technology to manage the bus for the safety of the passengers by integrating various technologies into a system, using various electronic devices such as RFID cards to count passengers' service. GPS satellite tracking system to specify bus location, and GPRS system to communicate information to users via smartphones [11].

2.3. Smart Bus Tracking

Smart bus tracking application uses the tools that students' parents use daily to monitor their children while traveling to school with various systems such as checking driver behavior, comprehensive travel security systems with real-time bus tracking systems, use student identification to board the bus, checking over speed-limit, checking bus schedules, checking bus delay, checking accidents along the route and students boarding. The completed system develops through procedures Alpha and Beta testing. This development used the Arduino board, which is cheaper compares to GSM on the Raspberry Pi [12].

2.4. Mesh App and Service Architecture

Mesh app and service architecture (MASA) are mobile applications, web applications, desktop applications, and internet of things applications connect to many backend services to create things that

people use as an application. The MASA connects to network on the architecture of cloud computing or serverless computing and microservices in the form of application programming interface (API). This is the connection from one system to another system to provide services quickly and easily. The users will be able to use any devices such as pc, notebook, smartphone, self-driving car to connect to the services with the MASA freely and able to access information or services any time even changing devices according to lifestyle the service connections will not uninterrupted [9], [13].

2.5. Synthesis of SBMSA using MASA

Table 1. Synthesis of Smart Bus Management System Architecture using Mesh App and Service Architecture

No	Titled	Authors	The proposed system
1	Smart Bus Management System using IoT	[1] Jayakumar. S, Raviteja.S, Yadhu Krishna.P.B, Sushovan Bhattacharya, and Adipta Biswas	The users will be provided with an android application and the IR sensor is being placed on the footboard of the bus and it will be connected with the Arduino board that transmits the data to the database. Users can scan QR reader instead of paper tickets.
2	Wifi Based Bus Tracking System	[2] Priyanka Mathapati, Shwetha Haigar, Meghana H, and Arundhati Y	Android application is provided to know the details of busses such as bus number, the route contains source and destination, location of the bus as well as the arrival time.
3	Smart School Bus for Children Transportation Safety Enhancement with IoT	[3] P.Ambedkar and P.Suresh Babu	This system will send a text SMS to the parent containing longitude, latitude of location of the school bus, children attendance status and also driver phone number. Once parents receive the SMS, then by using those data and Google maps the user could easily track the bus. School management has a web-based database-driven application that provides information about location of boarding and leaving, boarding and leaving status, RFID number, time and date.
4	BusMe: Automatic Bus Localization System and Route Registration	[4] Willian Mulia Mirandaa, Ricardo Tavares Ribeiro de Mendonçaa, Allef Anderson da Silvaa, André Márcio de Lima Curvellob, Flávio Luís dos Santos de Souzaa, and Henrique José da Silvaa	The solution uses Amazon AWS for cloud backend, unifying GPS transmitted data from buses to Android applications. The terminal installed in the bus consists in a Raspberry PiTM using a GPS receiver and HSDPA module for data transmission. The transmitted data is received in the Android application and is plotted in real-time using Google MapsTM, allowing the user to know where his desired bus is, and even to know its point on its route.
5	Implementation of a Vehicle Tracking System using Smartphone and SMS service	[5] Nusrath Jahan, Kamal Hossen and Muhammad Kamrul Hossain Patwary	The tracking lives the position of bus and shows it on Google Maps. To get location information using SMS if the internet connection is slow to load the map. To get location information in a situation where no internet connection is available, even bar phone users will be able to know location information.
6	RFID Based School Bus Tracking and Security System	[6] Shraddha Shah, and Bharti Singh	The recommends a SMS based solution which assists parents to track their children's location in real-time. To track the location GPS module is used and to identify the identity of the child a RFID card is used which is inbuilt in the system.
7	Bus Tracking System Based on Location-Aware Services	[7] Priyanka V. Narkhede, Radhika V. Mahalle,Priya A. Lokhande, Reetu M. Mundane, and Dhiraj M. Londe	The system basically tracks the busses, estimates their arrival times at specific bus stops and informs the users through prevents passengers unnecessarily to wait at bus stops and enables them to use their time more efficiently. Basically, in all these systems the GPS & GSM are used to track the bus. Using this system the user can determine where the bus is, how much time it requires to arrive. The user can access the position of his bus at any instant of time. This system is reliable and very secure.

