Towards Object Life Cycle-Based Variant Generation of Business Process Models

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Abstract—Variability management of process models is a major challenge for Process-Aware Information Systems. Process model variants can be attributed to any of the following reasons: new technologies, governmental rules, organizational context or adoption of new standards. Current approaches to manage variants of process models address issues such as reducing the huge effort of modeling from scratch, preventing redundancy, and controlling inconsistency in process models. Although the effort to manage process model variants has been exerted, there are still limitations. Furthermore, existing approaches do not focus on variants that come from change in organizational perspective of process models. Organizational-driven variant management is an important area that still needs more study that we focus on in this paper. Object Life Cycle (OLC) is an important aspect that may change from an organization to another. This paper introduces an approach inspired by real life scenario to generate consistent process model variants that come from adaptations in the OLC.

I. INTRODUCTION

In recent years, the increasing adoption of Process-Aware Information Systems (PAISs) has resulted in large process model repositories [1]. One of the ongoing research challenges in the PAISs area is variability management. Each process variant constitutes an adjustment of a reference or basic process model to specific requirements. Efficient management for process model variants is a critical issue for organizations with the aim of helping them reduce the huge effort of modeling from scratch, prevent redundancy, and tackle inconsistency in process models. Despite the effort done in current approaches e.g., in Provop [2], C-EPCs [3], and PPM [4] to manage process model variants, there are still un-addressed issues. Current approaches focus on dealing with variants coming from change in control and behavioral perspectives of process models. However, variants originating from organizational and informational perspectives still need to be studied.

The organizational perspective is one of the different views integrated in the process model. It identifies the hierarchy of the organization within which the process will be executed. Russell et al. [6] introduced a set of Workflow Resource patterns (WRP) to capture the requirements for resource management such as representation and utilization in workflow environment [6]. Awad et al. [7] proposed an extension metamodel for BPMN to enable representation of resource assignment constraints using Object Constraints Language (OCL) [8] to WRP [6]. We, in a previous work, discussed organizational structures, and resource assignment matrix as aspects of the organizational perspective in [9], [10].

Another important aspect of the organizational perspective is the Object Life Cycle (OLC). OLC enables organizations to understand the complete behavior of business objects. OLC is usually modeled using state machine [14]. The aim of this paper is to propose a context-based approach for generating consistent process model variants focusing on the different variations of OLC. We enrich the OLC for a given base model by a set of exceptional cases extracted from UML Sequence Diagram. Then, we enable the user to select the suitable case. Finally, we generate the variant of the base model in hand.

The rest of this paper is organized as follows: Section II introduces the basic concepts related to our approach and discusses a motivating scenario. Section III presents our OLC-based algorithms for generating consistent process model variants. Section IV discusses related work. Finally, Section V concludes our approach and outlines directions for future research.

II. BACKGROUND

In this section, we introduce in brief the background that is related to our approach. We present the work of Küster et al. [15] for generating compliant business process model based on OLC and exception handling in both Business Process Model and Notation (BPMN) [11] and UML Sequence Diagram (UMLSD) [12] in the sections II-A and II-B respectively. Then, we present our motivating scenario in section II-C.

A. OLC-Based Process Model

Küster et al. [15] introduced an approach for generating a compliant business process model from a set of OLCs. Compliance using OLCs verifies the consistency of organization’s processes and correct the execution of processes that spans several organizations. They formally defined the the compliance of a business process with an OLC using both OLC conformance and OLC coverage [15]. OLC conformance happens when process model induced only the object state transitions which are defined in OLC. OLC coverage means that process model must cover the transitions and states in OLC. OLC Composition consists of an integrated view for a set of OLCs synchronized together. Fig.1 represents a composition of Order, Product and payment OLCs. The
OLC initiated by \((I_{1}^{PO}, I_{2}^{PR}, I_{3}^{PA})\). Firstly, the transition \(\text{register}^{PO}\) registers the order with state “RG”. Then, the order either accepted or rejected. If rejected, the transition \(\text{Reject}^{PO}\) rejects the order with state “RJ”, the order is closed as a result of order’s rejection. If accepted, the transition \(\text{Accept}^{PO}\) \(\mid \text{Assemble}^{PR}\) will accept the order and assemble the object product with the state “\(AC^{PO}, AS^{PR}, I_{3}^{PA}\)”. Then, the transition \(\text{Ship}^{PR} \mid \text{Creater}^{PA}\) ships the products with the state “\(SH^{PR}, CR^{PA}\)”. Then, the transition \(\text{Receive}^{PA}\) changes the state to “\(RC^{PA}\)”. Then, the order is closed as a result of receiving the payment.

