Revealing Business Process for NFC Reservation-based Parking System as a Combined Business Process

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***Abstract*—This paper presents a business process of reservation for parking system. A car can park at a certain parking lot that already reserved in advanced. Furthermore the Near Field Communication(NFC)is a given technology to be implemented. This paper concerned the development of the process of creating a reservation-based parking system in a Business Process Model and Notation (BPMN). The main business process parking will be combined with a reservation-based, hotel like booking system. This business process is a combined business process, instead of merged business process, because it concerns the possibility of a parallel join of two business processes. A combine algorithm is proposed, and finally NFC technology is added into the baseline business process. This reveals the business process of NFC reservation-based parking system.**

***Index Terms*—business process, reservation, car parking, model and notation, algorithm**

I. Introduction

Several methods of smart parking system and their embedded technology are discussed in [1]. They categorized smart parking into Parking Guidance and Information System (PGIS), Transit-based Information System (TBIS), Smart payment system, e-Parking, and Automated-system. PGIS is formed by four major components: information disseminating mechanism, information gathering mechanism, a control center and telecommunication networks. TBIS is similar to PGIS with concentration on guiding user to park-and-ride facilities. Smart payment system is implemented in the effort to overcome the limitation of conventional payment methods by introducing new technologies. e-Parking provides an alternative for users to enquire the availability and/or reserve a parking space at their desire parking facility. Automated parking involves the user of computer-controlled mechanism, which allows users to drive the car to the bay, lock it and let the machine automatically place it in the allocated space. No detail business processes are included in Ref [1].

Reservation-based Smart Parking System [2] showed that a correct parking policy has the potential to simplify the operations of parking systems, as well as alleviate traffic congestion cause by parking searching. A simulation has been made that average driving distance was constantly achieved even in the peak hours. Nonetheless the business process description was excluded.

A real reservation-based parking system has been implemented in several airports in many cities in United Stated, Canada and United Kingdom [3, 4], as well in Germany [5]. The reservation can be simplified in a single web portal system run by third party or integrated within the airport web portal system. Business processes are implicitly depicted, but not in a clear Business Process Model and Notation (BPMN).

In Indonesia, the arrangement of parking lot is covered by government regulation [6]. This regulation did not include any information of the business process. Furthermore reservation-based park system is not a clear business yet. A common problem in a business area is not integrated in one parking-system. Current practices, the space availability cannot be informed to the users, before they entrance a parking lot.

This paper aim to reveals the reservation-based parking system in Business Process Model and Notation, as a combine two business-processes: common reservation system that derives from hotel like booking system, and common parking system. Both systems are referred to the Indonesian custom. We expect to answer a generic reservation-based parking system. Business Process Model and Notation will be used, as de-facto business process tool with BPMN 2.0 standard [7]. Theoretically, the combined business process can be a case study to create other domain of business from a given set of business processes [8] or a method for analyzing an integration business processes [9]. Such the previous project on automatic license plate recognition [10] can be implemented.

The organization of this paper as follows: basic system description of booking system and parking system in Section II, then the possibility of combination booking and parking activities, including the combine business process algorithm in Section III. Section IV describes the

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revealing NFC reservation-based parking system. Finally conclusion remarks the finding in Section V.

II. Basic System Descriptions

A. A Generic Parking System

In a building, there are specific place that allow a customer to park a vehicle. Usually it is a go-show activity, without any notification to where and how long the car will be parked. Before entering the parking lot, the customer takes a proof of entrance. This proof will be used to authenticate the car on the exit gate, and usually a certain amount will be charged as parking fee, as shown in Fig. 1. Two collapsed sub-processes "Park" and "Pay" are used to demonstrate the abstractness of BPMN.

Figure 1. Generic parking business process.

Fig. 2 and 3 show the expanded sub-process of "Park" and "Pay" respectively. The Pay sub-process considers the cash and card payment methods. The card must be verified. Upon error, the customer will be notified.

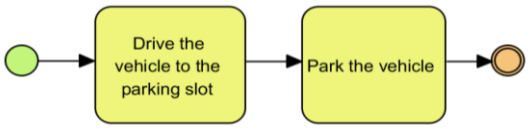


Figure 2. Typical park sub-process.

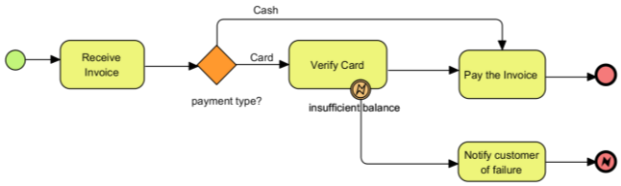


Figure 3. Typical pay sub-process.

