ICT Enabled Smart Parking System: Smartpark for Smart Cities

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Abstract: ***Smart Cities are having lot of challenges and issues to solve while facilitating citizens better place and environment to live. One of such challenges is getting a free parking lot to park the vehicle. In absence of parking rules and regulations or necessary infrastructure, people may park their vehicles at wrong place and or in wrong direction. This can lead to inconvenience to pedestrians, obstacles to moving traffic, traffic jam and similar unwanted problems. This paper has discussed the Software technology and ICT based Smart Parking solution "SmartPark" to avoid such problems. There are various techniques and solutions available for enabling Smart Parking systems, this paper has briefly covered details of some of such solutions as well as proposed the smart parking system based on image processing, Mobile App and Client Server technologies.***

Keywords: Smart Parking, Smart City, Image Processing, Mobile App, IoT

I. INTRODUCTION

Due to improvements in life style as well as upliftment of urban living life to a reasonable extent, now a day everyone is owning four wheelers. Most of the families staying in cities have almost two vehicles per family. Many times, the increasing number of vehicles when started running on the road at peak office hours causes traffic congestion. When vehicles reach to their destinations, if parking of vehicles is not properly taken care of then this also becomes major issue and major contributor for traffic congestion, accidents and inconvenience to pedestrians. Of course, limited transport infrastructure (roads, traffic control system, Parking arrangement etc.) is reality in major cities and it is the biggest cause behind traffic related issues. Hassle free Car Parking is becoming challenging day by day, and it is still considered as a tough activity since many times one does not get parking easily. This is mainly because of lack of system support to identify free parking lot and or the confined parking spaces while parking luxurious and bigger size cars. It is very common that while searching for parking space, drivers most of the time burns out the vehicle precious fuels without second thought. Smart Cities being smart need to handle this alarming global problem smartly. Many Smart Cities offer Smart Parking Systems for their citizens to park their vehicle conveniently. There are various ways to achieve Smart Parking. Let us understand what Smart Parking System is. Smart Parking System is one which facilitates its users getting real time parking space related information, allows making parking reservation request, facilitates guidance to navigate to the offered parking lot and facilitates paying fees for the Parking through app or through online system. Note that not all Smart Parking System offers all such facilities in one place but yes many of them supports the basic essential requirements.

Many Smart Parking System also offers parking data analysis for a specific geographical area. Besides, by using smart sensors, real time data analytics and interface with portable devices such as Tablets, Laptops, Smartphone etc., it also facilitates collecting of parking charges from the drivers, keeping entry and exit time details of vehicles from parking area, identifying the vehicles which are wrongly parked and also collecting of fines/penalties from the drivers in case of wrong parking of the vehicles and or for parking the vehicles beyond permitted hours. With additional features, Smart Parking System can easily be extended to support advance functionalities such as surveillance and monitoring activities in and around of the parked vehicles, preventing any misuse of parked vehicles, theft of Vehicles or damaged to the vehicles. There are various features of Parking System for smartly assisting the drivers in parking their vehicles easily and conveniently. An easy navigation to free parking lot can results saving of unnecessary wastage of fuels. According to an analysis report, it is estimated that successfully implemented Smart Parking could result fuels savings of 2,20,000 gallons till 2030 and approx. 3,00,000 gallons of fuels saved by 2050[8].

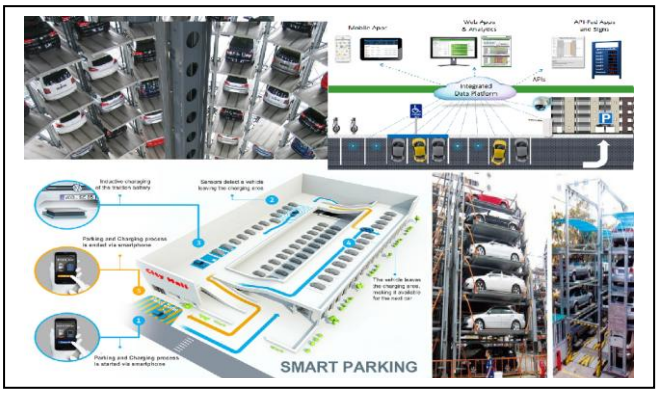

Fig. 1. Automated parking of Vehicles using Smart Parking System

Based on the functionalities offered and supported Smart Parking System are typically classifieds as follows

