A COMPARATIVE STUDY AND ANALYSIS OF DIFFERENT CARPOOL MODELS

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Abstract: Transportation is one of the major issues in our country leading to a lot of related problems. Lack of fast, adequate and secure public transport system leads to the use of personal transport which in turn leads to an additional overhead on roads and is a major reason for traffic jams. [1] Most commuters travel at the same time of day, resulting in the morning and evening rush hours and since our public transport systems are not designed or maintained well enough to cope with the peak demands it causes congestion and accidents on the roads. Cars carrying only one occupant use fuel and roads less efficiently than shared cars or public transport, also it is a major factor contributing to air pollution, road traffic and work delays during rush hours. Carpooling or car-sharing is the sharing of car journeys by the commuters who commute on a similar route which prevents the need for each commuter to use his vehicle to drive to work. Carpooling can help commuters reach their destinations more quickly, encourage people to socialize and spend time together while reducing air pollution and congestion on roads. In this paper, we review and discuss the various models of carpooling.

IndexTerms - Transportation, congestion, air pollution, carpooling.

I. INTRODUCTION

In recent years the number of vehicle owners has increased due to the lack of proper public transport systems and also it is time-sensitive, commuters prefer to have their transport as it gives flexibility concerning time, route and convenience.

Table 1 shows the amount of increase in vehicles registered in India from 2015-2018. This growing trend of driving to work by personal vehicles where each car has only a single occupant leads to an increase in the number of vehicles on roads during the rush hours, which further leads to related problems such as longer trip times, road traffic collisions. [3] The National Crime Records Bureau (NCRB) 2016 report states there were approximately 496,762 road traffic collisions in 2015. [2] Every year the lives of approximately 1.35 million people are cut short as a result of a road traffic crash and between 20 and 50 million people suffer non-fatal injuries, with many incurring a disability as a result of their injury.

Table 1: Number of Motor Vehicles Registered In India

Year	No of Cars
2010	1,37,49,406
2011	1,54,67,473
2012	1,75,69,546
2013	2,05,03,389
2014	2,16,71,515
2015	2,38,07,986
2016	2,56,34,824

Source: Ministry of Statistics & Programme Implementation

Traffic is also correlated to another major factor that is detrimental to not only human health but the planet as a whole that is air pollution. Traffic congestion leads to an increase in trip time, with the slow speed the vehicle inefficiently uses fuel and contaminates the environment which can lead to depletion of fuel levels.[5] As per a study based on 2016 data, at least 140 million people in India breathe air that is 10 times or more over the WHO safe limit. [4] 13 of the world's 20 cities with the highest annual levels of air pollution are in India.

Air pollution has contributed to the premature deaths of 2 million Indians every year and also has been the cause of severe diseases such as cancer, heart diseases and hence this issue needs to be taken care of at an intense level. An increase in the number of vehicles also leads to a lack of parking space not only in residential areas but also in workplaces because of the imbalance between the parking space available and the number of workers owning the car.

An efficient and sustainable solution to overcome all these issues is to reduce the number of vehicles on the roads by sharing rides with people who commute over a similar route and time, known as carpooling or car sharing. [6] By having more people using one vehicle, carpooling reduces each person's travel costs such as fuel costs, tolls, the stress of driving, air pollution, carbon emissions, traffic congestion on the roads, and the need for parking spaces.

The travel cost which earlier the single occupant had to take care of, with carpool the travel expenses gets divided equally between all the occupants of the vehicle. Carpooling can be easily achieved through many different mediums like web applications, smartphone applications, carpooling agencies, and pick-up points.

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II. ADVANTAGES

1. Readily reduce the traffic and congestion on roads during rush hours.
2. Availability of more parking space.
3. Reduction in carbon emission levels and air pollution.
4. Reduction in car collision accidents caused due to traffic.
5. Decreased use of fuel.
6. No work delays.
7. Help people to socialize and make rides convenient.
8. Less stressful than commuting alone.
9. Social justice: people will be able to make car trips without becoming car owners.

III. DIFFERENT MODELS OF CARPOOL

Various models of carpool have been proposed in the past years, in this paper we will analyse the following three models. They are carpool using an Android platform, intelligent carpool system, and carpool system based on cloud computing strategies. The different models are described below.

3.1 CARPOOLING SYSTEM ON THE ANDROID PLATFORM

The android is one of the booming platforms because of its flexible and open-source nature in mobile technology in the world today [7] as of 2019, Android held a share of about 91 percent of the mobile operating system market in India.

The carpool application based on the Android platform will not only render it as real-time and dynamic that will provide a safe, affordable ride at your fingertips from anywhere and at any time, but will also help in conserving the environment.

[8] The application will allow the user to register his/her role i.e. driver or passenger and once the user has logged in successfully the passenger or driver will enter his travel details. [8] The passenger gets information about the drivers who travel along the same route which they can confirm and a message will be sent to the driver who also confirms the passenger and accordingly the seats will reduce. Table 2 gives an overview of the events, inputs, and outputs required by the carpool application.

