Demand Responsive Transportation System for Low-Demand Parts of Metropolitan Area

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***Abstract*—This paper proposes an intelligent transportation system (ITS) for public transportation system that responses to demands in hybrid behavior, the system is set to work at low demand parts of the city. Therefore, the system has been tested through simulation on a small area of Gumi city, Korea. The system is to switch from normal mode to demand responsive when the vehicle reaches a usual low demand area at specific times. Where the bus-stop or booking by phone application to demand the service. The system would help to lower the vehicle movement which will be a huge help to the environment and it would let passengers arrive to their destination faster. Simulation results shows that, varying the scenarios still resulted better performance than normal system regarding travel time from deport to destination.**

***Index Terms*—Demand Responsive Transport (DRT), Intelligent Transportation System, Internet of Things (IoT).**

I. Introduction

The world advancement in technology is improving our daily life activities. But, till this day, the public transportation systems all around the world follows the same system that has been used since it started. For Example, the bus will deport from its station and it will go through each stop to either drop the passenger or pick up possibly waiting passengers there. But this kind of procedure is time consuming. because at some parts of the city at sometimes there is no one dropping or getting in the bus. still the bus has to go there to check if there is any passenger. Also, the more the vehicle moves, the more pollution it causes. This paper proposes a possible solution for this issue by reducing the travel time of the vehicle by using demand responsive transportation system. The main idea of the system is that the passenger has to announce that he desire to ride a specific vehicle by either using his mobile phone application, or through a panel at the bus stop which will update the route of the bus to include that stop point to pick up or drop the passenger. If there is no booking from the bus stop, the system will update the route to neglect that bus and enhance the trip schedule to the next demanded point. Using todays technologies such as 5G and Iot can bring this kind of approach to reality [1] [2].

The system works as follow, when someone want to use the public transportation system they have to book their desired bus and destination using either a mobile phone application or a panel at the bus stop. Where booking by the mobile application has some restrictions such as the person has to be 200 meters away from the bus stop itself. Either way of booking the passenger has to choose his destination. This demand message will be sent to a response gateway, then it gets forwarded to the scheduling algorithm which will deiced how to alternate the current bus route to include that stop point by comparing the existing data from the database. After that, the results of the module is stored in the database. The new bus route is to be sent through the response gate way by communicating with the bus through network connection which we assume it is 5G because of its speed and reliability. At all time the bus will be reporting his current location through GPS and the 5G connection. Fig. 1 shows the proposed system model [3] [4].

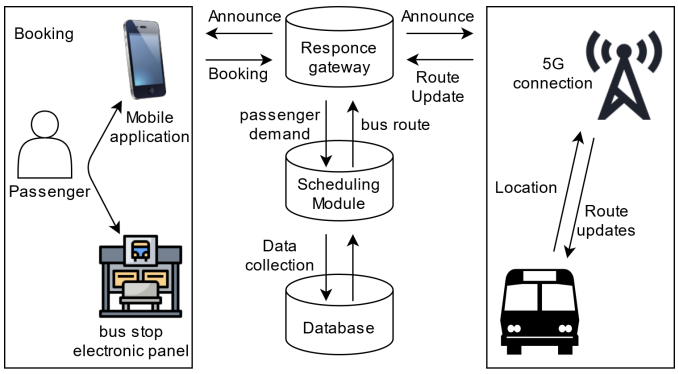

Fig. 1. The proposed demand responsive transportation system.

To test the proposed system through simulation, an area that has low demand through the day was chosen. This area has a bus route that has many curves and skipping such places at late night and early morning will shorten the travel-time and distance for the vehicle dramatically [5]. Fig. 2 shows the route with bus stops with an original map copy in top left corner.

The hybrid DRT system differs from existing DRT systems in terms of cloud computing technology. The back-end server is deployed on a remote Amazon Web Services (AWS) server and the operators and city authorities can introduce the service without the need for local server systems. The back-end server software was developed using JavaScript scripting language running on top of NodeJS, and the API was built using the ExpressJS framework. The system system data was stored using MongoDB a NoSQL data storage technology. Clients communicate with the back-end server through JSON packets.

