Smart parking

Current Parking Challenges:

Parking congestion, inefficient utilization of spaces, and frustrated drivers are common problems in urban areas. Traditional parking systems lack real-time information and smart management. *IoT*offers a solution by enabling real-time monitoring, intelligent parking guidance, and seamless payment mechanisms. Let's explore how IoT can revolutionize parking efficiency.

IoT and Smart Parking :

By leveraging *IoT*technology, parking becomes smarter and more efficient. Connected sensors and devices provide real-time data on available parking spaces, allowing drivers to find vacant spots effortlessly. Smart parking solutions also enable automated payment systems, reducing the hassle of manual transactions. Let's dive deeper into the components of IoT-enabled smart parking.

Sensors and Data Collection:

Sensors play a crucial role in smart parking solutions. They detect the presence or absence of vehicles in parking spaces, transmitting data to a central system. *Real- timedata* on parking occupancy enables efficient management, accurate guidance, and predictive analytics. With IoT, parking operators can make data-driven decisions to optimize parking resources and enhance overall efficiency Data Collection:

Intelligent Parking Guidance:

Finding an available parking spot can be frustrating. *Intelligentparkingguidance* systems use IoT data to direct drivers to vacant spaces quickly. Mobile apps, digital signage, and in-car navigation systems provide real-time guidance, reducing search time and traffic congestion. With IoT-enabled guidance, drivers can have a stress-free parking experience

Seamless Payment Mechanisms:

Traditional parking payment methods often involve manual transactions and long queues. *IoT-enabled*smart parking solutions offer seamless payment mechanisms. Integrated mobile payment apps and automatic billing systems make the payment process convenient and efficient. By eliminating the need for physical tickets or cash, IoT simplifies the parking payment experience for both drivers and parking operators

Beneits ofIoT in Parking :

The adoption of IoT for smart parking brings numerous benefits. It optimizes parking space utilization, reduces traffic congestion, and enhances user experience. Drivers save time and fuel by quickly finding parking spots, while parking operators gain

insights for efficient resource allocation. With IoT, revolutionize parking efficiency and create a seamless parking ecosystem

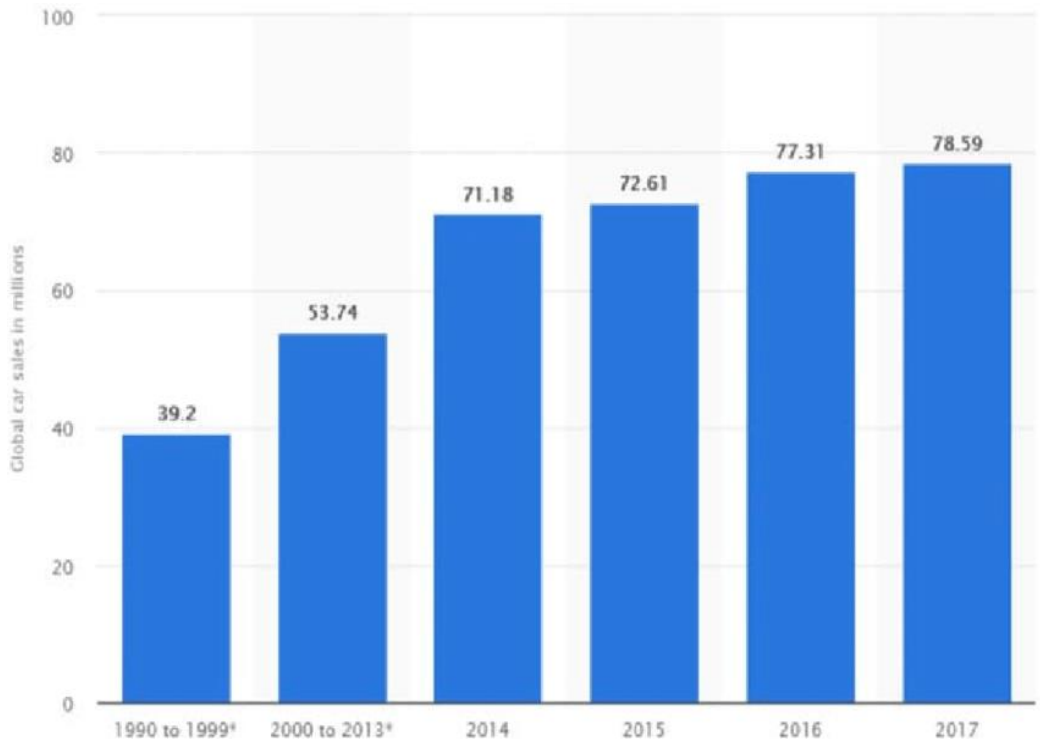

Fig 1: Number of cars sold worldwide from 1990 to 2017 (in million units) [2].

