Touchless Parking Payment System Using RFID Technology Integrated FinTech Payment Solutions

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***Abstract* – Urban traffic is now affecting living standards as more people place an emphasis on quality of life and parking concerns such as time-consuming parking payment process, increased congestion due to drivers looking for parking space and slowing down car speed, are becoming ever more aggravated. With the technology advancements, RFID Technology, IoT and FinTech solutions for parking payment system should be implemented particularly in high demand and scarce parking areas to enhance the parking process. Therefore, this research requires professions in related fields involved in the stratified and quota sampling process to gather reliable data and insights. Finally, the proposed system's outcomes are presented, followed by recommendations for related future study.**

Keywords— automated parking payment system, RFID Technology, touchless

I. INTRODUCTION

With the acceleration of global commercialization, the rapid growth of urban economy and income influence the improves of standard and quality of living, along with a beneficial consequence on shopping behavior (What Are the Consequences of Income Effect?, 2021). Improvements in living standards reflect a preference for comfortability of travel method, the majority of individuals are more favorable to travel by private vehicle overcrowded public transport. Hence, a smooth parking experience should be uninterruptible and has been a major concern for people who are intended to obtain a parking.

The purpose of this study is to discuss the parking payment system used in Malaysia's shopping centers and to develop a completely cashless, contactless and touchless parking payment system. By expediting the payment procedure, this system not only increases the convenience for vehicle owners but it also benefits shopping centers' parking management in keeping track on parking lots occupancy, reducing superfluous labors, obtaining more valuable parking related data and enhancing the safety and security in the parking environment.

Highly accessible parking can attract potential customers (Waldron-Curry, 2021). Hence, parking payment process should not be a challenge to affect the intention of an individual's shopping experience. However, the high implementation costs of required hardware is one of the drawbacks for contactless and touchless parking payment system.

II. LITERATURE REVIEW

A. *Domain 1 – Radio Frequency Identification (RFID) Technology in parking entrance*

RFID is one of the popular technologies under Automatic Identification and Data Capture (AIDC). AIDC uses a variety of technologies to perform automatically identify objects, gather data, and have the capacity to store data electronically in computer systems without human involvement. RFID utilizes electromagnetic fields to automatically perform detection and monitor tags or unique codes attached to objects. A RFID system is comprised of both hardware and software components. RFID tags, reader, antenna, cables, barriers and computers are utilized for the hardware requirements. While database management system and networking techniques are used as software components to collect and record parking-related data (Sagar Yadav, 2014).

RFID technology is used in the parking management by implementing RFID reader at the entrance and exit of car parks. The process of detecting and reading RFID tag is shown in Fig 1., a RFID reader device detects a RFID tag, it sends signals to activate the tag, once the tag is activated, the signal is relayed back to an antenna (Zeydin Pala & Nihat Inanc, 2009). Radio frequency radiation facilitates communication between the reader and tag by providing the tag with energy required to communicate. The communication works under an interrogation zone, allowing the object attached with the tag or label to be recognized. Passive sticker-based RFID tags are commonly being used in parking management which are smaller in size and it does not require additional device with battery to power its operation (AB&R®, 2022). Each vehicle will be assigned one unique RFID tag which the data is encrypted in a microchip and attached directly on vehicle's windshield (Daithi de Buitleir, 2021). Cables link the reader, computer and automation of barrier. After the vehicle has been authenticated, the data will be transferred and stored in the database. Upon exit, the tag will be scanned once again and if it exists in the database, the barrier will open. An ultra-high frequency passive RFID tag can read at ranges as far as 27 meters with a 10-millisecond response time.

The reasons passive RFID tag is employed are considerably more affordable for vehicle owners to obtain and avoid placing additional financial burden on the society. According to a research, a fully automated and touchless

parking system significantly save time, enhance driver's experience and solve complex parking issues (Ankita Gupta et al., 2019). Therefore, in this study, all hardware and software components enabling RFID technology will be integrated to implement smart parking.

