Maximizing Smartcard for Public Usage:
PDCA and Root Cause Analysis

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ABSTRACT

With the rise of smart cards, it has utilized so that multiple applications can be built into the technology. This research aims to offer a multipurpose smart card as a solution for the duplicate smart card system. Using a mixed methods approach, one hundred samples were collected from the public. The data was analyzed using descriptive statistics. A Plan-Do-Check-Act (PDCA) assessment and a Root Cause Analysis (RCA) were used to analyze the collected data. The results indicated that the public views the current smart card system serves only a limited function and are open to the idea of a multipurpose smart card system. Recommendations are given to raise the awareness of the current smart card problem and to provide insight to better serve the public.

KEYWORDS

Brunei Darussalam, Multipurpose Smart Card, PDCA, RCA, Smart Card

1. INTRODUCTION

Smart cards have revolutionized the way in which information is being documented as its introduction has allowed for the easy access and retrieval of personal as well as sensitive information of its users. Acknowledging its level of security, smart cards are now preferred over its conventional counterpart. In 2000, the Brunei government introduced its *Kad Pintar* or Smart Identity Card (IC) as a means of registration and identification purposes (Jabatan Imigresen Dan Pendaftaran Kebangsaan) with the hopes of encouraging efficiency in the traditional business process.

While the *Kad Pintar* is physically characterized by its distinct color, the individuals' photo and a microprocessor chip (chip) that stores the individuals' biometric information such as their fingerprint. Furthermore, the installation of such chip enables such card to become a multipurpose smart ID card (Dermalog, 2019). Despite its multifunctional abilities, a similar smart card was later introduced by the Land Transport Department in 2013 that not only functions as a permit for operating a vehicle but also as a means of identification.

Although Brunei has introduced smart cards to replace the need for paper identification, there arise the issue of utilizing the smart card to its full potential. Additionally, the similar functionality of the two smart cards brings about issues on carrying separate smart card for separate yet similar

purposes. Acknowledging the smart card's capability of storing vast information, there is a need to introduce a multipurpose smart card in Brunei.

The introduction of such integration will help overcome the redundant issue of producing multiple cards for similar purposes. Additionally, the proposed integrated identity card aims to streamline existing business processes and systems by incorporating a wide variety of applications introduced by government agencies.

This paper is organized as follows: Section 2 consists the literature review which is used to construct the main idea of this research. Additionally, this section introduces the problem-solving tools that have been used to identify and propose solution to the problem. Section 3 discusses the approach taken to investigate the problem highlighted in this study. Section 4 describes the findings of this research. In Section 5, results of the study are discussed, limitations of the research are introduced followed by recommendations. Finally, Section 6 summarizes the research and provide directions for future research.

2. LITERATURE REVIEW

This section aims to introduce smart cards and its uses. It intends to provide solutions as to the implementation of a multipurpose smart card that is for personal identification and other purposes.

2.1. Smart Card

What is a smart card? A smart card is a general definition for any credit-card sized device with the capacity of holding memory beyond its traditional counter parts. For the purpose of this paper, a smart card is defined to be a card that contains one or more integrated circuit chip (Haykin & Robert, 1988) with the ability to store and process both data and information (Latha et al., 2012; Pelletier et al., 2011; Shelfer & Procaccino, 2002). Due to its nature, a smart card can be programmed to be used in more than one area (Omar & Djuhari, 2004). Merckling and Anderson (1994) identified its usage with telephone calling and electronic cash payments whereas Farrow (2002) extended its uses to include merchant and banking account numbers and electronic cash.

Halawani and Mohandes (2003) have indicated the endless possibilities of smart cards. Since its introduction, the possible applications of smart cards include:

- **Telecommunication Services:** In many parts of the world, smart cards are used in telecommunication services such as in payphones and mobile communications. With today's technology, the implementation of smart card in telecommunication is regarded as one of its most innovative applications (Fancher, 1996). Smart cards that are used for telecommunications services are referred to as Subscriber Identity Module (SIM) cards. These cards store subscribers' information and allows network provider to identify itself while establishing a connection (Abbott, 2002; Paterson et al., 2002);
- **Financial Services:** Today's banking world have incorporated smart cards for its banking solutions. With its embedded micro-chip technology, it allows users to purchase products and services with ease;
- **Health Care:** Smart cards has also been introduced in the health care industry. By doing so, patients' records and information have been stored. Numerous literature have provided evidence for the benefits on the use of smartcards in healthcare. Honnegowda et al. (2013) have noted the use of smart cards in healthcare can help facilitate the portability of medical records. As patients' records are stored electronically, it allows health care professionals to accurately identify their patient and medical information, thus improving efficiency in providing emergency medical services to the patient (Honnegowda et al., 2013);

- **Identification Purposes:** With the technological advances today, many governments have initiated a move towards an e-government. As such, smart cards have been implemented as a means of identification (Gemalto, 2010). The smart cards offer the security and protection of an individuals' personal information.

