Towards a fitting representation method for redesign evaluation and cost-based optimization

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Abstract: The prospect of continuously modifying and improving the various business operations played a central role in the evolution of the concept of business processes (BPs). As a consequence, Business Process Redesign (BPR) emerged as a vital practice in the Business Process Management (BPM) discipline and is embodied in most BPM lifecycle models. So far, only a few BPR initiatives investigate how the improvement process can be methodically supported and what is also overlooked is the a priori evaluation of BPR impact. In this paper the authors present the representation phase of the Business Process Redesign Capacity Assessment (BP-RCA) framework and how this phase is formulated for a cost-based optimization technique. In this context, the authors elaborate on a fitting representation method that combines the established Business Process Model and Notation (BPMN2.0) standard and an adapted graph-based structure, initially designed for agent concepts. The method incorporates: (a) the necessary elements for capturing the execution logic, (b) the information for measuring performance and (c) the model constraints that affect redesign. Through applying the representation method to BP models from literature, the authors intend to showcase its usability and the fact that it is amenable to cost-based optimization techniques. By applying the representation, a practitioner is assisted towards a more straightforward calculation of complexity metrics that indicate the applicability of BPR. In this sense, the application of the proposed method is a fundamental feature of the BP-RCA and is essential for redesign decision making at an earlier-than-runtime stage.

Keywords: **Business Process Redesign, business processes, evaluation, representation, modelling.**

Introduction

The emergence of BPR derives from the need to be adaptable to the evolving organizational change towards modifying the process design, depending on the feedback of the process run-time, and/or the performance attributes (Tsakalidis et al., 2019a). Although the analysis of a BP induces various ideas and perspectives for redesign, it is often conducted in a non-systematic manner, and is predominantly considered a creative activity (Tsakalidis et al., 2019b). The need to evaluate the redesign capability of BPs has led to approaches [e.g. (Vanwersch et al., 2016)] that constitute supportive tools for the development of new process improvement methods, nevertheless, most of them require process feedback, since they are conducted at runtime. In most of these approaches, there is a lack of investigation of the fitness of BPs for BPR, e.g. by examining if they are modelled in a BPR-compatible technique, or whether the process model includes execution semantics and supports automation. By evaluating the stimulus, critical performance criteria and factors that influence the selection of process redesign projects, practitioners can reduce the eligible BPR methods, towards selecting the most appropriate one. By acknowledging the pertinence of a BPR method and the specified criteria, this can be achieved prior to BPR implementation, providing multiple benefits for organizations and competitive superiority. In essence, what is missing from literature is a methodology for assessing the redesign capability of BP models that: (a) evaluates the BPR capacity of models prior to its implementation through a systematic procedure, and (b) takes into consideration an inclusive set of criteria (BPR technique, performance criteria, redesign heuristics and BP indicators). This research work elaborates on a fitting representation approach (Tsakalidis et al., 2020) that is embedded to the representation phase of the BP-RCA framework (Tsakalidis and Vergidis, 2021). The representation method captures the visual and quantitative depiction of input models, through the BPMN2.0 standard and a graph structure that incorporates mathematical parameters for the control-flow, performance elements and statistical metadata of each model. The authors also demonstrate the usability of the method for evaluating the redesign capacity of models and it's compatibility to cost-based optimization techniques.

BP-RCA: The Representation phase

In previously published work (Tsakalidis and Vergidis, 2021), the authors introduced the BP-RCA framework (Fig. 1) which is developed through three phases, the *Selection*, *Representation* and *Assessment*. In the *Selection* phase of the BP-RCA framework, the redesign decisions of the particular redesign approach are committed through in a systematic and progressive manner.

