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Smart parking occupancy detection method using smart app

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Abstract: Population growth in cities results in a demand for parking lots from an increasing number of automobiles, which frequently contributes to the global problem of traffic congestion. This study presents the smart parking occupancy detection system as a technique to scientifically enhance the existing parking lot, i.e., parking guidance and information method or something else, occupancy detection system. The smart app named rPark is promoted as a cutting-edge method of parking detection. Ultra-high frequency static radio frequency identification chips are placed on the asphalt and cross-examined by Radio Frequency Identification interrogator aerials over the parking areas to initially assess utilisation status. This plan eliminates the majority of the challenges associated with current up-to-the-minute parking usage identification techniques. The parking detection accuracy of rPark, which was tested and used to illustrate an experimental analysis in a real-world outdoor parking space, has been confirmed to be about 100%.

Keywords: radio frequency identification; parking app; smart parking; parking garage; cloud database.

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1 Introduction

Nowadays parking issue is a very important problem because nowadays the number of automobiles is increasing in the urban area due to the lack of proper parking of automobiles as per the demand, chaos is created on the roads and as a result people's life is miserable. The parking issue has now become a political issue. As a result, the administration has undertaken various projects with special emphasis on how to solve the parking problem quickly.

Parkers with dynamic information on vacant slots inside organised parking garages as well as parking guidance are provided by the parking information and guidance method. The availability of parking slot/spaces is determined by

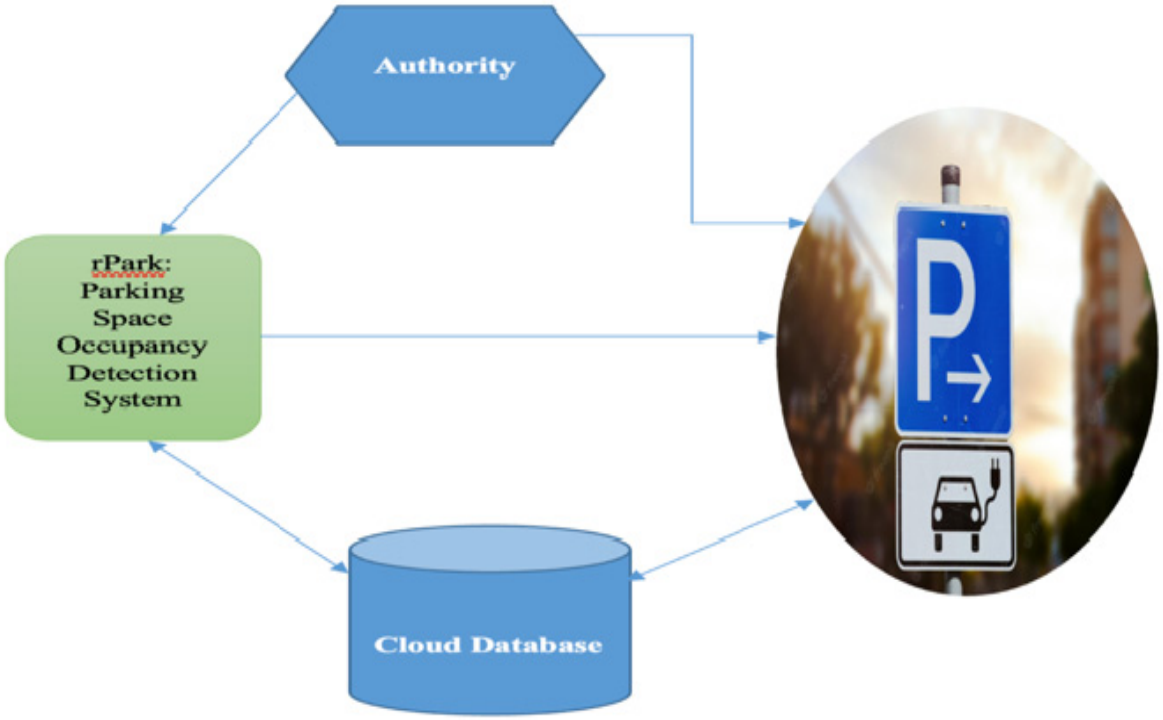
devices placed on or off the street, and this information is then communicated to drivers or users via a Virtual Message Sign on the road or online (Griffith, 2000; Liu et al., 2020). Parking guidance and information techniques are a by-product of the widespread implementation of intellectual transportation schemes in urban areas. Parking Guidance and Information (PGI)'s are designed to lessen the amount of span/time that vehicles occupy parking, thereby reducing traffic bottleneck. A significant amount of study has also been done in the part of Parking Booking Methods (PBM), which enables passengers to reserve guaranteed slots at their favourite terminals and receive a wealth of information prior to, during, or after their voyage (Rodier et al., 2021). PGI methods are typically included in the Parking Reservation Scheme's parking space observation module.

