Solve the Problem of Urban Parking Through Carpooling System and Blockchain Advertising

Sheng-Ming Wang[1](✉) and Wei-Min Cheng[2](✉)

[1] Department of Interaction Design, NTUT, Taipei, Taiwan
ryan5885@mail.ntut.edu.tw
[2] Doctoral Program in Design, College of Design, NTUT, Taipei, Taiwan
t108859003@ntut.edu.tw

Abstract. Currently, the problem of urban parking is getting serious. Limited by laws and regulation, cannot go through improving the parking fee to reduce the demands. This research tries to use the internet of things (IoT) and blockchain to provide a carpooling system to reducing the needs of parking and urban traffic congestion. The research design to build a platform which is through social internet of the vehicle to make a connection between urban of vehicle and need of customers. Making passengers who have the same destination can ride the car together at any time and reducing the needs of urban parking. The passenger needs to watching advertising and provide the basic information itself to exchange the service of riding. Through the simulation could find that the design mechanism could achieve the expecting, reducing the needs of parking problem during the urban peak hours. If the design mechanism and service pattern could attract most users and make a profit from user data, it is possible to let the system operation continued. Meanwhile, integrate the autopilot system could make the service system to become an important application of traffic service in the smart city.

Keywords: Car sharing system · Social internet of vehicle · Advertising of IoV · Carpooling system of IoV

1 Introduction

Following the development of the economy and ages, the vehicle is getting popular in life, and the number is growing every year. However, the space of urban is limited. Even cities with well-planned parking cannot cope with the growth of urban vehicles every year [1]. According to the normal planning of urban parking, the space for public parking is less than half the amount of cars. Currently, the problem of urban parking is getting serious. Even use all spaces completely, it still cannot be solved at popular spots during peak hours [2].

In order to protect fairness and justice in society, the government makes the law to limit the fee of parking, and one can have a right to parking no matter you rich or not in the city [3, 4]. Hence, Limited by laws and regulation, it is impossible to reduce the demands by upping the parking fee or planning more space for parking.

H. Krömker (Ed.): HCII 2021, LNCS 12791, pp. 144–155, 2021.
https://doi.org/10.1007/978-3-030-78358-7_9

Amount of vehicles in the city is growing, but the urban space of parking is limited, even we could have other ways to help, the best way to solve the problem is to reduce the amount of car using [5, 6]. With the increase of 5G network transmission speed and the popularity of self-driving car technology, carpooling systems and the social internet of the vehicle have become increasingly popular in cities [7]. In addition to public transportation, carpooling sharing system could improve the problem of insufficient parking spaces [9].

According to research findings, people who tend to ride-sharing mainly consider freight costs, and social and safety are also important indicators for determining whether to ride-sharing. Appropriate fare subsidies or higher-intensity social services may be helpful for the frequency of use of the urban carpool system.

This research purpose a design concept, establish a city car-sharing system by the internet of vehicle. Meanwhile, increasing subsidies for voluntary drivers and encourage the public to use the carpooling system in the city in order to reduce the need for urban parking spaces and ease traffic congestion. Besides, try to create a self-operating system model through the use of value-added ride-sharing data so that the carpooling system can continue to operate continuously through profit.

Blockchain has a particular characteristic of Decentralization. It has a significant value to preserve the public data, even could be used in save of decentralization data [10, 11]. If the system could collect the car-sharing data by blockchain, It can promise fairness without modification, also get the rely on advertiser and research institute to improve the willingness of using and paying [12]. In the end, If the blockchain can be used in conjunction with the Internet of Vehicles mechanism to create a decentralized system and reduce the system burden and traffic requirements of data obtained by the central host, it will also help the long-term operation of this system.

The research has two main goals: including how to design the carpooling system and how to measure the feasibility of this system.