Many local governments have their own regulation regarding parking space. Commercial facilities, for example, must provide enough parking spaces for their customers. Hong Kong government dictates that to match manifest operational requirements, commercial facilities should have 'sufficient on-site parking' [3]. In Houston, supermarket or convenience market should have five spaces per 1,000 ft2 (about 93 m2) Gross Floor Area (GFA) of the building [4]. Meanwhile, Northern Ireland authority requires food retail shops should have one space per 14 m2 GFA, and minimum recommended space for a car is 4.8 m by 2.4 m [5]. In some cases, the required parking area can be almost as big as the GFA of the building itself. The road parking area can be used as the temporary solution when parking area becomes overflowed, but this sacrifices the space for the road, and in most cases, causes congestion [6-8]. Nowadays, parking area becomes bigger and more difficult to be monitored. In addition, the bigger parking area also needs more resources to maintain. The location and the design of the parking area makes it hard, even for the parking management to monitor. This condition also makes it difficult, if not impossible, for the owner of the cars to monitor their cars all the time. While most of the people will be concentrated at the center of activities, such as office buildings or shopping centers, only a few people will be in the parking areas. This will

increase the probability for a person isolated and targeted for crime. Parking areas are open for public, and everyone can possibly have criminal intention [9]. In addition, they might attract people with criminal intention as the parked cars and uneven lightning provide the ideal place to hide. An assessment is needed to determine the security of a parking area as it measures the vulnerability by determining threats exist against the current security system. The assessment then answers whether parking management should provide the reasonable security system for their service. The security system should have a psychological effect on a potential criminal, discourage potential criminal for committing crime. This can be achieved by adequate lighting, the presence of CCTV, security guards, and signs installation 280 Giva Mutiara Andriana, Anak Agung Gde Agung and Rini Handayani indicating the presence of the security system. In addition, it should be preventative which enables to stop the potential acts of criminals physically. It includes the use of barrier gate and mechanism to prevent unauthorized access entering the site [10]. Security can be active or passive. Active security involves direct human involvement and the use of specific equipment (such as security guard and CCTV); meanwhile, passive security requires the design of the physical part of the facility to psychologically obstruct potential crime. This concept is known as Crime Prevention through Environmental Design (CPTED) [11]. CPTED is designed for parking area includes lightning, surveillance, access controls, sign and graphics, natural territorial reinforcement, maintenance of the area, and supported by legitimate activity [9, 10, 12]. In previous research, the determined sensors were found to detect vehicle at a parking space [13], and design a parking reservation system [14]. Thus, the objective of present study is to present a parking system, which allows the drivers to search and reserve an empty space before entering the parking area, and to monitor the vehicle during parking. This paper is organized as follows: Section 1 explains the condition of parking services and difficulties for a driver to get a space and monitor the car. Section 2 discusses the architecture of the proposed system. Section 3, 4, and 5 discuss scenarios of the system. Section 6 discusses implementation of the system. Finally, the last two sections offer discussion of the current research and conclusion.

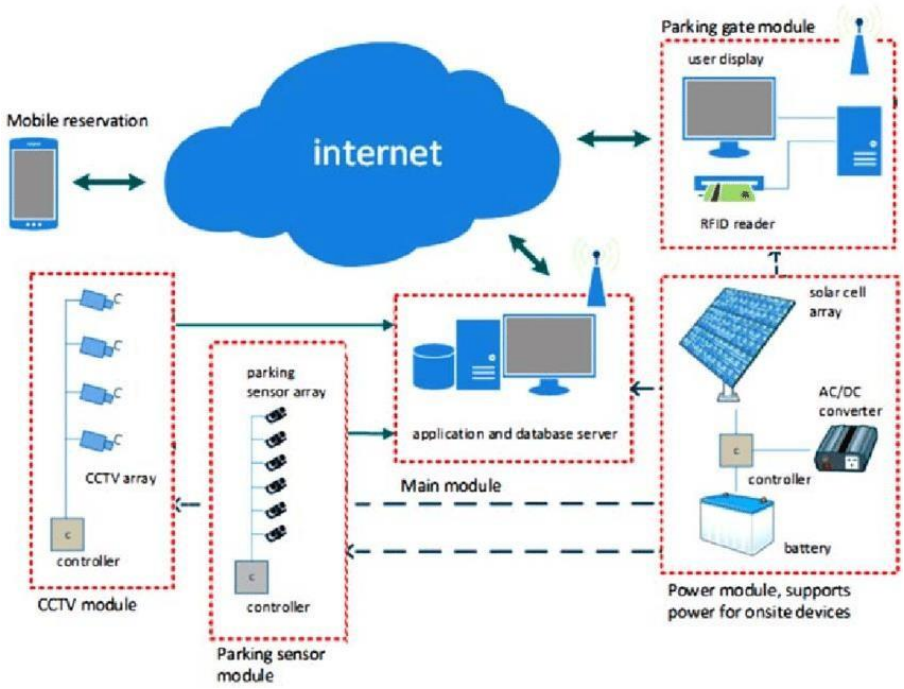

Fig 2: System architecture.

