

PHASE 3: IoT Device Development And Python Script Development

Urbanization is on the rise, and the complexity of city traffic is growing on a daily basis, especially post-COVID when everyone seems to be out on the road. Public transport is not easily accessible for all while parking a personal vehicle is even tougher (and costlier).

The requirement for an Internet of Things (IoT)-powered parking system has, therefore, gained prominence to minimize the ongoing traffic congestion and to reduce the unpredictability of parking availability. With numerous on the horizon, devising an IoT-based smart parking system is relatively easy now.

In fact, such infrastructure empowers drivers and parking facility managers with advanced information such as available slots and current parking fee.

But exactly, what is an IoT-based parking system

An IoT-based parking system is a centralized management that enables drivers to search for and reserve a parking spot remotely through their smartphones. It offers a convenient arrangement for drivers to park their cars when they are looking to avoid potential traffic congestion.

The system's hardware sensors detect available slots and communicate the information to the drivers in that area in real-time. IoT technology ensures that they do not have to worry about finding an available space again – allowing them to travel conveniently.

Besides, the connected device sends alerts about peak times and surcharges. No one wants to struggle to find a parking slot or pay more at any given point.

Using smart parking technology will help maximize the consumption of existing parking space, increase the effectiveness of parking operations, and facilitate easier traffic flow with just a few taps on a mobile app.

IoT provides the means to connect various devices and sensors in the parking ecosystem and fetch data that can be used to optimize operations. The future of smart parking lies in the integration of IoT with The arrangement would free up even more road space and make it easier for people to get around.

The massive problem with the current parking management

1. Overpaying

Sometimes, drivers still determine how long they will stay in a particular location. As a result, they may pay too much for parking while the duration may be much lesser.

2. Environmental impact

Besides time, a lot of fuel is consumed looking for an appropriate parking space. When it rains, numerous pollutants accumulated in the parking lots get a wash, creating dirty, wet mud and foul smells.

3. Parking inappropriately

The parking lot at the mall or the customer's intended destination is usually insufficient and they end up parking outside the designated spot. It results in greater traffic congestion.

4. Overcrowded parking spaces

The biggest issue right now is that there are more cars on the road compared to the parking spots. Talk about bumper-to-bumper traffic!

5. Insufficient parking space utilization

People frequently lack patience or are unaware of parking slot availability. They tend to park improperly due to the rush. Occasionally, they may not leave enough room for other vehicles to park. These lead to traffic blockages.

How IoT can be used in parking management

The rapid demand for parking spaces stems from two major trends – urbanization and car ownership. In a short period, the IoT-based parking management system has positively impacted all stakeholders involved in the process.

For instance, drivers can plan trips and commutes keeping slot occupancy in mind. Enforcement agencies can detect and evaluate the gravity of parking rules violations in seconds.

Parking facility managers can optimize the use of the personnel and the available space. Adding to that thought, IoT can be used in parking management in the following ways:

- Create “smart” parking meters that accept payments via credit card or smartphone and provide real-time information on space availability.
- Extend the operating time of an autonomous parking system by consuming less power with the help of network standard.
- Send real-time data from IoT sensors to a cloud server and share it with users to provide them with the details of free-parking spaces.
- Determine the number and position of vacant parking spaces precisely using **IoT sensors**.
- Reduce congestion and improve traffic flow by using sensors to monitor parking space availability and direct drivers to available spaces.
- **IoT gateway** and the LPWAN protocol help connect IoT devices and sensors in sizable parking lots.
- The parking management company can use a cloud-based IoT dashboard. It uses gathered sensor data to mine intelligible insights that are visually appealing and provides a clear picture of the parking facility.
- Optimize parking operations and improve security by tracking vehicles entering and exiting a parking facility.

Mobile applications can display parking data to drivers and send alerts in case of a security breach.