No	Titled	Authors	The proposed system
8	Smart School Bus	[11] Arifa K, Aryadas R, Asha KR, Amrutha J, and Anju P	Monitor children ridership in a safe and non-intrusive way. It will use a combination of RFID, GPS, GPRS technologies for monitoring entering and exiting of students. Each student is issued a unique RFID card to carry. As the student's tag is detected by the reader installed in the school bus upon entering or leaving the bus, the time, date and location are logged and transmitted to a secure database.
9	IoT Based Smart School Bus Monitoring and Notification System	[12] Judy Thyparampil Raj and Jairam Sankar	Tracking the location, the speed, the list of passengers onboard and the route of the bus and plotting these information on a map integrated using the Google Maps API, to the user interface of an android application which serves the administration, parents and drivers, to monitor the bus and the students within. The system will also identify each student as they board or a light the bus and push notifications to the respective parents' mobile device with the time and location of the event. Figure 1 shows the overall block diagram and the flow of the system.
10	UiTM Campus Bus Tracking System Using Arduino Based and Smartphone Application	[14] M.T.Kamisan , A.A.Aziz, W.R.W.Ahmad, and N. Khairudin	The GPS based vehicle tracking system is started with the initialize of Arduino UNO will send the command to Wi-Fi module for configuration and connecting to the router and getting internet protocol (IP) address. Arduino starts to initialize GPS for getting coordinate. GPS Module receives coordinates from the satellite in degree minute format (ddmm.mmmm). Arduino as a microcontroller will convert the degree minute format to degree decimal format. After convertion, LCD will show a 'Page Refresh' message. This means, users need to refresh the webpage, and Arduino will get the GPS coordinates and sends the same to the webpage (local server) over Wi-Fi with some additional information and a Google maps link in it. Now by clicking this link user redirects to Google Maps with current the coordinate.
11	Smart Bus Tracking and Management System	[15] M. Rishabh Sai Madhur, K. Sreenivasa Priyatham, K. Charan Raj, K. Bipin Nandan, and B.V. Sathish Kumar	To design a web-based application to the users who wants the real-time information of the bus using Arduino, Wi-Fi module, GPS module, and Google maps.
12	Smart Bus Tracking and Management System Using IoT	[16] K.Sridevi, A.Jeevitha, K.Kavitha, K.Sathya and K.Narmadha	The system provides relevant information regarding all the bus numbers going from users' source & destination along with the route details, real-time location. Generally, our system is operated by GPS which is attached to the bus.

3. Methodology

Research methodology divided into 3 phases according to the research objectives as follows: Phase I. Study smart bus management system architecture (SBMSA) using mesh app and service architecture (MASA). Phase II. Synthesize SBMSA using MASA. Phase III. Evaluate the suitability of the SBMSA using MASA by 7 experts in information technology.

4. Result

The study and synthesis of the related research, model, and design in the field of SBMSA using MASA as presented in the Table 1 synthesis of SBMSA using MASA indicated that process of the SBMS using MASA consists of 3 main components as follows:

The first component is the smart bus management system (SBMS) consists of 6 subcomponents:

1. Smart tracking system – a real-time bus tracking system to record bus route, location with GPS.
2. Smart camera – an IP camera system to monitor driver behavior and environment inside the bus.
3. Smart ETA – a calculation system to calculate bus arrival time based on GPS and Google Maps.
4. Smart gate attendance – a system to count the number of the passenger while boarding and leaving the bus with RFID card.
5. Smart alert - a notification system to notify bus over speed-limit, over temperature-limit, bus stop point, and off-route.
6. Smart suggestion - to receive notifications on the application via Mesh App.

The second component is the group of mesh application users such as students, parents, teachers, police, drivers, and related persons through devices such as smartphones, tablets, desktop, and smartwatch. MASA designs a solution that connects mobile applications, web apps, desktop apps, and IoT apps to the backend service to create an application for the users to co-integration.

The third component is the cloud server. It provides storage based on the integration of the users on mesh applications as shown in Fig. 1.

Fig. 1. Process of the smart bus management system using mesh app and service architecture.

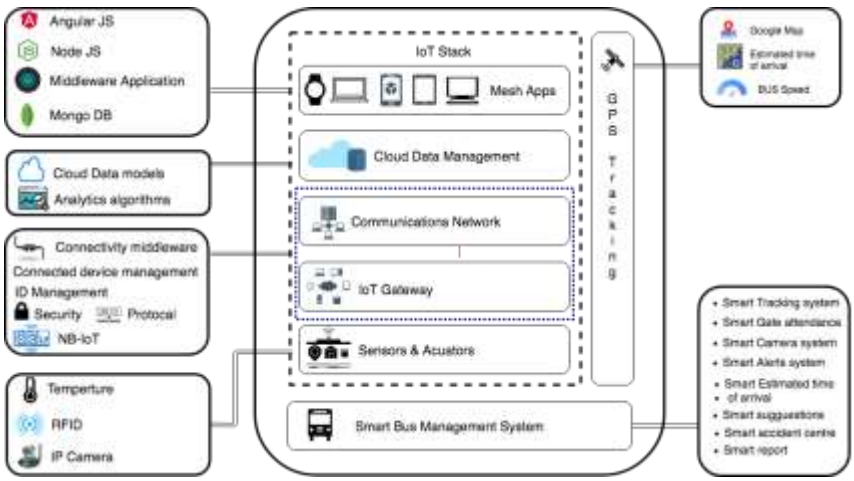

Fig. 2. Smart bus management system architecture using mesh app and service architecture.

