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Review of Parking Spaces Assistance Schemes in Vehicular Networks

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Abstract— **Car cruising for vacant parking spaces during heavy crowded scenarios has now emerged as painful challenge towards traffic congestion and pollution and now has become time consuming process. Finding a vacant vehicle parking space is becoming difficult owing to fact that innovative parking system has not gained much popularity especially in developing countries. Sometimes this also leads to the frustration of driver when if some other commuter takes the spot just before driver reaches it. Hence this paper reviews about the smart parking schemes that help commuters on the way to find vacant parking spaces using vehicular networks with much ease.**

Keywords— **Parking Assistance Schemes, Road side units, Sensor networks, Vehicular Networks, V2V Communications, V2I Communications, Vehicular ad-hoc network.**

I. Introduction

Recently VANET is an area of interest and a crucial issue in both industrial and academic levels and has become very popular in foreign nations. According Donald Soup [1] a surprising amount of traffic isn't caused by people who are on their way somewhere. Rather it is caused by people who have already arrived. Our streets are congested, in part, by people who have gotten where they want to be but are cruising around looking for a place to park. Moreover [1] discovers 30% of traffic congestion is caused by vehicles finding vacant parking spaces. Hence if drivers are provided with efficient and effective information then parking search costs, congestion and pollution would reduce to some extent. Due to current advancement in VANETs devices such as OBUs and RSUs, inconveniency faced by the commuters to find parking areas has been reduced.

II. Research on Parking Space Approaches

According to [2], vehicles are generally equipped with sensors which assist drivers by sensing location and free parking spots as they move around the city areas. Generally the sensors communicate using medium range radio communications technology such as 802.11x.

A. Based NAPS, OAPS, CAPS approaches

In [2], there are three ways in which proposals for parking assistance schemes can be divided as (i) Non Assisted Parking Search (NAPS) (ii) Centralized Parking Assisted Search (CAPS) (iii) Opportunistic Assisted Parking Search (OAPS). In NAPS driver searches for vacant parking space around the destination spot based on his experience about that area and no explicit guidance to him is available. He may wander or cruise around the spot until he finds an empty parking area. In CAPS since vehicles are equipped with on board sensor, these sensor communicate with centralized server about occupancy of parking spot when they must have encountered. The interested vehicle may query server for free parking spot around destination and the server based on FCFS services the query and returns the result to the requested server. In OAPS since vehicles are equipped with standard wireless interfaces communicate with each other and share information which they might acquired in due course of their search. Based on calculating relevancy of information the data stored in cache is filtered out and then is informed about the driver about various relevant event which he would successfully met.

Analysis

Various remarkable differences can be noticed among these schemes as centralized schemes requires huge infrastructural expenses with maintenance costs compared to opportunistic schemes. Also scalability issues in centralized schemes are prominent. But in opportunistic approaches the competition factor is likely since when two or more vehicles having same information of parking spaces may compete for the same at same time. OAPS and CAPS comparatively outperforms NAPS since in NAPS vehicles blindly wander around key destination without having proposed knowledge of any vacant parking spaces increasing search times as well as route length.

B. Based on infrastructural support in Occupancy Monitoring

Vehicle Detection Techniques includes Vision based method and Sensor based method.

Vision based methods use CCTV (Closed Circuit Television) i.e. one camera for at least more than one parking spaces and requires image processing software to detect vacant parking slot. This method leads to various disadvantages due to shadow effects, occlusion effects, vacillation of lighting conditions and perspective distortion. Light-colour cars in strong sunlight misleads detector as declaring the space as vacant; in the same way, a shadowed area over dark colour vehicle may provide misleading effect of an empty space to be occupied.

Sensor based methods can be classified as intrusive Sensors and non-intrusive sensors. Intrusive sensors require installation within the road surfaces or in ceiling of the car park and thus may lead in reducing the life of these roads or ceiling whenever they are being installed. These sensors are classified on basis of the costs, environmental conditions, calibration, accuracy, range implementation and on the design basis. Examples include Infrared sensors, Inductive Loops, magnetometers, magneto resistive sensors. Non intrusive sensors do not require massive invasive procedures during installation like former ones. Examples include ultrasonic sensors, RFID, acoustic sensors.

C. Based on existing proposed systems

In this section, state of art of proposed parking assistance schemes is discussed. Various demarking factors are considered such as art of disseminating of information, competition versus Cooperation versus Reservation parameters, Centralized or Opportunistic or Client Server approached followed, Infrastructural supports etc. Various approaches are as follows.

