Automatic parking service through VANET: A Convenience application

Biswa Ranjan Senapati[1], Pabitra Mohan Khilar[2]

[1,2] Department of Computer Science & Engineering
National Institute of Technology Rourkela, India
[1] biswa.rnjn@gmail.com, [2]pmkhilar@nitrkl.ac.in

Abstract: Determination of available parking slot with optimum time at the public places like shopping mall, cinema hall, railway station, airport, etc. is the major concern for all the vehicle users particularly for four wheelers. Searching for the available parking slot randomly increases the delay, the wastage of fuel, etc. Also, monitoring of the parking slot, collection of the parking fee is done manually. Increase in the number of vehicles gradually puts overhead on the parking services.

Vehicular ad-hoc network (VANET) is the emerging research area which basically focusses on the safety applications. Due to the presence of communication unit, the application area of VANET is widely increasing day-by-day. In this paper, an automated determination of available parking slot and an automatic parking fee collection is proposed through VANET. The proposed method is compared with the random searching method in terms of average waiting time and total service time. The proposed work is simulated using Network Simulator NS-2. For the maintenance of the parking slot, automatic collection of parking fees is simulated using an open source database called MongoDB and Node-red.

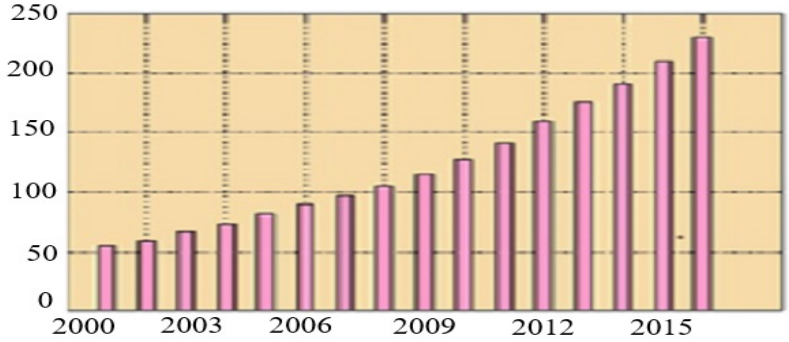
Keywords: Ad-hoc network, MANET, VANET, Total service time.

1 Introduction

Entertainment and luxury in life is now becoming an essential part for all human beings. Due to this reason frequent visit to different public places like shopping mall, cinema hall, park, etc. are increasing day by day. Increase in the population and increase in the number of vehicles (particularly four wheelers) put an overhead on determining the available parking slot. Determination of available parking slot is a challenging task in the public places during holidays. Also, for the maintenance of parking places, parking fees are collected manually. Manual collection at the entry point also increases the delay, create traffic congestion etc. The above real life problem demands the automatic determination of available parking slot and automatic collection of parking fees. VANET can plays the role for the automation of the above parking problems.

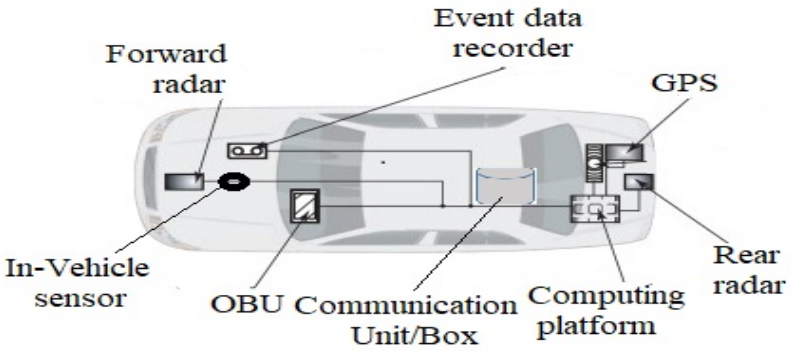
VANET is a sub class of Mobile Ad-hoc NETwork (MANET) [1]. Due to technological advancement and demand of increasing population, number of vehicles

manufactured per year is increasing day by day. Figure 1 shows the number of vehicles manufactured per year.