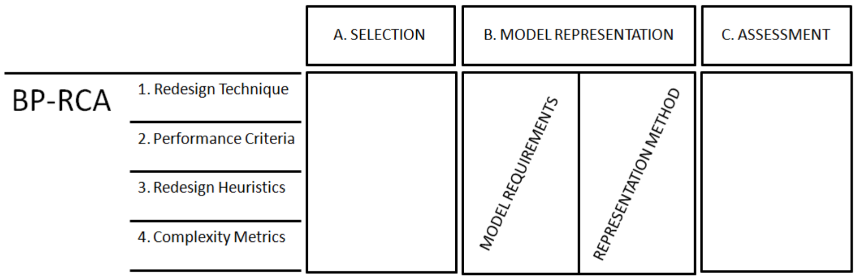

Fig 1. The BP-RCA Framework (Tsakalidis and Vergidis, 2021).

The *Representation* Phase of the BP-RCA is an intermediate framework phase aiming to: (a) define the input model requirements based on the redesign decisions taken, and (b) adopt or introduce a fitting representation method for both assessing the redesign capacity of feasible input models in the *Assessment* Phase and the redesign application at a later stage. The phase involves two concrete and interrelated steps, the specification of model requirements and the model representation. The model requirements step defines the particular characteristics of input models pertaining to the four BP-RCA framework components. When a model fulfills the set of requirements, it encompasses the fundamental characteristics for the assessment of its redesign capacity. To accomplish this, the model needs to be represented - in the second step - by using a method that encapsulates these model characteristics. In the probable case that there is a lack of a fitting representation method, a proper method should be introduced and applied.

The Representation phase for Data-centric Workflow Optimization

In (Tsakalidis and Vergidis, 2021), the authors illustrated both the adopted methodology of the BP-RCA and the selected redesign components in the context of the particular research. In detail, the selected redesign technique is data-centric workflow optimization and since this is a cost-based method, the deduced performance metrics are execution time and/or cost. These performance metrics are improved with the use of established dataflow optimization algorithms that resemble the selected redesign heuristics (RESEQ, PAR, KO, COMPOS, TRI). Finally, the selected redesign heuristics determine the BP quality indicators that facilitate or perplex its implementation. These metrics refer to the BP's size, control flow and structuredness and the selected metrics (NOAJS, CFC and CNC) are representative of these categories.

Model Requirements

Due to the variety of modelling techniques, different model types and applying constraints in a model, it is important to identify and specify the required features and BP elements. Each input model should: (1) Be modelled in BPMN2.0, be a private BP and be consisted of the most commonly used control-flow elements, (2) include the necessary information (e.g. execution time, cost and selectivity per task) for measuring performance, (3) include all model constraints that depict the execution logic and reduce the capability of activities to be resequenced, put in parallel, etc, and (4) be modelled in BPMN2.0 for a straight-forward and convenient calculation of selected complexity metrics.

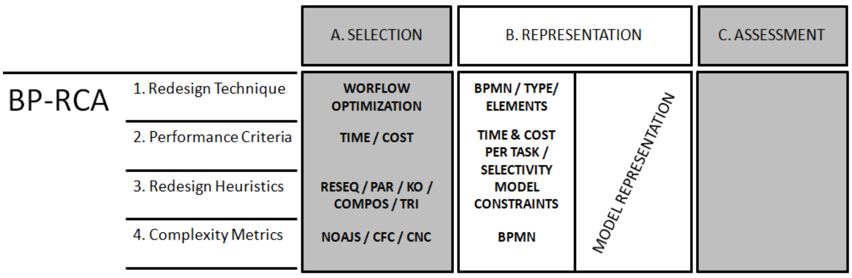

Fig 2. Complete Model Requirements of the BP-RCA Framework

The complete set of model requirements is incorporated in the BP-RCA framework and presented in Fig. 2, highlighting the connection to the previous *Selection* Phase.