1) Agent based approach

The system is based on assistant agents comprises of three modules [5]: a Communication module, an Itinerary module and a Decision module. Communication deals with exchange of messages with the neighbours. Itinerary module does the distance calculation between the parking spots and the current location of the commuter. Decision module makes the choice of spot based on the criteria specified by the driver. Decision modules maintains memory containing two disjoint lists: Free Spots (FS) list which contains information about free parking spaces and Occupied Spots (OS) list which contains information about spaces which were in FS but now are filled with moment when information was passed. This system uses pull based method where the needed vehicle ask for the empty parking spot leading to V2V communication and mostly designed for street lane parking purposes.

2) ParkNet: Drive-by Sensing of Road-Side Parking Statistics

The ParkNet architecture employs a mobile sensing approach which uses passenger facing ultrasonic rangefinders and GPS receiver to monitor road-side parking availability statistics. Central server collects aggregated data and builds real time map for parking availability and sends to the system requesting for the information. The system has also devised an environmental fingerprinting approach to achieve improved location accuracy.

It uses two types of parking information: Space Count and Occupancy Map. The Space count shows the number of parking spaces available on one given road segment and Occupancy Map shows each parking slot as occupied or vacant. The system deals with street lane parking slots. It used pull based client server approach.

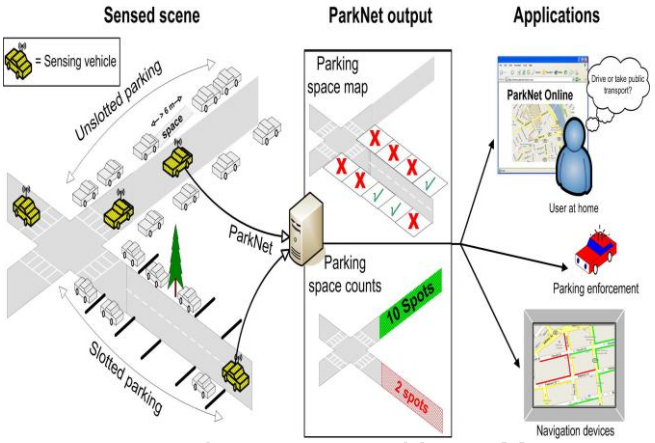

Fig1. ParkNet System using Mobile sensor [9]

3) Gravity-based Parking Algorithm Approach

This method is based on the Game Theoretic Approach where vehicles (players) competing for parking slots (resources with different costs). This approach emphasis on the providing commuter directly the location to park and discusses about the competitive approach. GPA uses incomplete information about the parking scenarios which in some cases outperforms the complete information scenarios and works on probabilistic methodology. The heuristic pushes vehicles towards areas where they are likely to find a vacant parking slot. The gravitational force depends on the (magnitude) distance between vehicle and slot and also on (direction) the location of the slot. The algorithm calculates resultant vector by adding all empty slot forces acting upon it and use that direction for the vehicle to move using formula $F=Gm1m2/d^2$ where masses are considered as constant resulting in the formula as $F(v, s) = 1/\text{dist}(v, s)^2$ where $F(v, s)$ is the gravitational force generated by slot s towards vehicle v.

4) IPARK-Intelligent Parking Guidance Using Parked Vehicles

IPARK system works basically on cluster formed by the parked vehicles in roadside which usually help to disseminate real time information about vacant parking

places and provide real time navigation within parking lot using parking occupancy map. Approach uses three types of components: parking lot cluster, intermediate nodes and end users. Parking lot cluster works as monitoring and data disseminating units. Intermediate cluster help to connect different parking cluster lots. End users are one who is in search of vacant spot as shown in fig 2. This works for parking lots and does not require any infrastructural investment. Query dissemination is based on pull based technique where intermediate node takes up the request and sends to the encountered parking cluster lot. If no space is vacant there in the reply then query is forwarded to next intermediate till it reaches farthest neighbour node.

