

A Systematic Review on Scheduling Public Transport Using IoT as Tool



Dharti Patel, Zunnun Narmawala, Sudeep Tanwar
and Pradeep Kumar Singh

Abstract Public transport can play an important role in reducing usage of private vehicles by individuals which can, in turn, reduce traffic congestion, pollution, and usage of fossil fuel. But, for that public transport needs to be reliable. People should not have to wait for the bus for a long time without having any idea when the bus will come. Further, people should get a seat in the bus. To ensure this, efficiently and accurately scheduling and provisioning of buses is of paramount importance. In fact, nowadays buses are scheduled as per the need. But these scheduling is being done manually in India. Our survey shows that there are many algorithms proposed in the literature for scheduling and provisioning of buses. There is a need to tailor these algorithms for Indian scenario. We present a brief overview of these algorithms in this paper. We also identify open issues which need to be addressed.

Keywords Scheduling · Provisioning · Public transport · IoT

1 Introduction

With an increase in population, the demand for public transport service also increases. This situation pushes the public transport infrastructure to its limits in peak hours. This has led to the late arrivals of public transport at their scheduled

D. Patel (✉) · Z. Narmawala · S. Tanwar
Department of CE, Institute of Technology, Nirma University, Ahmedabad, Gujarat, India
e-mail: 15mcen18@nirmauni.ac.in

Z. Narmawala
e-mail: zunnun80@gmail.com

S. Tanwar
e-mail: sudeep149@rediffmail.com

P. K. Singh
Department of CSE, Jaypee University of Information Technology,
Waknaghat, Himachal Pradesh, India
e-mail: pradeep_84cs@yahoo.com

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stops, inefficient use of resources, and a decrease in operating cost. And again this situation leads to switching of other modes of transportation by people which is undesirable. The traditional scheduling operation in India is not efficient for large-scale running routes [1]; i.e., public transport still lags behind in India. The intelligent public transportation scheduling becomes the main research area. Hence, by using the emerging technologies, public transportation can be scheduled in an optimized way to meet the public demand. Hence, to provide the better transportation services, the scheduling algorithms have been proposed which focuses on the many factors such as a number of passengers, the capacity of buses, waiting time of passengers, arrival time, and departure time. The best scheduling algorithm is one which leads to the decrease in waiting time of passengers while maintaining the capacity of the passengers in public transport. Hence, IoT is the most emerging technology which has been used by public transport services.

As per the survey of researchers, it has been concluded that all the present systems which are based on transportation system provide the service of either reservation or displays bus status. In transportation system, it is also important to maintain the schedule of buses. But due to traffic and many more parameters, schedules get disturbed. Usually, passengers have to wait for the buses because of bad scheduling, overcrowding, traffic congestion, and breakdowns. Overcrowding occurs because of not determining the correct frequency for demand and improper scheduling. Frequency relates to the number of trips which are needed to cope up with the passenger demand during a peak or fixed period. Hence, it is important to have exact traffic information to notify the exact arrival and departure timings of buses. This information can be available by using GPS [2]. Along with these, it is also important to schedule buses according to the requirements of the public. The solution is to develop efficient scheduling algorithm which can schedule the buses automatically by analyzing the historical data.

There are many scheduling algorithms available such as priority, round robin, first come first serve, last come first serve, and much more. But these algorithms are developed for operating systems. Algorithms like genetic algorithm [3], greedy randomized adaptive search procedure (GRASP) [4], trip frequency scheduling, and vehicle routing problem are such scheduling algorithms which either schedule the vehicles or finds proper routes for buses. These algorithms have the drawback in terms of a number of jobs or vehicles. There is a need of scheduling algorithm which can schedule buses as per the requirement of passengers on proper time and proper routes. Some algorithms use heuristics to calculate the parameters and schedule it accordingly. But these heuristics require same number of jobs with the same number of resources. Hence, if we use these algorithms for scheduling of buses, it will require the same number of buses with the same number of routes. It becomes compulsory to have the same number of parameters. Hence, it is necessary to develop such algorithm which can even schedule one bus. We can use assignment problem to assign buses for required route with heuristics to schedule the buses as per the requirement and reschedule the buses which are not required for that particular route.



Fig. 1 A future scenario of public transport

Figure 1 shows the present scenario of the public transportation system which uses RFID tags to track the public transport to have live data about the stops covered by the buses. It also uses GSM/GPRS to notify the passengers about the current status of buses. Servers are used from which data are fetched to notify the passengers. In more general, this system shows the school bus which is tracked using RFID tags and GSM/GPRS, and its status is notified to the parents so that their waiting time at the stops decreases waiting unnecessarily at stops.

