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On-Demand Route Allocation: A Smart Transportation Scheme

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Abstract

For effective crowd mobility, smart cities must have smart transportation. Smart cities need a transportation system that is intelligent, simple, and effective. Here is a creative idea for modernizing the current public transit system. Hardware modules based on the Internet of Things (IoT) that arerequired for implementation are discussed in this work. Traffic circumstances and extra elements have been added to Dijkstra's shortest path method. The proposed algorithm has been tested in a number of circumstances, and the outcomes have been displayed accordingly. At a cheaper cost, the suggested solution can upgrade the current infrastructure. With various request counts, the algorithm performs well.

Keywords: Smart Transportation, IoT, Route Allocation.

Air pollution has been becoming worse at an alarming rate due to vehi- cle emissions [1]. Although standards and emissions rules are followed, their impacts are moderated by the significant rise in vehicle usage [2]. To address this, one option is to promote the usage of public transport. In under- developed nations, there are currently inadequate public transport options with poor administration and service quality. In order to overcome the dif- ficulties in managing metropolitan areas, the concept of "smart cities" was proposed [3] [4] [5]. Transportation that is quick, safe, and effective makesa significant contribution to the growth of smart cities. Around the world,a number of pilot projects and initiatives related to smart cities were or- ganised. The Indian government recently unveiled its ambition to build 100

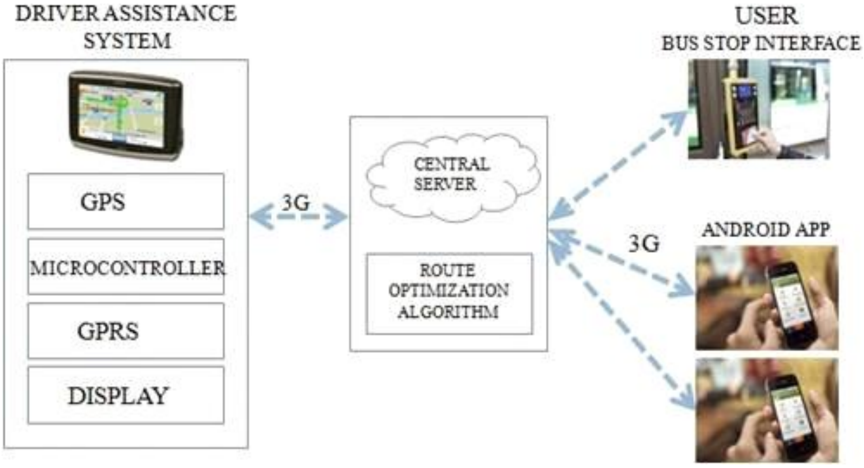

Figure 1: Construction of the prospective smart transportation scheme

smart cities [6], with a primary focus on sustainability and user friendliness. In order to manage traffic on busy routes and enhance transportation ef- ficiency, a number of systems have been developed. The primary objective of the Intelligent Transportation System (ITS) is to utilize suitable technological advancements in order to establish roadways, vehicles, and drivers that pos- sess enhanced intelligence. Advanced Travellers Information Systems (ATIS), Advanced Public Transportations Systems (APTS), and Advanced Traffic Management Systems (ATMS) were developed to improve operational efficiency [7]. Uncertainty in comprehending timetable, the information booklet, route maps, and bus stop names was the root of the poor passenger service. By giving users real-time information, APTS was designed to enhance ser- vices using cutting-edge electronic and telecommunication technology. The Internet of Things (IoT) concept and its applications in city administration show promise in this regard [2] [8].

Data collecting has grown to be a major concern as digitization has per- meated daily life [9]. An broad, mobile, networked infrastructure is necessary for every smart city programme to collect data. In multimodal transport net- works, a smart phone is an ideal platform for connecting people and their patterns of mobility [10]. The primary approach for implementing smart mobility in a developing nation is the smartphone-based data collecting and analysis, which is attracting attention. In a global and dynamic route planning system that encompassed the process of data sensing, collection, transmission, and analysis, Nimer et al. introduced urban traffic path planning [10]. Data analysis and wireless sensor network (WSN) technologies were used to create an intelligent system that could track the situation of urban traffic congestion in real time. The concept of a reliable cloud-based smart transportation system that prioritizes driver safety on the road [11] included services like traffic congestion, economy, pleasant driving, and pollution. Applications for smart transport are well suited for wireless-based technologies [12]. It is time-consuming and difficult to replace the current infrastructure for smart operations. The workable option is to retrofit smartness into already-existing infrastructure. Here, taking into mind these features, a wireless communication-based intelligent public transportation system is proposed. This solution makes it simple to modify the existing transportation network to meet the needs of intelligent operations. A proposed algorithm for the best route/bus selection is discussed together with the construction of the related hardware elements.

