ParkEase: Making urban parking effortless with IoT integration

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Abstract

Nowadays the exponential rise in automobiles brought about by urbanization has made parking management in urban areas more difficult. Traditional parking systems frequently have trouble making effective use of available parking spaces, which leads to traffic jams, lost time, and more pollution. One solution to these problems is the use of Internet of Things (IoT) technology in parking management systems. This paper aims to determine the architecture, use, and advantages of an Internet of Things-based smart parking management system. This solution increases user pleasure, encourages eco-friendly urban living, and maximizes the effectiveness of parking space allocation by utilizing IoT sensors, advanced data processing, and an Android application.

These systems will use an Android application and the Internet of Things to automate the parking and departure of automobiles. This IoT system will reduce human work and users will find parking more easily and securely. It will use number plates to verify the identity of cars and reserve parking spots appropriately. It would be suitable for all kinds of parking lots.

Users may locate parking lots in their area, check the availability of spaces in real time, make payments, and reserve parking spaces with the aid of the Android app. Data transfer will be managed by Raspberry Pi devices, which will oversee the parking lots. To extract car information and distribute parking places, they will collect data from sensors and cameras. The majority of the hardware in the system consists of Raspberry Pi 3, USB cameras, IR sensors, magnetic sensors, and ultrasonic sensors. Additionally, it makes use of databases and Android apps.

Keywords: **IoT, Sensors, Raspberry Pi, Android, USB Cameras, IR sensors.**

Introduction

The lack of parking spaces in today's cities is a huge drawback that has been worsened by the ongoing urbanization and growth without a corresponding increase in parking lots. This is tough for drivers because inadequate parking facilities cannot keep up with the population growth rate, resulting causing traffic jams, wasted time, and annoyed people. With this context in mind, connected devices are becoming increasingly popular and are thus expected to simplify parking management.

This study explores IoT-based smart parking management systems in the Indian Continental Platform. Nowadays, it is necessary to find some way of reducing traffic congestion and providing adequate solutions to address the problems of finding available space where vehicles can be parked due to the significant expansion of towns across India. Through Internet of Things technology, this problem can be addressed. The varied ways in which it can assist in efficient parking, less traffic congestion within cities, and easier movements around them are highlighted here. In this paper, we focus on changing IOT technology in traffic systems that can completely alter how the parking system functions within Indian cities.

IOT-enabled traffic management system has several functionalities with the aim of ensuring efficient movement of vehicles and improved safety. One such feature is giving drivers live directions, changing traffic lights according to current conditions, and monitoring vehicle presence using sensors. The result of this application is the efficiency of the traffic management system. With these kinds of systems, we can determine which parking spaces are occupied and which ones are not thus making it easier for motorists to find an available spot.
For example, Bangalore, Delhi, and Mumbai cities are great examples where IoT applications have found success in traffic management. This paper will focus on how incorporating IOT technology can help reduce traffic congestion and enhance overall mobility and transportation within urban areas.

However, despite its benefits, many challenges can be pointed out. These IOT systems need to focus on people's privacy to be protected and safe. They should also ensure that the data about available parking lots and vehicle movements collected by them should be treated in such a way as not to violate the privacy of other people. Therefore, they must have clear policies and guidelines for recording, storing, and sharing information to safeguard users' trust. The second challenge could be that it needs to be accessible by everyone in terms of socioeconomic status and also affordability of technology and digital literacy skills. In conclusion, this study titled "ParkEase: Making Urban Parking Effortless with IoT Integration" seeks to unravel

how IOT technology can significantly improve parking management in Indian cities. By examining how sensors are used and various IoT applications are pegged on traffic monitoring; the paper indicates how IoT integration has a potential for reducing congestion, enhancing safety as well as making efficient use of urban infrastructure.

Literature Review

This paper aims to discuss how IoT technology can help to solve parking problems in cities, especially in India, where parking issues are becoming severe due to rapid urbanization.

However, the available literature does not completely investigate the influence of IoT in Indian parking management. It overlooks critical issues such as data security and infrastructure readiness. This leaves a vacuum in knowing how IoT may successfully handle parking issues in Indian cities.