According to the Planning Commission (2013) [5] survey, it has been concluded that there is an increase in traffic of public transport as people refer it much for traveling. According to the survey, people prefer railways and roadways increasingly and it is expected to grow up to 11 percent and 7 percent per year, respectively. By this, it is expected that traffic could increase up to 16 factors by next 20 years. Since it was about 7 to 8 factors in last 10 years, it is growing very fast. Hence, this proves the need for public transport which should be scheduled according to the need. Figure 2 shows an increase in traffic in roadways and railways in billion passenger kilometer (bpkm).

1.1 Contribution of This Paper

The main contribution of this paper is as follows:

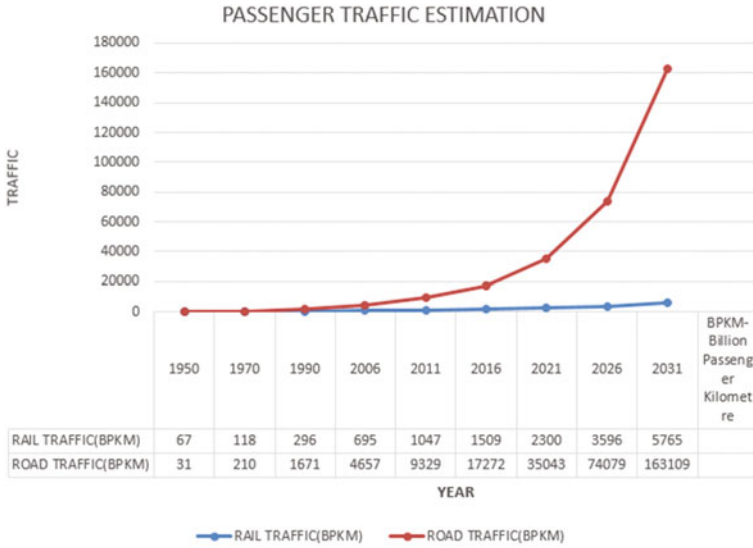


Fig. 2 Passenger traffic estimation

- A complete taxonomy of public transport, which can be further classified into general and selective approach, is provided using IoT as a tool.
- Approaches used for scheduling public transport are analyzed with respect to parameters, such as positioning, time.
- Finally, a systematic comparison of the various public transport system with pros and cons of each is provided in the text.

1.2 Organization

Rest of the paper is organized as follows. Section 2 presents the similar work done by various researchers in this domain with tabular comparison of each approach. Section 3 provides the challenges and open research problems in this domain, and finally, Sect. 4 concludes the article with future scope.

2 Literature Survey

This section provides the detailed description of the work done under this domain by various researchers. We have divided this description into two categories: generalized and selective. Next subsection explains each category in detail with pros and cons of each.

2.1 Generalized Approach

Since last few years, research has been carried out to develop the optimization models which will increase the convenience of passengers, and on the bus management side, bus operations are reduced. Depending on the approach for determining optimal solutions, the bus scheduling models studied so far can be classified into a number of types. These models use heuristics to calculate total traffic cost.

Fu et al. [6] proposed a new operating strategy in which service vehicles is followed by the lead vehicle with all stop service and also by providing the facility to skip some stops as an express service. Chen [7] measures bus service reliability, vehicle load capacity, by considering the headway adherence and average waiting time. Yan proposed a network flow problem using a mathematical model which uses Lagrangian relaxation. Kim et al. [8] constructed a schedule based on the starting point and stops by using travel time response model for critical scheduling areas.

2.2 Selective Approach

Vehicle Routing Problem In vehicle routing problem with time window, a number of vehicles are allocated to route and each with given capacity which is located at a single depot which is serving passengers dispersed geographically. In this problem, each passenger has been given the demand and they must be served in specific time window. The main objective of this problem is to minimize the total cost of traveling while serving the customers with minimum cost. Figure 3 shows the vehicle routing problem (VRP), and how a route is set up from base depot to each stop reducing the traveling cost. It reduces the path cost by setting the optimized route between stops from one station to other from depot. The main objective of VRP is as follows:

1. It minimizes the global transportation cost based on global distance.
2. Minimizes the number of resources needed to serve all customers.
3. Variation in travel time and vehicle load is least.