Furthermore, per capita of the Parking Guidance and Info (PGI) sensors has its private shortcomings. For example, the setting up of sensors similar to air-filled tubes, sound, magnetic, loop sensors and piezoelectric is difficult as well as costly for being interfering (Klein, 2001); they all need a big amount of tar drill which marks them costly in terms of setting and repairs. All of them are too unstable to high temperature as well as climate disorders (Idris et al., 2021). Air-filled tubes are particularly unstable to pressure, sound sensors undergo from adjacent noise, infrared and ultrasonic sensors are damaged by high temperature also the wind force. Dynamic infrared sensors are ruined by dims in the air. These shortcomings drive the statistic that recurrent repair is obligatory for the schemes utilising these sensors. Moreover, the general drawback is the necessity of energy, either over wires or batteries.

To solve this problem, our system proposed Radio Frequency Identification (RFID) based parking system where the full parking garage will be controlled with a smart parking space occupancy detection app named rPark. The main authority of the app will be the parking provider. As soon as all the information of the parking garage is updated, it will come to the cloud database and from this cloud database at the next time users can see according to their choice whether the selected slot is vacant, if so then he/she can use his/her preferred slot for the specified time. The complete system is graphically nicely shown in Figure 1.

The remaining parts of the paper are arranged as follows: The literature for this article is covered in Section 2, the proposed system is covered in Section 3, the results of the experiments are covered in Section 4 and the study is wrapped up in Section 5.

Figure 1 Proposed system



2 Literature review

A PGI method normally contains four major segments: parking observing system, parking spot info publication, telecommunications net and regulator hub (Tang et al., 2021). Traditional PGI methods normally usage blocks and UPC engines to compute cars arriving and leaving the parking places (Sakai et al., 2020). Yet, neither the parker nor the owner informs the usage standing of precise parking lots. Though a few PGI methods apply sensors else cameras by inserting this equipment in the margin of the parking range for car recognition in addition to observation (Cheung and Varaiya, 2007).

Figure 2 illustrates a sample structural design of an economic PGI method. Information about the usage status is caught from loop sensors and ultrasonic sensors then using RS-485 connected to a system controller. The parking info is hence available to a LAN by using IP switches and a Data Server.

Constructing on Parking Guidance and Information methods, bookings are promising to assure parking spots for parkers and escape the contest on parking spots. The Stochastic and Deterministic Parking Booking Method mainly accepts deterministic entrances-the user/driver entry time to the garage/parking spot has to be informed in advance, also there are enough parking resources to assist total inward cars incoming in one period (Mouskos, 2007). The parking spot work status/times are calculated into short span/time epochs. When the span/time epochs are shorter, the arithmetical puzzle goes greater objective as it goes closer to the real shape of parkers' entry plus exits. Parkers give the scheme their entry times, their present geographical spot and their target's geographical spot.

The application of any PBM method needs a communication method between the parkers and the PBM processing hub. The usage of mobile phones or else the internet is, therefore, a highly attractive and inexpensive method for communicating and observing info.