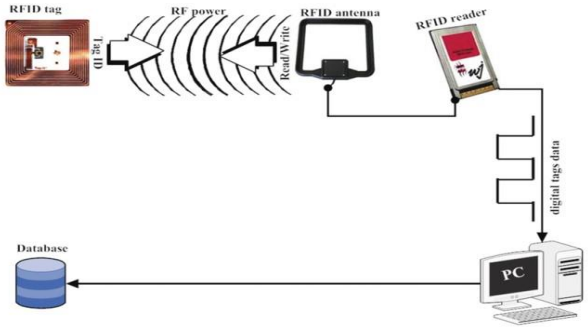

Fig. 1. Process of detecting and reading rfid tag

B. *Domain 2 – Fee calculation and payment process*

Traditional ticketing parking or cashless parking involves payment based on predetermined period of time (Abhijith Balachandrana et al., 2017). For example, parking lots with tickets would charge RM10 per entrance or per day, while malls or buildings with cashless parking systems would charge RM3 for the first two hours and an additional payment amount for each subsequent hour. Consequently, both approaches may now ensure the full utilization of money spent if the vehicle leaves the parking before the expected duration. By utilizing RFID technology, the connected database will store the vehicle's entry date and time. When the RFID tag is detected by the RFID reader installed at the exit point, the vehicle will be verified, and the date and time of exit are acknowledged. The duration of vehicle's stay is calculated by deducting the entry date and time from the exit date and time. Therefore, the amount of parking fee will be determined based on the duration. The process of parking payment fee calculation is shown in a flowchart in Fig 2.

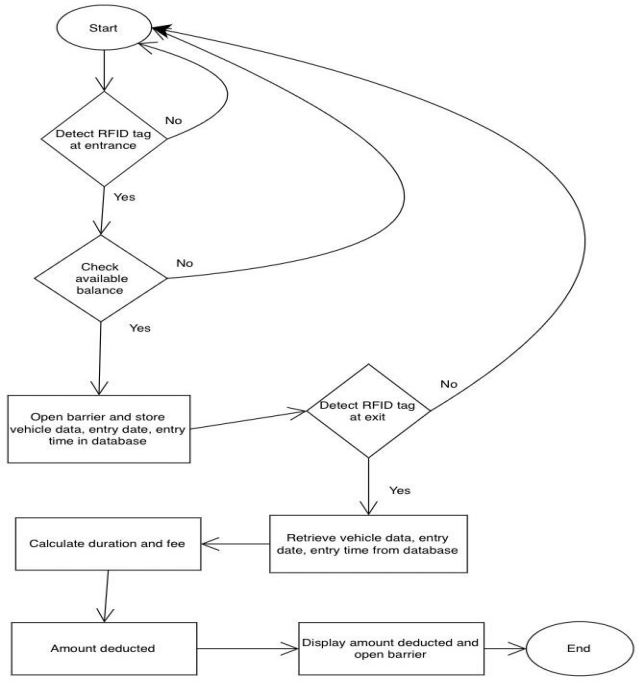

Fig. 2. Fee calculation and payment process

According to statistics shown in Fig 3., the volume of online and mobile banking transactions increased by 125% in 2020 as compared to 2019 (Fintech News Malaysia, 2021). This indicates that the society is adopting to digital payment and embracing a cashless culture. Therefore, the microchip in RFID tag will be linked to a mobile payment application, the parking fee will be deducted automatically from the application. Vehicle owners may reload their mobile payment application by linking to their bank card effortlessly. RFID parking payment system with financial technology solution will solve the scarcity of physical cash for vehicle owners and deliver fully automated parking experience.

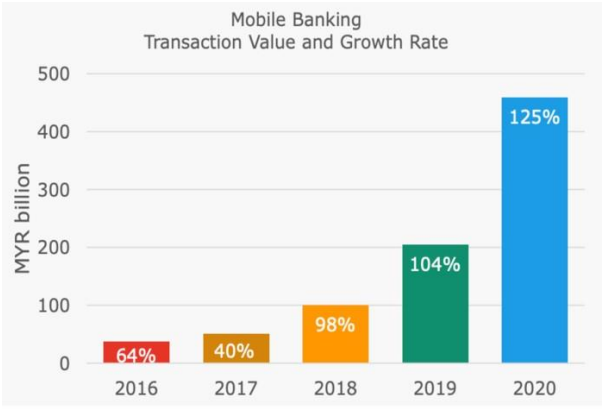

Fig. 3. Malaysia mobile banking transaction value and growth rate from 2016 to 2020