Online Dial-A-Ride Problem with Time Window (DARPTW) Routing and scheduling of buses can be referred as a On-line-Dial-A-Ride problem [7]. It takes care of the available set of resources and constraints. All the services related to the transportation is Web-based and handled by mobile phones. Here, request is generated one day prior to the beginning of service. Due to a high number of variables involved in it, the solutions available are based on heuristics. In the Online Dial-A-Ride Problem with time windows (ODARPTW) [9] requests are exhibited

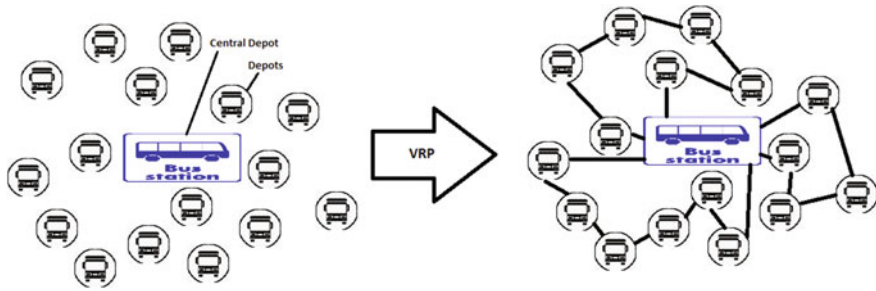


Fig. 3 Vehicle routing problem

after some time, requiring the server to convey the articles from sources to destination, while the server is en-route for serving the different request. On the off chance that a demand is to be served, the server must achieve the time between the demand's landing and its due date. The objective here is to plan techniques for the server to fill in whatever number of approaching requests as could reasonably be expected by their due dates in an on-line way. The system for ODARPTW neither has data about the discharge time of the last demand nor has the aggregate number of request. It must decide the conduct of the server at a specific minute of time as an element of the considerable number of request discharged up to time t (and the present time t). Interestingly, a disconnected technique has data about all requests in the entire succession as of now at time 0.

Assignment algorithm is operation research method to optimize the cost. It deals with the transportation problem and the assignment of jobs to the workers or assignment of resources to the workers. The ultimate objective is how to assign the jobs efficiently to the workers, and which worker should be assigned which type of job. In this problem, at least 3×3 matrix is required and also the same number of parameters. Assignment problem uses heuristics, in which the operating cost of the system can be maximized or minimized. If we are adding any constant in each and every element of columns and rows of the matrix, then it will generate a matrix, which can minimize the total effectiveness. A situation also exists, where we need to add a dummy column or a row when there are no exact number of resources, and jobs. The main disadvantage of this algorithm is a number of jobs must be equal to the number of workers or else allocation of jobs will not be efficient.

The data flow diagram of assignment algorithm is discussed below in Fig. 4. This diagram shows how assignment algorithm works with its two conditions. In assignment problem, basically there are two situations: First, when the number of cutting lines is equal to the number of rows and columns, and second, when the number of cutting lines is not equal to the number of rows and columns.