B. A Generic Booking System

The basic interaction in a hotel booking system could be started as follows: A customer sends inquiry to the availability a desire room at a certain time and period. Upon the agreed condition of booking, hotel reservation system will approve the reservation. Usually, hotel request the customer to pay the reservation bill. After a successful payment, a notification will be sent to the user as a proof of reservation. The customer may modify or cancel the reservation. Fig. 4 and 5 depict respectively the business process of generic booking system and its sub-process in BPMN 2.0. The "Pay" sub-process can be assumed as a generic as Fig. 3.

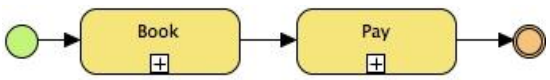


Figure 4. Generic booking business process.

The "Book" sub-process can be booked if the slot is available. The Error Marker activity is to trigger a termination of Book process upon a booking error. A Compensation Marker is to trigger the possibility user decide to cancel the reservation.

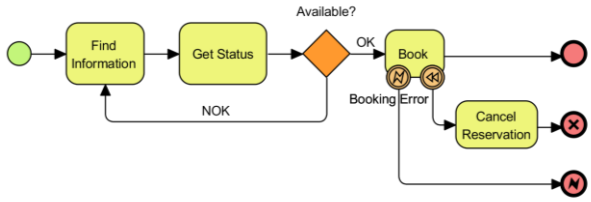


Figure 5. Typical book sub-process.

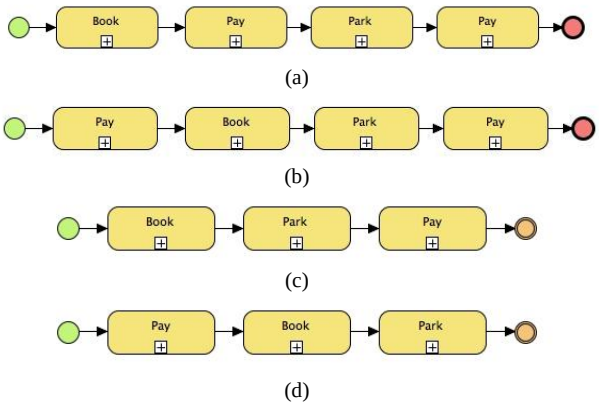
III. Combine Business Process

The integration of two business processes BP1 and BP2 can be implemented as a categorical product of the corresponding categories BP1 x BP2, meaning all possible pairs <*element from BP1, element from BP2*> [8]. When two business processes are integrated, the states of both processes are combined in which common elements have the same values likewise a natural join is performed on tables of a database. The process invariants are joined by logical conjunction. If the two invariants contain conflicting conditions, such that the combination resolves to false, e.g. no states possible, then the business processes are deemed incompatible. The combined invariant is applied after two unconstrained state spaces are joined. Event arrows are drawn between every pair of states for which the source state satisfies the pre-conditions and the target state satisfies the post-conditions while duplicate arrows are dropped.

A. Booking and Parking Combination

The integration of two business processes in Ref. [9] is called merging business process. The intention of merging is to integrate two or more business processes into a new business process by taking care the similarity and add the rest to the system. The merging approach ignores the possibility of parallelism, by means of parallel join. Fig. 6 shows the correct business process of constrained state spaces respectively, because "Book" shall be placed before "Park".

In our case, the integration Booking and Parking systems yield several possibilities, depends on the assumption of state space. Both systems considered that their process invariants are a non-conflicting condition. The pre- and post-conditions are satisfied.



(e)

Figure 6. Business processes of reserved parking.

Fig. 6(a) is a serial combine process of Booking and Parking without merging the "Pay" activity, while 6(c) with merging the "Pay". "Pay" may appear before "Park" or "Book", because it will reveal the possibility of Prepaid 6(d) and 6(e). If the prepaid balance is not enough, user must pay the leftover upon exit 6(b).

There are others possibilities, Fig. 7, by implementing parallel join. "Book" and "Pay" can be a parallel activity before "Park", 7(a). And possible pay twice 7(b) if the balance is not enough after "Park". Other possibility is parallel "Park" and "Pay" after "Book", 7(c).

B. Combine Algorithm

The aim of this algorithm is to find the valid constructed business processes from a set of extracted sub-processes from two or more business process. A contextual similarity [11] is considered in two equal sub-processes. It is assumed the business process matching [12] already identified, and the combine algorithm is defined over pair of business processes, and more.

