WEB DEVELOPMENT

Smart Vehicle Rental and Real-Time Tracking Portal

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Abstract

This portal aims to provide an online platform that would make vehicle rental and transport booking easier. Traditional vehicle rental can cause issues such as unclear availability of vehicles, confusion in service, double bookings, lack of visibility along the journey, unclear cost and providing too much of a person's personal information. This portal provides the ability to rent vehicles with a driver, with no driver, emergency taxi service and tour booking. The portal is designed with a first come first served booking system, fixed cost and distance/time based cost estimation, finding the closest driver, vehicle tracking using GPS, driver ratings and masked communication. The booking system ensures the integrity of the booking by ensuring it is timestamped, transactional and by providing a temporary lock on the vehicle. The system has a client-server layout with a web front-end, application and relational database. This paper outlines the design of the system, the modules included, process and initial evaluation criteria. As there are no results from the implementation yet, the benefits relating to performance are the design goals to be evaluated by functional and integration testing.

Keywords: bookings; pricing; GPS tracking; vehicle rental; communication

1 Introduction

Transportation services have become digitalised. Booking through online services can save the user time by reducing the amount of contact needed with multiple rental services. However, to allow for a useful rental service, the portal should provide visibility in terms of availability, booking times, cost estimation, driver assignment, visibility along the journey and keeping personal information private. Issues can occur if these are separated into different services or need to be manually managed. This can result in uncertainty around availability, cost and who will be providing the service.

The Smart Vehicle Rental and Real Time Tracking Portal is proposed to be a single online system that provides customers with the possibility to rent vehicles with no drivers and vehicles with drivers. The portal will also allow for emergency taxi bookings and planned tour packages. This portal will help customers who want to rent a vehicle for various reasons and help rental operators have an efficient system for managing vehicles, drivers and bookings.

A major consideration was the possibility of multiple bookings. There could be two customers wanting to book the same vehicle within a short timeframe. This can be overcome by having a timestamped booking system using a first come first served (FCFS). This should be supported by an atomic database and temporary lock on the vehicle. Another consideration was the cost of the booking. Fixed pricing can be useful for pre-planned trips however distance and time based cost estimation is more suitable for varying journeys. Both of these options are provided.

The system also considers GPS tracking, finding the closest drivers based on availability and pickup location, driver ratings and masking communication. This will help keep personal phone numbers

from being shown. This is a design goal to be implemented with the correct mapping, telecom and location services.

1.1 Aim and objectives

To design an integrated rental portal that will improve booking management, provide clear pricing, visibility and privacy. The objectives are:

- Provide bookings with and without drivers.
- Provide emergency taxi bookings and tour bookings.
- Ensure no double booking with a FCFS system and transactional lock on the vehicle.
- Provide fixed or dynamic pricing.
- Find drivers with the closest location and availability.
- Provide visibility of vehicle location during active booking.
- Provide driver ratings and temporary masked communication.

1.2 Research questions

- How will simultaneous booking requests for one vehicle be resolved?
- How will fixed pricing and distance/time based pricing be provided?
- How will location and availability be used to find drivers?
- How will customers view the vehicle they have been assigned?
- How will the platform keep customer and driver information private?

2 Related work

Previous work has been done to create online systems for vehicle and driver rental. Automating the vehicle distribution, booking times, pricing and driver assignments using a user and admin portal [1]. The system in this paper takes this further by including emergency rides, tour bookings, real time tracking and privacy focused communication.

Research has been done to detect accidents in rental vehicles. This can be done using a hardware and software solution to detect simulated crash events with alerts sent to the vehicle owner. Basri and Abass describe a system using accident detection to notify the owner [2]. Whilst accident detection is not a main feature of this portal it shows how connected vehicle services can be used to help keep the fleet safe.

Research has been done to track vehicles using IoT. This can be achieved using a NodeMCU ESP32 and GPS modules to send the vehicle's location to a cloud [3]. This shows how tracking can be achieved in rental vehicles. The system in this paper will follow the same idea of retrieving location data and displaying it on a map. However this depends on good GPS signal, network availability and device set up.

Intelligent rental management has been researched. Suganya et al. describe how the system can forecast, predict and optimise using time series forecasting, predicting vehicle usage and optimising fleet size and staff [4]. AI can be used to analyse customer behaviour within the rental system [5]. This could help with forecasting future demand but falls out of the scope of this project.