2.1.1. Smart Card in Finland and Malaysia

The smart card technology has since been adopted by many governments. In 1999, Finland issued the world's first ID card which utilizes such technology. The Finnish Electronic Identity Card (FINeID) is issued to locals and foreigners residing in Finland permanently (Legislative Council, 2002). Various documents have been built into the card as to allow the card to be used as a form of identification such as passport, identification card, driver's license, etc. Additionally, FINeID contains certificates that allows the card to be used as digital signature which helps enable the government's move towards adopting and encouraging e-Commerce and e-Government applications (Rissanen, 2010).

Additionally, Malaysia is another country that have leveraged onto the benefits of the smart card. In 2001, the Malaysian government introduced a multipurpose smart card, *MyKad* or Malaysian Card which incorporated the use of photo identification as well as fingerprint biometric data (Malaysian Digest, 2015). In addition to personal identification, *MyKad* have extended its uses to include driving license, passport, transit card, health document as well as public key infrastructure (National Registration Department, Ministry of Home Affairs, 2016). Furthermore, important government related activities such as voting registration and criminal records have also been built onto the smart card (Yap et al., 2012). This allows the government to monitor its citizens and safeguard the nation's security. By integrating multiple applications onto one card, the government aims to provide its public with "an incredible transformation [of] their lives" (Thomas, 2004).

2.1.2. Smart Cards in Brunei

Smart card was first introduced to Brunei in 2000 with the introduction of the implementation of the *Kad Pintar* or Smart Identity Card. The *Kad Pintar* is an official identification card issued to Brunei citizens at the age of 12 and foreign nationals with intentions of residing in the country for over three months (Immigration and National Registration Department, 2015). According to the provisions of Brunei's National Registration Act (2002), it is a requirement for members of the public to possess such card. This is to ensure the accurate identification of persons in cases of emergency as well as to safeguard the nation's safety. Additionally, the *Kad Pintar* consists of the holder's general personal data along with one digital photograph and a set of thumbprints.

Additionally, another smart card was launched in early 2013 that aims to combat the misuse of the Driver's License and prevent forgery (Borneo Post Online, 2013). Similar to the *Kad Pintar*, the Driver's License consists of general personal data and a digital photograph of the holder (Ministry of Communications of Brunei Darussalam, 2017). Unlike the *Kad Pintar*, the Driver's License features a 3D barcode which acts as a form of security prevention against forgery. Personal data is obtained by enforcement officers through 3D barcode scanning of the card using existing equipment. This allows for the easy retrieval of personal data during roadblocks and other related activities conducted by the enforcement agencies. Despite upgrading the Driver's License onto a smart card, the *Kad Pintar* is still required as its official form of identification.

2.2. Problem-Solving Approaches

There are numerous problem-solving tools which can be implemented in order to propose a solution. In implementing such tools, it allows for a better understanding to the nature of the problem and help provide solutions that can be implemented to the current situation (Anshari et al., 2019). Two problem-solving tools that have been commonly utilized are: Root Cause Analysis (RCA) and the Plan-Do-Check-Act (PDCA).

2.2.1. Root Cause Analysis

Root Cause Analysis is understood as a range of approaches and tools that are often used to identify the "root causes" of a problem and provide solutions in an attempt to prevent future recurrence of similar problems (Bagian et al., 2002; Peerally et al., 2016). Jucan (2005) defines root cause to be a specific or an array of logically defined reason, when identified will help prevent future recurrences (see Appendix).

According to Rooney and Heuvel (2004), RCA is a four-step process which includes:

1. **Data collection:** Data collection is a necessary step in RCA as it helps identify the problem background knowledge to the situation;
2. **Causal factor charting:** Once data is collected, it is then analyzed to help identify deficiencies in the knowledge;
3. **Root cause identification:** It is at this stage root cause identification begins with the help of a root cause map. Each root cause is examined and investigated by questioning why to the causal factors;
4. **Recommendation generation and implementation:** A solution to the problem can only be generated once its root cause has been identified while taking the causal factor into consideration.

