What Roles Do Decisions Play in Context-aware Business Process Management?

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Abstract: Recently, Business Process Management (BPM) is moving towards the separation of concerns paradigm by externalizing the decisions from the process flow. Most notably, the introduction of the Decision Model and Notation (DMN) standard provides a solution and technique to model decisions and the process flow separately and consistently integrated. In the area of context-aware BPM, decisions are still considered within business processes in a traditional way. In this paper, we examine how context affects business processes at design time and at run time. Different types of decisions influence the context-aware effect on business processes in their own way. Through analyzing these effects, we have observed that decisions play key roles in the ecosystem of context-aware BPM, including identifying the need of context-awareness, anticipating possible context-dependent variants and the contextualization of a business process. We also examine the opportunity to apply the DMN technique in context-aware BPM.

1 INTRODUCTION

Recent studies have explored context-awareness as a new paradigm and principle in BPM (Rosemann et al., 2008, Viaene et al., 2014). Decisions and rules have been used as a hidden work around to practically solve issues in the context-aware BPM research. However, the presentation of the roles that decisions play in context-aware BPM is still blank since decisions are traditionally considered within the business process. Lately, literature is moving towards a separation of concerns between process and decision models (Taylor et al., 2013). Most notably, DMN provides a suitable solution to fill the void of decision representation and model decisions and the process separately and consistently integrated.

DMN is a technique for documenting, modeling, and analyzing the decision dimension of processes (OMG, 2018). DMN has two levels that are to be used in conjunction. Firstly, the decision requirements level, represented by the Decision Requirements Diagram (DRD), depicts the dependencies between sub-decisions and the data requirements of decisions. Secondly, the decision logic level presents ways to specify the underlying decision logic, usually in decision rules. Figure 4 contains an example of a decision table and Figure 3 is an example of a DRD.

A context-aware BPM system consists of context-aware business process models, context-aware process execution, context models and decision models of the process. In this paper, we analyze how context affects a process at design and run time. We then observe that decisions play a key role in context-aware BPM at both design and run time. We also examine the opportunity to apply the DMN technique in context-aware BPM. It is of vital importance to understand the connection of these models to enable an ecosystem of context-aware BPM.

2 MOTIVATION AND RELATED WORK

A system is considered context-aware when it has the ability to discover and react to changes in the environment a system is situated in (Schilit and Theimer, 1994). Context plays a key role as context-awareness is accommodated to the BPM field,

(Brocke et al., 2016) for various benefits from processes being aware of its context. Research has also indicated that context should be considered in the whole lifecycle of BPM as an important source of scenario-related information (Flavia Maria et al.).

Decisions were hidden in the contextualization of processes and context-aware process modeling. And rules are practically identified as vital sources of the context of a business process, in other words, context-dependent rules. In (Bernal et al., 2010), processes are decomposed as a set of rules for modeling context-aware processes in order to respond to dynamic situations. These rules serve the decision-making in processes, for instance, pattern identification and user personalization. The contextualization of a business process is based on analyzing data leading to process variants (De La Vara et al., 2010, Rosemann et al., 2008). Different context values and their effects on decisions lead to process variants. In (Heravizadeh and Edmond, 2008), knowledge-intensive tasks of a process are decision activities, and context is needed to distribute knowledge to the appropriate person. Then contextual data that are involved in decisions are analyzed based on expert knowledge to constitute the context of the business process. In (Serral et al., 2015), rules are also used to manage and transform contextual data for inferring knowledge that the business process needs for the process adaptation.

In the existing research of context-aware BPM, a work around that is often observed in modeling practices is that a contextual variable becomes an explicit condition of process leading to a decision point. Moreover, rule-based methods are used to automate the decision-making since rules usually derivate from dynamic context. But decisions are still hardcoded in context-aware BPM, which impairs decisions' capability. Hence, it is of vital importance to fill in the blank of the roles that decisions play in context-aware BPM, which also helps to examine the opportunity to apply the decision modeling technique to context-aware BPM in a methodological way.

3 HOW CONTEXT AFFECTS A BUSINESS PROCESS?

In this section, we present how context affects a business process both at process design and run time.

3.1 Changes at Design Time

To model a complete and optimized business process at design time, context should be taken into account.