(Figure 1: Vehicles manufactured per year)

Nowadays vehicles are not considered as a traditional carrier. Due to the technical advancements in the electro-mechanical-material-science department various sensors for various applications are developed at affordable cost [2-8]. Availability of various sensors and the presence of communication unit in the vehicle makes the vehicle smart and intelligent. Figure 2 shows various component of modern vehicles.

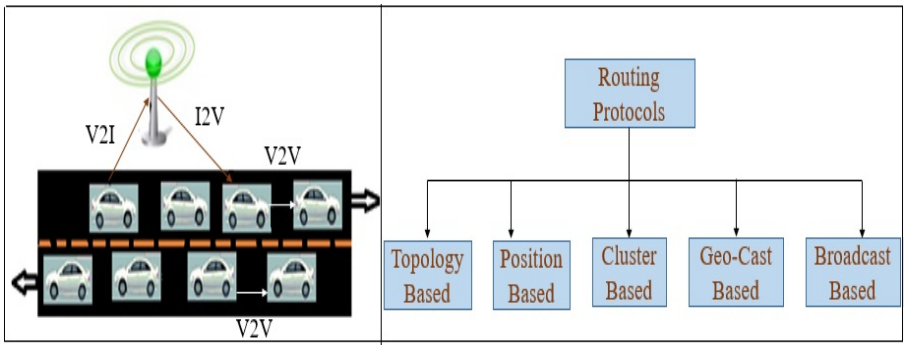


(Figure 2: Smart and intelligent vehicles)

Vehicular network mainly consists of two types of nodes. First one is the vehicle which acts as the mobile nodes. Second one is the Road Side Unit (RSU) which acts as the static node and have the fixed infrastructure. Based on these components the communication in VANET is classified into two categories [9].

1: Vehicle to vehicle (V2V): Communication between one vehicles with other vehicles present within the communication range is called V2V communication.
2: Vehicle to infrastructure (V2I or I2V): Communication between a vehicle with RSU or vice versa present within the communication range is called V2I or I2V communication.

For the effective use of VANET for various applications routing protocol plays an important role [10]. Figure 3 shows the types of communication and types of routing protocol used in VANET.



(Figure 3: Types of communication and Routing in VANET)

Due to random motion of the vehicles, variable speed of the vehicles, and frequent link disconnection between the vehicles; VANET prefers position based routing protocols. Some of the examples of position based routing protocols are Geographic Source Routing (GSR) , Greedy Perimeter Stateless Routing (GPSR), Anchor based Street and Traffic Aware Routing (A.STAR) protocol, Greedy Traffic Aware Routing (GyTAR), etc.

The major contribution of this paper is as follows.

(a) Computation of total service time for the overall parking service using M/M/1 queueing model.
(b) Determination of availability of free parking slot using a non sql based database MongoDB and performing the required operation of searching using node-red.
(c) Determination of the type of vehicle and automatic deduction of parking fee using MongoDB.
(d) Comparison of average searching time for the proposed search and random search using the network simulator NS-2.

The rest of the paper is organized as follows. Section 2 presents the motivation for this paper. Section 3 discusses the literature survey. Section 4 presents the proposed work. Simulation set up and simulation result is shown in section 5. Finally, conclusion and future scope is mentioned in section 6.