- E-Parking
- Parking Guidance and Information System
- Transit based Information System
- Automated Parking and
- Smart payment System

Each parking system is unique and has its own advantages and limitations as compared with the other systems. A better implemented Smart Parking System can offer much convenience to the drivers in locating the free parking lot and can offer

numerous benefits such as follows

- Savings of fuel which could have otherwise wasted while identifying the free parking lot
- Time Savings by quick identification of free parking lot
- Reduction in Carbon footprint and overall damages to environment by avoiding excess smoke emission while driving the vehicles in identifying free parking lots
- Reduction in traffic congestion
- Better utilization of available parking space
- Reduction in accidents on roads by avoiding wrong parking of vehicles at wrong places
- Facilitates better collection of parking fees and maintaining the financial records
- Increase in overall productivity due to avoiding unnecessary time wastage for identifying parking lot for vehicles
- Enables better facilities to citizens making living more enjoyable and better

This paper has reviewed some of the existing literature available for the existing parking systems and discussed the problems faced by conventional parking system. The paper has explained in detail the design and architecture of Smart Parking System called as SmartPark. The SmartPark solution is based on IoT based Vision Sensors such as IP Cameras and existing IT networking infrastructure of Smart Cities to interconnecting and networking of various elements of SmartPark System. The SmartPark facilitates identification of free parking lot, advanced reservation of parking lot based on user's request, monitoring of parking spaces across City, and assistance with automated fare collection and payment fees receipt generation.

II. LITERATURE REVIEW

Limited Parking space due to intensive growth in number of four wheelers and other bigger vehicles, has multi-folded the parking space issues. This leads to problems like traffic congestion, accidents, inconvenience to pedestrians and so on. To deal with such issues, worldwide demand and need for Smart Parking System is rapidly increasing. In today's Smart Cities, Smart Parking System is an essential requirement to be fulfilled. Worldwide research is going on which has resulted better solutions towards Smart Parking System. In this section, some related work is analyzed and reviewed for better understanding of existing solutions and technologies used in developing Smart Parking System.

A. Zhanlin Ji et al, "A Cloud-Based Car Parking Middleware for IoT-Based Smart Cities: Design and Implementation"

In this paper authors have discussed cloud based intelligent car parking services for Smart Cities. The proposed car parking service is based on IoT. Various IoT sensors such as CCTV Cameras, Radars, Lasers, Acoustic, RFID are used to collect relevant details of vehicles being parked at parking space. The prototype was developed, implemented and operated in University Campus to prove the concept. The Car Parking Solution consist of three different layers A Sensor Layer, A Communication Layer and an Application Layer. Authors have claimed that the proposed Car Parking Solutions can be well integrated into Smart City IoT Architecture. The solution includes technologies such as Kafka/Storm/Hbase clusters, a rule engine, Mobile Applications, OSGi web applications with distributed NoSQL etc. The Car Parking Service provides the information about best car parking slot available at nearest location on their mobile app of driver by using Always Best Connected and best Served (ABC&S) paradigm.

B. Pablo A. Perez-Mart´ınez, Antoni Mart´ınez-Ballest´e and Agusti Solanas, "Privacy in Smart Cities A Case Study of Smart Public Parking"

In this paper, authors have discussed the solution for managing parking payments considering privacy and data security related concerns of citizens of Smart Cities. For secure parking payment, authors have proposed a communication protocol between the parking system Server and payment software operating on portable device available with drivers such as Smartphone/Tab/Laptop etc. Authors have claimed that the proposed communication protocol allows un-traceability, anonymity, transparent multiarea parking and remote payment. To achieve this, authors have used techniques such as improved randomized hash-locks, pseudonyms and anonymous payments to ensure absolute data privacy of the users who park their vehicles in allotted parking lot.

C. Hongwei Wang and Wenbo Hey, "A Reservation-based Smart Parking System"

In this paper authors have proposed a new Reservation based Smart Parking System (RSPS) which broadcasts the real time parking lots information and facilitates accepting the reservation request from users for the vacant parking lot. Authors have claimed that the newly developed RSPS will assist vehicle drivers in easily identifying and reserving of the nearest vacant parking lot. Authors have made use of ZigBee based sensors for monitoring the real time parking lot occupancy status to Smart Parking Sensor. The Smart Mobile of vehicle drivers, communicates with the RSPS server through installed RSPS App using available Internet or wi-fi to get the parking lots information and to place reservation request for nearby vacant parking lot. Authors have also claimed that the driver's identity can be verified using Bluetooth enabled communication through smart phone app with the deployed sensors in parking area.