Model Representation

For the selection of a representation method the author considered different representation techniques from literature. To the best of the author's knowledge, there is no fitting technique available, a fact that led to the introduction of a novel representation technique. The aim of the representation is to capture, visualize and express a BP model in a quantitative way that allows the evaluation of input models in terms of redesign capacity, and the optimization of feasible input models using the selected redesign technique. The proposed representation is comprised of: (a) the established BPMN2.0 notation for providing the visual representation of input models, and (b) the Business Process Diagram (BPD) a graph-based notation that is based on (Endert et al., 2007; Ouyang et al., 2006) approaches and is modulated to previous cost-based optimization approaches (Gounaris, 2016; Kougka et al., 2020). The BPD is the following five-tuple graph:

Definition 1. (BPD-Graph) - Let BPD = (O, F, P, S, C) be a graph with

- **O** — the set of nodes (objects).
- **F** — the set of edges (message and SFs).
- **P** — the set of performance attributes of activity-nodes.
- **S** — the set of statistical metadata (selectivity) of activity-nodes.
- **C** — the set of constraints between activity-nodes.

Further partitioning of these sets is presented in (Tsakalidis et al., 2020) for distinguishing the different sets (nodes, edges, attributes and constraints) in the BPD-Graph. The methodology for creating the BPD-Graph is based on the following steps:

- Assign labels to the activities, events, gateway elements, participants (pool and lanes) and sequence flows; follow a top-down approach for gateway branches and first come-first serve for numbering. Create O (O^A, O^E, O^G, O^P) and F (F^S) sets.
- Assign labels to the performance and/or selectivity attributes. Create P and S sets.
- Extract the implicit constraints from the BPMN2.0 model and assign labels to both the implicit and given explicit constraints. Create C set.

The formulated five-tuple BPD-Graph incorporates the necessary model information for both the redesign assessment and the optimization at a later stage.

Representation of BP models from literature

For applying the proposed representation on case studies, we consider two BP models from literature. Each case study also includes a set of explicit constraints, which in real life scenarios should be provided by the BP modelers beforehand.

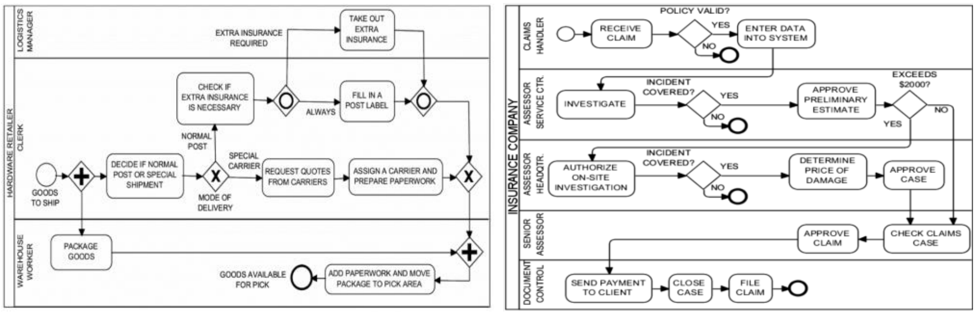

Fig 3. (a) Shipment Process (Object Management Group (OMG), 2010), (b) Personal Claims Process (April et al., 2006).

Case Study 1

The first case study considers a hardware retailer shipment process (Object Management Group (OMG), 2010) and Fig. 3a shows the related BP model. For the case study, there are no explicit constraints provided by the analyst and the authors introduce three indicative ones:

1. The task "ADD PAPERWORK AND MOVE PACKAGE TO PICK AREA" is the last task to be executed before the end event "GOODS AVAILABLE FOR PICK".
2. The task "CHECK IF EXTRA INSURANCE IS NECESSARY" directly precedes task "TAKE OUT EXTRA INSURANCE".
3. The task "REQUEST QUOTES FROM CARRIERS" directly precedes task "ASSIGN A CARRIER AND PREPARE PAPERWORK".

The BP model fulfills the determined requirements and by following the representation methodology, the authors extract the model representation, already presented in (Tsakalidis et al., 2020). The sets are presented in table 1.