Other research has been done into connected vehicle systems. A smart logging system has been created using peer to peer and edge computing to reduce reliance on storing sensitive data centrally [6]. Number plate recognition and automatic parking allocations shows how computer vision can be used to create intelligent mobility [7]. A car reservation information system has been created using a structured development methodology, showing how digitising the manual processes can be beneficial [8]. Blockchain has been discussed for creating a trusted and resilient system for intelligent vehicles [9]. IoT has been used to monitor vehicle maintenance using sensors [10].

The research has shown how to automate processes, track vehicles, intelligently manage the fleet, keep the vehicles safe and manage the data. The design of this system will allow customers to rent vehicles with different options, ensure no double bookings, provide fixed and dynamic cost estimations, driver rankings, real time tracking and temporary masked communication. This is to integrate the system (integration objective).

3 System methodology and design

3.1 Research and development approach

This project will focus on designing and developing a system. The requirements were identified from common issues with the rental process. The development process will focus on analysing requirements, designing the architecture, designing the database, developing the front-end, developing the back-end, integrating the modules and testing. The system will have a client-server layout with the browser communicating with the back-end APIs. The back-end will validate the requests and retrieve/update data using the relational database.

3.2 System architecture

The system will have three layers. The front-end will allow customers, drivers and admin to interact with the system. The application layer will handle authenticating users, searching for vehicles, booking, cost estimation, driver assignment, updating tracking, driver ratings and communication. The database will store customer and drivers details, vehicle details, availability, booking requests, payment references, trip locations and feedback. Mapping, GPS, payment and masked calling services may be needed.

3.3 Functional modules

User and role management – Users will have to login with their role.

Vehicle management – Operators will be able to update vehicle details including type, registration, capacity, rental cost and availability.

Booking management – Customers will choose whether they want to rent a vehicle with no driver or with a driver. They will enter the pickup, destination, date, time and booking type. Emergency taxi and tour packages can be selected.

Booking – Each booking will have a timestamp and status from the server. The booking will be checked for availability in the database using a transaction. The vehicle chosen will be temporarily locked. The first valid booking will be confirmed. If there are conflicting bookings, the user will be informed the vehicle isn't available. This will ensure no double bookings are confirmed more reliably than comparing click times.

Cost estimation – Fixed pricing will be used for pre-planned rentals or packages. Dynamic pricing will be calculated using the category of the vehicle chosen, estimated distance, expected time, base cost and any extra charges. The cost will be shown before confirmation. This may vary depending on the actual distance, time, waiting time and agreed extra charges. This should be made clear to the user.

Driver assignment and ratings – If a driver is required, the system will filter drivers based on availability. Drivers will be ranked based on closest pickup location and estimated arrival time. Before confirming, the driver should be checked to see if they are eligible and assigned. Once the trip has been completed, the customer can leave a rating. The top 3 eligible drivers will be displayed on the leaderboard. This will be calculated based on a set formula. There should be a minimum amount of completed trips to reduce bias from having very few ratings.

Tracking and privacy – The GPS or driver app will provide location data. This will be sent to the back-end and displayed on the map. Calls can be made using a masked number service. This will only be enabled whilst the booking is active. Once the booking has been set up to the defined handover/trip stage, it will be disabled. This will depend on the availability of the provider and privacy requirements.

3.4 Booking process

The customer will register and login. They will choose the booking type, enter vehicle and trip details. The system will calculate a cost. The booking request will be accepted. The back-end will validate the vehicle is available. The vehicle will be locked using the FCFS method. Once confirmed and any payments authorised, the driver will be assigned. Tracking and masked communication will be enabled. Once the trip has been completed, the booking will be closed. The vehicle will be updated to show availability. The customer can leave a rating for the driver.

3.5 Data and database design

The relational database should include links between entities. These will include users, roles, vehicles, drivers, bookings, trips, cost, payments, location updates, ratings and masked calls. Primary and foreign keys will be used to link the records together. The booking status, vehicle availability and driver availability should be updated consistently. Sensitive data should be kept secure by using authorisation, secure communication, password encryption and limiting how long it is stored. Card details should be handled by a compliant payment provider.