D. Yanfeng Geng, Christos G. Cassandras, "A new Smart Parking System Infrastructure and Implementation"

In this paper authors have discussed the new proposed parking system which can facilitate reserving an optimal parking space considering factors like parking cost, proximity to destination and efficient utilization of the overall parking capacity. Authors have claimed that the proposed system design addresses Mixed Integer Linear Program (MILP) problem at each decision point in a time-driven sequence. This ensures that there is no parking lot reservation conflict and user will always get allocated the parking lot having effective cost. Authors have discussed in detail various implementation issues such as guaranteed parking lot reservation, identifying the optimal parking lot and communication between vehicles and parking infrastructure. The proposed solution has made use of IoT based sensors for Parking lot

monitoring and control parking, GPS for location identification, ethernet driven TCP/IP based secured communication among various network nodes including sensors and Smartphone App.

III. SMART PARKING SYSTEM: SMARTPARK

After carefully analyzing the pros and cons of existing parking systems, taking into consideration the needs of vehicle owners for a low cost and efficient parking technology, an advanced network technology driven vision sensors based Smart Parking System named as "SmartPark" is proposed here. The SmartPark System architecture is based on Smart Cities existing IT network infrastructure where a Smart City secured Wi-Fi freely available for its citizens will be basically used as communication backbone for communication among various network nodes of this Smart Parking System. Refer fig. 2, which has shown high level block diagram of SmartPark System.

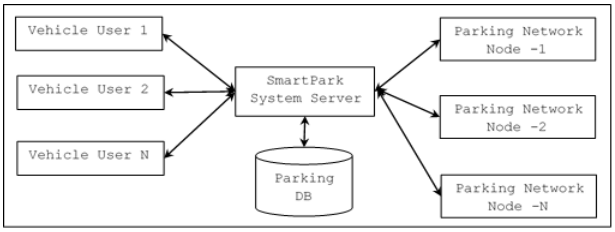

Fig. 2. SmartPark high level block diagram

As shown in fig. 2 above, the SmartPark consist of Centralized Parking System Server responsible for maintaining the entire parking related information for various parking spaces available in the city. Here each Parking Space, represented as Parking Node, has own network of vision Sensors such as Ethernet enabled CCTV IP cameras. These cameras monitor the allocated Parking Space area and provides the real time video footage of the parking space to the Parking Node Server. This server is responsible for maintaining the Parking node database and for maintaining communication among CCTV Cameras as well as with SmartPark App installed on User's Smartphone. The Parking Node server runs with the image and video processing Software to identify the parking lot occupancy information based on the real time video stream provided by CCTV Cameras.

The prime stakeholder that is vehicle user who supposed to use the Smart Parking System needs to install the SmartPark App on the Mobile. The SmartPark App is an Android based Application Software which is responsible for connecting the vehicle user with the SmartPark System Server for placing parking reservation request and with Parking Node Server for user authentication and for parking fees payment. To use the SmartPark App, it is necessary that it should be activated first by Smart Park Server. For activation of SmartPark App following information is needed by SmartPark Server.

- User Driving License Number
- User Aadhar Card Number
- User's Date of Birth and
- User Vehicle Registration Number

In typical scenario drivers reaches to destination first and then search the parking place for parking the vehicle. And if the destination is popular and crowded (i.e. market place) then mostly parking place is not available and driver has to waste the time and fuel in searching vacant parking place. If parking place is not found, then drivers some time even park their vehicles at non-parking place creating an obstacle to the traffic and inconvenience to pedestrians. SmartPark however offers facility to the driver through SmartPark App to enquire about vacant parking place even before reaching to the destination, The SmartPark Server then can provide the availability status of parking lot which belongs to the enquired Parking Place and in case non availability of parking at the required parking place, also can offer best suitable alternative parking spaces choices where user can reserve the parking place well in advance. The communication can take place through mobile internet or available free public wi-fi which is offered in Smart City. The communication messages between SmartPark App and SmartPark Server are as follows.