Table 1. BPD = (O, F, P, S, C) graph of Case Study 1

Graph Set	Elements
O	$O^A = \{T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8\}$, $O^E = \{\mathrm{Str1}, \mathrm{End1}\}$,
	$O^G = \{\mathrm{Xors1}, \mathrm{Ors1}, \mathrm{Ands1}, \mathrm{Xorj1}, \mathrm{Orj1}, \mathrm{Andj1}\}$, $O^P = \{\mathrm{Pool1}, \mathrm{Lane1}, \mathrm{Lane2}, \mathrm{Lane3}\}$.
F	$F = \{F_1^S, F_2^S, F_3^S, F_4^S, F_5^S, F_6^S, F_7^S, F_8^S, F_9^S, F_{10}^S, F_{11}^S, F_{12}^S, F_{13}^S, F_{14}^S, F_{15}^S, F_{16}^S, F_{17}^S, F_{18}^S\}$.
P	$P = \{P_1^T, P_2^T, P_3^T, P_4^T, P_5^T, P_6^T, P_7^T, P_8^T\}$.
S	$S = \{S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8\}$.
C	$C^L = \{C_1^L\}$, $C^{CP} = \{C_1^{CP}, C_2^{CP}\}$, $C^{OR} = \{C_1^{OR}\}$,
	$C^{CO} = \{C_1^{CO}, C_2^{CO}, C_3^{CO}, C_4^{CO}, C_5^{CO}, C_6^{CO}\}$, $C^{XR} = \{C_1^{XR}, C_2^{XR}, C_3^{XR}, C_4^{XR}, C_5^{XR}, C_6^{XR}\}$.

Case Study 2

The second case study considers a personal claims process at an insurance company (April et al., 2006) and Fig. 3b shows the related BP model. In the same manner, the authors introduce three indicative explicit constraints:

1. The task "RECEIVE CLAIM" is the first task to be executed in the process.
2. The task "CHECK CLAIMS CASE" directly precedes task "APPROVE CLAIM".
3. The task "SEND PAYMENT TO CLIENT" precedes task "CLOSE CASE".

The BP model fulfills the determined requirements and by following the representation methodology, the authors extract the model representation. The sets are presented in table 2.

Table 2. BPD = (O, F, P, S, C) graph of Case Study 2

Graph Set	Elements
O	$O^A = \{T_1, T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, T_{10}, T_{11}, T_{12}\}, O^E = \{Str1, End1, End2, End3, End4\},$
	$O^G = \{Xors1, Xors2, Xors3, Xors4\}, O^P = \{Pool1, Pool2, Pool3, Pool4, Pool5\}$
F	$F = \{F_1^S, F_2^S, F_3^S, F_4^S, F_5^S, F_6^S, F_7^S, F_8^S, F_9^S, F_{10}^S, F_{11}^S, F_{12}^S, F_{13}^S, F_{14}^S, F_{15}^S, F_{16}^S, F_{17}^S, F_{18}^S, F_{19}^S, F_{20}^S, F_{21}^S\}$
P	$P^T = \{P_1^T, P_2^T, P_3^T, P_4^T, P_5^T, P_6^T, P_7^T, P_8^T, P_9^T, P_{10}^T, P_{11}^T, P_{12}^T\},$
	$P^C = \{P_1^C, P_2^C, P_3^C, P_4^C, P_5^C, P_6^C, P_7^C, P_8^C, P_9^C, P_{10}^C, P_{11}^C, P_{12}^C\}$
S	$S = \{S_1, S_2, S_3, S_4, S_5, S_6, S_7, S_8, S_9, S_{10}, S_{11}, S_{12}\}$.
C	$C^I = \{C_1^I\}, C^{CP} = \{C_1^{CP}\}, C^P = \{C_1^P\},$
	$C^{XR} = \{C_1^{XR}, C_2^{XR}, C_3^{XR}, C_4^{XR}, C_5^{XR}, C_6^{XR} C_7^{XR}, C_8^{XR}, C_9^{XR}, C_{10}^{XR}, C_{11}^{XR}, C_{12}^{XR}, C_{13}^{XR}, C_{14}^{XR}, C_{15}^{XR}, C_{16}^{XR}, C_{17}^{XR}, C_{18}^{XR}\}$.