C. *Domain 3 – Parking availability detection*

RFID parking system with database connection can build a secure and well managed parking environment. A centralized database enables for the storage and tracking of records. The capacity may be enhanced to monitor the vehicle attendance and keep track of present of parking. Vehicle owners can be made aware of parking availability by integrating the RFID parking system with information displays and parking guidance. The number of vehicles that enter and leave the parking area may be counted and monitored using RFID technology. When the RFID reader verified the authenticity of RFID tags, the entry barrier automatically opens to let cars enter the parking area, and the number of availabilities will automatically decrease by one. Similarly, the number of availabilities will automatically increase by one when a car leaves the parking space. This data may subsequently be transferred to the information displays, providing drivers with the most recent information on parking availability (RFID Systems for Parking Lots and Garages, 2015).

D. *Similar System 1 – MAXPARK Autopay Station*

MAXPARK offers ticket-based parking payment systems with autopay stations. Before entering the parking area, vehicles will stop in front of the ticket dispenser to press on a button to issue a parking ticket. Barcode as an automatic identification and data capture technology is printed on the parking tickets to record date and time in. The process of making payment at ticket-based parking area is drivers visit the autopay point shown in Fig 4. and insert the ticket to make payment before exiting a designated parking area. Autopay machine will automatically compute the date and time check-in and check-out and calculate fees accordingly. Parking fee will be shown on the machine's display screen and customers

will make payment in cash. Parking fees might be adjusted differently based on the management decision (Autopay Station, n.d.).

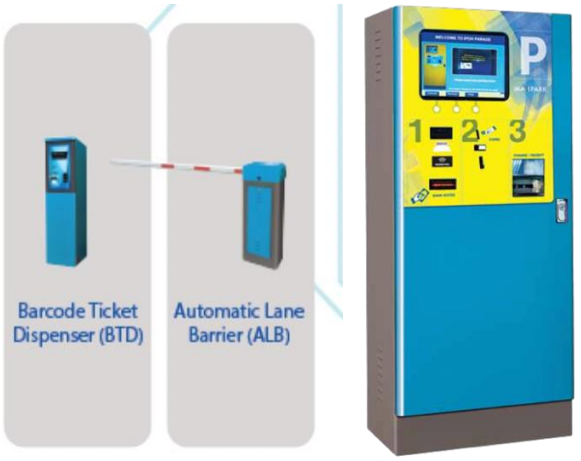

Fig. 4. Ticket Dispenser and autopay machine

E. *Similar System 2 – Smart Parking Sunway*

Smart Parking is a parking solution includes IT and IoT infrastructure such as applications, sensors or cameras to enhance visitor's parking experience. Smart parking at Sunway Pyramid Malaysia utilizes one of optical character recognition technologies – license plate recognition to provide ticketless and cashless parking experience for visitors. LPR cameras capture the image of car plate and preprocess the image through character segmentation. Each of the segmented characters are used to compare with the character stored in database. Correlation approach is used in optical character recognition to match the characters (Er.Prem Chandra Roy et al., 2018). If both characters match, then the car plate will be authorized and store in the database along with the time in. Drivers will scan a QR code found in the parking area to enter the payment website. By entering their car plate, drivers can pay parking fee with multi cashless payment options such as credit card, debit card, Touch N Go card, e-wallet, online banking, Pals For Life application using mobile phones shown in Fig 5 or visit autopay station to pay with Sunway Pals card shown in Fig 6. (Smart Parking @ Sunway Pyramid, n.d.). Card payment utilizes Near Field Communication (NFC) which enables a contactless payment experience for drivers. By tapping card and holding it against the payment terminal, it usually takes 1 to 5 seconds to capture the information.