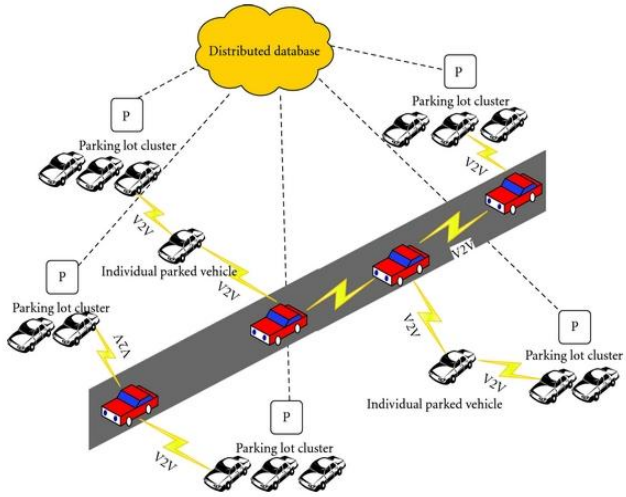

Fig2. IPARK Architecture [12]

5) Time Varying Travelling Salesman Problem Approach [7]

In this approach discovery of the parking space uses travelling salesman problem phenomenon which computes the route that a vehicle must traverse in order to visit all parking spaces known to be available. The criteria for the decision is based on time require arriving at destination place, time required to walk from spot to destination place and probability that the spot will be vacant on arrival. Hence it uses time varying TSP approach where it inputs both transit time b(x, y, t) as well as transit cost c(x, y, t) for each edge (x, y) at time t. Hence problems works as to start at pre-specified vertex s and visit each vertex only once such that total transit cost of traversed path is minimal. It follows dual approach [7]: firstly, deploys clustering algorithms to reduce the problem size by mostly working with representative points of our input in order to offer a near-optimal solution. Secondly, dynamically use disseminated-by-others information as a vehicle proceeds towards its destination in order to correct and re-adjust the path currently pursued. It outlines three different approaches as exact approach, clustering based approach and live approach. TSP works for street lane parking and basically is a push based query method.

6) PVCM-Multihop Communication Using Parked Vehicles

Parking Vehicles Communication Model (PVCM) uses parked vehicles as relay nodes to disseminate information during sparse traffic hours like night, suburban areas or during shadowing cost by vehicles as shown in fig 3. It claims that [14] that the automotive battery can be utilized to keep the on-board unit running without draining all its energy. This resembles V2V communication as well as V2I communication since parked vehicles resembles static nodes. It works efficiently in suburban areas rather than on highways removing some infrastructural implementation costs. But in order to uniformly work everywhere it also suggests certain such implementation along with store and forward techniques to enable full coverage in all environments for VANETs.

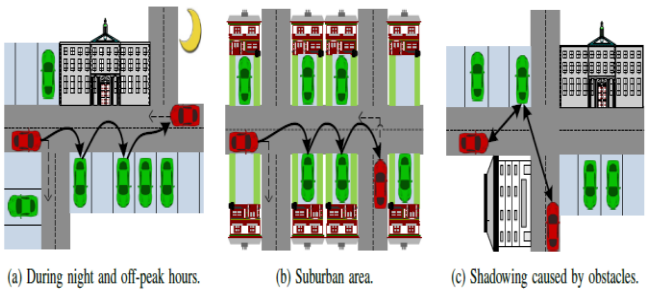

Fig3 Scenarios where PVCM can be used.[14]

7) PMNET- Multi-Hop Wireless Parking Meter Network

PMNET is a special class of ad hoc networks characterized by a combination of static, immobile nodes (parking meters) and mobile nodes (vehicles) [13]. Parking meter require inexpensive infra-red (IR) sensor to detect occupancy; and a short-range, low-power RF transceiver to communicate with neighbouring meters and nearby mobile vehicles. It uses concept of global ID as GUID which is comprised of local unique id and GPS location attribute forms a non volatile attribute. Other type of attribute includes volatile one which includes size of the spot, its current availability, the fee for using it, and the time limit. In addition to supporting drivers seeking parking, PMNETs can be used by the municipality to simplify and optimize revenue generation from fees or penalties. [13]

8) An Intelligent WSN-Based Parking Guidance System

iPGS works for parking lots consists of four system [4] the parking space allocation subsystem, the parking space monitoring subsystem, the driving guidance subsystem, and the vehicle detection subsystem. The system uses various wireless sensor nodes like central node, Status Indication (SI) node, Driving Guidance (DG) node, Space Monitoring (SM) node and Vehicle Detection (VD) node as shown in fig 4.[4] Communication among the nodes uses ZigBee wireless

technology. Parking Space Allocation Subsystem deals with allocation of the proper space to each car using virtual coordinate system in order to resolve error created by GPS system. Parking Space Monitoring Subsystem is used to validate vacant slots and report all statuses to the central node. Vehicle Detection Subsystem deals with sending virtual coordinates of the detected car to the central node based on which SI node gets indication of the parking allocation. Driving Guidance Subsystem deals with providing drivers proper guiding direction and parking space indication.