Context and contextual data can be used to anticipate possible situations for modeling a flexible or personalized process with context integrated.

3.1.1 Context-aware Process Modeling towards Process Flexibility: Strategic Decisions

Some strategic decisions could lead to business process variants. For instance, with different levels of requirements on implementation costs, quality control, or safety inspection, business process models may vary according to different contexts.

Context-awareness is an effective way to obtain flexibility by modeling context-dependent process variants (Nunes et al., 2011, Heinrich and Schön, 2015), and the process invariant is designed to keep the "identity" of the base process (Regev et al., 2007). Each process variant constitutes an adjustment of the base process according to requirements of the process context. Hence, contexts that could trigger the need of process variations and corresponding variants need to be anticipated. These possible contexts sentence from various effects of strategic decisions and contextual variables involved need to be identified. Then process variants need to be configured with the base business process by integrating contextual data.

As an example, we take a business process of truck pick-up cargo (Figure 1) to show how different contexts of strategic decisions affect the business process and how the process becomes flexible with context integrated. Initially, core activities constitute a base process model without considering the context, which can be incorrect in some situations. Context-dependent strategic decisions could lead to the base business process varying. For instance, if a truck comes to pick up cargos of a dangerous cargo type, high safety requirements are decided which can trigger the base business process changes. Similarly, if a truck comes to pick up cargos during the risk period (e.g., delivery frauds occur frequently by refitting trucks), high security requirements are decided. Three context-dependent process fragments are thus designed according to effects of strategic decisions for inserting and adapting the base business process. Consequently, the base process derives three context-aware process variants to achieve context-awareness and process flexibility. In order to support the business process changes to the dynamic context automatically, we need to identify adaptation points and contextual variables by analyzing the stimuli of process variants, i.e., context-dependent decisions. In this example, if the cargo type of an operation is a dangerous cargo type, high safety requirements are
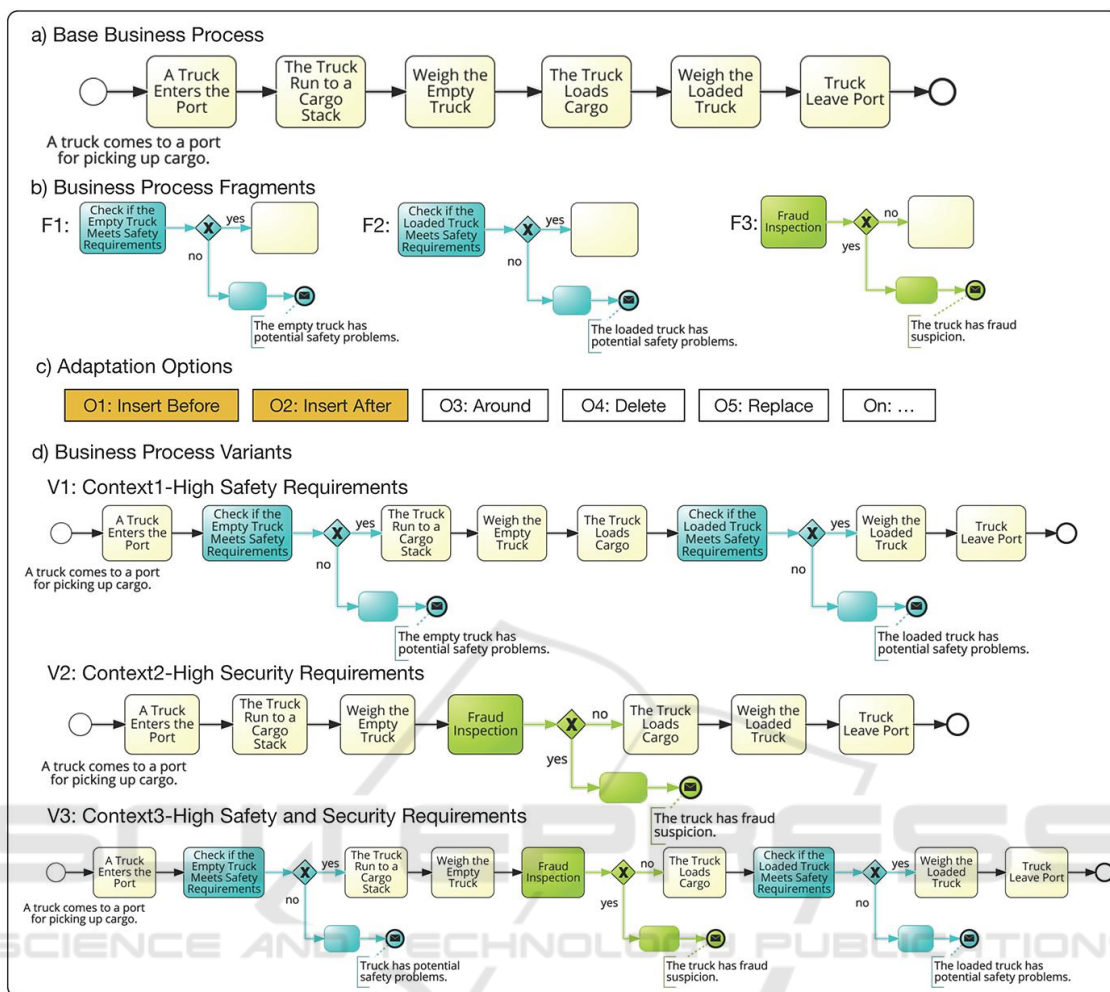
Figure 1: Modeling variants of the truck pick-up cargo business process with context taken into consideration in the process design time towards process flexibility.

