LOW-COST RASPBERRY-BASED MOBILE PAYMENT SYSTEM FOR CASHLESS TRANSACTION IN GASOLINE STATION

Rahmat Septian Wijanarko
Departement of Electrical Engineering
Universitas Pertamina
Email: rahmatseptianid@gmail.com

Meredita Susanty
Departement of Computer Science
Universitas Pertamina
Email: mereditasusanty@universitaspertamina.ac.id

ABSTRACT

To embrace the cashless future, PT PERTAMINA collaborate with various banks and LinkAja!, one of e-finance services in Indonesia, to accept cashless payment using QR code technology using mobile application. The cashless payment now accepted in both conventional gas station and self-service gas station. However, at a self-service gas station, customers generally make payments before refueling to an operator located in the control post (before the dispenser area/refueling area). It requires the customer to return to the operator in order to request the change when they stop refueling before reaching the requested volume. This research proposes some modifications toward the fuel dispenser so that the dispenser is able to accept cashless payment, provide correct amount of fuel, and guarantee payment for each transaction even when there are no operators around. The implementation of this prototype improves service at gas station by reducing queue time about three to seven second per vehicle, improve company efficiency by reducing the number of operators in gas station from one operator per dispenser to one operator per station, also, it removes the balancing process performed by the operator at the end of the shift. Sales reports are generated automatically in near real-time.

Keywords: cashless transaction; payment system; raspberry; gasoline station; mobile application.

1. INTRODUCTION

Pertamina, a state-owned company whose brand has been used in more than 6400 gas station in Indonesia, which makes Pertamina as the most important player in downstream oil industry in Indonesia [1]. In last few years, Pertamina has established another cashless payment method such as using debit, credit card, gazcard. Some method remains being used, while the other is no longer used due to easiness of use. As a part to continuously providing interesting program for the customer, Pertamina launched My Pertamina Loyalty Program in August 2017 [2]. In the beginning, My Pertamina [3] is a mobile application providing loyalty feature for customer. By redeeming some points obtained from previous transaction, customer can get discount, merchandise product or any interesting promotion for various Pertamina products including gasoline, LPG Bright Gas and Pertamina Lubricant. The mobile application has been developed many times and in the last update, it can be used as a cashless payment method in several gas stations using LinkAja!, e-finance provider in Indonesia by scanning a QR code at the merchant [4], [5].

In some areas, Pertamina gas station also has some distinguished features, such as self-service gas station. The self-service gas station as mentioned in its name, is a gas station where customer serve and help themselves, first they to the operator desk then go to specified dispenser to pick up the nozzle and do refueling by themselves.

In order to successfully deploying My Pertamina Program with cashless transaction feature in every type of gas station including regular, self-service, glite, and in every kind of ownership, an additional payment system is needed. One most convenient way to enabling cashless transaction in Pertamina is by using mobile payment (or m-payment), a means of payment transaction based on mobile device [6], [7]. The mobile payment system will let the customer make purchases from their mobile device. There are several major issues concerning the design, implementation and deployment of m-payment system such as the cost, reliability, inter-device communication, and data security. The paper will address the first three challenges as m-payment prototype system in Pertamina gas station.

The paper proposed a low-cost raspberry-based mobile payment system prototype for cashless transaction. The raspberry Pi as the main CPU for transaction will be supported with several additional

devices such as NFC reader, wi-fi router and supply system. By implementing this new system, mobile payment in gas station dispenser could be handled in each dispenser without requiring operator to make sure the customer pay the correct amount or assisting then in money refund. The implementation of this prototype is expected to improve service at gas station by reducing service and queue time, improve company efficiency by reducing the number of operators in gas station, reducing the time required in each gas station to create daily sales report [8].

The paper is organized as follow: Section 2 provides a research method, what is mobile payment system prototype which want to be be implemented in Pertamina gas station and its major subsystem included. This section also provides a brief role and specification of each subsystem. System design, cost breakdown and transaction cases in gas station are analysed in section 3. Section 4 focused on the conclusion and further possible research in the future.

2. RESEARCH METHODOLOGY

This research follows activities as shown in Figure. 1 which consist of requirement analysis and definition, design, development, testing, and cost analysis.