The advantages of this model are as follows.

1. [8] Pre-registration ensures security, as only identified people get into the vehicle so that trust can be established, before accepting the carpool request the user can view the profiles of the creator and vice versa.

The drawbacks of this model are as follows.

1. It lacked selection of the rides dynamically by the application based on the proximity of the user's source or destination, the user had to manually search from the displayed rides.
2. The route of the commute is decided by the driver hence it cannot be the optimal path always.

Table 2: Events in carpool application on Android platform

Sr no.	Event	Input	Description
1	User registration	Id	Auto generated Unique identification for every user.
		Name, Address, Ph. no, Email id, gender, dob, Photo, Password	Personal information of carpool users.
		User Role	Driver or passenger of the carpool
2	User login	Username, Password	For authentication purposes
3	Create a Carpool (created by Driver)	Event Id	Auto generated unique identification for each car
		Source, Destination, Time Vehicle details	Travel details, vehicle details include car number, car type and no. of seats available.
4	Join a Carpool (created by passenger)	Source, Destination, Time	Travel details

3.2 INTELLIGENT CARPOOL SYSTEM

With the advent of latest technologies, the handheld devices have undergone a metamorphic change to become intelligent. In this era of smart devices [9] the web-based carpool system has become more advanced and is now referred to as the intelligent carpool system (ICS). Through the use of smart devices along with Global Positioning System (GPS) navigation and mobile communication ability, users can instantly access real-time carpool service, with their current locations and other required information input by their smartphones, tablet, or other devices.

Intelligent carpool system (ICS) is divided into two main modules as described in Table 3

Table 3: Intelligent carpool system (ICS) main modules

Module	Description
MC Module	It is a dynamic real time mobile application built on some advanced platform, GPS enabled for providing users their current location details also it is used for creating and accepting the rides by the users.
CS Module	It provides interoperability between MC module and RESTful API, it uses Google cloud messaging a free service for message queuing and delivery from servers to target i.e. carpool application

[9] CSP is a multi-purpose optimization problem that deals with matching the maximum number of passengers with drivers, as well to minimize the average distance travelled by drivers, the average waiting distance of passengers, and the average travel distance of passengers.

The process of matching the best rides by the provided inputs is handled by GCRMA a genetic algorithm via the ICS. Fig.1 shows the composition of GCRMA which consists of two main modules, which contain different procedures respectively.

[9] EI (Evolution Initialization) consists of chromosome representation of the user's request and uses distance-based greedy heuristics to generate an initial population. The GE module can find the optimum carpool route and matching results.

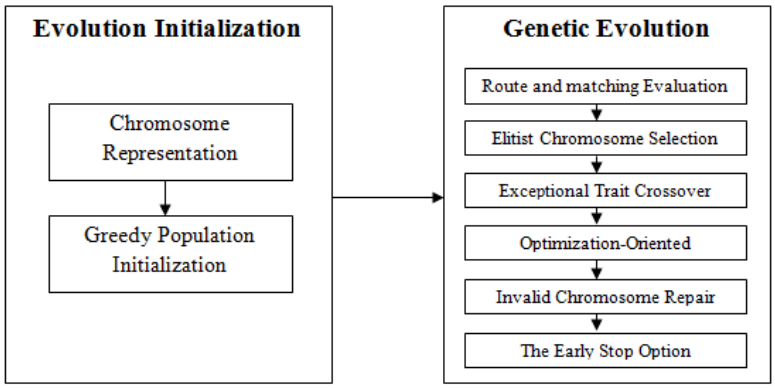

Figure 1: GCRMA Composition

The advantages of this model are as follows.

1. ICS makes carpooling easy for drivers and passengers, they can find a ride at any time and in any place.
2. It finds the shortest route among the available routes.
3. The system allows the passenger to the suitable driver automatically based on the specified parameters.

The drawbacks of this model are as follows.

1. Real-time traffic status is not considered, so it doesn't provide an optimal path.
2. Rides are considered to be free of cost, the system lacks an integrated charge calculator.
3. The system uses complex concepts and algorithms.

3.3 CARPOOL SYSTEM BASED ON CLOUD COMPUTING

Cloud computing is one of the finest technological innovations in information technology growing at a pace. Cloud computing is a wide pool of on-demand computer system resources such as data, computation, etc. available at any place and at any point of time without any human intervention or management.

Carpooling application was initially divided into two sections, the application which provided either classic or dynamic carpooling services. The classic [10] indicates that its users effectively schedule and advertise their plans for a trip well in advance via a searchable electronic bulletin board, seeking other users traveling in the same direction at the same time. The classic method was inconvenient and less preferred by the users. The solution was[10] dynamic carpooling mobile apps and website, indicated by their use of real-time passenger requests along with the real-time vehicle driving users' location data, foregoing the need for well in advance pre-scheduled and advertised trips.