decided; if an operation occurs during risk periods, high security requirements are decided. Cargo type and operation time are therefore considered as relevant contextual variables. To make the process context-aware, relevant data need to be collected to obtain these contextual variables, which may be from databases, sensors and IoT devices such as RFID.

3.1.2 Context-aware Process Modeling towards Personalized Services: Managerial Decisions

Recent advances in IT such as IoT and mobile devices provide ways to sense user contexts. A user-centric paradigm of ubiquitous computing allows users access to preferred services anytime (Tang et al., 2008). Delivering personalized services motivates managerial decisions and considering context in the process design (Jaroucheh et al., 2010).

Dynamic context and user preferences need to be considered in the process design to deliver preferred services with minimal user intervention. User context and managerical decisions towards user satisfaction are essential to model a context-aware process for providing personalized services. More specifically, according to the update frequency, user context can be broadly classified as user profile (static), user preference (mutable) and user situation (dynamic).

In the representative case, triggered by managerial decisions, preliminary check is needed which includes checking new customer and operation cancellation. A new truck needs to register as a new customer and then be guided to the cargo stack; customers can cancel operations due to rain or humidity in terms of certain cargo types such as coal. Then contextual va riables and data need to be identified to model the context-aware process. The truck VIN (Vehicle Identification Number) is identified as contextual data of the user
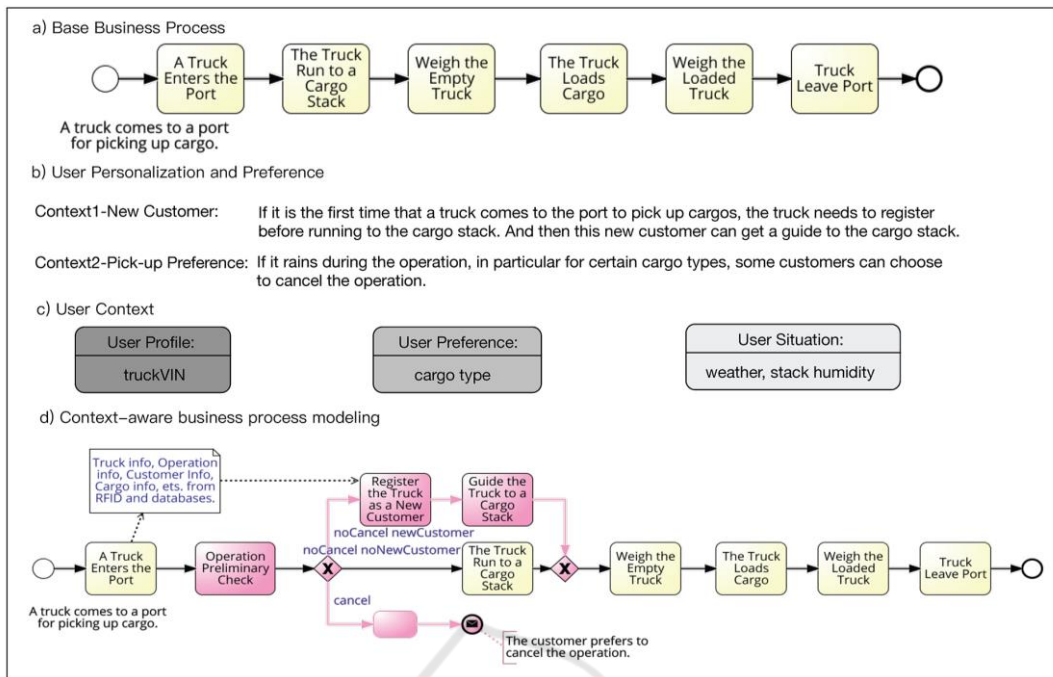
Figure 2: Modeling the context-aware business process of the truck pick-up cargo operation towards personalized services.
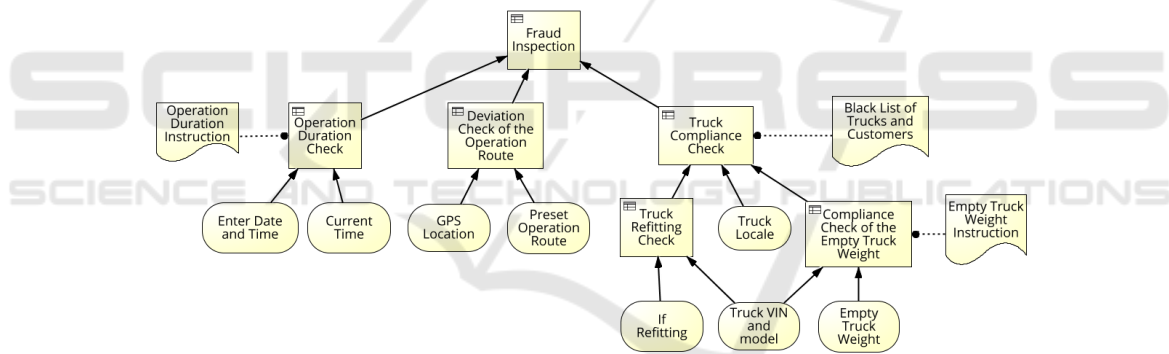

Figure 3: A DRD of the decision activity of fraud inspection.