Figure 2 Sample of a PGI method structural design (Akeparking, 2016)

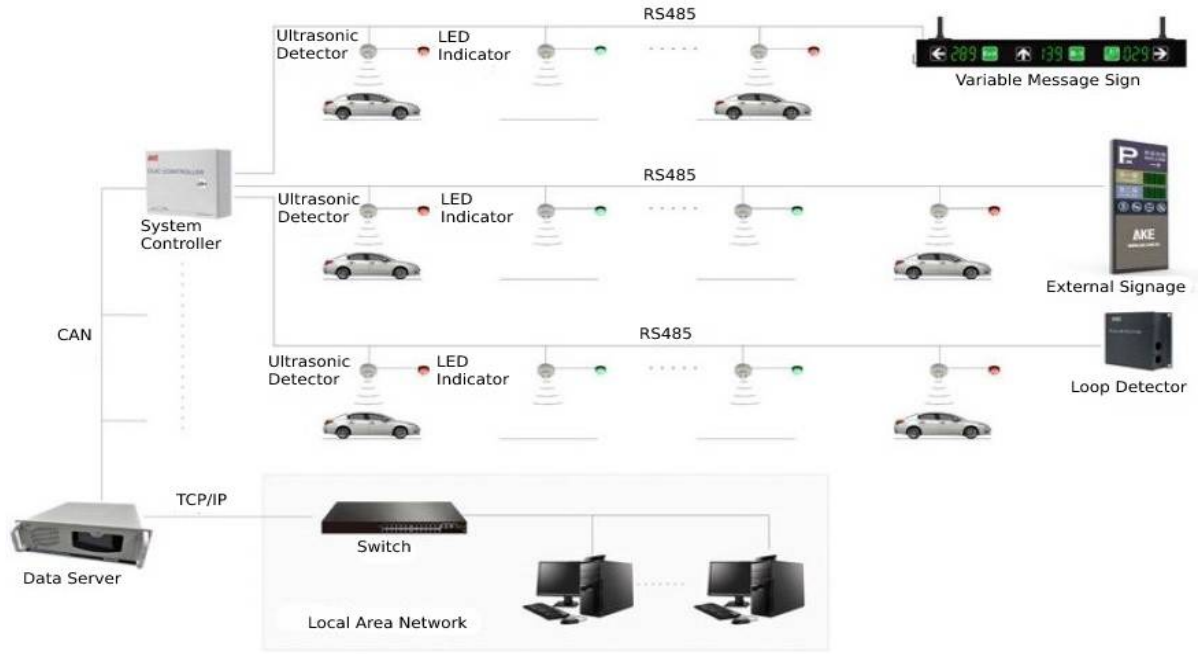
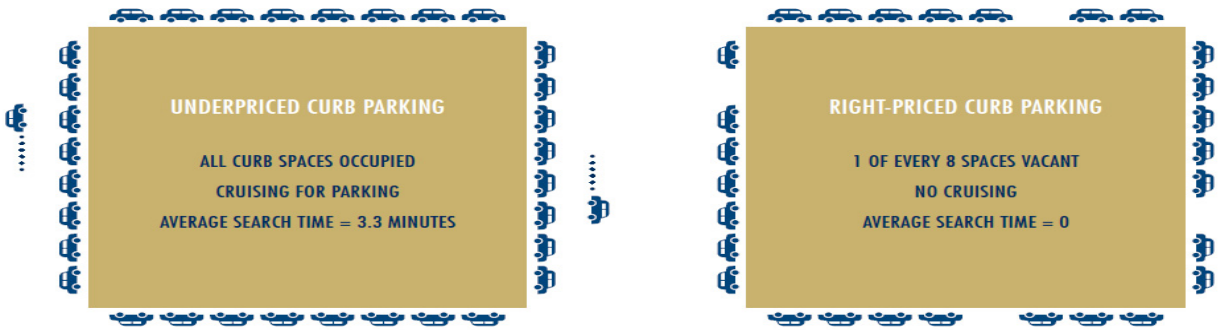


Figure 3 Curb parking costing and travelling (Shoup, 2006)



Trusiewicz and Legierski (2021) utilised Unstructured Supplemental Serving Documents (USSD) as an exchange method between parkers and parking booking schemes. Although it is not open to usage Unstructured Supplemental Serving Documents for a max of internet users, it is even an inexpensive as well as dependable tech. to implement in parking bookings.