2 Related Work

2.1 System Design

Platform

This idea is to design a shared ride platform that provides matching services between drivers and passengers. Then transform the data generated in the service into working capital for sustainable operations. Through the blockchain, The data is placed directly on the devices of all drivers and passengers who participate in this platform and is properly encrypted and stored. And all transactions on the platform will also be conducted through digital currencies similar to Bitcoin. The following is an explanation of the various roles in the service and its relationship with the platform:

Passenger

This service must provide passengers with an opportunity to find the car so that passengers can find drivers who drive in the same direction at the same time and travel together. Ridesharing allows you to meet more friends, and you can save the trouble of finding

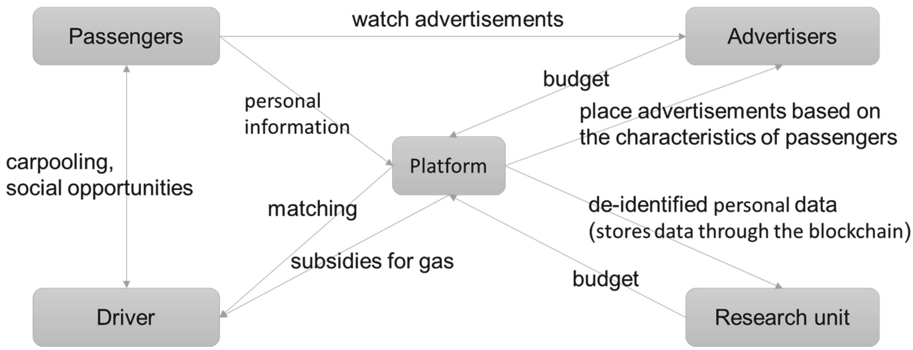

Fig. 1. System structure

parking spaces when you arrive at your destination. Not only reduces exhaust emissions, but it also lowers car expenses! To obtain the platform's services, passengers must agree to provide departure location and destination data and the time spent on the ride for free during the service period or assist in clicking and watching the advertisements provided by the platform so that the platform can continue to operate.

Driver

The platform provides drivers with a service to subsidize fuel costs. In addition to giving drivers the opportunity to meet more friends, this shared ride platform will also offer appropriate fuel subsidies based on the length of the route they drive, and at the same time help the government solve the city problems of traffic congestion and insufficient parking spaces. If the government unit can actively encourage such high-capacity driving and give them rewards, I believe it will significantly improve urban traffic.

Research Unit

This service provides research units with an opportunity to obtain a large amount of personal movement path data. This platform uses the mechanism of blockchain. The information provided by this service is credible and traceable. Moreover, the information of the starting point and ending point can be accurately grasped, so there is an opportunity to obtain cooperation and profit from the research unit through this service. This service can maintain long-term operation by assisting research units in conducting surveys of audiences to obtain higher compensation.

Advertisers

Since this service can obtain the movement trajectory of drivers and passengers, the trajectory information can be further analyzed and used. The analyzed data can be used to create advertising products with more commercial potential. In the current advertising market, most of the advertising is to analyze the ethnicity or region and place the advertisement in the right place. Less based on the movement trajectory, if the movement trajectory can be provided and provide various advertising services closely related to life, It is believed that such applications will become a new trend in the future development of 5G.

2.2 Main Services

Ride Matching

The operation of the platform must be profited mainly by obtaining the rider's trajectory data. Therefore, the more users use, the more data they use, which is crucial to the growth of the platform. Thus, the operator must try to match drivers and passengers through various methods to increase the matching rate between drivers and passengers. The methods that can be used include allowing potential drivers to see the needs of passengers or providing more passengers with different types of needs to obtain ride-sharing services. The service mechanism can provide passengers with an interface for making demands. After statistics, the system exposes all the routes that need to be provided with driving services and uses various reward mechanisms to make drivers willing to provide services. The feasible method includes allowing drivers to choose passengers or giving different levels of fuel supplements, and these supplements can also be provided by the passengers. At the same time, if the travel path can be arranged appropriately, it will be able to meet the travel needs of more passengers.

Matchmaking

If ride-sharing data can be used, it may be able to create more value in the current standard social services. Shared riders must provide accurate destination and time in order to be matched to a suitable rideable vehicle. Therefore, users cannot provide fake data, so the data can be trusted, and the accuracy rate is high. After statistical analysis, it is possible to know when and where each passenger will be at, so it can accurately confirm the moment of encounter between any two passengers. If the meeting between people is cleverly packaged into a social service product, there will be a chance to profit from it. For example, the following types of social products may be mentioned: New friends who appear in the same place today, friends who often meet, friends who meet at a particular time, friends who meet in a specific location, friends who often go to the same place, and so on. As long as you use data analysis to get different lists of friends, you can provide various services to allow users to follow their personal preferences and pay the price they are willing to pay to expand their connections.