Based on Figure 2, mobile reservation module contains application to view, to select and to reserve a parking space. Meanwhile, the parking gate module performs access control, for incoming and outgoing cars. A driver can also view, select and reserve a parking space at the parking gate module. Then, the parking sensor module is located in each space and detects the presence of the car. In addition, CCTV module provides monitoring for the whole area, and accessible by the parking driver. Then, the power module uses solar panels to provide alternative electricity for the system. From Figure 2, it is clearly shown that the whole module is controlled by the main module, which contains the application and the parking database. Each module is discussed as follows. First, the parking gate module provides on-site reservation for the driver. The RFID reader is located at the parking area's entry gate will be as the place for reserving parking ticket when the driver tap his/her RFID card. When the driver chooses a parking space, his ID from RFID and the space ID 282 Giva Mutiara Andriana, Anak Agung Gde Agung and Rini Handayani is recorded. The parking gate module uses a NodeMCU with embedded WiFi, provides wireless connectivity with the main module. The pre-registered driver can also view, select and reserve a parking space using an application installed in the mobile device. The reservation will make sure the driver gets a parking space when he/she arrives at the parking area. Second, the parking sensor module is installed on the floor of every space [15]. This module consists of an ultrasonic sensor, a microcontroller and an array of LEDs. The module uses HC-SR04 ultrasonic sensor, and placed at 90° angle. The sensor detects the presence of a vehicle and updates the status of each parking space to apply in the main module. A NodeMCU, embedded with an ESP8266 Wi-Fi SoC (System on Chip) is used as the microcontroller. The array of LEDs is connected to the controller display visual information whether the space is available or occupied. Then, CCTV cameras are used to

monitor the parking area. The use of CCTV can reduce, but not eliminate the security personnel. CCTVs can record events in the area, which can be used as an evidence when needed. Each CCTV is mapped to cover certain space. A sign indicates the presence of CCTV is placed within the area to discourage potential criminal and creating secure feeling for the parking easier. More about access control to the CCTV will be discussed in surveillance scenario

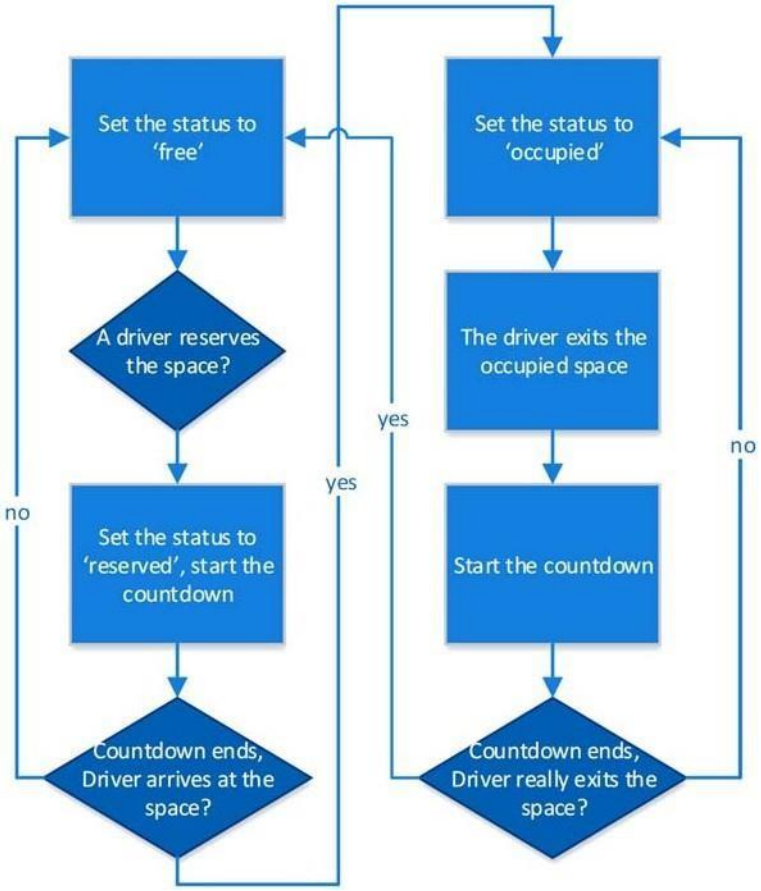

Fig 3: Reservation flow diagram.