Finally, the paper addresses this gap by proposing a holistic solution targeted to Indian cities, emphasizing IoT's potential to change parking management and build smarter, more sustainable urban settings.

There are various pieces of literature available that address smart parking as it is of great importance.

(Ashutosh Kumar Singh1, Apr 2019) [1]This article presents a Smart Parking System that uses IoT. It uses an Android app, a Raspberry Pi, and sensors to manage parking and provide real-time availability updates. Through the use of image recognition and car number plate verification, users may book appointments and make payments via the app. The report describes sensor installation, Raspberry Pi integration, and Android interface with an emphasis on decreased emissions and congestion.

(J. Cynthia, November 2018) [2] This paper discusses a mobile app for users and parking spot owners that is introduced together with an Internet of Things (IoT)-based Smart Parking System. It allows users to be guided to open spots, reserve parking spaces, and authenticate themselves via RFID tags. Using infrared sensors, the system locates available parking spots and uses WiFi to transfer data to the smartphone app. Along with descriptions of the system's modules, architecture, and implementation, it offers suggestions for future developments and possible advantages.

Methodology

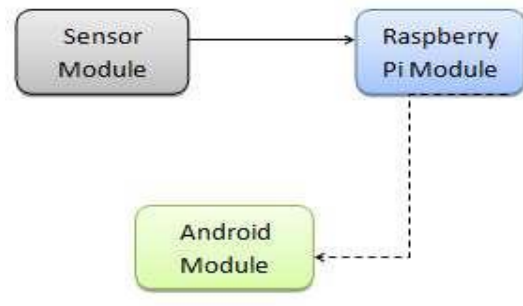The system will be implemented in three modules:-

Figure 1: Modules

Sensor Module

Raspberry-pi module

Android module

Sensor Module: The sensor plays a crucial role in the functioning of a smart parking management system. It enables real-time monitoring of parking space availability, reservation management, and decision-making according to the data collected. Different types of sensors used are:-

Ultrasonic Sensor:- [3]Ultrasonic sensors are the most important components in a parking system, as they allow drivers to locate vacant spaces in parking areas more quickly, avoiding unnecessary struggle for drivers. These sensors radiate high-frequency sound waves beyond the human hearing range and measure the time taken by these waves to bounce back from nearby objects. This bounce-back time helps to calculate the distance to the object accurately. These sensors are operated within the frequency range of 20 kHz to 200 kHz. It is powered by a transducer that helps convert electrical energy into ultrasonic waves.
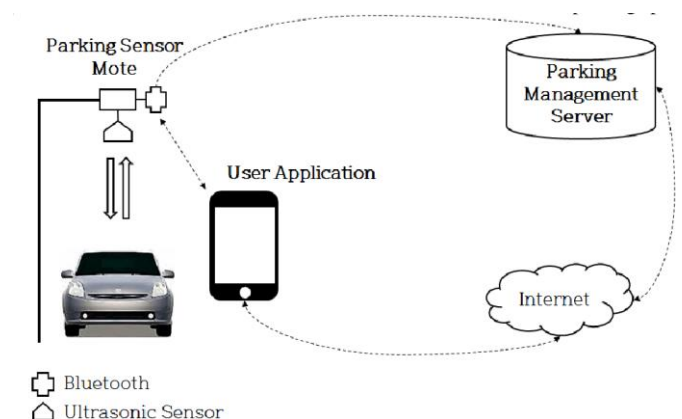

Figure 2: ultrasonic sensor[4]

It uses a method called time-of-flight measurement, where ultrasonic sensors calculate the distance by the time travel duration of sound waves to and from an object. Ultrasonic sensors provide real-time data based on the detected distance, and they also offer both analog and digital outputs. Ultrasonic sensors are not only used in parking systems but are also included in various areas such as robotics, automation, and many more.