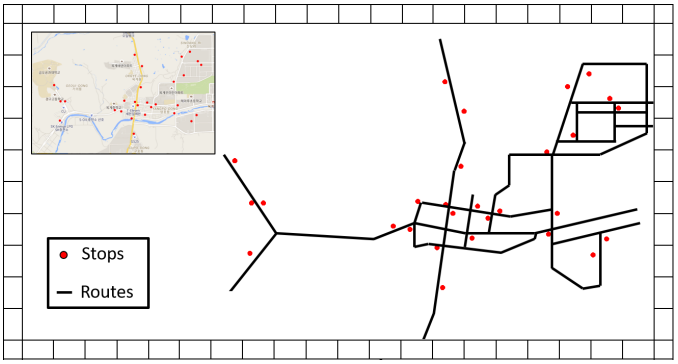

Fig. 2. The chosen area to run the simulation (Okgy-dong, Gumi city,South Korea).

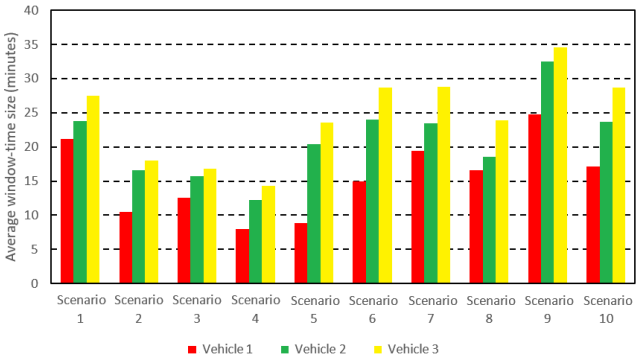

Fig. 3. Comparing different vehicles with different scenarios, Vehicle 3 takes the traditional route. While, vehicle 1 and 2 uses the proposed system. In all scenarios the proposed system shows better time window than the traditional system.

JSON is a syntax designed to store and move data sent between back-end servers and front-end applications. The road network was implemented utilizing Google Maps Application Programming Interface (API), onto which the coordinates for stops, vehicles current location indicators, and commuter populations were overlaid, along with possible routes and traffic congestion. The motivations for adopting this approach include: low cost, information security, simpler horizontal scaling to clusters of machines on the cloud, and finer control over availability.

II. Proposed System and Results

To test the proposed system we assume 10 different scenarios across 3 different vehicle. Vehicle 1 and 3 has the same speed, while vehicle 2 is considered slower via speed. But, vehicle 1 will take the tradiotional route without skipping any stops even though some stops has no passengers. While, vehicle 2 and 3 will use the method proposed in this paper. Fig. 3 illustrates the results that have been found from the simulation. Even while considering vehicle 2 has lower speed, still at all scenarios the proposed system has better results than the traditional method. While Scenario 6 has shown a decrease in travel time to almost 50%, which shows how the world could benefit from shifting of the traditional systems to DRT systems.

although if the system to be tested on a fully booked stops it will behave the same of traditional system, the main propose here is to fix the low demand period of time and not to solve the congestion at rush hour. The simulation and comparison also brought to light areas that needed improvement in the proposed hybrid DRT system. For instance, in the simulation, the demand-responsive algorithms consistently reduced the vehicles' travel distance compared to fixed-route conventional public-transport. Unfortunately, the saving to the operator associated with the reduction in travel distance came at a slight expense to the passengers in terms of access-time size, as the initial timetables of vehicles may shift throughout the course of a day.

III. Conclusion

Demand responsive system is a must in the future, lowering the traveled distance will lower fuel usage which will decrease tthe amount of carbon dioxide in the air. Also, will help with transporting passengers to destinations more efficiently. With these days technologies of communications and IoT we could establish an amazing new public transportation system. the proposed system in this paper showed great results regarding all of the previous issues. The traveling time has been lowerd in some cases more than 50%. still the system could be improved by an algorithm that will shuffle the bus schedule therough each other to choose the best route while combining another route. In future work, an implementation to be done for the proposed system since we already started developing an application on android. Also to consider a demand from a skipped stop.

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