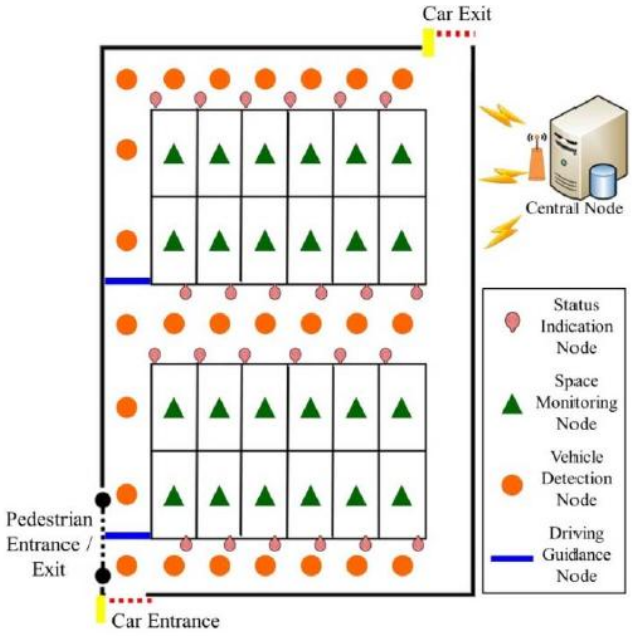

Fig 4 Layout used in iPGS [4]

9) Vehicular Event Sharing with mobile P2P Architecture

The system deals with V2V communication using inter vehicular network. VESPA focuses on data management issues such as finding relevance of information, data dissemination protocols based on relevance of data items, data aggregation approaches that can help the vehicles to extract and share knowledge about the environment by summarizing data item, data querying approaches and exchange of multimedia messages. Moreover it deals with handling competition between scarce resources such as finding vacant parking spaces. It does this by handling reservation of the resources. The proposed algorithm works as follows: first the vehicle leaving the parking space acts as a coordinator for that space and broadcasts the vacant space message in the nearby communication range and waits for potential answers. Based on received answers the coordinator sorts answers based on relevancy and notifies the winning candidate. If no answers are received which happen when no candidate is interested in the resource then notification range is extended by choosing a new coordinator that is done by the former one. In this approach the competition is resolved since the most promising candidate gets the actual specific information about the parking space. But only the coordinator leaving the parking space advertises about its own vacant space and if along with is it if more spaces are vacant are not communicated further. Also if spaces are vacant and no one is leaving then utilization ratio falls down i.e. the vehicles might be searching for the space but no information about it is available. This approach saves infrastructural and maintenance costs since all communication are V2V.

10) SPARK: A New VANET-based Smart Parking Scheme for Large Parking Lots

The proposed scheme can provide the drivers with real-time parking navigation service, intelligent antitheft protection, and friendly parking information dissemination and also ensure the conditional privacy preservation of the OBUs, which is regarded as the basic security requirement in VANET communications [10]. Three entities participate in the communication Trusted Authority (TA), On Board Unit (OBU) in the vehicles and Road Side Units (RSU). The system works for huge parking lots in which three RSUs are placed in such a way that it covers the entire parking unit as shown in figure 4.

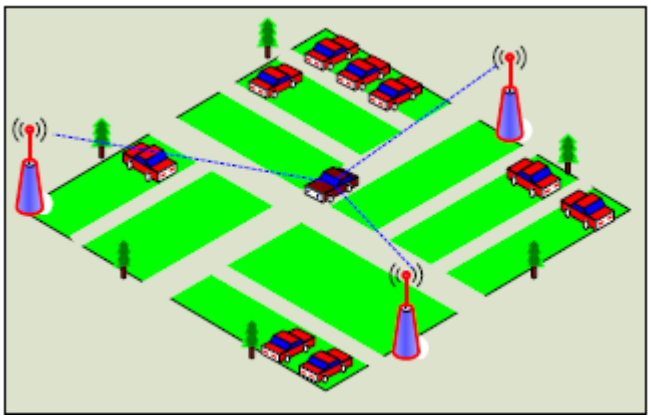

Fig5 Parking lot with RSUs [10]

TA deals with registration of OBUs and RSUs. OBU is installed in the vehicle which has its unique identifier as IDi. In order to protect the privacy of the OBU, when an OBU with ID*i* registers itself to TA, TA first converts the real identifier IDi into a pseudo-ID PID*i*, and generates a private key *ski* corresponding to the pseudo-ID of the OBU. [10] This system is based for huge parking lots where RSUs installed across a parking lot can survey the whole parking lot. This system leads to infrastructure cost with heavy maintenance. It uses V2I and V2V communications. Though implicitly this system handles the privacy which none of the above system provide.