Inaba et al. (2022) used Radio Frequency Identification chips to stock and bring up-to-date the bookings state and they examine the variation between actual and part-time bookings where the variation concerning them is that in part-time bookings, parkers should use the facility in a defined arrival and departure time slice as they part the resource time/span. Whereas in actual bookings, they are permitted to stay/park for an indefinite time for being uncommitted to other parkers. The parkers can book a slot with the help of a page on the internet. The web page they implement offers actual pictures of the garage/parking spots so that the parkers can simply identify the usage status.

Wang and He (2018) presented a model for a distributed scheme at which there is one chief CPU that collects the booking demands also sends these demands to the related confined CPUs. Their scheme usages Bluetooth plus wireless-fidelity to sense the usage status within parking spots, and inform the parkers over a cell phone application with vacant slots consequently.

Small Memo Services bookings were discussed in numerous research papers. For instance, Hanif et al. (2021) advanced an embedded Short Message Service booking method utilising μ-controller, keypad, entry monitoring and a Distant Station Unit (DSU). μ-DSU is a standalone station with a CPU and a Global System for Mobile Communication (GSM) unit to collect Short Messages and prompt Input/output pins. Booking through the web was shown in Shiyao et al. (2021) by utilising a sensor net of ZigBee plus pressure sensors to sense the usage status of parking places and the bookings were permitted utilising an internet site.

3 Proposed system and methodology

The above-mentioned Figure 1 graphically shows our proposed system. From the figure, we see that our proposed Smart Parking Occupancy Detection System named rPark has four main components, namely Authority, rPark app, Parking garage and Cloud database. The parking admin controls the parking garages with the help of implemented smart parking space occupancy detecting apps. The parking apps collect occupancy status from the cloud database, and the occupancy status is measured and stored in the cloud database using our proposed smart parking occupancy detection system. Below is a discussion of how the various components of our proposal work.

3.1 Smart occupancy detecting app

Both the user and the administrator use this section to make the best use of the parking lot. A user can reserve and access his/her reserved slot using this app throughout the allotted time frame. Because the app is made in accordance with our suggested occupancy detection mechanism, users can take advantage of a high detection capability while using it. We noted that the parking detection accuracy of our suggested occupancy detection devices is close to 100% in the results section.

3.2 Parking garage

The parking garage is equipped as shown in Figure 4. From the figure it is shown that, it comprises a transceiver, transponder and aerial. The transceiver or else Radio Frequency Identification interrogator examines the transponder or synonymously RFID chip to scan its solo identification over the RFID reader aerial. To sense the usage status of a garage, Radio Frequency Identification interrogator aerials are positioned in the parking region and the Radio Frequency Identification chip is positioned within the car. When a car's chip is scanned through the RFID interrogator, the parking spot state is switched to unavailable. The best RFID chip that fits our proposed smart parking occupancy detection scheme is chosen by verifying different functionality of numerous RFID chips. Resulting in that, the chosen RFID chip, Radio-frequency identification reader and the Radio-frequency identification interrogator antenna are verified for the biggest read-scale dimension, both hypothetically and practically. Finally, the rPark scheme's performance is analysed by using this parking garage set-up.