Infrared Sensor:- [5]Infrared sensors are like heat detectors used in smart parking systems. They work by sensing the heat emitted by objects, such as vehicles. These sensors are mostly installed above the parking spaces or integrated into parking spaces so that they can cover the parking area more effectively. When a vehicle enters or exits a parking space it interrupts the infrared radiations which are detected by the sensor, that indicates the occupancy of the parking space. These sensors are very crucial in smart parking solutions as they detect accurately the presence of vehicles and enable efficient management of parking spaces worldwide.
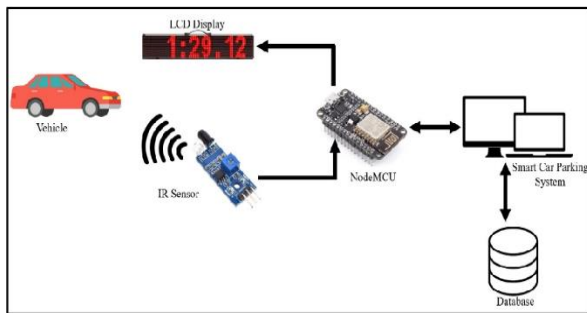

Figure 3: Infrared sensors[6]

There are two main types:-

   i.   Passive infrared sensors

   ii.   Active infrared sensors

i.Passive Infrared Sensors:-Passive infrared sensors are used to detect heat levels within their view. It always blocks the heat causing the sensor to detect occupancy, whenever a vehicle enters into the detection zone. These sensors are just like detecting energy and notice the change in heat whenever a car or person enters a parking space. They can get confused by things like rain and snow but are great at spotting activity. They work well inside but struggle outside, usually, they are placed under the ground or ceiling.

ii. Active infrared sensors:- Active infrared sensors are used to radiate heat and measure how it bounces back. If ever a vehicle blocks the bounces back and they know that the parking space is already occupied. They create

their heat and check always how it bounces back. Usually, they work best indoors.

Camera-Based Sensors:- Camera-based sensors use cameras that are installed inside the vehicles to provide visual assistance when parking or squeezing into tight spaces. This system provides real-time footage of the available vehicles in the surroundings on a dashboard system inside the system. They provide features like parking guidelines, that help drivers to judge the distance and alignment with obstacles.

Most of the time cameras are put on the back of the cars but in some cars, cameras are also on the front or sides too. whenever the driver puts the car in reverse the camera sensors start working and show what's
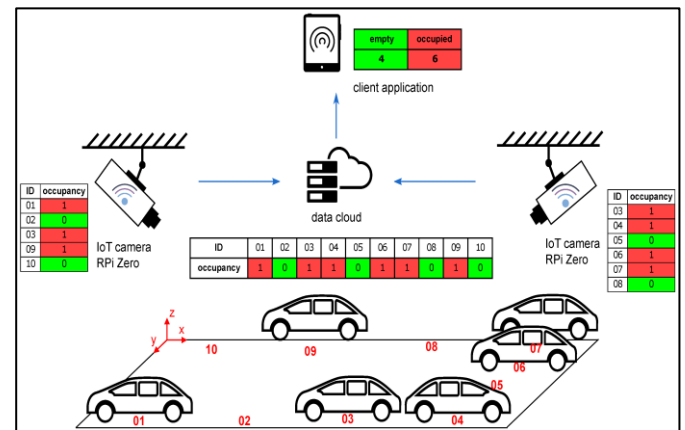

Figure 4: Camera Based sensors[7]

behind the car. Some advanced system also offers different angles that can show you everything around the car and make the parking easier no matter how the complex situation is.

Raspberry Pi:- Consider the Raspberry Pi parking system as a helpful buddy in your car. It uses ultrasonic sensors that tell you if there is any obstacle around you or anything nearby you. Mostly these sensors are fitted on the bumpers of cars that emit high-frequency sound waves. Whenever these sound waves hit any obstacle, they bounce back like echos and the sensor catches them. To make this algorithm work we connect the sensors to Raspberry Pi using wires. We can think of it as plugging them into the brain of the system. In short, we can say that Raspberry Pi is a small computer that controls everything.
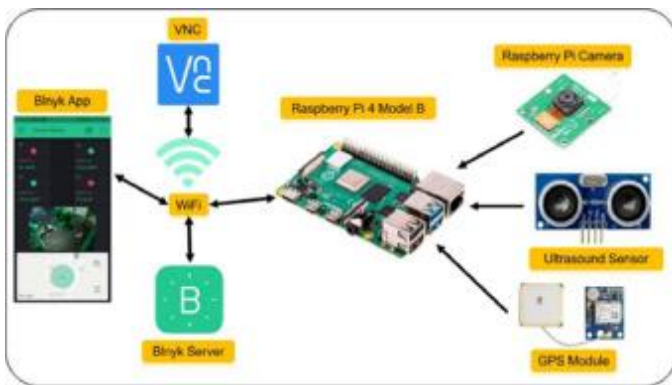
Figure 5: Raspberry Pi Sensors[8]