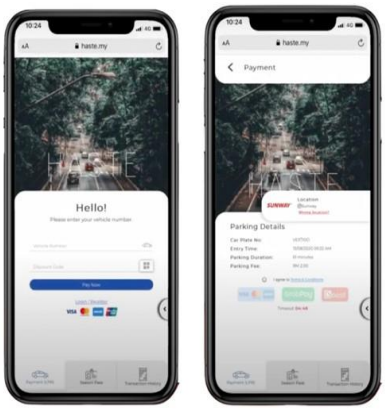

Fig. 5. Smart parking sunway payment website

Fig. 6. Smart parking sunway autopay station

F. *Compare and Contrast Table*

Table 1 shows the different features and components of both similar systems. Both similar systems use barcode and QR code as AIDC technologies, database to store data and control over barriers to automatically open and close for entry and exit. Besides, some ticket-based parking provides parking availability information displays for visitors. The proposed system will somehow exclude the cash payment method in order to delivery an efficient payment procedure. Although Smart Parking Sunway offers a variety of cashless payment methods, drivers still have to search for QR code and enter their card or bank details to pay for the parking charges or visit the autopay machine. Therefore, features and components including Automatic Identification and Data Capture (AIDC), Radio Frequency Radiation, Radio Frequency Identification, cashless payment, touchless, database, automated barrier and parking information displays are taken into consideration of the proposed solution.

TABLE I. COMPARE AND CONTRAST TABLE

Similar Systems Features/ Component	MAXPARK Autopay Station	Smart Parking Sunway
Automatic Identification and Data Capture (AIDC)	✓	✓
Radio Frequency Radiation		
Radio Frequency Identification		
Payment Method	Cash	Credit card, debit card, Touch N Go Card, e-wallet, online banking, application
Cashless Payment		✓
Touchless		
Database	✓	✓
Automated Barrier	✓	✓
Parking Information Displays	Yes and No	No

III. PROBLEM STATEMENT

Before the rises of Covid-19, pressing the button on the ticket machine in front of the barrier to generate a ticket before

entering parking lots and paying with cash at the parking machines before leaving was the traditional practice of paying for parking. By using cash, there are some situations where the machines are not able to read notes with poor condition, resulting in the notes not being accepted (Noor, 2019). Parking information including ticket number, date and time of the entrance and exit and others are encoded into barcodes and magnetic stripes printed on parking tickets may get blurry if they come into contact with water and ticket loss can trouble the payment process. In addition, if the people had stopped in front of the barrier and realized that the payment had not been made, they must reverse their car and return to the autopay machine which is extremely dangerous and inconvenient for both the vehicle owner and the vehicles waiting behind. People experiencing these setbacks must proceed to the ticket counter in order to overcome these troubles. In short, cash transaction on parking payments are time consuming, inefficient, and incompatible with offering a cashless and contactless parking access (Why Every Car Park Should Offer a Cashless Payment Option, 2022).

License Plate Recognition (LPR) cameras were implemented as an advanced smart parking method and integrated with cashless payment with using credit or debit cards and Touch N Go, becoming an alternative as well as the latest trend when the COVID-19 pandemic hits in Malaysia. Parking payment must be made cashless and ticketless to minimize interpersonal contact. LPR cameras implement infra-red sensors and character recognition technology to detect and scan through car plates with 98% accuracy, avoiding unnecessary operations and bringing parking lots users with efficiency and convenience. However, there might be extreme situations such as heavy snow, rains or mud and faded characters on the car plate which may impact the camera's reading (Smart Technology of Private Parking Lots in Malaysia, 2021). Additionally, parking space in some prosperity area may not be able to sustain the demand (Jamie Arjona et al., 2020). Drivers searching for a parking lot without parking availability information in these areas contribute to an increase in traffic flow.

Teh Hon Seng, the CEO of TimeTec Group found the following:

All of these payment methods achieve a cashless objective. But, when it comes to touchless, all of them failed in user convenience because users still have to wind down their car window to tap cards on a machine or turn on a smartphone to scan the QR code at the in and out parking lanes." (Team, 2022).

As a consequence, irrespective of ticketing-based or cashless payment method, manual procedure is indeed necessary. It causes other vehicle owners to queue, resulting in congestion problems and by combining these inefficiencies, the idea of a smart city is undermined (Smart Parking Applications Using RFID Technology, 2007).

IV. RESEARCH AIM

This research aims to develop an IoT integrated with FinTech solutions for parking payment system to provide an effortlessly parking experience.

V. RESEARCH OBJECTIVE

1. To deliver a touchless parking access using RFID technology.
2. To avoid having payment related inconveniences in front of the autopay station or barrier by connecting to a payment application.
3. To provide parking availability information for drivers.

VI. RESEARCH QUESTION

The research questions are as follows:

1. How RFID technology is being implemented to deliver a touchless parking experience?
2. What is the payment related inconveniences faced when processing a payment?
3. What parking availability information will be provided for drivers?