IoT-based sensing devices commonly used for smart parking systems include:

- Ultrasonic sensors measure the distance of a target object by eliminating ultrasonic sound waves and convert the reflected sound into an electrical signal.
- Electromagnetic field detection is helpful to detect metals as they pick up minute changes in the magnetic field.
- Infrared sensors can detect motion and gauge temperature changes in the immediate surroundings.

How IoT can solve the existing parking management problem

The I o T data picked up from the sensors gets transmitted over a wireless connection to a cloud server. The information is collated and analyzed in real-time to create a map of available parking slots, which is reflected on the smartphone application.



Io T-driven parking management systems assist in meeting parking needs by solving various issues in the following ways:

1. Improving car control and safety

By alerting drivers when they are going to leave a car in a no-parking area, smart parking systems increase the safety of vehicles. Connected systems provide pertinent data about the areas with the highest violation density and the peak timing for parking violations. IoT also monitors traffic law reinforcement structures. It enables the creation of an efficient framework for tracking and controlling parking violations.

2. Monitoring the parking space in real-time

IoT facilitates search simplification and accelerates the parking procedure. Automated parking and reduced human intervention remove uncertainty and guesswork in seeking open parking spaces. The technology also prevents drivers from wasting time driving around crowded parking lots. IoT solutions help find a parking space by monitoring the facility occupancy in real-time.

3. Anticipating the traffic flow by examining parking patterns

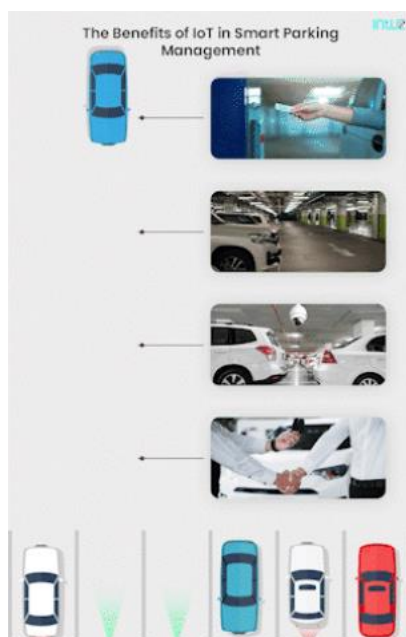
High traffic zones like shopping centers, office buildings, and airports can use IoT-based smart parking solutions for optimization. IoT technology helps gain more clarity and insight thanks to connected parking management software, which fills a crucial decision-making gap.

4. Making the most of time and space in a congested urban environment

There will be less search activity on the street as smart parking technologies make finding an open spot more manageable. As a result, the issue of traffic jams can be reduced, allowing city people to save potentially valuable time.

The benefits of IoT in smart parking management

As mentioned before, smart parking uses sensors like any other IoT application. The goal is to automate and reduce the time spent manually searching for a parking space—which is frustrating and tedious for the drivers.



Some IoT solutions may comprise a complete suite of services, including car searching functionalities, online payments, and parking time notifications. An IoT-connected parking solution can significantly benefit the driver and the parking facility owner. The key benefits of using an IoT-powered smart parking management are:

1. Reduced costs

Using IoT in parking management, you can reduce the overall costs associated with running a parking facility. For example, you can use sensors to detect when a space is vacated and open up that space to other vehicles, reducing the need for manual labor.

2. Enhanced security

IoT enhances security as the sensors detect the vehicle and raise an alarm in case of unauthorized access. Security cameras and license plate scanners can be integrated into an IoT platform to detect and track suspicious activity automatically. The vehicle is constantly monitored so the driver can be stress-free.

3. Increased efficiency

The driver will be redirected to the nearest available parking spot saving time and fuel. In contrast, the parking company can easily manage more vehicles with an IoT system than with a human-based workflow.

4. Improved customer experience

IoT in parking management makes it possible to provide a better customer experience with functionalities such as real-time information on parking availability, guidance on the nearest available parking spot, and automated payment options. Easy parking improves the customer experience and allows businesses to realize greater benefits through repeated customer visits.