profile for obtaining the context variable of a new customer by comparing it with historical records. Moreover, cargo type, weather and stack humidity are identified to obtain the preference of operation cancellation. The truck VIN and cargo type can be automatically collected by RFID when the truck enters the port. Contextual data of weather and stack humidity are collected by sensors deployed dynamically. Figure 2 depicts the context-aware process modeling case of the operation by integrating user context towards personalized services.

3.2 Changes at Run Time

Context should be considered as a data perspective of processes to ensure the correct execution. Especially a knowledge-intensive process needs to be context-aware to deal with its probability. These knowledge requirements are involved and processed in the decision dimension of processes. Moreover, rules are often used to present the knowledge logic. Contextual data are used to obtain meaningful knowledge to support both decision points and decision activities of a business process, i.e., operational decisions.

3.2.1 Changes in Decision Activities to Execute a Context-dependent Calculation

Context can affect process execution in decision activities by providing contextual data as parameters for calculation. It does not lead to changes in flow

splits of business processes, but the outcome can be incorrect without up-to-date context integrated.

For instance, in Figure 1, the decision activity of fraud inspection needs contextual data to execute based on decision rules and domain knowledge. Figure 3 depicts a DRD of the decision activity of fraud inspection when high security monitoring is required. This DRD presents the requirements and the dependencies of fraud inspection between elements including sub-decisions and data involved in the decision activity. In this example, the decision activity of fraud inspection need the outputs of three sub-decisions including operation duration check, deviation check of the operation route and truck compliance check as its input data. To support the execution of these decisions, various contextual data and domain knowledge are needed. For instance, the enter time of the truck is collected by RFID for calculating the operation duration to check if the operation is overtime; the real-time truck location is collected by GPS to check if the truck deviates from the preset operation route; various contextual data of truck including profile data and weighing data are used to check if the truck has potential fraud risk based on domain knowledge.