VII. RESEARCH SIGNIFICANCE

Running through this research would not only be advantageous to the drivers as well as some contributions could be made to the parking lot management. Parking lot management can reduce significant operating costs and increase revenue. Operation costs including printing physical parking tickets, salaries of administrative staff and workers collecting parking fee at the entrance can be eliminated. In addition, limited parking information causes drivers to become frustrated with not being able to find a parking space and leave the parking lot to find other available parking areas result in lost revenue. Therefore, by implementing RFID technology and FinTech solutions in parking payment system, drivers and parking lot management could experience the benefits stated in this research.

VIII. METHODOLOGY

A. Respondents Identification

With the rapidly changes in new technologies and innovations, people with experiences in Internet of Things and Financial Technology field as well as actively working in such industries will be involved in the sampling process. Therefore, expert with certain characteristics are stated as follow:

1. Experience in either Internet of Things, Financial Technology or both.
2. With 5 years, 10 years or 15 years experiences in related fields stated.
3. Circumstances in the prescribed fields. Presently lecturing or working in these fields.

By combining these characteristics, the subgroups formed are as follows:

1. Lecturing in Internet of Things for 5 years.
2. Lecturing in Internet of Things for 10 years.
3. Lecturing in Internet of Things for 15 years.
4. Lecturing in Financial Technology for 5 years.
5. Lecturing in Financial Technology for 10 years.
6. Lecturing in Financial Technology for 15 years.
7. Lecturing in Internet of Things and Financial Technology for 5 years.
8. Lecturing in Internet of Things and Financial Technology for 10 years.
9. Lecturing in Internet of Things and Financial Technology for 15 years.
10. Working in Internet of Things for 5 years.

11. Working in Internet of Things for 10 years.
12. Working in Internet of Things for 15 years.
13. Working in Financial Technology for 5 years.
14. Working in Financial Technology for 10 years.
15. Working in Financial Technology for 15 years.
16. Working in Internet of Things and Financial Technology for 5 years.
17. Working in Internet of Things and Financial Technology for 10 years.
18. Working in Internet of Things and Financial Technology for 15 years.

Targeting in terms of knowledge, skills and experiences in Internet of Things and Financial Technology are significant for collecting usable and relevant data to support this research. A person with five years of experiences are assumed to possess necessary skills and build qualifications in related field however too extensive experience makes it challenging to evaluate the value of experience. Therefore, considering between 5 and 15 years of experience is a reasonable guide. Besides, target respondents who are presently lecturing or working in both fields, as keeping up with new knowledge and technology advancements is necessary.

B. Sampling Method

In this research, in order to obtain a greater accuracy and precise estimation, a combination of probability sampling and non-probability sampling will be applied including stratified sampling and quota sampling.

Stratified sampling method one of probability sampling, divides a target population into distinct subgroups or called as strata where the elements in each stratum are similar to one another in selecting important characteristics to the research (Van L. Parsons, 2017). As this research includes IoT and Financial Technology solutions, specialist and analyst from both fields will be involved. As a result, it is significant to divide into different groups according to professions and characteristics.

Fig. 7. Stratified Sampling Example

Quota sampling one of most commonly used in non-probability sampling method aims to include equal numbers of different types of respondents (Nikolopoulou, 2022). Therefore, this method is based on non-random selection of a specified number of respondents to represent the population. Following stratified sampling, the target population is separated into several subgroups accordingly, quota sampling will then use to determine a quota for each subgroup. Based on the identified respondents, the sample will include 50% from IoT field and 50% from FinTech field. Moreover, quotas can be further divided based on additional characteristics. In IoT and Fintech field, made up 20% with 5 years' experience, 30% with 10 years' experience and 50% with 15 years' experience. Besides, according to circumstances in both professions, made up 40% are currently lecturing and 60% are currently working. The entire population is able to represent this research according to the quota and obtain insight about the characteristic of each subgroup.

C. Sample Size

1000 respondents are involved and key data required is stated below.

1. Name of company or institution
2. Domain of company or institution
3. Field of erpertise
4. Years of experience
5. Position

D. Data Collection Method

Data may be beneficial to researchers; however having too much information and inappropriate data are pointless for an efficient research. Therefore, the approach used to collect data is crucial. In this research, interview and questionnaire will be used to collect useful data and findings from the sample.