Although RCA aims to prevent similar problems from occurring, Peerally et al. (2016) criticized it as being a mere procedural ritual which has little impact on preventing such occurrences. Furthermore, RCA only focuses on finding the problems' root cause but fails to best address each causal factor (Needs Assessment, 2011). Additionally, as the main aim of RCA is to find the root cause of the problem, this can lead to a blame culture in cases where problems involving humans does occur. Although organizations aim to promote a 'just culture', the outcome of RCA may hinder such approach (Marx, 2001).

2.2.2. Plan-Do-Check-Act Cycle

Developed by Walter A. Shewart and W. Edwards Deming in the 1950's, the Plan-Do-Check-Act cycle is a process-oriented approach that is used to encourage continuous improvement (Singh & Singh, 2015). Known as the Deming Cycle, it is a four-stage problem-solving process that is used to identify and access problems which are re-iterated at PDC stage until a suitable solution is achieved (Lodgaard & Aasland, 2011; Teli et al., 2012). Moen and Norman (2010) describes the PDCA cycle to be a flow chart that is used to learn and improve a product and/or a process.

According to Chakraborty (2016), the PDCA cycle is a four-step process which includes:

1. **Plan:** An initial investigation of the situation is required in order to understand the nature of the problem and develop potential solution of which will be tested;
2. **Do:** During this stage, action plans for improvements are implemented. Here, data is collected to develop further understanding of the problem;
3. **Check:** It is during this stage where collected data is analyzed. Using the analyzed data, the results are reviewed and compared against problems. New information gathered during this stage is also recorded for discussion purposes;
4. **Act:** As the final stage of this four-step process, solutions are implemented as results.

Samuel and Novak-Weekley (2014) determined that although the PDCA cycle is effective over a long period of time, it is time-consuming and requires plenty of resources to perform root cause analysis of a certain problem. Reed and Card (2015) indicated that prior investigation upon utilizing PDCA as a problem-solving approach in order for the problem to be properly understood. Additionally, they indicated PDCA's inability to address multiple and complex improvements (Dixon-Woods et al., 2014), particularly when dealing with a large scale of investigation.

3. RESEARCH METHODOLOGY

3.1. Sampling and Data Collection

As part of the problem-solving process, data collection is required in order to help identify and examine the problem. Therefore, this study uses quantitative approach to collect respondents' responses as well as to identify the problem. Additionally, qualitative approach was also employed to understand the motivation behind the respondents' reasoning. This study targeted local citizens specifically those that possess both the Smart Identity Card (IC) and a driver's license. As a result, the research was able to collect a total of 100 responses, amongst which 98 were usable.

3.2. Instruments

In order to collect the data, this research adapted the questionnaire developed by Islam (2010) to help examine and assess the current implementation of the smart card in Brunei. The questionnaire is divided into four sections. The set of question was targeted at collecting the demographic data. The remaining questions were focused on collecting the respondents' opinions in relation to the Smart Identity Card (IC) and the driver's license as well as the prospects of integrating a multipurpose smart card.

Prior to data collection, a pilot study was conducted on a number of independent individuals in order to identify any potential issues the questionnaire might have as well as a means of improving the study's design in undergoing the research. The findings from the pilot study prompted the electronic distribution of the questionnaire. In doing so, the research utilized a voluntary sampling technique in order to gather data from independent individuals across Brunei. Additionally, such a technique allows the research to collect unbiased thoughts and opinions of individuals regarding the topic. Following data collection, PDCA and RCA were used to examine and identify the issue of smartcard usage in the country (see Appendix).

4. DATA ANALYSIS

In this section, the data collected are analyzed for interpretation which will be discussed further.

Following the distribution of questionnaire, the research was able to collect 100 responses in total and amongst those responses 98 were useable.

Table 1 shows the demographic profile (gender, age group and occupation) of the respondents. The table illustrates that out of the 98 useable responses, 75.5% of the population consisted of female

Table 1. Demographics distribution of respondents

Variable	Items	%
Gender	Male	24.5%
	Female	75.5%
Age	18-30	87.7%
	31-45	12.3%
Employment	Government Officer	9.2%
	Self-Employed	4.1%
	Manager	1%
	Students	76.5%
	Others	9.2%

respondents while the remaining 24.5% were male. Amongst the 75.5% female respondents, 89.2% belonged to the 18-30 age group while the other 10.8% were of the 31 – 45 age group. Additionally, a majority of the respondents were undergraduate student (55.1%) with the exception of a few post-graduate students (40.8%).