3.2.2 Changes at Decision Points to Execute a Context-dependent Branch

Decisions points involved in a business process could lead to gateways to handle different scenarios, which may need to identify context to correctly execute one of process branches in case that decisions are context-dependent. Multi-sources contextual data is needed to produce up-to-date knowledge to identify dynamic context. Moreover, contextual data can be raw data or composite data, which leads to semantic hierarchies. Hence, reference rules are often needed for context fusion and reasoning to extract useful information. In order to ensure the correctness of context abstraction, semantic rules should be consistent with business rules (or decision rules). In other words, context interpretation should follow the business logic.

We take the gateway of new customer and operation cancellation in Figure 2 as an example to present how context affects process execution at the decision point, which is depicted in Figure 4. Through analyzing the decision rules, we know this decision point is context- dependent. Then, two decision rules are analyzed and two contextual variables are then identified, i.e., if the truck is new customer and if the
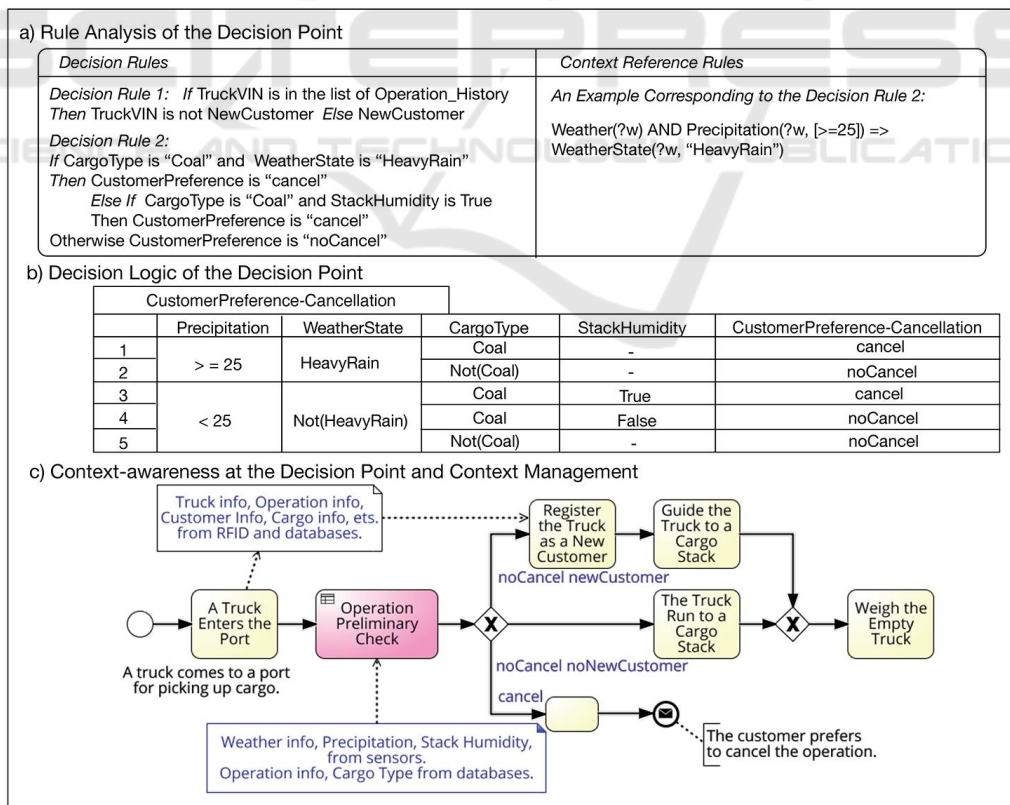

Figure 4: The Context-awareness at the Decision Point of New Customer and Operation Cancellation.

customer prefers the cancellation of the operation. Querying the truck VIN in databases to collect the contextual variable of new customer is straightforward. But considering the contextual variable of customer cancellation, we need to analyze the decision logic (i.e., decision rules) to identify relevant contextual data that can be collected by sensors, IoT devices and databases. Then context reference rules need to be developed for the context abstraction based on these decision rules.