The aim of Küster et al. [15] work is introducing a novel approach to generate a compliant process model using OLC. However, our approach addresses the issue of generating consistent process model variants from exceptional cases based on context that are not covered in OLC.

B. Exception Handling

Each business process may be exposed by an exception that deviate a process from its normal execution flow. In general, Exceptions are classified into two types: business related (e.g. customer cancels order late), and IT related (e.g. system errors or crashes) [16]. In BPM, we classify exceptions into three types: external (i.e. something goes wrong outside the process), internal (i.e. something goes wrong inside the process), and timeout (i.e. activity takes a longtime) [16].

UML Sequence Diagram is the most common type of interaction diagrams. It is used to show the interactions between objects arranged in time sequence [12]. The break combined fragment are used to model exception handling [13].

We make use of these exceptional cases as adaptations in our approach to generate variant process models for the base process model in Section II-C.

C. Motivating Scenario

In this section, we introduce a real life scenario that motivated the development of our approach. We introduce the base model for “Oder Fulfillment” business process based on OLC in Fig. 2.

Oder Fulfillment is one of the most frequently executed business processes in organizations. The process starts when a customer sends a Purchase Order (PO) to an organization. Then, the organization registers the PO after receiving it. Then, it checks the stock for the availability. If the products are not available, the organization rejects the PO. Otherwise, the organization accepts the PO, assembles the products, ship products and finally receives payment from the customer. Fig. 2 represents a base model for the “Oder Fulfillment” process.

Fig. 1. Composition of the Order, Product, and Payment OLCs

Fig. 2. Order Fulfillment - Base Process Model

The Oder Fulfillment process may vary from one organization to another. We discuss in detail how these variants may be generated in section III

III. OLC-BASED VARIANT GENERATION

In this section, we introduce a solution for generating consistent process model variants based on OLC and Exception Handling mentioned in Section II. We present two OLC-based algorithms as follows: “OLC Adaptations” and “OLC-Based Process Variant Generator” in the sections III-A and III-B respectively.

A. OLC Adaptations

The “OLC Adaptations” algorithm is responsible for retrieving the exceptional cases which are not covered by OLC for a given base process model as in Fig. 2. Firstly, OLC Adaptations starts with reading the different break combined fragments from UML Sequence Diagram as in Fig. 3. Secondly, we enable the user to select the exceptional case suits the context.

Fig. 3. Order Fulfillment - UML Sequence Diagram
Algorithm 3.1 OLC Adaptations.

Inputs: OLC is the object life cycle of the base model, UMLSD is the UML Sequence Diagram contains break combined fragment(s).

Outputs: AOLC is the adapted OLC with a selected break combined fragment.

Variables: BCF[] is an array of break combined fragments, BCFInitiator is the initiator type for BCF such as Internal, External, or Timeout Exception, BCFTrans are set of transitions, PT represents previous transition for BCF, NT represents next transition for BCF, P is a specific position in AOLC.

1. AOLC = OLC;
2. For each BCF in UMLSD
   BCF[] = AddBcf(BCF)
   For each BCF in BCF[]
   BCFInitiator = BCF.getInitiatorType()
   BCFTrans = BCF.getTransition()
   PT = UMLSD.getPreviousTransition(BCF)
   NT = UMLSD.getNextTransition(BCF)
   P = AOLC.getPosition(PT, NT)
   AOLC = InsertBcf(P, BCFTrans, BCFInitiator)
3. End For
4. End For
5. return AOLC

Line 1 initiates AOLC by the OLC of the base process model. Line 2-3 reads all BCFs in the UMLSD and insert them into array of break combined fragments. Lines 4-11 perform a number of actions for each BCF. Firstly, we get the type of initiator for BCF such as Internal, External, or Timeout Exception in Line 5. Secondly, we get the transitions in BCF in Line 6. Thirdly, we get both previous “PT” and next “NT” transitions for the BCF using the UMLSD in Lines 7-8 respectively. Fourthly, we get the position inside AOLC using “PT” and “NT” transitions for the BCF in Line 9. Fifthly, we update AOLC by BCFTrans and BCFInitiator in Line 10. Finally, we return the AOLC in Line 13.

B. OLC-Based Process Variant Generator

The “OLC-Based Process Variant Generator” algorithm manages the issue of generating consistent process model variants caused by adaptations in OLC generated by “OLC Adaptations” algorithm in section III-A.

Algorithm 3.2 OLC-Based Process Variant Generator.

Inputs: BM is the base model of a process; AOLC is the adapted OLC with a selected break combined fragment.

Outputs: VPM variant process model.

Variables: OPR represents the operation based on BCFInitiator of AOLC, EEP is external exception pattern, IEP is internal exception pattern, TEP is timeout exception pattern, VPM initially is the base model.