For each business process, it is constructed into several sub-processes. The inside sub-process is considered as a valid independent modular sub-system. A valid business process is constructed by all of those sub-processes. The algorithm is as follow:

1) For each business process, extract the sub-processes, n.
2) Determine non-permitted sequence of sub-process as the rule of deletion, e.g. "Book" cannot be place after "Park".
3) Determine equality sub-process, e.g. "Pay".
4) Draw all possible sequential sub-processes arrangement, $n!$ business processes.
5) Draw all possible single parallel join, with k sub-process yield a combination $C_n^k\ (n-k+1)$ business processes.
6) Draw all possible multiple parallel join, if any.
7) Apply the rule of deletion. Yield $\frac{n!}{2}$ business processes in sequential.
8) Reduce the appearance of nearby equality sub-processes as a single sub-process.

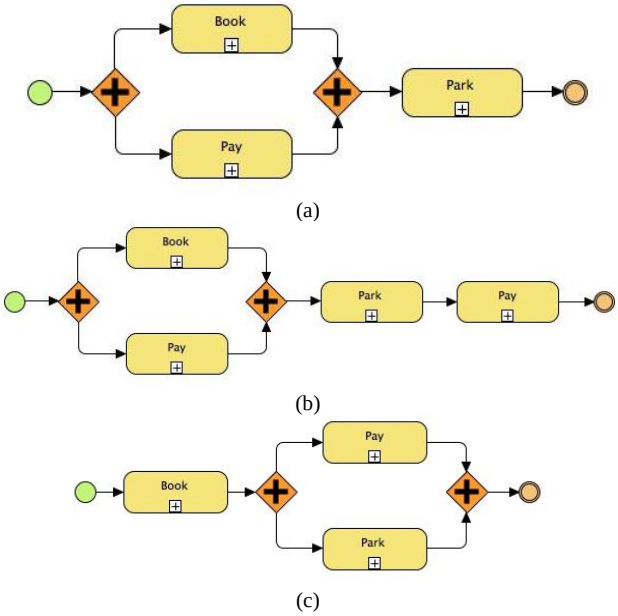


Figure 7. Other possible business processes of reserved parking.

IV. NFC Reservation-based Parking

Near field communication (NFC) technology enables the exchange of data between devices, such as smartphone. It can store logistics and make payment [13]. The NFC-enabled use cases are seamlessly mobile service approach [14], i.e. contactless electronic identity, mobile electronic ticketing and personal point of sales. It is a transparent technology platform and a common methodology to reduce the cost of launching an NFC application. Study on NFC-based technology for parking management has been reported by [15, 16]. While the possibility for an automated payment system for car parks based has been studied by [17]. None of the references depict clearly in BMPN.

A proof of concept NFC-based parking has been created, using NFC-enabled Arduino [18]. The Android application has been implemented by using passive NFC tag. Both of the implementations are out the topic in this paper. The implementation of NFC technology in booking-parking system affected individual sub-process.

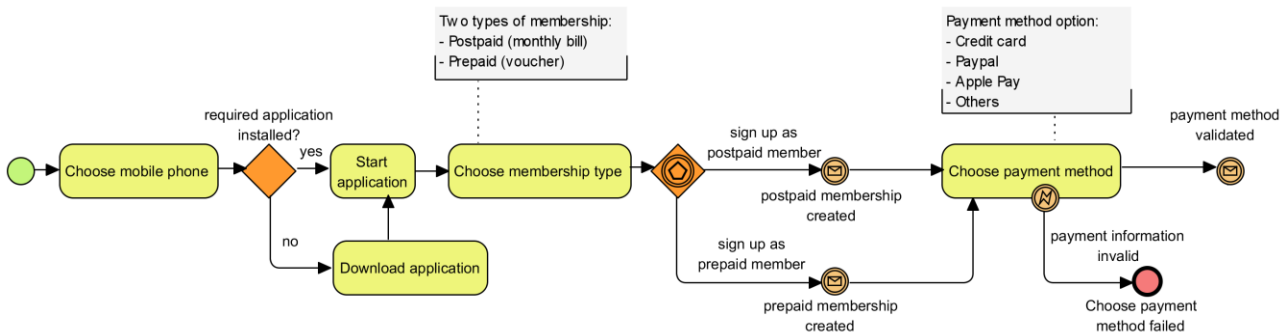


Figure 8. Excerpt business process of a member registration.