Advertising Matching

The primary source of profit for the platform is advertising. Therefore, how to provide advertisers with various advertising needs is the core of this service. Standard advertising services in the market generally analyze user groups based on their behavior and provide advertising services. The service we hope to provide is not to judge user groups through their behavior. Still, the trajectory of movement, frequency, and location are directly used as the criteria for placement so that advertisers can directly contact the customer groups on a specific moving path. The advertising platform's design uses blockchain to create an advertising system that truly belongs to the Internet of Vehicles. The goal is to store all advertising content directly on each car networking node in the ecosystem. When a specific user needs information, each node will assist in providing content to reduce flow demand. Also, all the shared data is not stored in a particular location by a specific unit. After collection, information is placed on all participating nodes through algorithms and encryption mechanisms to ensure the data's authenticity (Fig. 2).

2.3 Data Analysis

Carpooling Data

Ride-sharing data is composed of the starting point of the ride to the end of the ride of a specific object, and it also contains the purpose of the journey and the time of movement. We can organize the item's data, starting point, ending point, purpose, and time, and cooperate with various statistical algorithms to gradually transform the ride-sharing data into different service needs. Including conversion to frequency, period, touchpoint, amount, trajectory, and then conversion to a group, key path, gathering point, meeting point, and finally, you can get the necessary information for social and advertising applications. The following table is a reference for some data calculation results (Tables 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10).

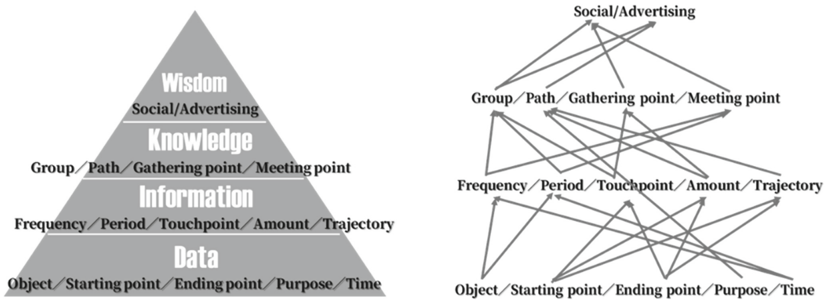

Fig. 2. Data structure

Table 1. Object/Starting point/Ending point/Purpose/Time

Object	Starting point	Ending point	Purpose	Weekday	Time
Person1	Dongmen	Xihu	Working	Tuesday	18
Person1	Dongmen	Kunyang	Traveling	Saturday	10
Person2	Huilong	Xindian	Working	Monday	9
Person2	Huilong	Xindian	Working	Wednesday	9
Person2	Huilong	Xindian	Working	Friday	9

Table 2. Frequency/Time

Object	Location	Time	Frequency
Person1	Xihu	9	17
Person2	Xindian	14	22
Person2	Tamsui	18	30
Person3	Zhongshan	8	30
Person3	Zhongshan	18	22
Person3	Zhongshan	21	14

Table 3. Touchpoint/Amount

Touchpoint	Weekday	Time	Amount
Shongshan	Monday	9	146
Shongshan	Monday	10	22
Zhongxiao sogo	Monday	17	45
Zhongxiao sogo	Friday	19	144
Guanghua	Friday	12	65
NTUT	Sunday	12	11
NTUT	Sunday	15	33

Table 4. Trajectory

Path	Weekday/Weekend	Time	Amount
Shongshan-Dongmen	Monday	12	129
Shongshan-Dongmen	Monday	13	213
Tamsui-Zhongshan	Monday	8	131
Tamsui-Zhongshan	Thursday	8	153
Tamsui-Zhongshan	Friday	8	164
Kunyang-Xindian	Saturday	15	382
Kunyang-Xindian	Sunday	15	453