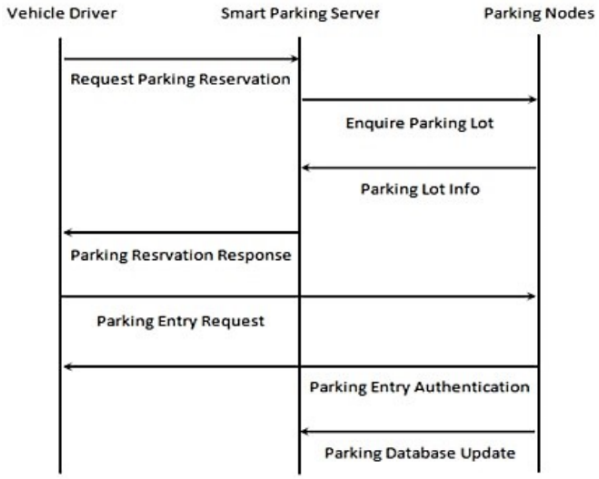

Fig. 3. Message Flow among User, Parking Node & SmartPark Server

As indicated in fig.3. above, the SmartPark server while communicating back the status of Parking lot availability to the requesting user, first enquire with the Parking Node Server about the vacant parking lot. The SmartPark Server considers following information before recommending the free parking lot to the SmartPark App user.

- Destination Place
- Location coordinates of the vehicle
- Distance of available Parking Spaces from the Destination Place
- Parking Availability status at various Parking Nodes
- Vehicle type (Two Wheelers, Three Wheelers, Four Wheelers, Heavy Vehicles like Bus, Truck, Tempo etc.)

To demonstrate how the Server recommends the best suitable parking lot for the user, consider the following fig. 4, which has presented the distance of destination place from various parking nodes, as reference. The DP point presented in the figure is nothing but Destination Place for the User and P1, P2, P3 etc. are the nearby Parking Nodes. The numbers presented on the line represent the distance of parking node from each other.

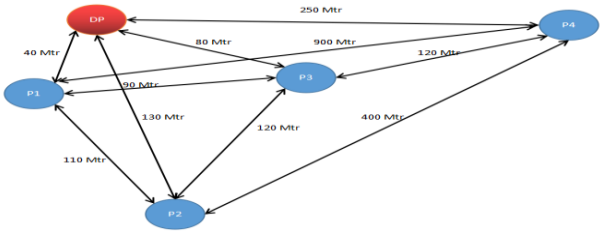

Fig. 4. Identifying best parking space as per destination place

The SmartPark Server once receives the parking reservation request along with the necessary information from the user, allocates the parking lot considering following

$$Pl(n) = f(sD, pA) \quad (1)$$

As stated in above equation Parking lot (Pl) is basically function of distance of parking node from the destination point (sD) and the availability of parking at the nearest node from the destination point (pA). The SmartPark Server already has distance related information about available parking nodes in specific geography such as the one represented by fig.4. Note that the distance is indicated in meters. Additionally, Server also enquire about parking availability from each parking node. Now with the distance information as indicated in following Table T1 and parking availability information as indicated in Table T2, it is easier now to allocate the parking lot to the user. Since the nearest Parking Node is P1 for destination DP and P1 doesn't have available parking the Server can allocate the next free parking lot to the user from the next nearest parking node from destination place and that is parking Node P3.

TABLE I. **DISTANCE MATRIX - PARKING SPACES AND DESTINATION**

	DP	P1	P2	P3	P4
DP	0	40	130	80	250
P1	40	0	110	90	900
P2	130	110	0	120	400
P3	80	90	120	0	120
P4	250	900	400	120	0

TABLE II. **FREE PARKING LOTS AVAILABILITY AT PARKING NODE**

P1	P2	P3	P4
0	10	9	23

Now let us try to understand how the vision sensors installed in the parking node works. The fast Ethernet enabled simple CCTV surveillance cameras are more than enough to monitor the parking space area and to determine the availability status of parking lot. Many low cost good quality CCTV IP cameras are available in the market which can be best used for this purpose. Please refer following figure fig.5, which has represented the typical parking space which has facilitated parking of four wheelers as well as two wheelers and the mounted CCTV cameras over pole. The CCTV cameras monitoring the four wheelers and two wheelers parking space separately. It should be noted that based on the area of Parking Node and parking arrangement made for parking various types of vehicles, the number of CCTV Cameras required may differ. It also depends upon how much area once CCTV Camera can monitor which basically depends upon its Field of View (FoV) considering the CCTV camera resolution and mounting height of the camera over pole.