The next part is programming where we write code usually in Python to tell the Raspberry Pi how to talk to the sensors. In simple we can say that it gives instructions using Python language. The program tells the sensors to send the sound waves and to measure how much time it takes to bounce back from the objects that are present around the car. On that basis, it also calculates how far they are present

Once the Raspberry Pi calculates the distance it can show this distance inside the car on the screen, so the driver knows how close they are to hitting something. It can also make alarms go off- like beeping sounds or flashing lights, if the car gets too close to that object. It warns the driver to stop. Lastly to run all these Raspberry needs some power to do their job without any hiccups.

Magnetic Sensor:- [9]In a smart parking system magnetic sensor helps to identify the presence and absence of vehicles in the parking area. It works by identifying the alterations in the magnetic field Because of the presence of vehicles in parking areas. These variations are then converted into electrical signals to find out if there is space available or not to park the vehicle. Different sensors like Hall effect sensors, magneto-resistive sensors, etc are the common types of magnetic sensors that use unique principles for working.
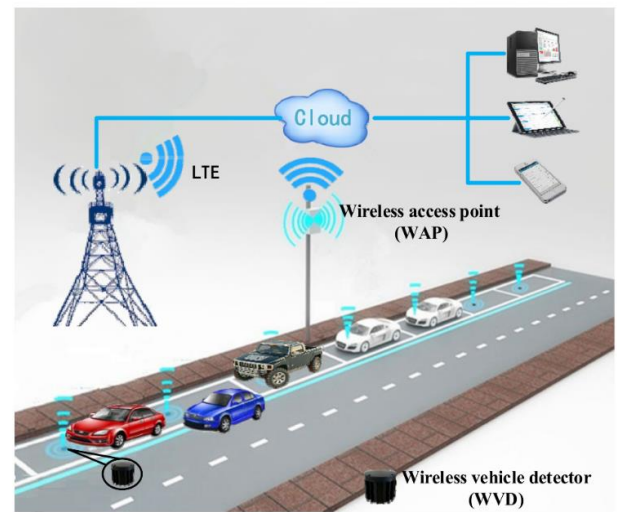

Figure 6: Magnetic sensors[10]

 Magnetic sensors are mostly installed under the surface of parking spaces. These sensors are mostly not visible to the drivers but it covers the entire parking area very efficiently. When a vehicle is parked over the sensors it disturbs the magnetic field then it leads to a change in the magnetic flux of density.

Then this disturbance is effectively detected by the sensors that indicate the available area for parking in the parking space. The detection range of magnetic sensors is limited to the proximity of sensors, i.e. within a few centimeters to a meter. These sensors are not affected by different weather conditions which makes them more suitable for outdoor applications.
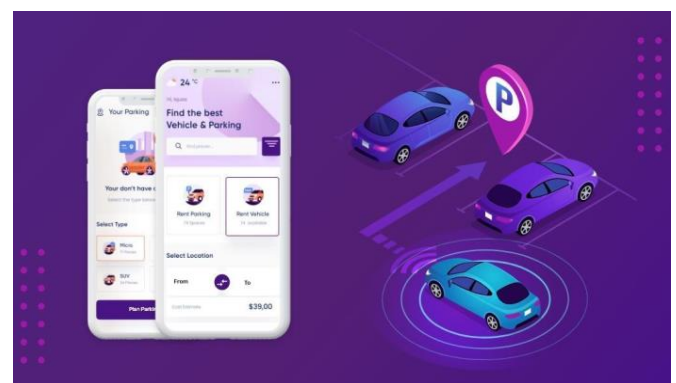
Android Module:-

Figure 7: Android Module[11]