The challenges of implementing IoT in smart parking management

Smart parking is an emerging market with immense potential. According to a recent study, the global smart parking market is expected to grow from \$3.8 billion in 2020 to **\$5.4 billion** by 2025. In the US, more than **\$8 billion** yearly revenue is generated through commercial parking lots and the garages industry.

But even with such a large market, only a small percentage of parking facilities have adopted smart parking technologies. Several challenges are causing the slow adoption rate, including:

A. Organizational challenges

1. Awareness and acceptance

It is an enormous undertaking to transform a culture that has existed for many centuries. Parking has always been a current business involving direct financial exchange. The incorporation of technology represents a cultural shift that will take some time.

2. High cost of implementation

The capital investment required to install smart parking infrastructure can be very high. For example, a single parking space can cost upwards of \$1,000 to equip with the necessary sensors and IoT devices. When you multiply that by the number of parking spaces in a given facility, the costs can become prohibitive.

B. Technical challenges

1. Correctness of information

A key challenge is ensuring correct information is displayed to the users on the application at all times. Inaccuracy or delays in receiving the data may result in drivers traveling to different places than the designated parking spots - causing much mayhem and confusion on the roads.

2. Availability of standard IoT tools

The service providers use technological platforms like the P&E PARC and PUCRS to manage the parking process which is so extensive. These include computer clients, servers, wireless and wired telecommunications systems, hardware sensors, dynamic messaging systems, traffic management devices, and application interfaces.

The biggest obstacle to lowering the price and complexity of IoT smart parking is making it possible for all these devices from hundreds of different vendors to speak with one another and connect to a single platform.

3. Lack of talent in the smart technology space

Automated parking management systems will require professionals who are familiar with IoT and can provide immediate troubleshooting. Deploying such intricate **smart solutions** requires the finest advice for carrying out the projects correctly.

Creating a smart parking system involves various components such as sensors, a backend system, and possibly a user interface. Below is a simplified example using Python for a console-based implementation. Keep in mind that a real-world system would require more complexity, possibly involving web frameworks, databases, and hardware integration.

python

```
class ParkingSpace:
```

```
    def __init__(self, number):
```

```
        self.number = number
```

```
        self.is_occupied = False
```

```
class SmartParkingSystem:
```

```
    def __init__(self, num_spaces):
```

```
        self.parking_spaces = [ParkingSpace(i + 1) for i in range(num_spaces)]
```

```
    def check_availability(self):
```

```
        return [space.number for space in self.parking_spaces if not space.is_occupied]
```

```
    def park_car(self, space_number):
```

```
        space = self._get_space_by_number(space_number)
```

```
        if space and not space.is_occupied:
```

```
            space.is_occupied = True
```

```
            return f"Car parked in space {space_number}."
```

```
        elif space and space.is_occupied:
```

```
            return f"Space {space_number} is already occupied."
```

```
        else:
```

```
            return f"Invalid space number: {space_number}."
```

```
    def leave_space(self, space_number):
```

```
        space = self._get_space_by_number(space_number)
```

```
        if space and space.is_occupied:
```

```
            space.is_occupied = False
```

```
            return f"Space {space_number} is now vacant."
```

```

elif space and not space.is_occupied:

    return f"Space {space_number} is already vacant."

else:

    return f"Invalid space number: {space_number}."

def _get_space_by_number(self, space_number):

    spaces = [space for space in self.parking_spaces if space.number == space_number]

    return spaces[0] if spaces else None

```

Example Usage

```

smart_parking = SmartParkingSystem(5)

print("Available Spaces:", smart_parking.check_availability())

print(smart_parking.park_car(2)) # Park in space 2

print(smart_parking.park_car(4)) # Park in space 4

print("Available Spaces:", smart_parking.check_availability())

print(smart_parking.leave_space(2)) # Vacate space 2

print("Available Spaces:", smart_parking.check_availability())

```

This example demonstrates a basic smart parking system with parking space occupancy tracking. Depending on your specific requirements, you might need to expand this code and integrate it with external systems or hardware components.