- **Overview of the scheme**

The intelligent transportation system being proposed consists of several components, as depicted in Fig. 1. These elements consist of an Android application, a server, a user interface, and an on-board Driver Assistance System (DAS). The DAS unit connects wirelessly to the central server to ex- change data. Real-time bus position updates are provided by the GPS device connected to DAS. Drivers are updated and instructed by a display device in the DAS on route selection and passenger boarding locations. DAS's process- ing unit was a Raspberry Pi 3 [13]. The device connects to the central server using 3G connectivity. The user interface is made up of an Android applica- tion and a Bus Stop Interface (BSI) module. Interface modules with wireless or wired communication networks have the potential to be incorporated at various or all bus stops. On NodeMCU, the BSI units were developed [14]. Each BSI unit is given a predetermined location before being deployed at particular bus stops. Users can choose from the various destinations and submit service requests using the display unit with BSI. The Android app can be used by the user to submit a service request. The requests generated by the system are stored in a database, and a selection process is conducted to determine the optimal route, leading to improved operational efficiency.

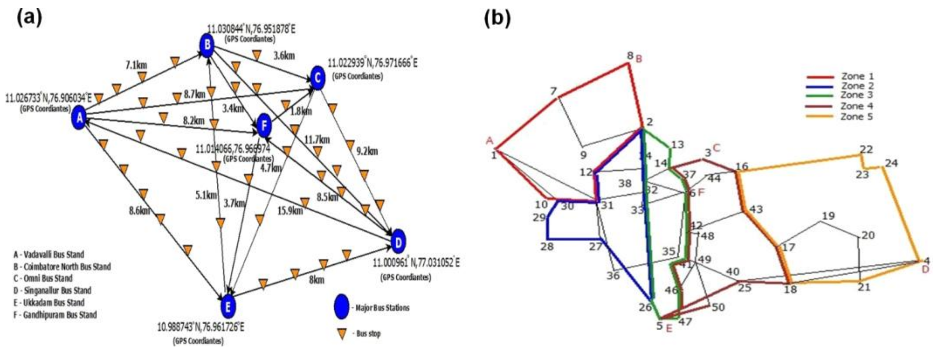

Figure 2: (a) Vital bus stoppages and interlinks considering blocks, and (b) route map illustrating zones

- **Route optimisation**

To cut operational costs, choosing the best path is crucial. In a metropo- lis, the traffic situation is constantly shifting. The shortest path is frequently determined using Dijkstra's Algorithm [15] and A-Star [16], which is insuffi- cient for smart transport operations.The Dijkstra algorithm was adjusted to take into account variables including city speed restrictions, traffic circum- stances, the number of passengers on board, and wait times for passengers.The method weights each potential route for a certain request according tothe aforementioned criteria, and the set of routes with the lowest weight is chosen as the ideal path. The algorithm keeps track of both the total number of people on board and the buses' maximum carrying capacity. The system also calculates and considers the waiting times for users who requested as- sistance as well as passengers who are currently on board.

$$W = Min(D, C, Max(S), Max(N_r)) \quad (1)$$

Where, D is the longest possible route between the source and the desti-nation in kilometres. C is the measure of how congested the traffic is, with 0 being the least congested and 1 being the most. There are different routeswith specified city speed (S) limitations. the total quantity of requests (N_r) arriving from every location along that particular route.

Table 1: bus count: region & inter-region

Region	Static Bus Count	Dynamic Bus Count
Region-1	6	4
Region-2	11	5
Region-3	8	5
Region-4	6	4
Region-5	4	3
Inter-Region	21	14

- **Algorithm**

Given that Coimbatore is one of the 100 smart cities under the mission, the algorithm is evaluated for this city. The examination of only a few city blocks is depicted in Fig. 2(a). These metropolitan blocks, which span a 50 square km region, provide a wide variety of routes, bus stations, and bus stops. Fig. 2(a) displays latitude and longitude information for the six main bus stops A, B, C, D, E, and F. Every stop on a route is taken into account. The bus stops will contain a BSI module so that customers can make service requests. There are two different kinds of bus services that are taken into consideration: static buses, which travel along a fixed route at regular intervals, and dynamic buses, whose itineraries are chosen and changed by an algorithm.

Fig. 2(b) displays a route plan in detail for the city blocks that have been divided into 5 zones. A zone is represented by each coloured outline. Numerous request possibilities were taken into account. i) Several requests from the same source.Multiple requests with the same source and destina- tion are conceivable. Requests that have different sources but share the same destination can be classified into categories iii and iv, respectively. All such requests may be intra-zone or inter-zone, depending on the source and desti- nation zones. The static buses database for the specific zone is first examined for these requests. If the demands can be satisfied by one of the static busesin the zone, users are allocated to that bus. The dynamic bus database forthe zone is reviewed for requests that static buses cannot fulfill.

5 static buses were thought to be in zone 1. Ten static buses were evalu- ated for zone 2. In zone 3, 7 static buses were also taken into consideration. It was believed that the bus arrival times would always be five minutes apart.