3 Feasibility of System

Because of the different conditions in each city, the way of lane planning and the dense working places are also different. For the convenience of explanation, we first use a relatively simple model to look at the possible effects and results of this whole mechanism. We can simulate a city with a commute distance of about one hour and observe the results

Table 5. Group

Group	Monday	Tuesday	Wednesday	Thursday	->
Office worker	22	21	18	20	->
Backpacker	2	3	2	1	->
Retired people	18	14	12	14	->

Friday	Saturday	Sunday	Working	Entertainment	Traveling
23	1	1	22	1	4
7	12	12	1	1	6
18	16	20	0	8	10

Table 6. Path

Path	Percent of weekday	Percent of weekend	Level
Area1->Area2	20	80	1
Area3->Area5	70	30	4
Area7->Area12	40	60	3
Area15->Area9	45	55	2
Area6->Area13	10	90	6
Area25->Area16	5	95	6

Table 7. Gathering point

Path	Level of weekday	Level of weekend	Average amount per day
Area1	C	B	2232
Area2	B	A	1543
Area4	C	B	1643
Area5	B	A	2289
Area7	C	C	889
Area8	A	A	4388

of the changes in vehicle movement to determine whether the carpooling mechanism can operate smoothly in the city. Suppose there are some fixed main lanes in this city, and commuters must travel through these lanes when they want to go to work. Also, for office workers in a particular area, we assume that commuters can initially come from

Table 8. Meeting point

Object A	Object B	Meeting place	Time
Person1	Person2	Area3	9
Person3	Person2	Area7	22
Person1	Person4	Area2	12
Person5	Person3	Area6	15
Person4	Person3	Area9	8
Person2	Person5	Area4	16
Person5	Person4	Area8	17
Person3	Person6	Area1	4
Person1	Person8	Area5	23

Table 9. Social

Time	Weekday/Weekend	Location	Type	Amount
Morning	Monday	Area3	New friend	336
Morning	Tuesday	Area5	New friend	543
Afternoon	Tuesday	Area7	Meet each other sometimes	888
Evening	Wednesday	Area1	Meet each other sometimes	456
Evening	Sunday	Area6	Meet each other always	292

Table 10. Advertising

Group	Path	Frequency	Amount
Office worker	Area2->Area21	High	336
Office worker	Area4->Area16	High	543
Office worker	Area15->Area18	Middle	888
Office worker	Area3->Area17	Middle	456
Office worker	Area2->Area6	Low	292

lanes in various directions. Therefore, after simplifying the entire model, we can use the following path reference diagram to illustrate (Fig. 3):

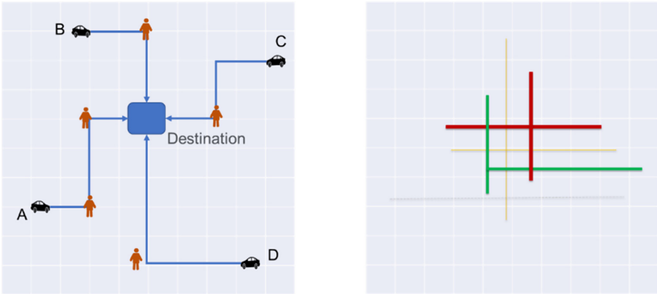

Fig. 3. Vehicle trajectory simulation

As shown in the picture above on the left, there are four ABCD vehicles in the picture. When these vehicles depart for a specific destination, they will take passengers to the destination on the way. Therefore, the use of traffic arteries in the city may be There will be changes as shown on the right. A road with fewer vehicles may not have a greater impact, but for certain traffic arteries, the number of vehicles is reduced, so it is bound to help ease the traffic on the path. This help will produce different levels of size according to different carrying capacity. There are two situations worth discussing here, one of which is the impact of commuting time to and from get off work, and the other part is the impact of non-working hours.

When the number of vehicles is reduced by half from the original number, it will theoretically affect the two projects, including the smoothness of the traffic path and the demand for parking spaces. Since the shared ride is to carry passengers along the road to a specific destination, it is not necessarily The ride-sharing service is used throughout the journey. Therefore, if the traffic conditions of the whole journey can be reduced by half, more people will use the ride-sharing service. However, this is related to the distribution of households and offices in the city, and this Part is not the core theme of this research, so I won't discuss it in depth for the time being.