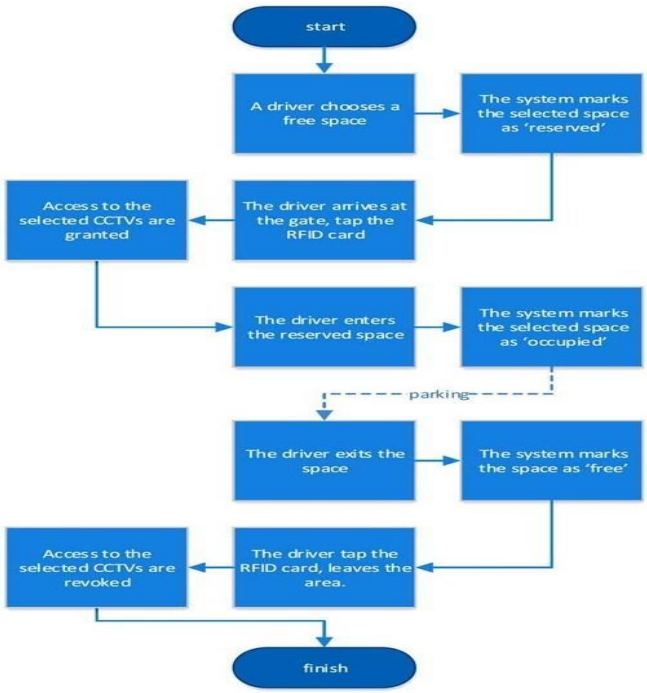

Fig 4:Parking scenario.

If the car arrives at the space within the specific time, the parking sensor module triggers the system to change the status from reserved to occupy. When the car leaves the space, the parking sensor triggers the system to start another countdown, to make sure the leaving car exits the space properly. If the car does not enter the space again within specific time, the system change the status from occupied to free, so the space can be reserved by anothe driver immediately. The overall parking scenario is illustrated in Figure 4.

Advantages:

- **Optimized parking** – Users find the best spot available, saving time, resources and effort. The parking lot fills up efficiently and space can be utilized properly by commercial and corporate entities.
- **Reduced traffic** – Traffic flow increases as fewer cars are required to drive around in search of an open parking space.
- **Reduced pollution** – Searching for parking burns around one million barrels of oil a day. An optimal parking solution will significantly decrease driving time, thus lowering the amount of daily vehicle emissions and ultimately reducing the global environmental footprint.
- **Enhanced User Experience** – A smart parking solution will integrate the entire user experience into a unified action. Driver's payment, spot identification, location search and time notifications all seamlessly become part of the destination arrival process.
- **New Revenue Streams** – Many new revenue streams are possible with smart parking technology. For example, lot owners can enable tiered payment options dependent on

parking space location. Also, reward programs can be integrated into existing models to encourage repeat users.

- **Integrated Payments and POS** – Returning users can replace daily, manual cash payments with account invoicing and application payments from their phone. This could also enable customer loyalty programs and valuable user feedback.
- **Increased Safety** – Parking lot employees and security guards contain real-time lot data that can help prevent parking violations and suspicious activity. License plate recognition cameras can gather pertinent footage. Also, decreased spot-searching traffic on the streets can reduce accidents caused by the distraction of searching for parking.
- **Real-Time Data and Trend Insight** – Over time, a smart parking solution can produce data that uncovers correlations and trends of users and lots. These trends can prove to be invaluable to lot owners as to how to make adjustments and improvements to drivers.
- **Decreased Management Costs** – More automation and less manual activity saves on labor cost and resource exhaustion.
- **Increased Service and Brand Image** – A seamless experience can really skyrocket a corporate or commercial entities brand image to the user. Whether the destination is a retail store, an airport or a corporate business office, visitors will surely be impressed with the cutting edge technology and convenience factors.

Disadvantages:

- approximately 3 times more expensive than magnetometers or reflected intensity;
- higher current drain: at 1Hz sampling rate it will run on typical D size battery approximately 5 years;
- higher footprint 5x3mm which can be further increased for additional crosstalk compensation;
- it is sensitive to any optical obstruction and obviously road may not be as clean and tidy as the lab settings;
- a narrow emitted beam of light can be reflected in unpredictable ways as the bottom of the car is not flat.