The proposed baseline reservation-based parking system is discussed from Fig. 8 to Fig. 16. This baseline is referred to combination Book-Park-Pay sub-processes, Fig. 6(c). It consists two actors, non-member and member. Upon member registration process, a non-member will be changed to a member. Only member with a valid NFC mobile phone can make a reservation. A mobile application must be installed in an NFC enabled mobile phone. The unique NFC signature is used to be the valid ticketing system for opening the gate of the parking lot. Finally the settlement of payment can also be made.

In the beginning, all are non-members. They must register themself, Fig. 8. They need to decide their type of membership: prepaid or postpaid, and their payment method. A NFC device must be registered before it can be used as identity, make reservation, proof of park and payment. Fig. 9. Only valid devices can be registered.

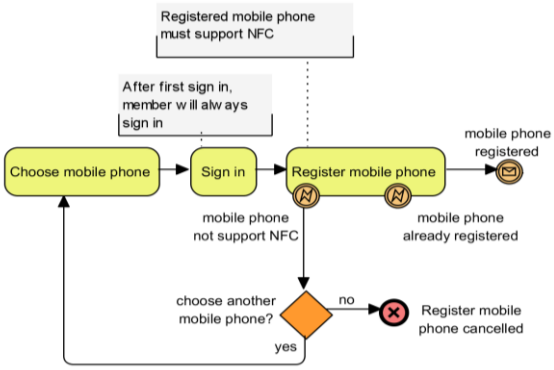


Figure 9. Excerpt business process of register an NFC mobile phone.

Member may make reservation, Fig. 10, after registering their NFC mobile phone. Some marking can be used to handle the possible ending, such as desired parking area are full so they decide to cancel the reservation, or voucher balance not sufficient for prepaid member so they must buy a voucher, or postpaid member must pay the unpaid bill.

Before the venue, one can modify or cancel the reservation, Fig. 11. The expanded sub-process of make new, modify, extend or cancel reservation are shown in Fig. 12.

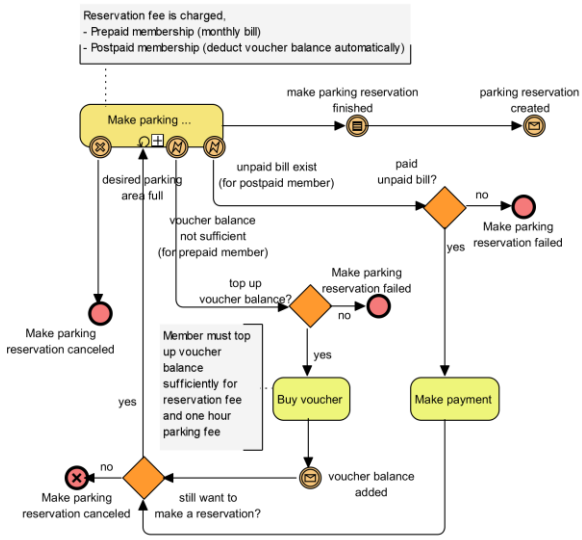


Figure 10. Excerpt business process of make parking reservation.

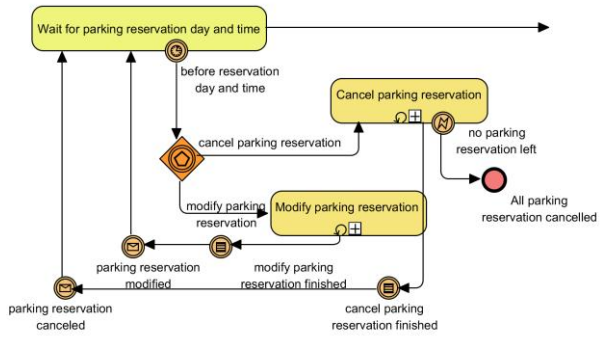


Figure 11. Excerpt business process of wait for parking reservation time.