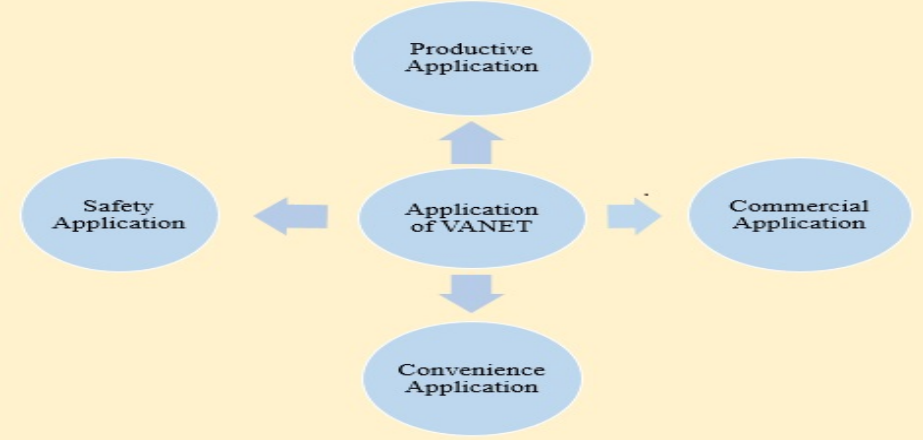
2 Motivation

1: Random search for the determination of available parking slot incurs increase in delay as well as increase in overall service time.
2: Manual collection of parking fee at the entry or exit point also increases delay.
3: Many vehicles are going through the parking slot every day. Providing hard copy of receipt through paper is costly which is valid only for 3 to 4 hours.
4: Also, searching for the available parking slot, drivers may neglect the presence of other drivers, vehicles, obstacles, etc. which causes accidents in the parking lot.

Thus, presence of communication unit in the vehicle, to reduce the average searching time for the determination of available parking slot, to decrease the wastage of paper receipt, to minimize the overall waiting time and service time, to avoid accidents in the parking lot motivates for the development of automatic parking service through VANET.

3. Literature Survey

Due to the presence of communication unit and development of various sensors at affordable cost, vehicular network is used for the wide range of applications. The application of VANET is classified into four categories which is shown in figure 4.



(Figure 4: Classification of different application of VANET)

Combined with Intelligent Transportation System (ITS) VANET provides safety applications like intelligent traffic system [11], reduction in traffic congestion [12]. Convenience application of VANET includes the toll tax collection [13], movement of emergency vehicles [14]. Commercial application of VANET includes marketing on wheels [15], sharing of Wi-Fi through VANET [16]. Productive application of VANET includes environmental monitoring through VANET [17].

Various approaches are also proposed for the determination of available parking slot. Sensor based determination for the available parking slot using probabilistic approach was proposed by Suhr et al. [18]. But probabilistic approach may not always predict the accurate result as the demand for the searching of the available parking slot vary with respect to time. Sharma et al. proposed an IoT based approach for the determination of available parking slot by displaying the available parking slot at the entry point through LCD [19]. But during the peak demand for the parking slot the available parking slot is updated very quickly. So while reaching at the predetermined parking slot may not be available after reaching the location of the available parking slot. This paper thus proposed an automatic parking service through VANET which not only reduce the search time, also reduces the waiting time at the entry of the gate for the collection of parking fee.

4. Proposed model

The proposed work focuses on two important aspects.

(a) Determination of available parking slot.
(b) Automatic parking fee collection.

4.1 Determination of available parking slot.

RSU is assumed to be present at the entry and exit point of the parking slot. Vehicle which wants to enter into the parking slot sends the request consisting of vehicle number to the RSU. A database is maintained at the RSU which consists of the three fields. First field is the parking lot no. which refers to each single location where the vehicle can be stored. Second one is the parking status which is either available (A) or not available (NA). When the request arrives, then the available parking slot present nearer to entry point is sent as the reply. At the same time the status of the parking slot is changed from available to not available and the corresponding vehicle number is stored in the database as the third attributes. When the vehicle leave the parking slot again sends the request to the RSU present at the exit side of the parking slot. At that instant the same database is updated. The parking status changes from not available to available. Corresponding value in the vehicle No. becomes null.

4.2 Automatic parking fee collection

Another database is maintained which consists of the three fields and are Vehicle No, Owner_Name, and Account_No. When the vehicle sends the request with vehicle number as one of its attributes, then the corresponding vehicle number is searched from the database. If the information is present in the database, then the corresponding parking fee is deducted from the account registered for the corresponding vehicle. If the vehicle is not registered in the database, then the corresponding vehicle information is added to the database for the future automatic parking fee deduction. Figure 5 shows the attributes of the database used in both the phases.

Parking Slot No.	Parking Status	Vehicle No.

(a) Attributes of the database to determine the available parking slot

Vehicle No.	Owner_Name	Account_No

(b) Attributes of the database for the automatic parking fee collection

(Figure 5: Attributes of the database for the automatic parking service)

The pseudocode for the overall parking service is mentioned in algorithm 1.