Android module consists of creating an Android app for parking stations that focus on user comfort and effortless working. The user interface(UI) should be easy to use and navigate. It should involve features like a map for showing nearby parking stations, and filters for decreasing the search results based on distance, whether

the space is available or not, and cost. Including services such as GPS, which ensures the exact location of the user and displays all the nearby parking lots using APIs such as Google Maps. keeping the important parking information in a database gives easy access to details like location, capacity, availability, and cost. Supporting pre-booking functions and having a safe payment option for paid services also makes it easier for users to book parking spots before the time.
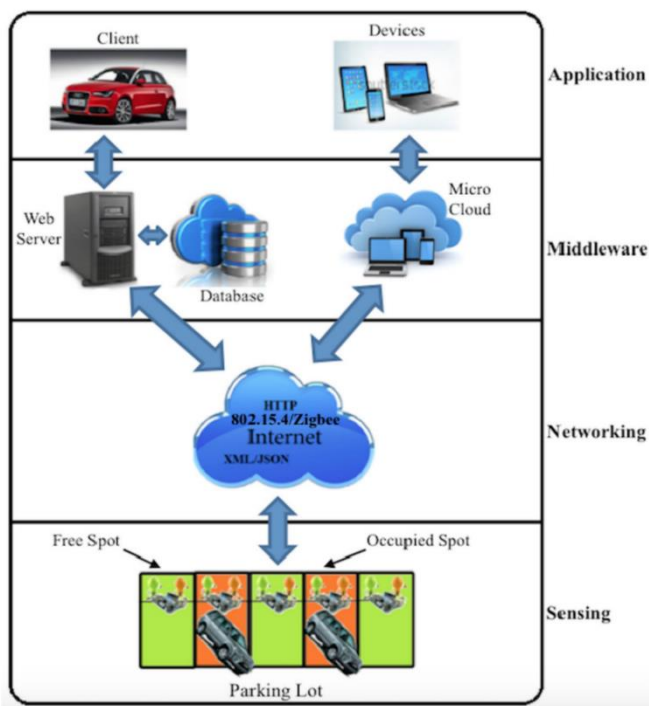
Implications:-

Figure 8: Smart Parking System[12]

[13]Smart parking technology has been gradually implemented in various cities across India to address parking congestion and improve urban mobility. Here are examples of cities in India where smart parking solutions have been deployed along with details of the technology used:

Pune:-

Sensors Used: Pune has implemented smart parking solutions utilizing ultrasonic sensors, magnetic sensors, and mobile app-based payment systems.

In Pune people have introduced a smart parking system to make parking easier and less stressful. They have used special sensors in parking areas of JM Road and FC Road. These sensors help to detect if a car is parked or not in the parking area. It uses an ultrasonic sensor that works like sonar and helps to sense the presence of a vehicle. It also uses a magnetic sensor for parking on the street.

To make this process more efficient, they have created a smartphone application that tells drivers which parking spaces are available in real-time. So the drivers can easily check for parking spots before heading to the location. Also, they do not need to worry about carrying cash as they can easily pay for parking through the app. This smart parking system helps to make parking easier, reduces traffic congestion, and saves time for everyone.

Hyderabad:-

Hyderabad:

Sensors Used: Hyderabad has implemented smart parking technology featuring ultrasonic sensors, magnetic sensors, and mobile app-based payment systems.

In Hyderabad, people have introduced a smart parking system to make parking easier and less stressful. They have used special sensors in parking areas of Banjara Hills and HITEC city. These sensors help to detect if a car is parked or not in the parking area. It uses an ultrasonic sensor that works like sonar and helps to sense the presence of a vehicle. also uses magnetic sensors for parking on the street.

To make this process more efficient, they have created a smartphone application that tells drivers which parking spaces are available in real-time. So the drivers can easily check for parking spots before heading to the location. Also, they do not need to worry about carrying cash as they can easily pay for parking through the app. This smart parking system helps to make parking easier, reduces traffic congestion, and saves time for everyone.

Challenges:

putting into effect IoT-enabled parking systems has some challenges which are mentioned below:

1. sensitive information: Sensitive information This includes securing data and preventing access to sensitive information such as vehicle numbers and payment information.
2. Cybersecurity Risks: Cybersecurity risks involve protecting parking sensors and communication network sensors against viruses, cyber-attacks, and unverified access
3. Interoperability and vendor lock-in: this involves taking care of the compatibility problems between different companies or vendors' systems. this is done via communication, collaboration with different systems and platforms, and freely available solutions.
4. Infrastructure and connectivity: for the sensors to work efficiently reliable internet connection

is a must and it also needs a stable power supply to function properly, especially in rural areas.