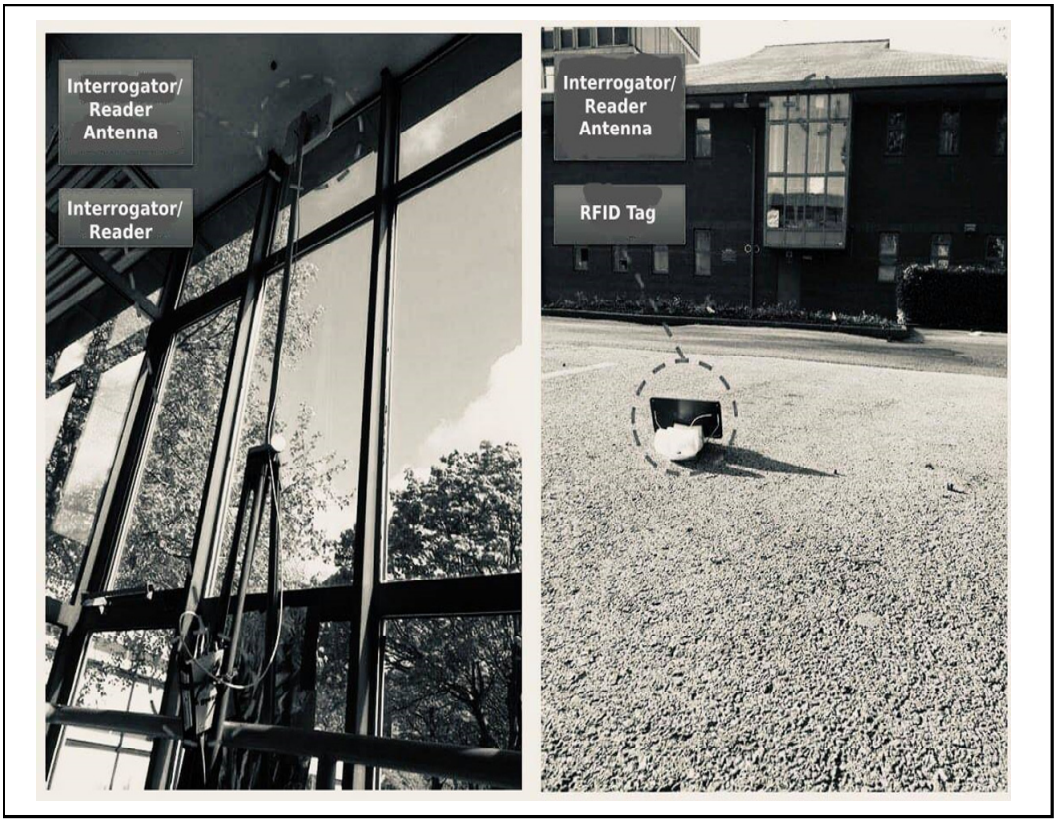
3.3 Authority

The parking administrator or authority can manage their parking garage and increase their profit by doing so with the aid of produced smart apps. The parking garage is solely under his or her control. With the created smart parking occupancy detecting apps, the parking manager can simultaneously monitor his or her parking garage, ensuring proper usage without any pressure. In this way, the efficient use of resources is managed, the parking manager may profit more and more from the parking garage and the customers are also happy since they can utilise the parking garage as they anticipate.

3.4 Cloud database

Using the smart parking occupancy detecting named rPark scheme, calculate the usage status of a parking garage and store it in the Cloud database so that parkers can get information about the availability of slots inside his/her preferred garage.

Figure 4 Out-of-doors parking spot a) Antenna, interrogator of RFID placed then linked to an out-of-doors parking spot and b) Static chip on the pitch and adapted to the interrogator aerial



4 Simulation results of our proposal

Figure 4 shows an analysis of the innovative Radio Frequency Identification (RFID) based occupancy detection method in a conventional outdoor car parking area.

Here, two various jobs were looked at. The primary use is to park an automobile over an RFID chip. In a meaningful parking scenario with erratic movement of people and vehicles, this is the second objectives and the second objective looks for potential flaws in our proposed smart occupancy detection system or rPark method.