1. **Input:** RSU with two database at the entry and exit point.
2. **Output:** Automatic determination of parking slot and collection of parking fee.
3. **If** vehicle wants to enter a parking place and $distance_{(Veh\text{-}RSU)} <$ Transmission range
4. Send requests to the RSU with vehicle no as the input.
5. From the 1st database Search the nearest available parking lot.
6. **if** ∀ parking status ∈ Not available
7. Send reply not to enter the parking area.
8. **else**
9. Send the nearest available parking lot number.
10. Change the status of the parking slot Not available and add the vehicle No.
11. **end if**
12. Search the vehicle number in the second database.
13. **if** Vehicle No ∈ 2nd database
14. Deduct the parking fee from the registered account number.
15. Transmit the acknowledgement of deduction to the registered mail-id and mobile number.
16. **else**
17. Register the information of the vehicle in the 2nd database for the automatic parking fee service.
18. **end if**
19. **end if**
20. STOP

(Algorithm-1: Automatic parking service)

Definition of performance metric:

- **Average search time (AST):** Search time refers to the time for the identification of available parking slot.
- **Total service time (TST):** Total service time refers to the sum of searching time, collection of parking fee time, and entry of the vehicle to the predetermined parking slot.

  TST is a queueing problem and is evaluated using M/M/1 queueing model.

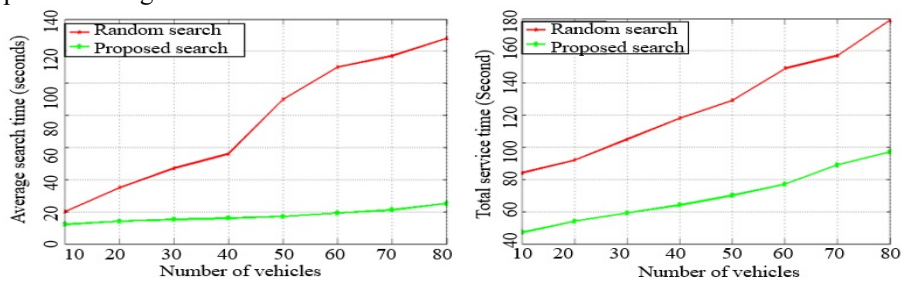
5. Simulation set up and simulation result

The computation of AST and TST is performed by using a network simulator tool NS-2. For the database operation tools used are MongoDB and node-red. The simulation area is set to 2000m × 2000m. The communication range between the nodes is set to 200m. The size of the transmission packet is set to 512 bytes. Priority queue is used having queue length set to 50. IEEE 802.11p is set as the MAC layer protocol. The overall network set up parameters are represented in Table-1.

Table-1 Simulation Network set up parameters

Parameters	Parameter Value
Simulation area	2000m × 2000m
Communication range	200 m
Size of packet	512 bytes
Speed of the vehicles	20-50 km/hr
MAC protocol	IEEE 802.11p
Number of vehicles	5-85
Simulation Time	250 sec

Figure 6 shows the comparison of the proposed search with random search with respect to average search time and total search time.



(Figure 6: Comparison of proposed search with random search)

From the above comparison proposed work performs better. Searching from the database for the available parking slot takes almost constant time which is independent of the number of vehicles present in the parking slot. Also, due to limited data present in the database, the operation on the database is faster than manual searching of the available parking slot and manual parking fee collection.

7. Conclusion & Future Scope

In this paper, an automated parking service with the help of vehicles and RSU is proposed. The performance of the proposed work performs better as compared to random search in terms of average search time (AST) and total service time (TST). In future, a real test on VANET could be performed using trans-receiver module in the vehicles and RSU. Also, some security aspects could be added during the transaction of parking fee from the registered account number.

References

1. Bhoi, S.K., Khilar, P.M.: Vehicular communication: a survey. IET Networks 3(3), 204{217 (2013)
2. Das, H., Naik, B., Pati, B., & Panigrahi, C. R. (2014). A survey on virtual sensor networks framework. International Journal of Grid Distribution Computing, 7(5), 121-130.