1. VPM = BM;
2. OPR = AOLC.getBcfInitiator()
3. If OPR = Insert External Exception Then
   VPM.insertPattern(AOLC, IEP)
4. Else If OPR = Insert Internal Exception Then
   VPM.insertPattern(AOLC, IEP)
5. Else If OPR = Insert Timeout Exception Then
   VPM.insertPattern(AOLC, TEP)
6. End If
7. return VPM

Line 1 defines and initializes VPM to BM. Line 2 retrieves the operation of AOLC. Then, the algorithm checks the type of OPR. Lines 3-4 if correct, algorithm performs an insert external exception pattern. Lines 5-6 if correct, algorithm performs an insert internal exception pattern. Lines 7-8 if correct, algorithm performs an insert timeout exception pattern. Line 10 returns the generated VPM. Fig. 4 shows the generated variant of the base model in Fig.

Fig. 4. Order Fulfillment - Late Cancellation Variant Process Model

So, we can conclude that the common source for the variant introduced for the process of “Order Fulfillment” before is the changes in OLC.

IV. RELATED WORK

Several approaches have been developed in recent years to manage the different variants of process models, Such as PROcess Variants by OPtions (Provop), Configurable Event-driven Process Chains (C-EPCs), and Partial Process Models (PPM). In this section, we state the pros and cons for each approach.

Provop is an approach for managing a set of related process variants throughout the entire Business Process Life Cycle (BPLC) [3]. In Provop, a specific variant is derived by adjusting the basic process model using a set of well-defined change operations [3]. Change Operations represent the difference between basic model and variant such as INSERT, DELETE, and MOVE process fragments, and MODIFY process elements attributes. Furthermore, Provop supports the context-aware process configuration either statically or dynamically [17]. The Provop lifecycle [18] consists of three major phases: the modeling phase, the configuration phase and the execution phase. Provop has been extended with a procedure to guarantee the correctness and soundness for a family of configurable process variants [19]. An extension has been developed for ARIS Business Architect to cope with variability in process models based on Provop [2]. Provop uses a bottom-up technique from process variants to the basic process model. Each variant is
maintained through the base model only. So, the changes in any variant may not be consistent with other variants of the same process.

The concept of configurable process model has been defined by [4]. It merges variants of process models into a single configurable model. Configurable process models are integrated representations for variants of a process model in a specific domain. A framework to manage the configuration of business process models consists of three parts: a conceptual foundation for process model configuration, a questionnaire-based approach for validating modeling, and a meta-model for holistic process configuration [20]. C-EPCs are configurable version of EPCs, which provides a means to capture variability in EPC process models. C-EPCs identify a set of variation points which are called configurable nodes in the model and constraints, which are called configuration requirements to restrict the different combinations of allowed variants in order to be assigned for variants called alternatives [20]. La Rosa et al. [21] proposed C-iEPC, that extends C-EPC notation with the notions of roles and objects associated to functions. C-iEPC supports variants from organizational perspective. C-EPCs uses a top-down technique from holistic or reference process model to process variants. Specifying all variants in a holistic reference model for a particular process is difficult to maintain.

PPM is a query-based approach that depends on defining process model views to maintain consistency among process variants [5]. These views are defined using a visual query language for business process models called BPMN-Q [22]. Based on BPMN-Q, a framework for querying and reusing business process models has been developed by [23]. PPM is using inheritance mechanisms from software engineering to make best use of the reusability as a concept of Object-Oriented Modeling of object orientation [5]. PPM approach provides support for consistency of process model variants, and allows handling issues for multiple inheritance levels. PPM uses both top-down and bottom-up techniques in handling process variants. Context issues related to variants of business process are not covered in the PPM approach.

Despite the significant effort that has gone into the current approaches to manage process models variants, the organizational perspective has many aspects still need to be studied. So, our approach focus on OLC as one important aspect of organizational perspective to manage generating the process model variants consistently.

V. CONCLUSIONS AND FUTURE WORK

This paper introduces an approach to manage the generation of consistent process model variants that come from adaptations in OLC. The approach helps practitioners, such as process owners and/or designers in generating consistent variants of their process models depending on the case in hand. The most significant finding behind the approach is the importance of the organizational perspective’s aspects such as OLC. In this paper, we presented two context-based algorithm to derive variants of process models based on OLC. We applied the approach to real life process models to further illustrate our ideas.

In future work, we seek to apply the approach for more real world cases in different domains. Furthermore, we look for other aspects from the organizational perspective to complete our approach. Finally, a proof-of-concept prototype that validates the concept behind approach will be implemented.

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