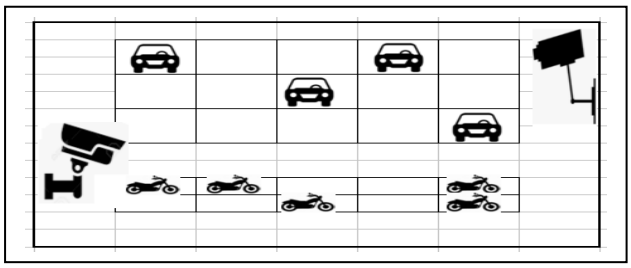

Fig. 5. Parking Layout plan for Parking Node

The proposed solution for identifying the parking lot occupancy is based on arranging parking lots as per the vehicle types and according to the row and columns matrix fashion. Refer fig. 5 above which has shown the suggested parking arrangement. Here each parking lot is identified based on its Row & Column number as shown in following Table III. The Parking status if we consider for four wheelers as shown in above figure then the occupancy status of each parking lot is presented in the Table IV below.

TABLE III. **PARKING LOTS IDENTIFICATION WITH ROW COLUMN**

CAR	R1C1	R1C2	R1C3	R1C4	R1C5
CAR	R2C1	R2C2	R2C3	R2C4	R2C5
CAR	R3C1	R3C2	R3C3	R3C4	R3C5
BIKE	R4C1	R4C2	R4C3	R4C4	R4C5
BIKE	R5C1	R5C2	R5C3	R5C4	R5C5

As shown in Table-III and Table IV, the parking lot R1C1, R1C4, R2C3 and R3C5 are already occupied with parked vehicles and remaining parking lots are free. Similarly, in case of two wheelers parking lots R4C1, R4C2, R4C5, R5C3, and R5C5 are occupied with parked two wheelers and remaining parking lots are free to occupy.

TABLE IV. **PARKING LOTS IDENTIFICATION WITH ROW COLUMN**

CAR	1	0	0	1	0
CAR	0	0	1	0	0
CAR	0	0	0	0	1
BIKE	1	1	0	0	1
BIKE	0	0	1	0	1

As shown in fig. 5, there are two CCTV Cameras used to monitor the parking space for Cars and bikes separately. Depending upon the parking area to be covered under monitoring, it is possible to have multiple CCTV Cameras installed at different locations to cover entire parking area. Following figure fig.6, shows the high-level block diagram of SmartPark Node System architecture.

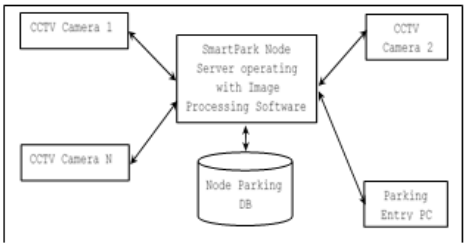

Fig. 6. High Level Block Diagram of Parking Node System

The SmartPark Node Server operates with Image Processing Application Software. As shown in fig. 6 above, the CCTV IP cameras are connected with SmartPark Node Server through ethernet. The connection can be wired, or wireless based on the available ethernet network infrastructure in Parking Node. The Node Server gets video feeds from CCTV Cameras over wired or wi-fi ethernet. The system operates on secured ethernet TCP/IP communication message protocols, for communicating with all the network elements connected in Local Area Network. The SmartPark Node Server also has responsibility to have two-way communications with SmartPark System Server to inform the real time parking status information of its Parking Node.The Image processing application operating on Node Server is responsible for monitoring the parking space and identifying the occupancy status of parking lot. This application receives the video footage stream of parking space from multiple CCTV cameras over TCP/IP communication protocol through high speed available ethernet interface. All the CCTV cameras are basically ethernet enabled PTZ IP Cameras. Refer fig. 8, which has presented some reference parking space images, captured via installed CCTV cameras.

Refer fig. 7, which has shown the message flow among vehicle driver, SmartPark Node Server and installed CCTV IP cameras. Once the parking reservation request made by User is granted by SmartPark Server, SmartPark Server also communicates the Parking Node and allocated parking lot information to the User. When User reaches with the vehicle to the Parking Node, a User needs to get authenticated through Parking Node Server first. Here user needs to raise Entry Request through SmartPark App with SmartPark Node Server. Node Server then reconfirms the Parking Lot availability with the installed CCTV Cameras by requesting the fresh footage. After reconfirming the parking lot availability based on analyzing the fresh video footage, Park Node Server authenticate the user by demanding user authentication information. Parking Node Server also demands Parking fee online through SmartPark App once the user is authenticated. After granting entry to the user in Parking Node, SmartPark Node Server then updates its parking data base and communicates the updated parking availability information to the SmartPark Server.