3. Mohapatra, Santoshinee, and Pabitra Mohan Khilar. "Forest fire monitoring and detection of faulty nodes using wireless sensor network." In *2016 IEEE Region 10 Conference (TENCON)*, pp. 3232-3236. IEEE, 2016.
4. Mishra, BB, S Dehuri, BK Panigrahi, AK Nayak, BSP Mishra, and Himansu Das, "Computational Intelligence in Sensor Networks", vol. 776, Studies in Computational Intelligence, Springer, 2018
5. Mohapatra, Santoshinee, and Pabitra Mohan Khilar. "Artificial immune system based fault diagnosis in large wireless sensor network topology." In *TENCON 2017-2017 IEEE Region 10 Conference*, pp. 2687-2692. IEEE, 2017.
6. Sarkar, J. L., Panigrahi, C. R., Pati, B., & Das, H. (2016). A novel approach for real-time data management in wireless sensor networks. In Proceedings of 3rd International Conference on Advanced Computing, Networking and Informatics (pp. 599-607). Springer, New Delhi.
7. Panigrahi, C. R., Sarkar, J. L., Pati, B., & Das, H. (2015, December). S2S: a novel approach for source to sink node communication in wireless sensor networks. In International Conference on Mining Intelligence and Knowledge Exploration (pp. 406-414). Springer, Cham.
8. Mohapatra, Santoshinee, Pabitra M. Khilar, and Rakesh R. Swain. "Fault diagnosis in wireless sensor network using clonal selection principle and probabilistic neural network approach." *International Journal of Communication Systems* (2019): e4138.
9. Schoch, Elmar, Frank Kargl, Michael Weber, and Tim Leinmuller. "Communication patterns in VANETs." *IEEE Communications Magazine* 46, no. 11 (2008): 119-125.
10. Singh, Surmukh, and Sunil Agrawal. "VANET routing protocols: Issues and challenges." In *2014 Recent Advances in Engineering and Computational Sciences (RAECS)*, pp. 1-5. IEEE, 2014.
11. Khekare, Ganesh S., and Apeksha V. Sakhare. "A smart city framework for intelligent traffic system using VANET." In *2013 International Mutli-Conference on Automation, Computing, Communication, Control and Compressed Sensing (iMac4s)*, pp. 302-305. IEEE, 2013.
12. Knorr, Florian, Daniel Baselt, Michael Schreckenberg, and Martin Mauve. "Reducing traffic jams via VANETs." *IEEE Transactions on Vehicular Technology* 61, no. 8 (2012): 3490-3498.
13. Senapati, Biswa Ranjan, Pabitra Mohan Khilar, and Naba Krushna Sabat. "An Automated Toll Gate System using VANET." (2019).
14. Buchenscheit, Andreas, Florian Schaub, Frank Kargl, and Michael Weber. "A VANET-based emergency vehicle warning system." In *2009 IEEE Vehicular Networking Conference (VNC)*, pp. 1-8. IEEE, 2009.
15. Bhoi, Sourav Kumar, Deepak Puthal, Pabitra Mohan Khilar, Joel JPC Rodrigues, Sanjaya Kumar Panda, and Laurence T. Yang." Adaptive routing protocol for urban vehicular networks to support sellers and buyers on wheels." *Computer Networks* 142 (2018): 168-178.
16. Tufail, Ali, Mike Fraser, Ali Hammad, Kim Ki Hyung, and Seung-Wha Yoo. "An empirical study to analyze the feasibility of WIFI for VANETs." In *2008 12th International Conference on Computer Supported Cooperative Work in Design*, pp. 553-558. IEEE, 2008.
17. Senapati, Biswa Ranjan, Rakesh Ranjan Swain, and Pabitra Mohan Khilar. "Environmental monitoring under uncertainty using smart vehicular ad hoc network." In *Smart Intelligent Computing and Applications*, pp. 229-238. Springer, Singapore, 2020.
18. Suhr, Jae Kyu, and Ho Gi Jung. "Sensor fusion-based vacant parking slot detection and tracking."*IEEE Transactions on Intelligent Transportation Systems* 15, no. 1 (2013): 21-36.
19. Sharma, Ankush, Shilpi Bansal, Shivam Mishra, Praveen Kumar, and Tanupriya Choudhury. "Automated Car Parking with Empty Slot Detection Using IoT." *Available at SSRN 3403921* (2019).