Fig. 4 Assignment algorithm

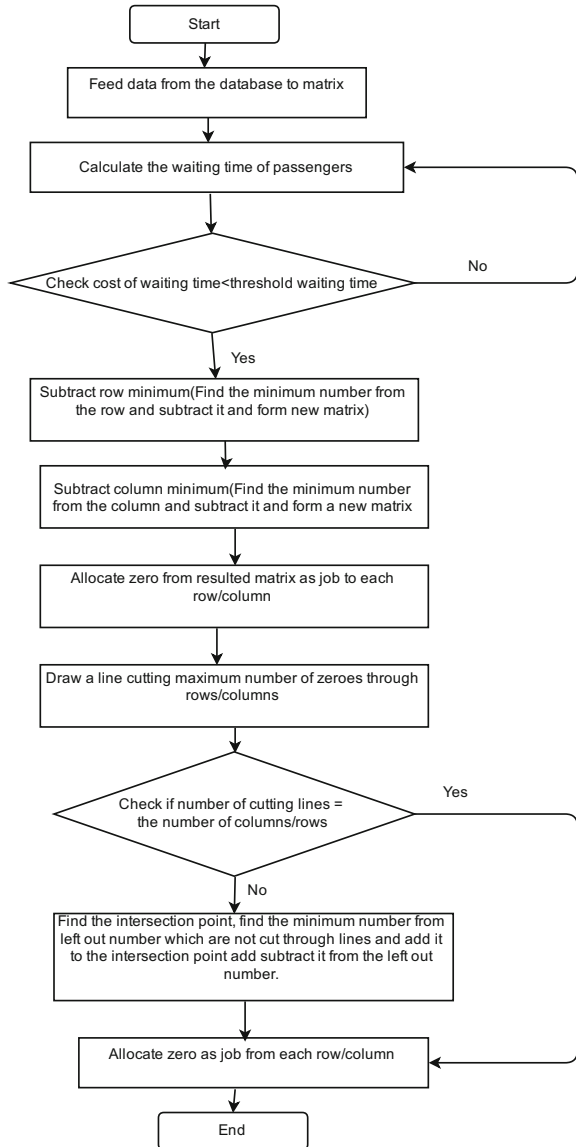


Table 1 represents the summary of the whole survey. In the table, there are four columns. The first column is the name of author, second is the algorithm/method they have used for implementation, third is what are the pros of paper, and the fourth one is what can be added/improved or cons in paper.

Table 1 Comparative summary of all existing approaches

Authors	Methodology	Pros	Cons
Nagadapally et al. [10]	GPS tracking is merged with mobile application to get the exact location of the bus on the map by reducing the waiting time of passengers	Displays the exact bus location	In situation there is lack of data in mobile, this system would not give an accurate result and it works only for selected versions of android and iOS
Asaad Abdul et al.	Developed a Web-based system, which allows passengers to check the availability of tickets with cheap prices.	Allowed passenger to choose their own seats and payment gateway	The passengers must be registered for searching and reservation
Sarma et al. [11]	Developed an algorithm, which predicts the bus arrival time by using existing GPS system	Determines the traffic at routes and also the seat availability	User receive the SMS using USSD technique and such messages cannot be saved so user does not have any other backup
Menon et al. [12]	System used sensors at entry and exit point to calculate the vacant seats of the bus	Used IoT to predict real-time traffic at routes	Cost of system increase installation of costly IoT-enabled components
Lau et al. [13]	System source and destinations timings were fixed to feed them with their order from depot	Source and destination timings are fixed to feed them with their order from depot so it returns an optimized solution which serves as many customers as possible	Restricted number of vehicle is used.
Guy et al. [14]	Heuristics approach used to minimize the cost of the system	Objective function was developed, which minimizes the cost of the system	How to order the nodes is the main problem of this system
Sulaima Le bbe [15]	GPS technology was used with RFID	This system provides data for future forecasting, congestion identification, travel route planning, and modeling	System is handled manually
Singh [16]	Focused on how assignment is done using different methods	Methods are used to optimize the cost of system	Some methods lack in optimization due to improper assignment

(continued)

Table 1 (continued)

Authors	Methodology	Pros	Cons
Olarthichachart et al. [17]	Used to find optimal trip frequency	Reduces cost of operation passenger service quality by efficient scheduling	Applicable to finite set only
Sulaima et al. [18]	Used wireless sensor networks to provide visual information for real-time system	Gives real-time information about the buses using GPS/GSM and Arduino	Only registered passengers can have real-time information

3 Challenges and Open Research Problems in Scheduling Public Transport

In existing public transportation systems, passengers need to register compulsory for traveling. Scheduling of transportation service is limited for the limited resources. Scheduling of public transport is not much efficient as it requires accurate data on traffic. Due to this, the waiting time of passengers increases. Passengers used to travel in public transport mostly in peak hours. Therefore, in peak hours due to nonexistence scheduling mechanism, passengers increase beyond the capacity of public transport. As capacity of public transport increases, the counting of passengers in the existing system is not efficient. Waiting time of passengers increases at stops in peak hours that is in morning and evening which increases traffic in buses. Hence, there is a need to develop an efficient and accurate system for scheduling and provisioning of buses dynamically based on current demand.

Public transport should provide safe traveling, cheap fare, and less travel time. In order to achieve these attributes, govt must focus on road network, optimal routing, and minimum delay. Public transport efficiency depends upon all other related factors, i.e. optimization of route, transfer optimization, and coordination among feeder bus service.

4 Conclusion and Future Scope

In India, traffic congestion problem is increasing day by day in urban centers. It is because of increase in population in urban areas with very high rate, and people prefer private vehicles over public transport, as they need to wait for a long amount of time to get a bus and often buses are crowded too. Hence, it is important to develop an efficient scheduling and provisioning of public transports so that waiting time of travelers reduces and everyone gets seat in the bus. Many algorithms have been proposed by various researchers as discussed in Sect. 2. These proposals do have their drawbacks as highlighted in Table 1. We need to improve these algorithms in terms of scheduling and provisioning of public transport for Indian scenario.

In future, we can develop a system which can allow seat reservation in real time. Sensors can be used to track seat occupancy and allow reservation for unoccupied seats.

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