5. Physical Damage and Environmental Challenges: outdoor parking sensors need to be designed in such a way that they can handle harsh weather conditions and possible physical damage. This needs the combination of tough design ideas and strong safety measures.

6. Scalability and Maintenance: The increasing number of IoT devices and parking spaces makes managing and scalability more challenging. Handling this requires centralized management tools and regular maintenance.

Future Scope:-

1. Integration With Public Transport:-
    Parking systems can work together with buses, trains, or other public transportation. This makes it easier to plan our trip with the help of one application. It helps to find a parking spot near the public spot where we can easily switch with bus or train.

2. Real Time Parking Updates:-
    We can check the empty parking spaces available for parking using the mobile application before heading to the location. It uses different sensors to sense the available spots in parking lots.

3. Environment Monitoring:-
    Some parking system helps us to check the air quality and temperature around them. It helps cities to keep track of the pollution level and helps to make changes to keep the air cleaner.

4. Digital Payments:-
    We can pay for parking space using our phone or digital wallet instead of using cash. This makes it easier for everyone as we don't need to carry cash or coins to pay the parking fees.

5. Smart City Initiatives:-
    These are the projects that use new and innovative technologies to make cities better for everyone. Smart parking is just one part of making cities more efficient and enjoyable for people to live in. It is all about using different technologies to solve problems and improve people's lives.

Conclusion:-

The potential of IoT in Indian cities is tremendous. By using IoT technologies India can tackle and solve all the challenges related to urbanization and traffic congestion.

IoT systems mostly rely on sensors that are spread throughout the whole city. It provides the real-time data to make more informed decisions. These sensors help to

upgrade the parking systems, enhance the traffic flow, and reduce pollution.

These sensors help to monitor environmental factors like air quality and pollution control. In places like New Delhi, these sensors help to track pollution levels guide the highly polluted areas, and keep informed to all citizens.

In public transportation, IoT is used to make things smoother and easier. It integrates the metro stations and bus terminals to provide real-time updates on parking areas. This makes traveling easier and saves time.

In conclusion, we can say that IoT offers a promising path towards smarter and more sustainable Indian cities. But there is one thing that we need to take care is making sure our data is safe and all the systems can work together efficiently. Once we do that, IoT can lead to efficient traffic management, enhanced safety, and improved urban quality.

References:-

[1] Ashutosh Kumar Singh1, Mohit Prakash2, Shailesh Yadav3, Asst. Prof. Pavan Sharma4, (2019, April), "Smart Parking System Using IoT",
https://www.irjet.net/archives/V6/i4/IRJET-V6I4635.pdf

[2] J. Cynthia, C. Bharathi Priya, P. A. Gopinath, (2018, November), "IOT-based Smart Parking Management System",
https://www.ijrte.org/wp-content/uploads/papers/v7i4s/E1996017519.pdf

[3] https://parksol.lt/solutions/ultrasonic-sensor

https://product.tdk.com/en/techlibrary/applicationnote/park-assist_sensor-disk_ultrasonic_mlcc.html

[4]Figure
https://images.app.goo.gl/v4Kx6QwoNwCKguAFA

[5]
https://ietresearch.onlinelibrary.wiley.com/doi/10.1049/iet-its.2017.0406

[6]Figure3:https://images.app.goo.gl/NAFwmgnkqPD4Y3Jr8

[7]Figure 4:

https://images.app.goo.gl/Bkxdsi8HyVDSWiyw8

[8]Figure 5:

https://images.app.goo.gl/c54qcVKoeCzDaQqd6

[9]   https://parksol.lt/solutions/wireless-magnetic-parking-sensor

[10]Figure 6:

https://images.app.goo.gl/JFmpnqCJ2ufYjCL96

[11]Figure 7:

https://images.app.goo.gl/RhG6Ggsymdtmrz1UA

[12]Figure 8:

https://images.app.goo.gl/5YErrwPtbrv5QHFF8

[13]   https://parkplus.io/blog/cars/smart-parking-solution