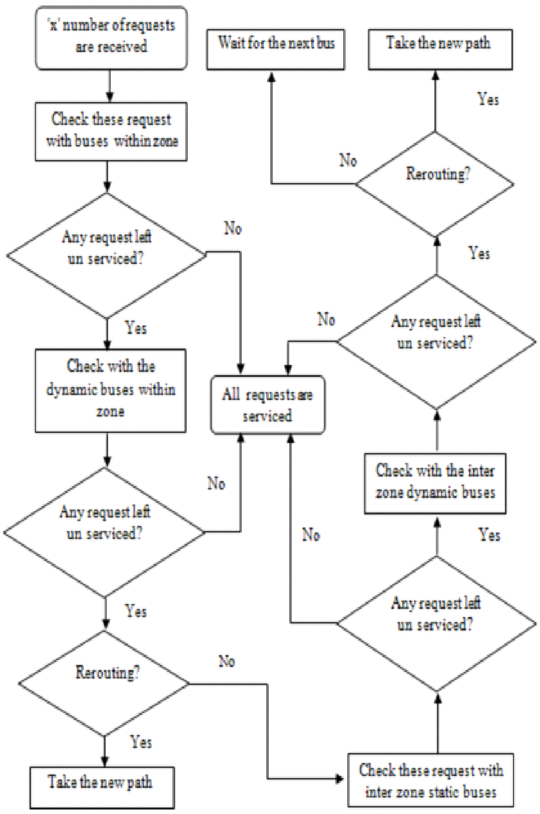

Figure 3: Flow chart/work flow of optimum preferred route

The number of buses in each zone and inter-zone is shown in Table I. For the evaluation, 50 requests from each zone are taken into account. Requests within a specified zone are organized and examined for bus availability based on the source and destination. The allocation of these requests to individual buses is dependent on the present geographical position and the passenger count in each zone. The user is advised to proceed to the nearest bus station that may be operational during the requested period, even if the desired bus stop is not serviced by any buses at that time. Unfulfilled requests are com- pared to the dynamic buses in the zone. Three dynamic buses are present in Zone-1, four are present in Zone-2, and three are present in Zone-3. Re- quest is still not being fulfilled. In order to further reroute dynamic buses, the algorithm also considers inter-zone static and dynamic buses. Rerouting occurs when the calculated weight of a prescribed path exceeds the weight of the rerouted way by a predetermined value provided by the operator. For the rerouted journey, the passengers waiting time is assessed, and rerouting is forgone if the waiting time exceeds a certain threshold. The dynamic bus follows the new route if rerouting is possible. Through the DAS, the position and path of the passengers are sent to the bus driver. The customers who have not received service are then instructed to await the next static bus. Fig. 3 depicts the algorithm as a flowchart. For all zones and requests in- volving other zones, the algorithm was assessed. Fig. 4 shows the rerouting of an inter-zone request.

The predetermined course of a dynamic bus is represented by the red route in Fig. 4. A total of 25 requests were considered for transportation from bus stop 42 to 31. Since there aren't any buses using route 42 at that time, rerouting might be considered. To fulfill the request, it is possible to redirect a dynamic bus departing from bus station 5 and heading towards destination 1, by routing it through 42. Even though there is a greater distance to travel, the new route has less traffic. The selection of the new route is based on the criterion of minimizing the waiting time for both passengers on board and desired users, ensuring that it remains below a predetermined threshold.

- **Conclusions**

For effective crowd mobility, smart cities must have smart transporta- tion. At a cheaper cost, the suggested solution can upgrade the current infrastructure. With a variety of request circumstances and request volume, the algorithm performs effectively. In order to enhance the efficacy of a planning tool for smart city transportation, it is possible to further enhance the algorithm by incorporating recommendations for the optimal allocation of static and dynamic buses in any given urban area.

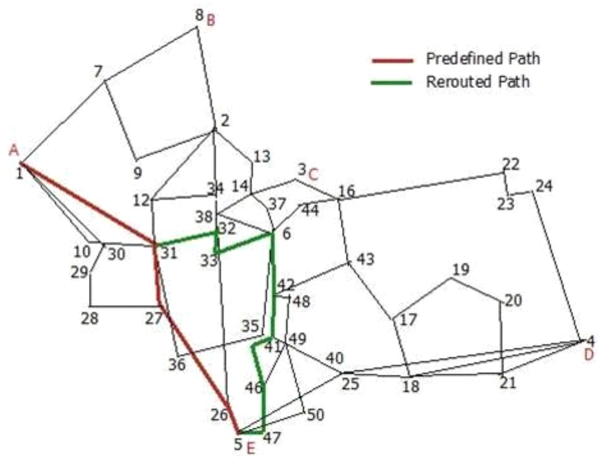

Figure 4: Inter-region request and re-routing

- **Conflicts of Interest**

There are no conflicts of interest to declare.

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