In case of complicated context of a process, contextual data and their relations should be organized in an extendible way. Ontology can be a suitable technique to model the context, which also supports embedded an reference engine. As long as a business process integrates contextual data and reference rules to obtain context-awareness, the process can automatically identify the situation and execute the right process branch at the decision point.

4 HOW TO UTILIZE DECISIONS IN CONTEXT-AWARE BPM?

Context affects business processes both at process design time and run time. At the design time, context is considered to optimize process models to respond to different requirements of situations and customers. At run time, context is integrated to execute process correctly and automatically. Through analyzing how context affects business processes, we observe that decisions play a key role in context-aware BPM.

Decisions were considered and modeled within the business process traditionally. Lately, literature is moving towards a separation of concerns between the process and decisions. Most notably, DMN provides a solution to support that decisions and processes can be separated and consistently integrated. Decisions are the key to figure out why we need context-awareness for a business process, how can we make a process context-aware and what we need for the context-awareness of the business process. Figure 5 depicts the roles that decisions play in the system of context-aware BPM.

4.1 The Need for Context-awareness

Not all business processes need to be context-aware such as routine processes. Hence, from a base business process to the corresponding context-aware business process, the primary focus is determining if this process needs to be context-aware.

Context-awareness can bring a business process flexibility, personalization and automation besides the base process only if this process may change according to dynamic context. Decisions are crucial stimuli that may trigger a business process changes in different situations. If various types of decisions (including strategic, managerial or operational decisions) may influence the business process changes on either process modeling or process executiing, this base business process then needs context-awareness. Otherwise, context-awareness is not essential for the context unrelated process.

4.2 The Anticipation for Context-dependent Process Variants

After confirming the business process may change according to dynamic context, we need to figure out how to make the process context-aware to correctly respond to different situations. Context-dependent process variants and adaptation options therefore need to be anticipated in the process design phase. Comprehensive anticipation of the context-awareness can ensure appropriate contextual data collecting and process executing.

On the basis of the stimuli, how the business process varies from different outcomes of decisions is important to anticipate process variants. Then the adaptation points and options can be anticipated by identifying how different outcomes of decisions are utilized in the business process.
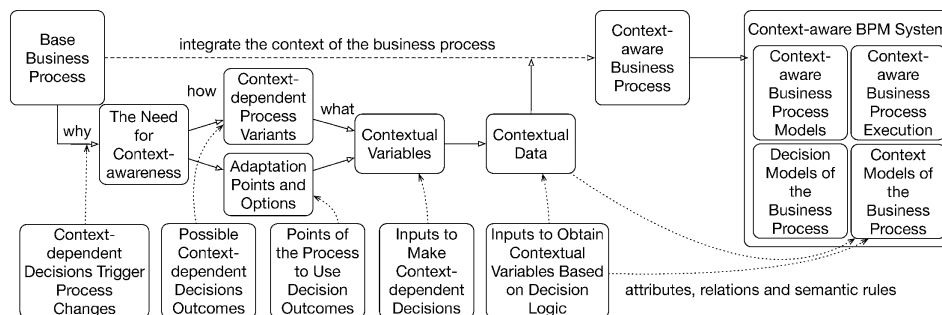

Figure 5: The roles that decisions play in context-aware BPM.

4.3 The Contextualization for the Business Process

The base of modeling or executing a context-aware business process is integrating the context in the base business process. So what contextual variables and data a business process need is the next issue to solve, i.e., the contextualization of a business process. It cannot merely rely on expert knowledge which may lead to incompleteness or redundancy, especially in complicated situations.

The data inputs of context-dependent decisions and their sub-decisions are the essential sources to identify relevant contextual variables of a business process. However, these contextual variables may not be able to be directly collected by databases, sensors or IoT devices, etc. Thus, other contextual data are needed to be aggregated or reasoned to obtain these meaningful and utilizable variables. The context reasoning is based on certain semantic rules, which must be consistent with the decision logic to ensure the correctness of context interpretation. Hence, decision logic and rules can be the source and assistance to identify contextual data involved in the business process.

5 DISCUSSION

Context-aware BPM consists of four components, which are (1) a context-aware business process model, (2) decision models of a business process, (3) context models of a business process and (4) context-aware process execution. In the modeling phase, context needs to be integrated in the process model.