Figure 1. Research Methodology

2.1 Requirement Analysis and Definition

The objective of this stage is obtaining the existing problem and future objective from the company. As shown in Figure 2, this stage starts with stakeholder identification then followed by requirement elicitation from stakeholders using interview and focus group discussion technique. Once the requirements are discovered, it is categorized and prioritized. Analysis is performed by elaborating the requirements with available technologies, rules and regulation in Indonesia. The result from this stage is a list of features that are required to solve and improve the current business.

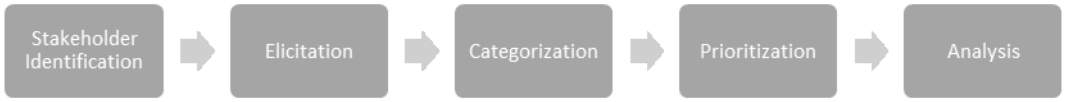

Figure 2. Requirement Analysis and Definition Activities

2.1.1 Mobile Application and Mobile Payment

Currently, Pertamina has already own a mobile application named My Pertamina. This application can handle mobile payment transaction but limited to My Pertamina Card. This research opens a possibility to leverage this application. Enabling alternative mobile payment beside My Pertamina card provides flexibility for customer. It will become an added value in Pertamina fuel station compares to its competitors [9].

M-payments has broad classification based on its payment basis (based on customer account or token/exchange currency), payment access (through bank account or not), payment amount, payment timing (cash, prepaid or postpaid) and payment location (either from remote or local transaction) [10]–[14]. There are various technologies used in authenticating the mobile payment such as QR code, NFC, PIN and OTP autenthication. The mobile payment system designed in this paper will use NFC technology because this alternative requires additional device in the fuel dispenser.

2.2 Design

This research use component reuse method. There are several advantages of component reuse such as reduce process risks and overall development costs and accelerate the development process [15]. As depicted in Figure 3, the first step in this method is component analysis which covers identify whether a component is suitable for reuse in a particular situation, understand how those components work, sometimes modify the components to make it adaptable. The result from component analysis is used in

system design. System design is described using component diagram [craig larman]. The following sub section explains the new component and the capability/functionality

Figure 3. Design Activities

2.2.1 Raspberry Pi

First generation of raspberry Pi was released in early 2012 (raspberry Pi 1 model B) and consistently getting more sophisticated hardware update in the next generation. The latest version of raspberry Pi is the third generation, model 3B+ announced on Pi Day 2018. Briefly, raspberry Pi is a credit card-sized integrated circuit (IC) board which has basic feature of modern computer. It has central processing unit (CPU), graphic processing unit (GPU), meory, I/O ports and secondary memory. Nowadays, it can operate on some operating systems, such as Raspbian (official operating system from raspberry Pi foundation), Windows 10 IoT Core, RISC OS Pi and Retro Pi.

Besides its tiny size, raspberry Pi was widely used because it is supported by many open source software, many modules to extend its features, wireless connectivity and available at affordable price. Modules are available in the form of miscellaneous sensors and electromechanical components such as temperature sensor, pressure sensor, humidity sensor, moisture sensor, gas detection sensor, barometer, ultrasonic sensor, magnetic relay, RFID - NFC reader module, GPS module, gyroscope, wireless infrared (IR), Bluetooth module and many else. Some papers have brought out various application of raspberry Pi as prototype [16]–[23].

2.2.2 Web Service

Web service serves as machine-to-machine/inter device communication over world wide web. The web service is designed to provide web-based interface for mobile application mockup. File/data transfer is using JSON format, not the XML due to much smaller data size. The web service will gather informations such as customer ID, balance and update the balance information after every transaction performed. The calculation and balance update processed by web service will be forwarded into customer account which can be accessed in his/her mobile phone. In security aspect, the web service is chosen so that credential information can be secured centrally, which means every dispenser does not store customer ID and balance information.

2.3 Development

The development activity consists of several tasks as shown in Figure 4. First, imitating existing component when we cannot use the real component, for example pump in a fuel dispenser. Next, developing new component when the existing one incapable to support the functionality. Last, integrate re-use component, modified component, and the new one.

Figure 4. Development Activities

2.4 Testing

Unit testing where individual program units or object classes are tested aims to testing that component to ensure its dependability, Unit testing involves verifying that each unit meets its specification.

System testing during development involves integrating components to create a version of the system and then testing the integrated system. System testing checks that components are compatible, interact correctly and transfer the right data at the right time across their interfaces where some or all the components in a system are integrated and the system is tested as a whole. System testing should focus on testing component interactions.