Table 11. Trial calculation of the influence of carpooling system on the number of parking spaces

	Fixed parking space	Temporary parking space	Total
Passengers number	2		
Original parking space	1000	100	1100
Original total number of vehicles	1000	250	1250
Original remaining parking spaces	0	−150	−150
Number of vehicles after sharing	800 (Not 500)	125	925
Remaining parking spaces after sharing	200	−25	175
Reduced number of vehicles	200–500	125	325–625
Impact ratio	62%	38%	100%

Let's take a look at the impact of shared rides on the number of parking spaces. Due to the limited parking spaces in the city, each workplace of course has its own parking spaces. If the number of parking spaces can be reduced, this part of the there is a chance that the usage can be converted into temporary parking spaces during normal business hours. Therefore, the use of parking spaces that can be affected by shared rides can not only reduce the usage of general temporary parking spaces during the day because of ride-sharing but also allow more regular parking spaces for work are released for temporary parking (Table 11).

As shown in the above table, we assume that there are 1,000 fixed parking spaces for work in an area, and there are 100 temporary parking spaces in the area. The area has 1,000 vehicles that must be parked for work. The number of temporary stops at the same time is 250. Obviously, the number of parking spaces in this area is not sufficient. Once the parking is full, there will be about 150 vehicles with no parking spaces.

When using the shared ride system, we assume that the number of people in each car is 2; that is, the total number of vehicles should be at least half. Therefore, for parking spaces that originally needed to be parked for work, it may save up to 50% of Vehicles, but considering human nature may not be willing to accept, especially some long-distance commuters, so we assume that only about 20% of the vehicles will be reduced in the end, that is, 200 vehicles. Generally speaking, it may be easier to accept shared rides due to the temporary parking needs of public utilities. Therefore, the same calculation is carried out by saving 50% of the vehicles, which is 125 vehicles. After calculation, we can finally get 175 available parking spaces that should have a chance.

In the above figures, the demand for fixed parking spaces and temporary parking spaces for work is estimated from observations. Generally speaking, the number of parking spaces is only about half of the peak period. From the above figures, it is not difficult to see that if the fixed parking spaces used above can be moved out and used, and the number of temporary parking spaces can be reduced by half, it is actually easy to solve the problem of insufficient parking spaces during peak periods, and this is just based Each car only carries one more passenger, not to mention the situation when it carries 3 or 4 people.

4 Discussion

According to the result simulating of the experiment, by reducing self-driving and using the carpooling system, the need for parking spaces in popular locations can be effectively reduced, and urban social relationships can be strengthened, giving the public the opportunity to meet more friends from the daily geographical life circle. However, there are two important conditions for the operation of this service. First of all, is expansion. There must be enough participants to maintain the operation of the system so that everyone is willing to continue to use the service and allow the service to continue to expand in size. Secondly, there must be a stable profit so that the service can be a sustainable operation, so how to build on this service and further enhance the value of the service, to enhance the profitability of the service is another important thing.

How to Extend

Since the number of users and driving may be insufficient at first, consideration could be given to working with specific operators to bring the volume of traffic to a certain level in the first were, thus enabling the service to continue to operate. If the self-driving system continues to develop in the future, it may also be considered to complete this ride-2 mechanism through self-driving cars, or even to achieve a full ride-driven system in smart cities, but due to different laws and regulations and different acceptances of new technology models, such innovative solutions still need to be officially supported before they can be gradually promoted.

User expansion at the beginning of the platform is very important. The fastest way is, of course, through word-of-mouth introduction, but to make the average user willing to go to another person's car is not so easy. Here we can consider several modes, such as allowing users to get used to it from vehicles with fewer co-occupants to vehicles with more co-occupancy or by pairing users with the same friends to increase familiarity and reduce their anxiety. If the number of users is enough, you can also use interests to categorize or even do a ride together for dinner or outings and constantly pull more new users in.