The Radio Frequency Identification (RFID) interrogator antenna was positioned 500 cm outside the base plane and indoors in a foam at a distance of around 2000 cm from the RFID chips in all subsequent testing. Also, in accordance with the regulations of the Federal Communications Commission, the diffusing power was set at a maximum of 1 W. The results of all tests are presented and discussed below:

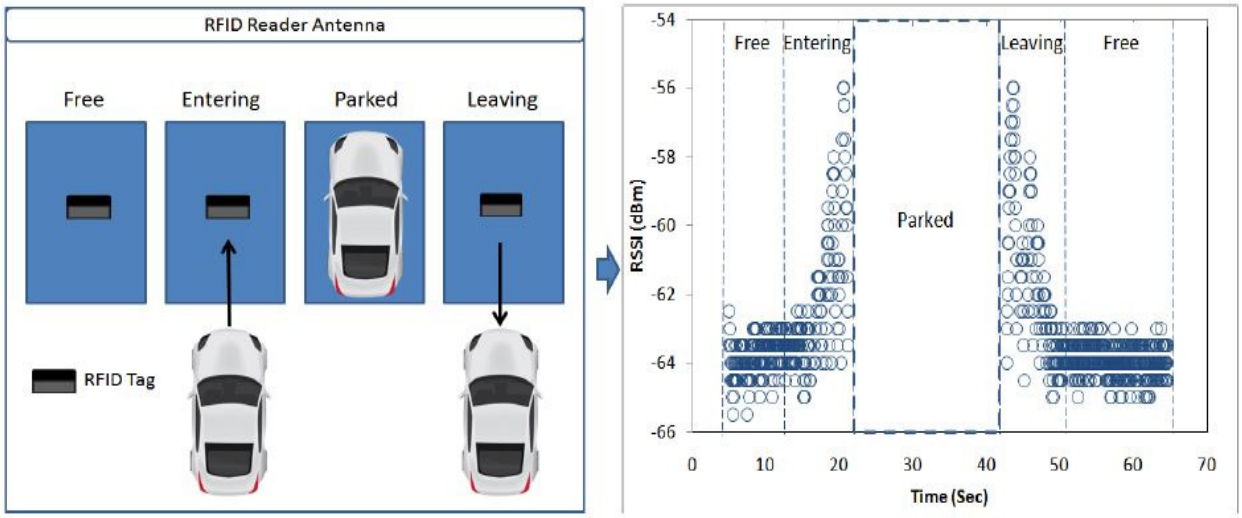
4.1 Parking detection: experiment 1

The Received Signal Strength Indicator signature of an automobile parking technique is shown in Figure 5. The three phases of a typical parking term are arrival, parking halt and departure. The parking space is primarily unoccupied, and the RSSI ranges from –64.95 to –62.95 dBm. The Received Signal Strength Indicator increases by 6.95 dBm as a car pulls into a parking slot shortly before it covers the chip. The characteristics of the RFID chip play a role in this action. Indeed, only a small percentage of chips are designed to work more on metals than off metals. The innovative plasmatic configuration of the Omni 3000 chip is optimised to prevent interference from water or metals when used in a positive mode of the Radio Frequency (RF) field.

The subsequent phase is parking-stop, where a car totally shields the Radio Frequency Identification chip. It is noticed here that the Radio Frequency signal is under no circumstances sent back to the interrogator from the chip. As anticipated, the UHF signal that has usually a 0.1–1 m wavelength, is gridlocked via the car. Immediately, the detection method will conclude that a vehicle has parked.

To end, it is noticed that the Received Signal Strength Indicator rolls back to its prior state when the vehicle is departing and the slot is available for another time. The detection method will then conclude that this parking slot is available.