11) SmartParking: A Secure and Intelligent Parking System Using NOTICE.

The proposed parking system is a novel infrastructure which addresses both security/privacy issues and efficient services [11]. Their main contributions are: Privacy is considered in their infrastructure. Vehicles' privacy information is transmitted from belt to belt or belt to parking site, instead of being exposed to other vehicles. Security of transaction and user information is considered. The communication is activated only when a vehicle's front wheels press on a belt. This mechanism prevents most security attacks. For example, roadside malicious hackers cannot eavesdrop on the communication. Parking sites can frequently publish their advertisements. The advertisement can be transmitted through wireless transceivers and updated on the NOTICE belt infrastructure. Drivers can view and reserve parking spots on the fly. A non-stop parking service can be provided to drivers. [11]

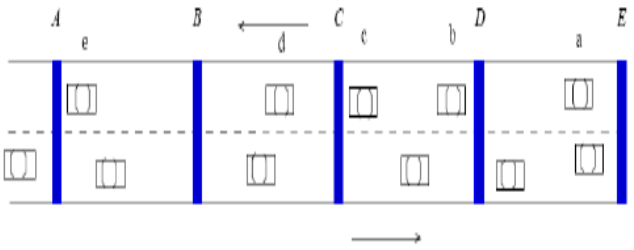

Fig6 A collection of belts on a two-lane road [11]

This system provides combination of various facilities like reserving parking spaces on the go, privacy of the drivers is considered and protected, by using the NOTICE infrastructure and security of the information is protected by using the belt infrastructure and encryption/decryption approach. The only disadvantage of the system is it heavily relies on the infrastructure to render above facilities.

12) Parked Vehicle Assistance : Stopped vehicles are not silent

Parked vehicles plays important role in content distribution during light and sparse hours. The parked vehicle using rechargeable battery can communicate with the vehicles nearby passing. Clustering based approach can be also used where two heads: Cluster Head and Quasi Head and cohorts can communicate with each other for better administration of parking spaces. The parked vehicles can act as cost effective relaying nodes.

D. Comparison between reviewed systems.

TABLE I
REVIEWED SYSTEMS

System	Area of focus			Interaction				Mode		Comm.		Req		Res	Com
	PL	SP	PM	V2V	V2I	I2I	CS	Push	Pull	WAN	AH	I	S		
VESPA	●	●	●	●				●			●			●	●
WSN	●			●	●	●			●		●				●
Agent		●		●							●				●
GPA		●													●
TSP		●		●				●			●				●
Smart-Park		●			●	●			●		●	●	●		
Park Net		●					●		●			●	●		
SPARK	●				●	●			●		●	●	●		
NOTICE		●			●				●		●	●	●	●	●
PMNET			●		●	●			●	●	●	●	●	●	●
PVCM		●		●	●				●		●	●			
PVA	●	●			●				●		●	●			

III Future Work

Lot of work has already been commenced using sensor networks with effective use of infrastructure. Recently research on the infrastructure less guidance system is being done since it reduces expensive costs and regular maintenance requirements. VESPA focuses on V2V communication where the moving vehicles communicate and finds the promising candidate for the parking lot. The challenging task in V2V communication is handling competition and reservation since there is no centralized system available to handle the requests and update centrally. Since parking is the scarce resource it should not be communicated to all interested vehicles. Hence the promising candidate only must be informed about the vacant parking spot without creating any confusion.

IV CONCLUSIONS

Cruising randomly around destination spot in search of the empty parking lot has led to more and more pollution, fuel consumption and drivers frustration. Hence if drivers are provided with efficient and effective information then parking search costs, congestion and pollution would reduce to some extent. Various systems have been already studied that guides commuter towards empty parking spot. Above work surveys such systems and tries to provide comparison among them. This provides future insights for development of infrastructure less parking guidance system with low cost and maintenance effectiveness.

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