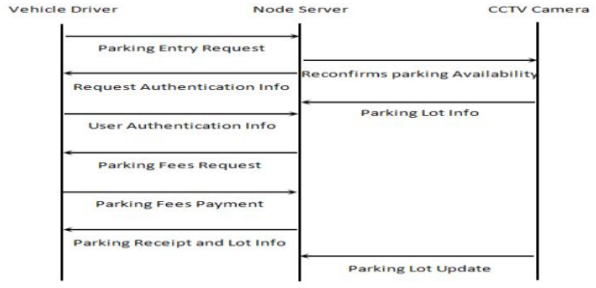

Fig. 7. Message flow among User, Node Server & CCTV Cameras

Fig. 8. Images captured by CCTV Cameras in Parking Node

The Image processing application software running on SmartPark Node Server performs following stated image processing steps to identify vacant and or occupied parking lot and updates its database accordingly.

A. Dataset training and Model Building

- Reference Image Capturing for empty parking lot and occupied Parking Lot
- Image Dataset pre-processing
- Train and validate dataset
- Model training and validation

B. Parking Lot Status Identification and database update

- Input Video Stream
- Video Processing
- Frame Separation
- Image pre-processing - remove noise and blur if any
- Row and Column wise Image comparison and status detection (Based on reference Image Data Set and train Model)
- Each Parking Lot status identification
- Update the Database
- Report the status in real-time to SmartPark Central Server

IV. RESULTS AND DISCUSSION

The Proof of Concept (POC) developed for SmartPark is tested locally in a laboratory environment using sample video footage of various parking nodes and communication with SmartPark Server and SmartPark Node Server. The parking nodes were having parking for Motorcycles as well as Car where all the vehicles were parked in a drawn rectangular boundary. The Parking Node Sever as well as SmartPark Server were configured on Windows 7 operating system high speed desktop machines. The Parking Node Server was operating with Matlab based Image processing software which is used for identification of free or occupied parking lot. The Android based simple SmartPark App is developed to use the Google map for navigation and to communicate with a SmartPark Server having static IP address. A simple user-friendly front-end User interface is developed with C# for the SmartPark Server Application configurations and reporting. I used the MySQL as a Database which proved to be simple but very effective for this application.

Overall the system worked well. The User feedback collected while testing the SmartPark POC and many users appreciated the developed solution. Some value-added suggestions also were received to improve the overall usability and performance of SmartPark Solution. The Parking fees collection feature though supported could not be fully tested and verified. The first-hand evaluation of SmartPark solution has found following improvement areas.

- When the vehicles were parked properly in a parking lot, such parking lots were identified properly, however when the vehicles were wrongly parked (i.e. not properly aligned with the parking lot boundary or when the vehicles were parked in such a way that they were occupying two parking lots partially instead of one parking lot) such cases could not be properly handled by the Parking Node Server
- SmartPark App to be made compatible and installable with IOS Phone as well
- The Fees Payment receipt is transferred to SmartPark App but the hard copy of same should also be facilitated to the user
- The SmartPark Node Server should provide audio and or visual warning in real time to the user in case vehicle is found wrongly parked (i.e. not properly aligned with the parking lot boundary or when the parked in such a way that it occupies two parking lots partially instead of one parking lot)
- The Parking Node must have proper lighting arrangement so that the video footage captured by CCTV Camera in the night is clear and visible. Without proper lighting, in the night, it was found that Parking Node Server - Image Processing Application Software was not able to identify the occupancy status for the parking lots where lighting condition was poor.
- Identification of the situation and alerting the user if user has parked the vehicle in wrong parking lot
- Instead of numeric number, from scalability and easy identification perspective the Parking Lot number should be alphanumeric.

V. CONCLUSION

The testing of POC of SmartPark System successfully demonstrated that SmartPark solution is very useful for making advance reservation of Parking Lot as per user's requirement. SmartPark ensures offering the best suitable parking lot to user after analysing multiple vacant parking lots from multiple parking nodes, taking into consideration user's destination place and its distance to nearby parking node. The facility for automated collection of parking fees after vehicle driver's authentication makes this system more policy friendly with the current Smart Cities Policies and framework. The SmartPark App integrated with Direction Map makes the navigation for Vehicle driver very easy to find out route to the parking space. The validation results for SmartPark POC are very encouraging and it is undoubtedly recommended to develop the full-fledged system as per requirements to get full benefits from SmartPark Solution.