E. Data Collection Method 1 – Interview

Interview is a qualitative approach that collects reliable data by asking relevant questions. There are three categories of interview: Structured, Semi-Structured and Unstructured. Semi-structured and unstructured interview will be conducted in the form of one-to-many in this research. Open-ended questions will be asked to gather detailed data.

F. Data Collection Method 1 – Questionnaires

Combination of open-ended and close ended questions are included in the questionnaire. Before the questionnaire is distributed, it requires to go through pretest, pilot test and real test to reach a satisfactory design. Although respondents will be in IoT and FinTech fields, questions will be kept precise as well as jargon and lengthy questions are avoided to maintain the overall efficiency. Questionnaire are designed using Google Form as it allows immediate feedback. Besides, email will be used as a formal method to distribute the questionnaire. Sample of questions are shown in Fig 8.

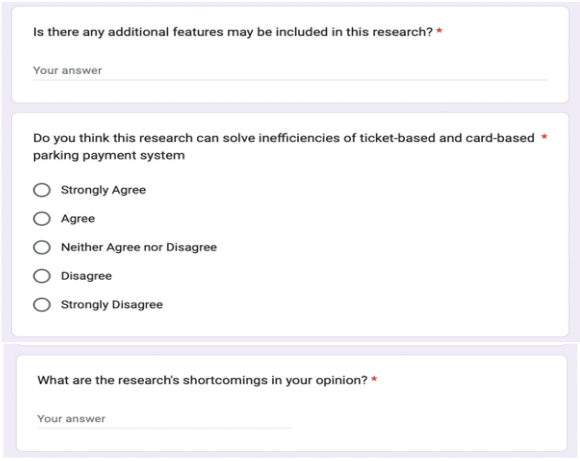

Fig. 8. Sample open-ended questions

IX. OVERVIEW OF PROPOSED SYSTEM

Flowchart in Fig 9. shows the process of proposed system. Firstly, driver need to purchase a RFID tag and each vehicle plate number is only subjected to one RFID tag. Driver requires to activate and link the tag received to the payment application. Next, the RFID tag must be attached to the top left

of vehicle's windshield in order for the reader to detect. Before entering a parking space implemented with RFID technology, the driver needs to ensure their payment application has sufficient balance, otherwise the tag will not be successfully authenticated. Once the reader authenticated successfully, the barrier will open to allow vehicle to enter the parking area. Information including vehicle plate number, date and time in, payment application id will be stored in the database. Besides, another system managing parking availability data will decrease by 1 and display the information for other drivers. When the vehicle arrived in front of the exit barrier, the reader will detect the RFID tag again and retrieve the data from the database and calculate the duration and payment fee. Payment charges will be deducted automatically in the application and the barrier will open for the vehicle to exit. Lastly, after the vehicle left, the parking availability will increase by 1. Therefore, the driver has experienced a touchless payment process and other drivers are able to acknowledge the parking availability.

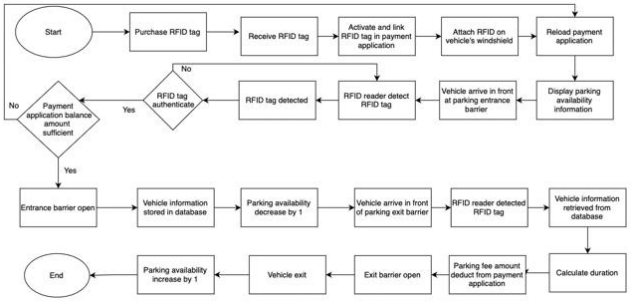

Fig. 9. Flowchart – Proposed System Overview

X. CONCLUSION

In comparison to barcode tickets which requires a visit to an autopay station and a lengthy process to complete a parking payment, card payment utilizing NFC requires 1 to 5 seconds to read a card as well as online banking which necessitates manually filling in card details, RFID technology integrated with payment application is much faster and more effortless. Although the cost of implementing RFID may be higher yet it will only be incurred once. Additional IoT solutions may be included in future similar research to provide drivers with more parking availability information. However, in this research, it is proven that by utilizing RFID technology and FinTech solutions are able to address problems stated and benefit different perspective including parking lot management, drivers and environment.

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