The aim was not to restrict the application to mobile platforms but to make it ubiquitous and available for web platforms as well. To achieve this ubiquity, the best option is to use a combination of HTML/CSS for user interface (UI) rendering. The real-time web technologies such as XML (AJAX), web 2.0 all relied on HTTP, Apart from its real-time nature these techniques had few drawbacks such as notwithstanding client-side implementation difficulties, the amount of server-side, network, hardware resources they consume. Hence new techniques such as HTML specification Server-Sent DOM Events (SSE), Web Sockets API which provides full-duplex communication and lower latency make them the best option for building real-time communication on the web.

In WS communication, the concept of [10] vertical scaling of server hardware resources can be expensive and still limiting. The solution to the problem is horizontal distribution. In horizontal scaling, we also have to consider the scaling of data. Relational data scaling is much harder, we have shifted to non-relational data (NoSQL). NoSQL databases besides easier scaling, offer better performance. Ideally, any global real-time solution would be best served in one's server farm, but it incurs hardware as well as maintenance costs, therefore renting cloud resources is more suitable.

To make the system real-time, a library called SignalR which is capable of WS protocol communication in .NET was used. [10] SignalR is an open-source library for ASP.NET to add real-time web functionality to .NET applications it is also capable of supporting clients written in .NET, JavaScript, and some other programming languages.

The system was deployed on Microsoft windows azure cloud platform and a NoSQL key-value memory cache data store named Redis was used. [10] Since a new server node can be cloned, and any cloned node's Redis instance can then be easily subscribed to a Redis instance of an existing node, we can easily increase the number of new server nodes to meet all of our scaling needs. Besides Redis NoSQL, it incorporated another NoSQL document-oriented geospatial indexing data store for ease of scaling, named MongoDB.

[10] All the clients also use a reactive programming paradigm, connecting to the backend via code using the Reactive Extensions for JavaScript (RxJS) library. If the mobile device's web browser does not support WS transport, SignalR client in JavaScript will gracefully fall back to other means of seemingly real-time transports, which RxJS will continue to process as asynchronous events. Windows Azure built-in Access Control Service (ACS), allowed the users for the single sign-on.

The solution was tested in the real world and once it becomes stable it will be open for all the public to use. Some other difficulties, such as security and privacy, will also need to be tackled for which the [10] 3rd party location-based service (LBS), which used OAuth protocol to authenticate and subsequently authorize which exact set of users would be allowed access to the authorizing user's location was employed but soon LBS was shutdown.

The advantages of this model are as follows

1. High uptime and availability of the service because it is hosted on the cloud.
2. The UI is user-friendly as it is totally based on novel web technologies.
3. It runs across all the platforms i.e. web, mobile.

The drawbacks of this model are as follows

1. Security and privacy is still an issue when it comes to cloud storage.
2. The application can face downtime since it is hosted on the cloud.

IV. CONCLUSION

Carpooling is an effective solution to overcome the problems relating to traffic, air pollution, accidents, etc. It also encourages socialization, where the commuters meet new people making new connection also it can help to reduce the stress and loneliness of the driver, It also takes a step forward in the reduction of the carbon footprint which is total emissions caused by an individual.

Various carpool models discussed in this paper revolves more around the static carpooling approach which is not practical to be implemented in the real world across the globe. We need some real-time dynamic solution which can handle multiple requests and responses by the users. A ubiquitous solution that can work across all the major platforms. Also, attention is required in terms of security and privacy so that the user's data is preserved safely. Since carpooling is a time-critical activity the processing of rides, showing the best possible rides, routes and fare calculation has to be brisk enough and in real-time to meet the requirements of the users to make the system widely acceptable by the people across the globe.

REFERENCES

[1] https://en.wikipedia.org/wiki/Commuting
[2] https://www.who.int/news-room/fact-sheets/detail/road-traffic-injuries
[3] http://ncrb.gov.in/StatPublications/ADSI/ADSI2015/chapter-1A%20traffic%20accidents.pdf
[4] https://factor.niehs.nih.gov/2018/9/feature/3-feature-india/index.htm
[5] https://ig.ft.com/india-pollution/
[6] https://en.wikipedia.org/wiki/Carpool
[7] https://www.statista.com/statistics/262157/market-share-held-by-mobile-operating- systems-i n-india
[8] Avila Antao, Venisha Correia, and Savio Gonsalves (April 2015). Carpooling Application in Android. International Journal of Current Engineering and Technology, Vol.5, No.2, pp. 955-958.
[9] Anuja Shete, Vedashree Bhandare, Leena Londhe (2015), P.B.Mali. Intelligent Carpooling System. International Journal of Computer Applications (0975 – 8887) Volume 118 – No. 4, May 2015, pp. 26-3.
[10] Dejan Dimitrijević, Nemanja Nedić, Vladimir Dimitrieski (2013). Real-Time Carpooling and Ride-Sharing: Position Paper on Design Concepts, Distribution and Cloud Computing Strategies. Proceedings of the 2013 Federated Conference on Computer Science and Information Systems, IEEE, pp. 781–786.