Functional testing aims to validate the system or check whether the system meet its requirement. During functional testing, the system is treated as a black box whose behaviour is determined by examining its inputs and the related output.

Figure 5. Testing Activities

2.5 Cost and Benefit Analysis

There are several common methods to judge whether an investment or project should be accepted or not in terms of economical aspect. In order to evaluate from economic point of view, it is very crucial for planner to predict the value of any single cost to spend (capital cost, labor cost, O&M cost and any overhead cost) and profit expected over lifetime project. In this paper, Benefit Cost Ratio (BCR) analysis [24] will be implemented to evaluate whether the benefit can exceed the cost. BCR method is chosen among the other popular method, since the calculation of every cost and profit expected are not quite complex in this project. Moreover, the method can clearly show the stakeholder, how significant the projects's outweigh its cost. Thus, in near future, if there are any other option as alternative for the project, stakeholder can compare it with the previous one and decide which one will be the most profitable.

3. RESULT AND DISCUSSION

The simulation of prototype will be discussed in this section, starting from whole system design to understand all components included and how it is connected into each other. In the second subchapter, all possible cases in fuel transaction will be analyzed and how the m-payment system will handle each case. In the last subchapter, the cost breakdown of system components will be calculated and how long it takes to make the system is break-even when it is implemented in Pertamina gas station.

3.1 Requirements Specification

The shift to a cashless future is also supported by the growing number of digital savvy consumers in Indonesia. It is shown from high penetration rate that reach 91% [25], [26]. The mobile payment are using various technology such as barcode generator, NFC or application based. In addition, key success factor for implementing new cashless system, in this case in gas station, should comply with health, safety, security and environment (HSSE) standard. Although comply with HSSE standard, contact/contactless card is not preferred due to inflexibility in money refund. Both QR code and NFC technology are comply with HSSE standard, compatible with existing mobile application, and flexible in terrms of refunding customer money. Eventhough QR code wider market since more phones can read them than those that can read NFC tags, this research user NFC because of the two reasons. First, the flexibility in storing information. Business can simply overwrite the information currently on the tag and create new info without every creating a new NFC tag compared to QR code where business have to use a computer program to regenerate image when they want to change the information that is link to the code and reprint a new image of QR code. Second, ease of use. With NFC technology, the user waves the phone near the NFC tag area and the information is transferred instantly. No need to open a scanner app on their smartphone, hover over the QR code, and wait for the phone to analyze it and react to the code.. The tag and reader communicate with each other to complete complex transactions quickly and securely.

3.2 System Design

The design process of the system is started by identifying every components ini fuel dispenser. The main components in the fuel dispenser are nozzle, flow sensor, fuel pump, CPU, push button and display. The prototype used in this paper are replicating the whole process in the fuel dispenser with some component replacement which has identical function with the existing component in fuel dispenser as shown in Table 1. The replication are needed to simulate the real-life process, but for simulation purpose, smaller components are being used. However, the CPU as the most important component used in prototype is the same one as the one that is being used in real fuel dispenser. Moreover, to enable mobile tapping for account identification some additional components in Table 2 is needed. Raspberry Pi and NFC Sensor is added and integrated to CPU. The Raspberry Pi will process account information read by sensor, send it over into main server and retrieve any information during transaction process such as balance, transaction nominal and the amount of fuel refueled.

Table 1. Existing fuel dispenser components

No.	*Component in fuel dispenser*	*Equivalent Component in Prototype*
1.	Nozzle	
2.	Flow sensor	Digital Pulser
3.	Fuel Pump	
4.	CPU	CPU
5.	Push Button	Mini push button
6.	Display	Mini Display

Table 2. Additional and modified components in the prototype

No.	*Component*	*Component Function*
1.	Raspberry Pi 3 Model B+	Additional CPU for processing transaction data
2.	NFC Reader Module	Module to read customer account data from NFC mobile phone
3.	SD Card 16 GB	Internal storage for Raspberry Pi
4.	Router	Device for connecting the system into srver via internet