Based on thorough Verification and Validation (V&V) of SmartPark system POC, it is confirmed that SmartPark is a user friendly and very powerful Smart Parking System. It is robust and reliable and does the parking allocation based on the images acquired through network-based CCTV cameras installed in the Parking Node. The SmartPark system is comparatively low cost but powerful and effective system. If it gets deployed properly then it can effectively offer smart parking solution to the citizens of smart cities and can facilitate reducing overall traffic congestion and vehicle parking related problems.

VI. FUTURE WORK

The SmartPark V&V provided very encouraging results and hence in future the fully equipped and fully functional SmartPark system is recommended to develop. Also, while evaluating SmartPark, the add on improvements were identified, which are recommended to implement to get full benefits from SmartPark System. The list of such add on improvements is as follows.

- SmartPark App for IOS Smart Phone
- A facility to cancel parking lot reservation request
- Detection of wrong parked vehicles
- Audio or Video warning to the vehicle driver in case driver wrongly parks the vehicle
- A facility to collect penalty from the user in case of violation of parking laws
- Identification of parking trends based on vehicle types, peak hours, parking hours etc.
- Multiple options to user to select the parking lot from the list of available parking lots and available parking nodes
- Audio or Video warning in case someone tries to damage the parked vehicles

REFERENCES

1. Adil Hilmani, Abderrahim Maizate and Larbi Hassouni, "Designing and Managing a Smart Parking System Using Wireless Sensor Networks," Journal of Sensor and Actuator Networks, 2018
2. Aleksejs Zacepins, Vitalijs Komasilovs and Armands Kviesis, "Implementation of Smart Parking Solution by Image Analysis,"Proceedings of the 4th International Conference on Vehicle Technology and Intelligent Transport Systems,2018, pp 666-669
3. Antoine Bagula, Lorenzo Castelli and Marco Zennaro, "On the Design of Smart Parking Networks in the Smart Cities:An Optimal Sensor Placement Model," Sensors 2015,pp 15443-15467
4. Daniele Di Mauro, "Scene Understanding for Parking Space Management," DCETE 2018, pp 3-11
5. Dr. Dipak Gade, "Technology Trends and Digital Solutions for Smart Cities Development", International Journal of Advance and Innovative Research, Volume 6, Issue 1(2019) : Part - 4, 29-37
6. Dr. Dipak Gade, "Introduction to Smart Cities and Selected Literature Review", International Journal of Advance and Innovative Research, Volume 6, Issue 2(2019) : Part - 4, 7-15
7. Hongwei Wang and Wenbo Hey, "A Reservation-based Smart Parking System," The First International Workshop on Cyber-Physical Networking Systems, IEEE, pp.701-706, 2011
8. Li Chen, Qiuyan Liu, Sayan Majumdar, Hana Murphy & Tim Spaulding, "Saratoga Smart City SMART PARKING INITIATIVE: Current Technologies," 2017, pp 1-10

9. Muftah Fraifer, Mikael Fernström, "Investigation of Smart Parking Systems and their technologies," Proceedings of Thirty Seventh International Conference on Information Systems, 2016.
10. Muhammad Alam,Davide Moroni,Gabriele Pieri,Marco Tampucci,Miguel Gomes,José Fonseca, Joaquim Ferreira , and Giuseppe Riccardo Leone, Real-Time Smart Parking Systems Integration in Distributed ITS for Smart Cities, Hindawi Journal of Advanced Transportation, 2018
11. Pablo A. P´erez-Mart´ınez, Antoni Mart´ınez-Ballest´e and Agusti Solanas, "A Case Study of Smart Public Parking," Proceedings of the 3rd International Conference on Pervasive Embedded Computing and Communication Systems,2013, pp 55-59
12. Yanfeng Geng, Christos G.,"A new Smart Parking System Infrastructure and Implementation," Elsevier ScienceDirect, Procedia - Social and Behavioral Sciences, 2012, pp. 1278-1287
13. Zhanlin Ji 1, Ivan Ganchev,Máirtín O'Droma, Li Zhao, and Xueji ZhangA,"Cloud-Based Car Parking Middleware for IoT-Based Smart Cities: Design and Implementation," Sensors,2014, pp 22372-22393.