The research further revealed a number of factors which is of a concern to the respondents in regard to the current implementation of the National Identity Card. One of the main concerns reported by the respondents was the time it takes for the card to be recovered in cases of loss or theft. Similar concerns were reported for the existing Driver's License as illustrated in Figure 2. Additionally, a majority of the respondents reported their use of such card with the legal obligation that requires them to carry such card as a permit to operate a vehicle.

Despite the reported satisfaction with using multiple smart card, an overwhelming majority of respondents (92.9%) agreeing to the usefulness of implementing a single multipurpose smart card. There are various factors that can account for such implementation, namely ease of convenience for the user. The survey revealed that respondents were frustrated with the limited functionality followed by the aesthetics of carrying multiple smart card (Figure 3).

5. DISCUSSION

Using the responses collected, the RCA method was implemented to identify its causal factor and root causes of the current issue. The research found that most respondents are regular users of the government issued smart card, i.e., national identity card and driver's license. Despite their regular use, the results revealed their regular use is due to the law that binds them to carry such card. For example, many of the respondents reported their use of carrying the drivers' license was due to the law surrounding the card.

The research further revealed that a high percentage of respondents agreed to the usefulness of implementing a multipurpose smart card (Figure 4). This is consistent with the study conducted by (Evans et al., 2015) which highlighted the convenience aspect in adopting an integrated card.

As illustrated in Figure 1 and 2, it indicates that the respondents believe that the current smart cards serve no purpose. Additionally, several respondents have reported the inoperability of the current Drivers' License to be utilized as a form of personal identification. This reveals that the current implementation of the smart cards introduced in Brunei lacks the knowledge on the potential of the smart cards, in terms of its benefits and application.

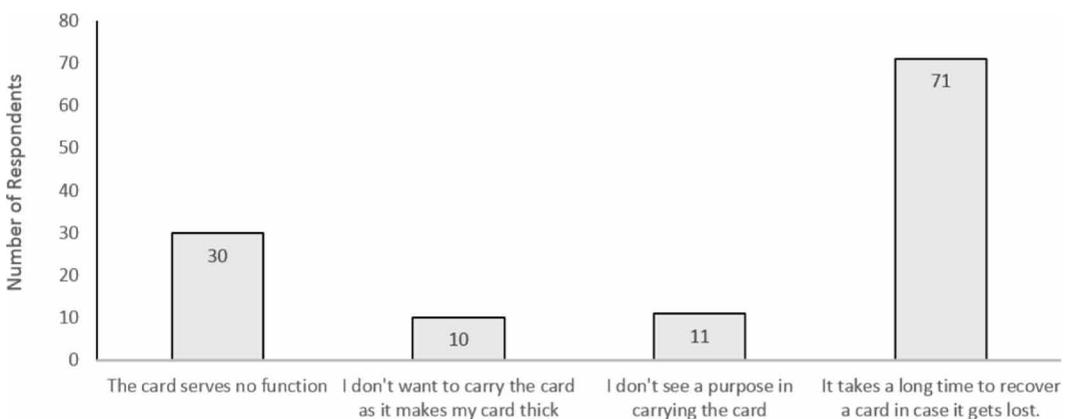Figure 1. Respondents' concerns regarding the use of National Identity Card

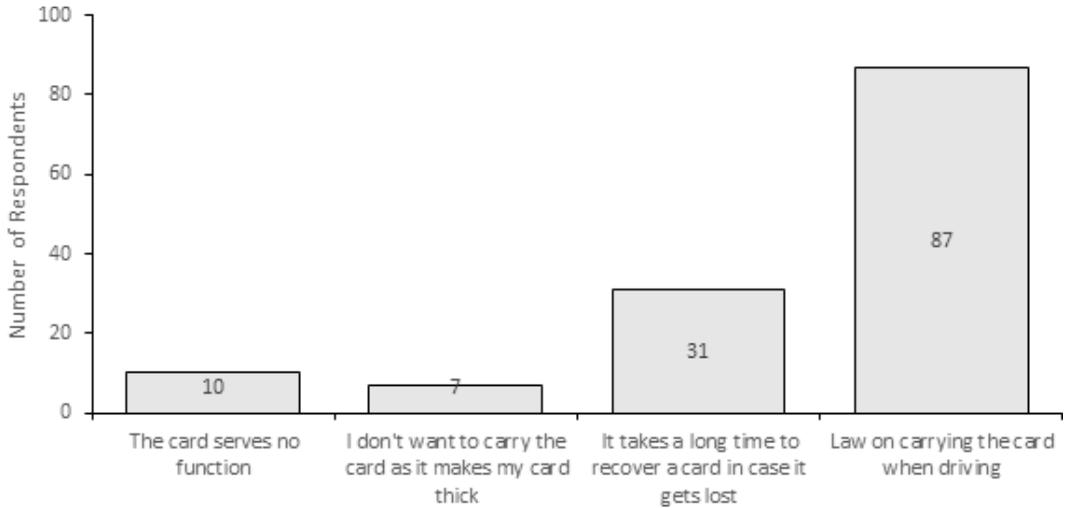Figure 2. Respondents' concerns regarding the use of driver's license