The detail specification of the prototype is shown in Table 3. The raspberry Pi as a second CPU beside existing main dispenser CPU will read My Pertamina Card tapped, send customer info to web service and retrieve customer number ID and his/her balance before refueling process starting. After that, the main CPU handle the amount of fuel requested and drive the pump to flow the fuel into specific nozzle. Meanwhile, the raspberry Pi will fetch the amount of transaction data and send it to web service, so that the customer balance will be updated. There are several reasons behind the use of raspberry Pi to process cashless transaction. Firstly, the CPU dispenser should not be modified or replaced because it can break the warranty of the dispenser itself. Secondly, if Pertamina want to make cashless transaction as the additional feature on existing dispenser, thus there should be an additional system that can be easily connected into CPU dispenser and can act as plug & play device. Thirdly, the device must be able to read the NFC tag (in this case, My Pertamina card). Last but not least, the device has sufficient memory and processing ability to send information to web service in secure way. All of requirements mentioned before can be satisfied using raspberry Pi. The low-cost, compact size, ability to synchronize with CPU dispenser, NFC-reading and wireless connectivity become the reasons why raspberry Pi is chosen as prototype to cope with cashless payment in Pertamina gas station. Raspberry Pi used as prototype is raspberry Pi 3 model B+ which has 1 GB RAMand 1.2 GHz processor. Another important feature is micro SD card slot for additional storage and wireless connectivity for retrieving and sending information from web service.

Table 3. Raspberri Pi 3 model b+ specification

Parameter	*Specification*
Model	Raspberry Pi 3 Model B+
Operating System	Raspbian
Processor	Quad Cortex A53 @1.2GHz 64bit CPU
RAM	1 GB SDRAM
Storage	16 GB micro-SD
GPU	400 MHz VideoCore IV
I/O feature	GPIO 40
Ethernet	10/100 Mbps
Wireless connectivity	802.11n/Bluetooth 4.0

System communication in m-payment system designed includes communication between CPU dispenser and raspberry Pi, raspberry Pi with My Pertamina Card, raspberry Pi with web service, web service with customer mobile phone application (account) and My Pertamina Card with customer mobile phone application. Communication among device holds important role to ensure the reliability of the system. Furthermore, the security of data transfer over wireless service requires secure communication means. In this paper, the detail about system communication will be discussed in brief way, not in the detailed one, because this issue is outside the main topic discussed. The communication interdevice in the m-payment system designed in this paper can be summarized in the table 4.

Table 4. The brief communication inter-device on m-payment system

Device 1	*Device 2*	*Commmunication*
raspberry Pi	CPU dispenser (pump pulser)	Interrupt I/O
raspberry Pi	My Pertamina Card	NFC reader module
raspberry Pi	Web service	Internet-based
mobile phone	Web service	Internet-based
mobile phone	My Pertamina Card	Internet-based

3.3 Development

The whole m-payment system discussed in this paper can be seen in figure 1 below. Figure 1 (a) describes the flow of control signal between keypad input (as well as nozzle), CPU dispenser and fuel pump and information signal in the system between keypad input (fuel amount information), raspberry Pi and My Pertamina Card (ID information). The fuel amount and ID information is sent wirelessly to web service. For simulation purpose, fuel pump is replaced with Arduino pulser and My Pertamina Card is replaced with NFC tag.

3.4 Testing

3.4.1Unit Testing

All equivalent component in prototype must be verified to ensure that they can work nearly the same as the component in real fuel dispenser. Firstly, the digital pulser signal are set to work as counter to count up from Rp 0 to the number from push button input in any range from 0 – Rp 999,999.Then the CPU setting is mainly the I/O, since there are additional component in Table 4 need to be added. The mini push button and mini display does not need to set because those component in the prototype are already in the same package with the CPU.

The additional component such as Raspberry Pi and its storage must be installed properly along with its power device. The NFC reader module are tested with NFC pin, to ensure the reading process for account data.

3.4.2Integration Testing

Once all components are tested. The interaction among components is tested. The first is testing the Raspberry to send the transaction information to the server and retrieve deducted balance data after transaction from the server. The most important thing about testing raspberry Pi is coding process and library that is used to connect into module extension, in this case NFC reader must be tested several times before reading process is complete. The database in NFC pin is using MySQL to store customer account information and their available balance. Finally, the integration process of every component from pulser, button, display, CPU-Raspberry, NFC reader module and Server are comissioned properly for single modified fuel dispenser for mobile payment system. However for more mature deployment testing, particularly to know response time for data sending and retrieveing between Raspberry and Server, several units of modified dispenser need to be operated at a single time.