3.6 Implementation technologies

The technologies to be used are HTML, CSS, JavaScript, React.js, Node.js, Express.js and MySQL. React.js will be used for the front-end. Node.js and Express.js will be used for the back-end API. MySQL will be used to store structured data. GPS and mapping will be used for location.

4 Preliminary evaluation and results

This project provides information on the design of the system and what should happen. There is no data from testing so this section will outline the initial evaluation criteria. The following should be carried out:

- **Booking:** Multiple bookings should be made within a short timeframe for the same vehicle. Ensure no more than one is confirmed. Log the timestamps, transaction and final vehicle status.
- **Cost:** Compare the fixed cost for packages and dynamic cost. Ensure the calculation is showing as per the set pricing rule.
- **Driver assignment:** Create a list of drivers with and without availability. Ensure the chosen driver meets the criteria based on the pickup distance.
- **Tracking:** Ensure the coordinates shown on the map match the GPS or test app. Note the delay in updates and any signal issues.
- **Privacy:** Ensure only the masked contact method is shown on the customer and driver portals. Disable once the end stage has been reached as set.
- **Ratings:** Enter sample ratings after the trip. Ensure the average is calculated and the leaderboard is correct.

The initial design of the system has been created to overcome the issues identified. Double booking will be avoided using the FCFS lock. Unclear pricing will be overcome using fixed and dynamic cost estimation. Limited visibility will be overcome using GPS to update the map. Closest drivers will be found using availability. Driver ratings will be provided. Personal numbers will be limited using masked communication. All of these are expected outcomes.

5 Discussion

The main benefit this portal provides is the integrated functionality. The customer can easily rent vehicles with no drivers, with drivers, emergency taxi and tour packages. The rental operator can have everything in one place to help manage the vehicles and bookings. The FCFS is an important part of the system as having a timestamp doesn't fully guarantee the booking will be intact. The database needs to serialise the conflicting confirmations and ensure the vehicle is available.

The dual pricing system allows for different types of trips. To ensure clarity, the inputs for dynamic pricing should be clearly explained. The cost should also be made clear that this is an estimated cost. Finding drivers with the closest availability will help reduce unnecessary searching. However, the driver should be willing to take the job, have a compatible vehicle and be within the service area. The driver leaderboard may encourage good service. This should use confirmed completed trips and precautions taken to avoid fake or revenge ratings.

Using real time tracking can help increase customer awareness and help manage active trips. However this will depend on location permissions, battery life, GPS signal and network. Using masked communication can help reduce personal numbers being shown. However this won't fully guarantee privacy. This will depend on the provider, call details and how long the data is stored. Overall this design will provide a practical integrated system for rental management and connected transport.

6 Limitations and future work

The system relies on an internet connection to allow for booking synchronisation, real time tracking and communication. The GPS may not be as accurate inside, in busy urban areas or if no satellite signal can be received. Using mapping, payment and masked number services can cause costs, dependencies and region restrictions. The vehicle availability and driver status will rely on timely updates. Authorisation, secure communication, password security, careful handling of location history and data retention policies should be used to ensure security and privacy. The database may need to be optimised if there are more vehicles being used. Caching, load balancing and monitoring can be implemented.

In the future AI can be used to forecast demand, optimise routes, predict vehicle maintenance, multilingual mobile apps, automated emergency notifications and extra payment options. These should be prioritised once the core booking, tracking and privacy have been validated.

7 Conclusion

This paper outlines the design of the Smart Vehicle Rental and Real Time Tracking Portal. The portal will allow customers to rent vehicles with no drivers, with drivers, emergency taxis and tour bookings. The system will be integrated with vehicle and booking management, FCFS booking, fixed and dynamic cost estimation, closest driver assignment, GPS tracking, driver ratings and temporary masked communication. This has been designed to overcome practical issues with the fragmented booking process.

The system will be reliable if the booking locks are carefully implemented, the cost rules are accurate, the driver and vehicle details are trustworthy, the location updates are consistent and the third party communication is secure. This manuscript outlines the design of the system and how it will be evaluated. There are no claims that improvements have been measured as the tests have not been completed. The effectiveness, scalability and suitability for real world rental will be determined once the system has been implemented and tested.

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