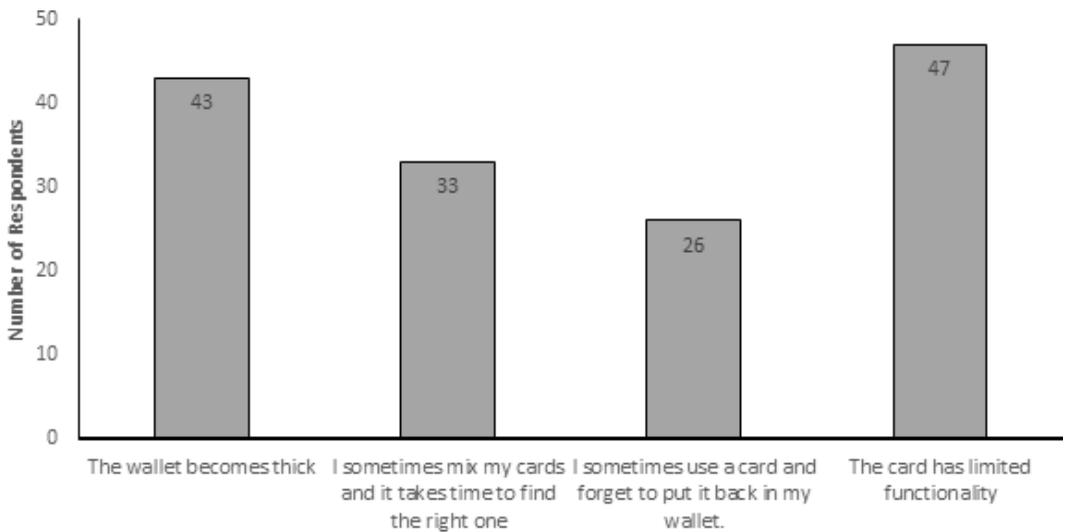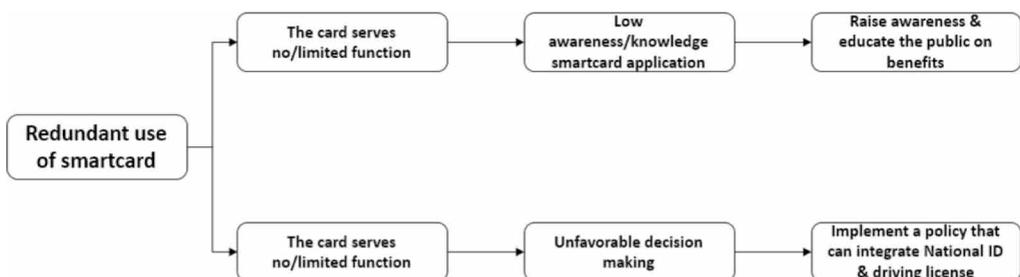Figure 3. Respondents' concerns regarding the use of smart card

Figure 4. Root Cause Analysis (RCA) of the current problem

Despite a large number of respondents reporting their satisfaction with the performance in the current use of smart card, there is an overwhelming number of respondents concurring with the implementation of a multipurpose smart card. The implementation of such smart card will only be successful if additional applications or functionalities such as healthcare documentation are embedded into the card.

Furthermore, in discovering the usefulness of implementing a multipurpose smart card in the current climate, the research revealed a number of factors that pose as a concern to the users, such as the length of time in recovering the card.