3.4.3Functional Testing

During transaction, several information gathered by raspberry Pi are customer ID number, fuel type, volume requested and customer balance. Based on that information, there will be some possible cases shown in table 3. The balance is available balance in customer account, fuel amount requested is the amount entered by customer using dispenser keypad, fuel amount stopped by nozzle is the fuel amount where the refueling process ends and amount paid is the final amount deducted to customer balance at the end of purchasing. In case no. 3 and 4 below are simulations to accomodate if customer requests fuel amount more than his/her balance. In case no. 2 and 4, it can be seen that there are some possibility the nozzle stopped by customer before it reaches the initial fuel amount requested. It could happen by some reasons, for example when customer fuel tank is already at full condition in the middle of refueling process, so refueling process should stop.

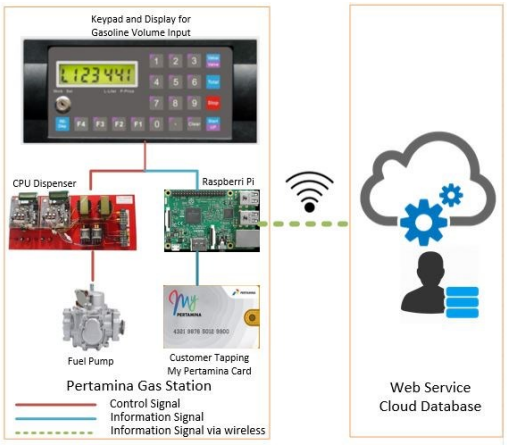

Figure 5. Block Diagram of Proposed M-Payment System

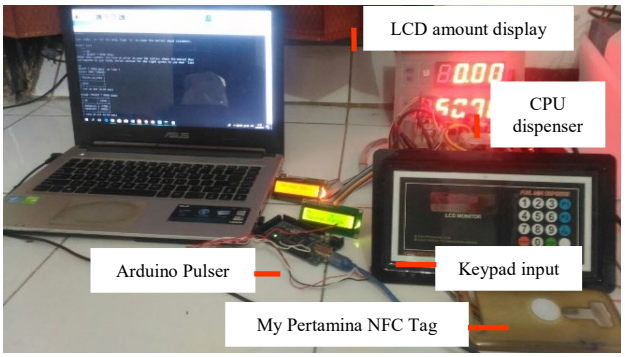

Figure 6. Complete Prototype with Its Components

Directly to prevent overfilling. Case no. 2 and 4 are very unique cases that can only be found in refueling case, where the amount paid by customer can be different with the amount entered by customer in the beginning of transaction. All those cases can be handled by implementing some stopping algorithm in raspberry Pi supported with balance information provided by web service.

Table 5. All possible transaction cases in fuel refueling (number shown in Rupiah)

Case no.	*Balance*	*Fuel amount requested*	*Fuel amount stopped by nozzle*	*Amount paid*
1.	100,000	100,000	100,000	100,000
2.	100,000	100,000	50,000	50,000
3.	100,000	200,000	100,000	100,000
4.	100,000	200,000	50,000	50,000

3.5. Cost Breakdown and Break-Even Point Calculation

BCR analysis in this paper will be undertaken based on actual and historical data in Pertamina Gas Station in Northern Sumatra Area. Several key assumptions behind the calculation process are:

a. Project lifetime range is 20 years
b. Project cost include capital expenditure (capex) and operating-maintenance cost (MC)
c. Labor cost is not included because the project will be supported by existing labor
d. Project profit (PP) is based on consumer queue reduction or incremental consumer expected
e. Hurdle rate (HR) is based on average risk ratio in Oil & Gas downstream business

Table 6. BCR analysis for cashless system installation (number shown in rupiah)

Project Year/Asset Age		*0*	*1*	*2*	*3*	*4*
Aspects	*Total*					
PP	11,788,000,000	589,400,000	589,400,000	589,400,000	589,400,000	589,400,000
Capex	10,000,000					
MC	280,000,000		14,000,000	14,000,000	14,000,000	14,000,000
HR	11,17%					
DCF Benefit	4,641,880,719	-	530,179,005	476,908,343	428,990,144	385,886,610
DCF Cost	120,258,449	10,000,000	12,593,326	11,327,989	10,189,790	9,165,953
Benefit/Cost	**38.60**					