Applicability of the Representation

This section highlights the way in which the proposed representation facilitates the calculation of complexity metrics and the degree of redesign heuristics applicability. The calculation of particular complexity metrics and further evaluation bears substantial benefits, primarily in enhancing the correctness, maintainability and understandability of BP models (Cardoso et al., 2006) and can also prove to be a redesign decision point. In previously published work (Fotoglou et al., 2020; Tsakalidis et al., 2020; Tsakalidis and Vergidis, 2021) the authors selected three established and representative complexity metrics (NOAJS, CFC and CNC), that primarily focus on size, control-flow and structuredness of a process model. Their calculation is performed manually through their equations by counting the corresponding elements from the BPMN2.0 model, a task which could prove error-prone and time consuming. On the other hand, using the proposed representation at this – early to the BPR – stage renders the calculation of the same complexity metrics a more straightforward and simple procedure:

Case Study 1

- NOAJS = $|O^A \cup O^G|$=> **NOAJS = 14.**
- $CFC_{XOR-split}$ = fan-out => $CFC_{XOR-split}$ = 2 (for $O^G_{S,X} = \{Xors1\}$), $CFC_{OR-split}$ = 2^{2-1} => $CFC_{OR-split}$ = 2 (for $O^G_{S,O} = \{Ors1\}$), $CFC_{AND-split}$= 1 (for $O^G_{S,A} = \{Ands1\}$), which entails that $\boldsymbol{CFC_{abs}(P) = 5}$.
- CNC = $|F| / |O^A \cup O^G|$=> **CNC = 18/14=1,29.**

Case Study 2

- NOAJS = $|O^A \cup O^G|$=> **NOAJS = 16.**
- $CFC_{XOR-split}$ = fan-out => $CFC_{XOR-split}$ = 2+2+2+2=8 (for $O^G_{S,X} = \{Xors1, Xors2, Xors3, Xors4\}$), $CFC_{OR-split}$ = 0, $CFC_{AND-split}$= 0, which entails that $\boldsymbol{CFC_{abs}(P) = 8}$.
- CNC = |F| / $|O^A \cup O^G|$=> **CNC = 21/16=1,31.**

The representation of each case study includes all the necessary process information for cost-based optimization. In particular, for applying data-centric workflow optimization (Kougka et al., 2020), one should include the set of tasks V, the set of gateways G, the set of edges E (sequence flows), the set of actors A (pools and lanes) executing the tasks, the set of input events I, and the output events O. In addition to the precedence constraints applying to the model, the quantitative metadata types needed for the optimization is cost per task (in either time or actual monetary cost units) and selectivity per tasks. What is evident is that the representation includes all the necessary data for applying the optimization method.

Discussion and Conclusions

This paper elaborated on a novel representation method that is embedded to the BP-RCA framework for the systematic assessment of the redesign capability of BP models prior to implementation. The method is amenable to cost-based optimization techniques and supports the evaluation of BPs towards the BPR practice, by combining a visual perspective -through the established BPMN2.0 standard- and a quantitative graph-based structure. The method incorporates: (a) the necessary elements for capturing the execution logic, (b) the information for measuring performance and (c) the model constraints that affect redesign. The usability of the method is demonstrated through the representation of two BP model from literature in which the calculation of critical complexity indicators is significantly simpler and straightforward. Another contribution of the representation method is that it incorporates a gamut of model constraints, originating from declarative BP modelling, that affect the applicability of redesign heuristics. As a future work, the representation will be embedded to the transformation phase of BPMN2.0 models to Directed Acyclic Graphs (DAGs), prior to applying the optimization method. The mapping of BPMN2.0 elements to the corresponding DAG symbols will be facilitated by the graph-based structure of the representation and the authors intend to automate this procedure.

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