Figure 5 For a car parking method RSSI signature. The signal is absolutely consumed by the car metals while the car is fully coating the RFID chip



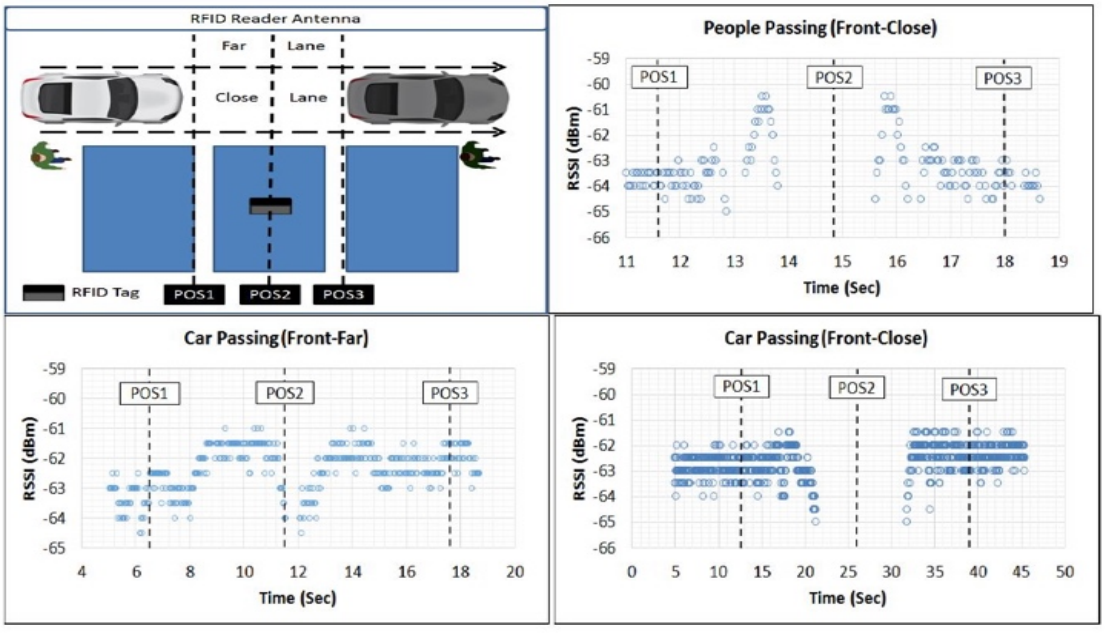
4.2 Parking detection: experiment 2

It is expected that people and vehicles will move omni presently to available parking spaces in any parking area. As a result, it's possible that the transient items cause the radio frequency interfaces between the Radio RFID antennae and chips to become jammed. This effect is depicted in Figure 6 at point 2, when individuals or vehicles are perfectly positioned between the RFID interrogator antenna and the chip. With this setup, the item's altitude and the proximity of the RFID chip to the object determine the length of time the signal is gridlocked. The duration is significantly shorter when the object is not close to the chip since the RFID interrogator antenna is 500 cm or more away from the base.

Last but not least, it was experimentally proven that when the item is between the locations of 2 and 3 and 1 and 2, the RSSI increases by an average of 1.99 dBm. This increase is approximately 2.99 dBm when an object is a person, and it is around 0.95 dBm when an object is a vehicle.

From these above-mentioned experiment results, we infer that our proposed method is a vigorous occupancy detecting method and by using this system a user can benefit because they know about their desired slot information earlier and make another choice if their desired slot is not available. The authority can manage their garages smoothly with the help of our proposal and can earn a lot of money without any kind of hassle. Furthermore, the existing parking garage occupancy detection problem can be solved with the help of our proposal.

Figure 6 RSSI signature during objects shifts



5 Conclusion

With the planned rPark system, we first demonstrated how asphalt-mounted Ultra High Frequency static Radio Frequency Identification chips might be used to monitor parking spot utilisation. Secure RFID interrogator antennas are used to do this, which cross-examine RFID chips positioned on the asphalt at pre-determined time intervals and update the cloud database server that broadcasts the parking garages information for user activities. Also, two tests were carried out, including parking detection in experiment 1 and the impact of crossing people and vehicles in experiment 2, using the smart parking occupancy detection method named rPark in our suggested parking garage settings. Based on such testing, we found that the parking detection accuracy of our systems is close to 100%.

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