5.1. Limitations

A number of limitations which presented itself during the course of this research. Despite distributing the questionnaires online, a majority of the respondents were found to be students between the age of 18-30. Additionally, as the population were solely Bruneians, its results cannot be generalized to population outside of Brunei. Due to the limited time constraint, the study was not able to interview relevant parties, i.e., the Immigration Department and the Land Transport Department, to gain their insight to the issue at hand.

5.2. Recommendation

Based on the results of this research, Bruneians strongly accept the idea of a multipurpose smart card that functions as their National Identity Card and Drivers' License. However, there are still concerns in regard to the privacy of its data.

The government should implement a single multipurpose smart card that functions as a National Identity Card, Drivers' License and much more. In doing so, knowledge sharing is highly recommended (Yeow et al., 2007) between government and the public. This allows the public and its stakeholders full knowledge on the benefits, drawbacks and capability of the smart card. Additionally, government agencies and enforces must do their part in encouraging such implementation by emphasizing the convenience of carrying a multipurpose smart card.

Furthermore, the integration of both the National Identity Card and Drivers' License onto one single multipurpose card would signify the existence of a centralized hub for the purpose of storing personal information of citizens. Doing so will help to further reduce the issue of redundancy faced at multiple level and alleviate obstacles in information retrieval. This can effectively further assist relevant parties, such as enforcement agencies, to streamline their operations and provide efficient services to the public in high volumes.

In addition, the government should collaborate with relevant stakeholders such as banks and hospitals to allow this multipurpose smart card to be accepted as a form of identity. Currently, the national identity card is regarded as the superior form of identification in Brunei. Although the Driver's License offers a visual form of identification, it is deemed inadequate particularly in banks and other financial institutions. By implementing a multipurpose smart card, this will reduce such issue.

In order for the multipurpose smart card to be fully accepted by the public, the government plays a role in ensuring the efficient delivery of its services. As illustrated in the findings, many are concerned with the time it takes to recover their card in cases of theft. By tackling this concern, the government should be able to implement a single multipurpose smart card that is accepted by the public.

6. CONCLUSION

The research found that a number of Bruneians find it beneficial to implement a multipurpose smart card, reducing the government issued smart card to one. Despite agreeing to such implementation, there are concerns arising to the data and its sustainability. The author is in view that if the provided recommendations are followed, the redundant issue of the current smart card system can be resolved.

However, much can be done to develop a sense of recognition towards implementing a multipurpose smart card in Brunei as well as its integration into the public's lives.

6.1. Future Research

Future research can be conducted from this research to investigate factors that prevent government agencies from implementing and encouraging the use of a multipurpose smart card. Additionally, future research can be conducted to investigate the relationship between the implementation of a multipurpose smart card system and an efficient government process.

Furthermore, investigating the public's concerns and frustration with the current smart card can prove beneficial to further illustrate the need to maximize the smartcard to benefit the public. In doing so, engaging with relevant parties should be considered to provide better recommendations and insight to overcome this issue. As this research only scratches the surface of the current smart card problem in Brunei, further research can help build better solution using better problem-solving tools.

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APPENDIX

Problem

1. What do you see happening? Redundant use of smart card.
2. What are the specific symptoms?
    The card serves no function.
    The card serves no purpose.
    The law on carrying the card

Data Collection

1. What proof do you have that the problem exist? Insert respondents' answers.
2. How long has the problem existed? Since 2000.
3. What is the impact of the problem? Ease of convenience

Causal Factors

1. What sequences of events leads to the problem?
2. What conditions allow the problem to occur?
3. What other problems surround the occurrence of the central problem?
    Unfavorable decision-making

Root Cause

1. Why does the causal factor exist? Low awareness of smart card applications.
2. What is the real reason the problem exists?

Recommendation and Implementation of Solution

1. What can you do to prevent the problem from happening again?
    Implement a policy that can integrate the National ID card and the Driving License.
2. How will the solution be implemented?
    Terminate the use of old identity card after a certain date. While they do that, the government is
        responsible for encourage its citizens to apply for such card and to fully utilize all applications
        embedded in the card.
3. Who will be responsible for it?
    Government agencies and vendors
4. What are the risks of implementing the solution?
    Acceptance from the public – see Yeow et al. Accepting Multipurpose "Smart" Identity Cards
        in a Developing Country.

Lack of understanding to the benefits and drawbacks of the fully integrated smart card – details of its benefits should be provided. The public should be convinced on how an all-in-one function card will benefit them. Officers must be seen carrying card readers to demonstrate their commitment of the government's use of an integrated smart card.

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