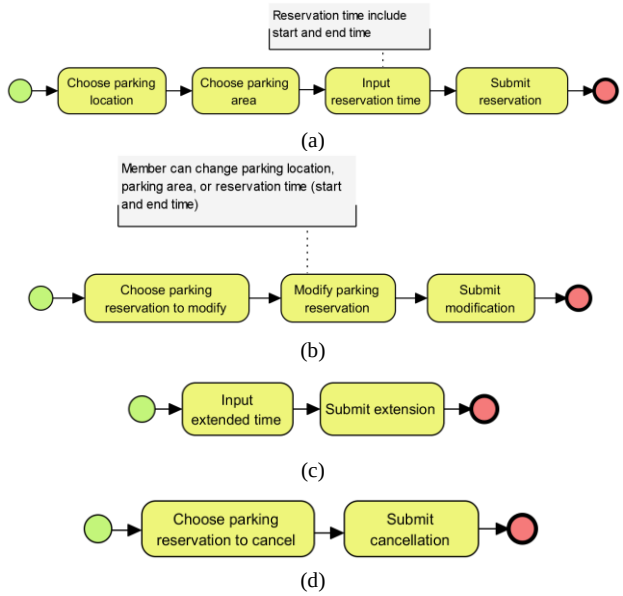


Figure 12. Sub-process of make new (a), modify (b), extend (c) and cancel (d) of a parking reservation.

Fig. 13 shows the excerpt of park activity. Expanded sub-process of park, extend parking reservation and settle payment are shown in Fig. 14, 15 and 16 respectively. There are two NFC-tags, one at the entrance and one at the exit.

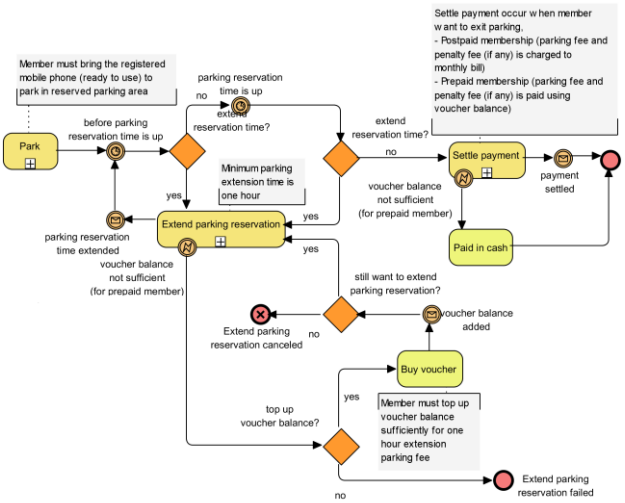


Figure 13. Excerpt business process of park and settle payment.

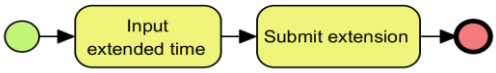


Figure 14. Extend parking reservation sub-process.

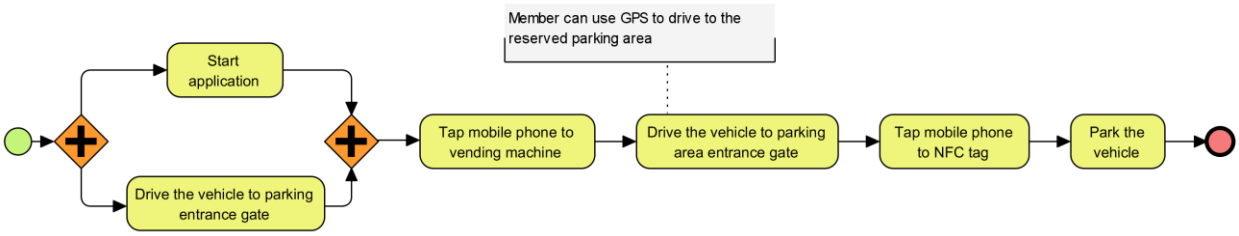


Figure 15. Park sub-process.

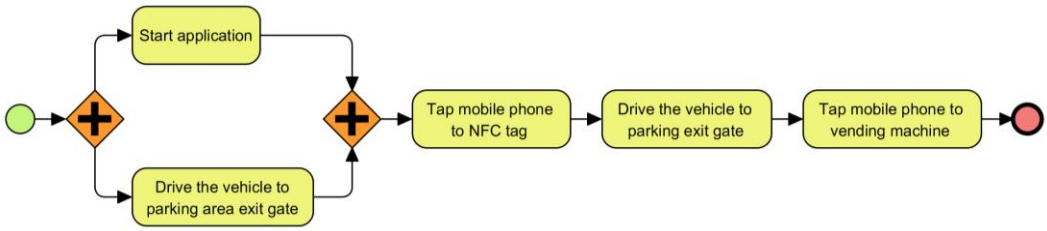


Figure 16. Settle payment sub-process.

V. Conclusions

A business process for reservation-based parking system can be derived from a combine parking and booking business processes. The combined processes are not equal to merge business process, since possibilities a configurable of sub-process combination. The NFC-based technology is included in the proposed system. This result is clear enough to be used in further stage of project development.

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