From Fig. 2 The SBMSA using MASA consists of 3 main modules: smart IoT stack, smart GPS tracking system, and smart bus management system (SBMS).

Module 1: Smart IoT stack. It consists of 5 sections: 1) sensor-based connectivity and actuator devices section, 2), 3) gateway section of the internet of things. It acts as a medium between devices to connect to the cloud service, which allows the devices to communicate and interact through the MQTT protocol, 4) cloud section with a wide range of resources for heavy-duty support, such as screening from large searching and complex applications such as network intrusion detection. There are also tools with advanced algorithms that can be used to create powerful applications, 5) applications section is an integration of MASA connects through mobile applications, web applications, desktop applications and internet of things through APIs service on multiple levels and across enterprise boundaries, suitable to users' need and flexible service[13], [17], [18].

Module 2: GPS. It installed in the smart bus using MASA. The users can track location and route via Google maps and find the right route to schedule time as needed from the starting point to the destination. While traveling the user will receive instant notification when the bus runs over speed-limit, record users' bus service, and estimate bus arrival time. These data include in the report which users can check through the SBMS using MASA [19], [20].

Module 3: Smart bus management system. It consists of 8 subsystems: smart tracking, smart gate attendance, smart camera, and smart alert, smart estimate time of arrival, smart suggestions, smart accident center, and smart report.

5. Discussion

The suitability evaluation of the SBMSA using MASA from the 7 experts was 4.77, at the highest level, and the standard deviation was 0.36, at the high level. The evaluation of individual modules was as follows: smart IoT stack was 4.85, at the highest level, sensor and actuators was 4.71, at the highest level, IoT gateway, communications network, cloud data management, and mobile applications were 4.85, at the highest level. The evaluation of the GPS tracking system was 4.85, at the highest level, and the smart bus management system was 4.85, at the highest level. The relationship score of each module was 4.28, at a high level.

6. Conclusion

The findings can be summarized in 3 main modules: smart IoT stack, smart GPS tracking system, and smart bus management system. The 3 main modules are also divided into 8 subsystems: smart tracking, smart gate attendance, smart camera, smart alert, smart estimate time of arrival, smart suggestions, smart accident center, and smart report. The findings of this research could contribute to the development of the SBMS in the future by applying it in the appropriate context or area. The smart IoT stack can be used to add, reduce sensors, such as adding sensors to detect smoke in the bus or add a driver's alcohol measurement sensor. The smart tracking system can integrate with other modules to track the bus, such as modules that have both GPS and GPRS built-in, etc. The SBMS can be implemented by adding useful subsystems such as a car search system to search by driver name or by license plate, etc.

However, the researcher expects the limitation of the implementation of the smart camera system. Because the camera must send real-time data, which is the problem of NB-IoT which can not support big data from the camera. It may have to use a car camera instead of a camera connected to the Android board system that will benefit the bus tracking system. Therefore, the suggestion of implementation of this SBMSA requires the cooperation of users who use through MASA to report and provide feedback through the system for the safety of users. The bus tracking system must be tested for the delay of data transmission via

the 4G telephone signal network which may cause incorrect bus location notifications.

Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

Surachet Sangkhapan studied relevant research documents, analyzed, conducted research experiments, summarized and wrote the paper. Panita Wannapiroon and Pachyanun Nilsook as advisors approved the final version.

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Surachet Sangkhapan is a Ph.D candidate in division of information and communication technology for education, Faculty of Technical Education, King Mongkut's University of Technology North Bangkok (KMUTNB). He is a lecturer at the Department of Management of Information Technology, Faculty of Management Science, Princess of Naradhiwas University, Thailand. His research interests focus on smart bus tracking system, internet of things, and mesh app and service architecture.

Panita Wannapiroon is an associate professor at the Division of Information and Communication Technology for Education, and the Director of Innovation and Technology Management Research Centre (ITMRC), Science and Technology Research Institute (STRI), King Mongkut's University of Technology North Bangkok (KMUTNB), Thailand. Presently, she works in the field of ICT in education.

Prachyanun Nilsook is an associate professor at the Division of Information and Communication Technology for Education, King Mongkut's University of Technology North Bangkok (KMUTNB), Thailand. He currently works in the field of ICT for Education and Vocational Education Technology Research Centre. He is a member of Professional Societies in the Association for Educational Technology of Thailand (AETT).