How to Profit

Because of the characteristics of co-multiplied data, which provides accurate geographic information, such data is of great use-value to a location-sensitive surveyor or advertiser. Therefore, if the research unit is willing to pay directly to commission the survey of geographic user data, this will be the system's best source of profit, only in the platform in accordance with the user's path to provide the relevant questionnaire, can be directly in exchange for income. Of course, because we have the frequency of user exchanges, so even if the survey unit to carry out user identification requirements, we can immediately provide a relevant reference. Another extension of the application is advertising. The same data can also be direct as a filter for ad delivery so that advertisers can search directly through the data to filter out the need for the object and advertising, will also be the main source of profit for the service. As for the novelty of the data, because the same place will continue to have new users to enter, and therefore the demand unit will continue to invest funds repeatedly.

Another project that has the opportunity to suck money is the social needs of human nature. The nature of co-location data depends on the location, and it is easy to connect people to a specific time and place, so by packaging the results into merchandise, you can continue to create a steady stream of new buying needs, both for advertisers and the general passenger, which is very attractive, as technology becomes more advanced, and may even achieve more immediate geographic interaction and charge higher service charges.

5 Conclusion

The study is designed to be based on social vehicle networking, where passengers exchange anonymous information in exchange for free or cheaper transport services, drivers use social vehicle networking to increase social opportunities, and platforms that mediate passengers and drivers through car networking and urban parking problems are addressed jointly by providing services to reduce the need for parking spaces during peak urban periods.

This research design will be mediated when the supply and demand side of the information provided by the calculation, into available geographical area user group data, and in accordance with the needs of service objects and advertisers, further design-related social services or advertising mechanism, so that the system can take advantage of this long-term profit, but can be the sustainable operation of the self-operation mechanism, but also enable the demand side of all walks of life to enjoy a long-term sustainable geographical area survey analysis and mass access system.

References

1. Ali, Y., et al.: The impact of the connected environment on driving behavior and safety: a driving simulator study. Accid. Anal. Prev. **144**, 105643 (2020)
2. Roopa, M.S., et al.: DTCMS: Dynamic traffic congestion management in social internet of vehicles (SIoV). Internet Things 100311 (2020)
3. Butt, T.A., et al.: Privacy management in social internet of vehicles: review, challenges and blockchain based solutions. IEEE Access **7**, 79694–79713 (2019)
4. Zia, K., Shafi, M., Farooq, U.: Improving recommendation accuracy using social network of owners in social internet of vehicles. Future Internet **12**(4), 69 (2020)
5. Hamid, U.Z.A., Zamzuri, H., Limbu, D.K.: Internet of vehicle (IoV) applications in expediting the implementation of smart highway of autonomous vehicle: a survey. In: Al-Turjman, F. (ed.) Performability in Internet of Things. EICC, pp. 137–157. Springer, Cham (2019). https://doi.org/10.1007/978-3-319-93557-7_9
6. Hammoud, A., et al.: AI, blockchain, and vehicular edge computing for smart and secure IoV: challenges and directions. IEEE Internet Things Mag. **3**(2), 68–73 (2020)
7. Li, Y., et al.: Fog-computing-based approximate spatial keyword queries with numeric attributes in IoV. IEEE Internet Things J. **7**(5), 4304–4316 (2020)
8. Tao, M., Wei, W., Huang, S.: Location-based trustworthy services recommendation in cooperative-communication-enabled internet of vehicles. J. Netw. Comput. Appl. **126**, 1–11 (2019)
9. Hyland, M., Mahmassani, H.S.: Operational benefits and challenges of shared-ride automated mobility-on-demand services. Transp. Res. Part A: Policy Pract. **134**, 251–270 (2020)
10. Gurumurthy, K.M., Kockelman, K.M., Simoni, M.D.: Benefits and costs of ride-sharing in shared automated vehicles across Austin, Texas: Opportunities for congestion pricing. Transp. Res. Rec. J. Transp. Res. Board **2673**(6), 548–556 (2019)
11. Gerte, R., Konduri, K.C., Ravishanker, N., Mondal, A., Eluru, N.: Understanding the relationships between demand for shared ride modes: case study using open data from New York City. Transp. Res. Rec. J. Transp. Res. Board **2673**(12), 30–39 (2019)
12. Rathee, G., et al.: A blockchain framework for securing connected and autonomous vehicles. Sensors **19**(14), 3165 (2019)