Then context needs to be collected, identified and invoked correctly for the process automation in the execution phase. Moreover, if the environment in which the business process embeds is complicated, context models are needed to organize, reason and utilize contextual data in an extendible way. Furthermore, decision models are needed to separate the consideration of decisions from the business process and then provide the capability to support the ecosystem of context-aware BPM.

For this representative example of pick-up cargo process, decisions are utilized to optimize the base business process to obtain context-awareness. Figure 6 depicts the context-aware business process model, with context that triggerred by various types of decisions taken into account. This model integrates relevant contextual variables and data for responding to different situations in terms of customer personalization, strategic requirements and knowledge-intensive activities.

This context-aware business process is more complete and flexible, compared to the base business process. Using decisions for context-aware process modeling is more systematic with less reliance on experts knowledge. With relevant contextual data integrated, this process can execute correctly and automatically according to dynamic context.

Context of this representive process is considered as uncomplicated and not presented in the context model in this case. Nevertheless, this context-aware process model should be associated with decision models and context models to constitute the ecosystem of context-aware BPM, which would be able to support the self-organized and self-evolved capabilities at the design time and run time.
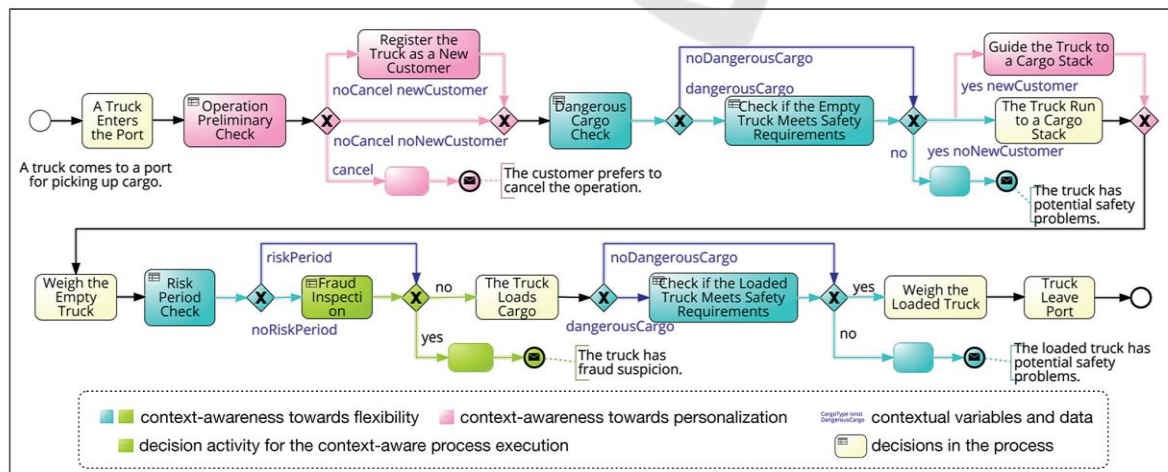

Figure 6: The context-aware business process model of the truck pick-up cargo operation.

6 CONCLUSIONS AND FUTURE PERSPECTIVES

Different types of context-dependent decisions (i.e., strategic, managerial and operational decisions) can trigger a process changes from different perspectives, including process flexibility, personalized services and knowledge-intensive tasks. Context is also essential for context-dependent decision points and decision activities during the process execution. After analyzing how context affects the business process at process design and run time, we observe that decisions play a key role in the system of context-aware BPM, including determining the need of context-awareness, the anticipation for the context-awareness and the contextualization of a process.

Decisions are traditionally considered as part of business processes, which impair the maintainability, scalability, and flexibility of both processes and decisions. Hence, more and more researchers have sensed benefits of the separate consideration. The main contribution of this paper is separately considering decisions from the business process and enabling the use of decisions to understand the rationale of the context-aware BPM and optimize the procedure of modeling the context-aware business process with less reliance on experts.

In future endeavours, we plan to propose a methodological approach to use DMN techniques for modeling context-aware processes. Moreover, using the ontology technique to model the context of the process is also planned. We will also investigate more real world cases to apply our approach to achieve context-aware BPM including process models, decision models, context models and context-aware process execution.

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