Project Year/ Asset Age	*5*	*6*	*7*	*8*	*9*	*10*
Aspects						
PP	589,400,000	589,400,000	589,400,000	589,400,000	589,400,000	589,400,000
Capex						
MC	14,000,000	14,000,000	14,000,000	14,000,000	14,000,000	14,000,000
HR						
DCF Benefit	347,113,978	312,237,095	280,864,527	252,644,173	227,259,308	204,425,032
DCF Cost	8,244,988	7,416,558	6,671,366	6,001,049	5,398,083	4,855,701
Benefit/Cost						

Project Year/ Asset Age	*11*	*12*	*13*	*14*	*15*	*16*
Aspects						
PP	589,400,000	589,400,000	589,400,000	589,400,000	589,400,000	589,400,000
Capex						
MC	14,000,000	14,000,000	14,000,000	14,000,000	14,000,000	14,000,000
HR						
DCF Benefit	183,885,070	165,408,896	148,789,148	133,839,299	120,391,561	108,295,009
DCF Cost	4,367,816	3,928,952	3,534,184	3,179,081	2,859,657	2,572,328
Benefit/Cost						

Project Year/Asset Age	*17*	*18*	*19*	*20*
Aspects				
PP	589,400,000	589,400,000	589,400,000	589,400,000
Capex				
MC	14,000,000	14,000,000	14,000,000	14,000,000
HR				
DCF Benefit	97,413,879	87,626,049	78,821,669	70,901,924
DCF Cost	2,313,869	2,081,379	1,872,249	1,684,131
Benefit/Cost				

In BCR analysis shown in Tabel 6, the ratio between benefit and cost (B/C) is 38.60. If B/C > 1, it can be concluded that the project is feasible and the higher the number shows how significant the project profitability.

Another important key-enabler to deploy the prototype successfully in any Pertamina gas station dispenser is the cost of the raspberry-based m-payment system. Table 7 shows the cost breakdown of every single component. This system will be attached in one dispenser and connected into CPU dispenser and keypad input in existing dispenser, thus for example if there are 4 dispensers, gas station owner must provide 4 systems (it costs $118.0 x 3 = $354.0). However, before the installation, the owner should prepare required supporting device for this system such as power supply.

Table 7. The brief communication inter-device on m-payment system (Let $1 = Rp 14,000)

No.	*Device 2*	*Component Cost*
1.	Raspberry Pi 3 Model B+	$34.2
2.	NFC Reader Module	$16.0
3.	SD Card 16 GB	$9.6
4.	Router + Internet Voucher	$25.0
5.	Casing Box and Mounting	$30.0
6.	Wiring	$3.2
	TOTAL COST	$118.0

3.6 Optimization

One of the gas stations in Medan installed two cashless dispensers for car and two cashless dispensers for motorcycle. Based on field observation in one of refueling station in Medan, cashless dispenser reduces the refueling process about 3 – 7 second for each vehicle. The saving time is obtained from the time operator calculate and provide the change. Cash transaction requires 6-10 seconds while the cashless transaction takes 3-6 seconds to synchronized with the user's account.

Currently, one dispenser requires one operator. The cashless dispenser does not require an operator. So, we can reduce the operator from one operator per dispenser to one operator per station. Each operator elimination in Medan can save about 38 million rupiahs annually. This number obtained from (13 * the regional minimum wage) + uniform + work insurance.

Another optimization is in reporting task. At the end of the operator shift, they have to do the balancing process. The operator checks the total transaction and the cash they received then record it. This process usually takes about 20 minutes per operator. With cashless dispenser, the report can be produced in near real-time.

4. CONCLUSION AND FUTURE WORK

The basic design of m-payment prototype to enable cashless transaction system using raspberry Pi are successfully giving satisfying result. The connectivity inter-device among existing CPU dispenser, raspberry Pi, My Pertamina card and web service are reliable enough to ensure the concept of plug & play raspberry Pi system in Pertamina gas station. Several different payment cases are discussed to cope with different balance, amount requested and nozzle stopping in the middle of refueling. Those cases can be done by coordinating the control and information signal from raspberry Pi, dispenser pump pulser and web service. Based on cost breakdown analysis, it can be conluded that the proposed raspberry-based m-payment system is affordable to be implemented in Pertamina gas station even in lowest-class one.

The application of raspberry Pi as the processing unit of simple yet reliable payment system opens various possibilities. Several further research and testing need to be conducted before the commersialisation stage of the prototype such as data encoding-decoding and data security. Moreover, additional electrical protection circuit is also very important to mitigate if any short-circuit event happens in the system.

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