Towards a method engineering approach for business process reengineering

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Abstract: Business process reengineering (BPR) assists organisations in improving their internal functions to better achieve their business objectives. Various methodologies have been developed for applying BPR, through which organisational processes are identified, analysed, and improved. However, the need still remains for custom methodologies which are tailored to fit the specific characteristics of organisations and BPR projects. Process patterns are abstract representations of common and effective processes that can be reused as method parts for building custom methodologies; an approach that is commonly referred to as situational method engineering (SME). This study aims to use SME in the context of BPR by proposing a collection of cohesive process patterns for BPR; these process patterns have been extracted through studying prominent BPR methodologies and abstracting their similarities. The patterns have then been organised into a generic framework for BPR methodologies. A method for using the framework has also been presented which prescribes a process for selecting suitable process patterns and adding them to a core process to yield a bespoke BPR methodology. This flexible framework forms a knowledge base that is not only useful for improving BPR practices, but also provides a basis for future research in this context.

1 Introduction

In recent years, methodologies for business process reengineering (BPR) and business process improvement (BPI) have played an important role in improving organisational structures and processes, depending on the level of improvement intended: radical or incremental [1, 2]. Although a myriad number of methodologies have been proposed and utilised for applying BPR in organisations, they tend to neglect the specific characteristics of organisations and BPR situations, and quality suffers as a result. Two decades after the reviews reported in [3], there is still no general methodology that can be used in all contexts, and BPR planners are often confused as to which methodologies are best suited to their projects. Situational method engineering (SME) [4], the discipline focusing on developing bespoke methodologies for software development projects seems a promising means for addressing this problem, as it has already been used in similar contexts; examples include the process configuration approach proposed in [5], the IT process engineering approach introduced in [6], and the framework proposed in [7] for reengineering software development methods. SME can thus help organisations develop BPR methodologies that fit their particular needs.

A pattern describes a proven solution to a common problem. Similarly, process patterns describe successful activities and techniques. Process patterns were initially defined as patterns of activity within an organisation [8], but were later redefined in the context of software development as ‘successful proven approaches or series of actions for developing software’ [9]. A comprehensive collection of process patterns has been proposed for object-oriented software development [9, 10]; in this collection, process patterns are categorised into three groups according to their granularity: Phase, stage and task. A task process pattern defines the steps required for executing a specific fine-grained task in a project; a stage process pattern consists of several task patterns which are executed as steps in a project stage; and a phase process pattern is a coarse-grained activity of the lifecycle consisting of interacting, iterative stage patterns.

Process patterns capture the knowledge and experience gained in a particular process context (such as software engineering or BPR). Phase process patterns constitute a general lifecycle (framework) for the process context, and they are in turn divided into finer-grained stage and task process patterns. Generic process frameworks have thus been constructed for agile software development [11], aspect-oriented development [12], and component-based development [13]. A specific, custom process can be generated by instantiating this framework and its constituent phase, stage, and task process patterns. Process patterns can thus be utilised as components for assembly-based SME [14], in which pattern instances are used as method parts, assembled to form methodologies that address the specific requirements of the project situation at hand. Process patterns can be stored in repositories to be used as method parts [15, 16]: As an example, OPFRO [17, 18] provides a comprehensive repository of method components, most of which are process patterns. The pattern-based SME approach described above can also be used for developing BPR methodologies. To this aim, we propose a collection of process patterns elicited from BPR frameworks and methodologies. These patterns have been organised into a generic process framework for BPR processes, which we have chosen to call the business process reengineering process (BPRP). BPRP and its constituent process patterns can be entered into a computer-aided method engineering (CAME) tool [19–21] to facilitate the assembly of custom BPR methodologies. We have also explored the applicability of each pattern in specific project situations: A set of situational requirements influencing the selection of BPR patterns has been identified and mapped to the patterns; this has resulted in the development of a set of guidelines and a process for the application of BPRP for engineering BPR methodologies.

Our proposed method for situational engineering of bespoke BPR methodologies (consisting of BPRP and the process for its application) has been evaluated by a number of analysis methods, and also through application to an industrial project; the results have highlighted the merits and applications of the proposed method.

The rest of this paper is organised as follows: Section 2 reports on previous research, introduces the proposed framework (BPRP), provides detailed descriptions for its constituent process patterns, and presents a process for applying the framework; in Section 3, we report on the results of applying the proposed method to an
industrial project; the validity of the proposed method is evaluated in Section 4; in Section 5, the contributions/limitations of the method are discussed; and Section 6 presents the conclusions and suggests ways for furthering this research.

Table 1 Prominent BPR frameworks and methodologies: sources for extraction of process patterns

<table>
<thead>
<tr>
<th>Index</th>
<th>Author(s)</th>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method 1</td>
<td>Kettlinger et al. [23]</td>
<td>1997</td>
<td>Introduces a Stage-Activity (S-A) framework for tools and methods of Business Process Change (BPC), covering 25 BPC methodologies.</td>
</tr>
<tr>
<td>Method 2</td>
<td>Sharon et al. [24]</td>
<td>1997</td>
<td>Introduces the Workflow Reengineering Methodology (WRM), which utilizes workflow management automation for enabling BPI. WRM is obtained through combining BPR and process improvement methodologies.</td>
</tr>
<tr>
<td>Method 3</td>
<td>Mayer and Dewitte [25]</td>
<td>1999</td>
<td>Introduces a phased BPR approach that uses an integrated collection of methods which are applied incrementally; the risk of failure is hence reduced.</td>
</tr>
<tr>
<td>Method 4</td>
<td>Castano et al. [26]</td>
<td>1999</td>
<td>Introduces the ARTEMIS methodology and a corresponding tool for analysing business processes (as part of BPR). In ARTEMIS, business processes are modeled as workflows and are analyzed from two aspects: Organizational Structure and Operational Structure.</td>
</tr>
<tr>
<td>Method 5</td>
<td>Valiris and Glykas [27]</td>
<td>1999</td>
<td>Introduces the Agent Relationship Morphism Analysis (ARMA) approach which provides a holistic organization-wide aspect to BPR efforts.</td>
</tr>
<tr>
<td>Method 6</td>
<td>Wastell et al. [28]</td>
<td>2000</td>
<td>Introduces SPRINT (Salford Process Reengineering method Involving New Technology) as a BPR framework. SPRINT has since evolved into a comprehensive BPR methodology as well as a change management method.</td>
</tr>
<tr>
<td>Method 7</td>
<td>Tatsiopoulos et al. [29]</td>
<td>2002</td>
<td>Introduces a methodology for implementing an E-Commerce enabling BPR, thus focusing on a rather different aspect of the field.</td>
</tr>
<tr>
<td>Method 9</td>
<td>Simon Kai [31]</td>
<td>2003</td>
<td>Introduces a methodology which focuses on re-designing core BPR processes through proposing value-added processes and applying the necessary alterations in organizational variables to accommodate such processes.</td>
</tr>
<tr>
<td>Method 10</td>
<td>Cameron and Braiden [32]</td>
<td>2004</td>
<td>Introduces a generally applicable methodology for determining the main elements of BPR through scrutinizing BPR experiences in specific companies. In this context, the tasks of 20 BPR methodologies have been used to form a Methodology Comparison Matrix (MCM).</td>
</tr>
<tr>
<td>Method 11</td>
<td>Muthu et al. [33]</td>
<td>2006</td>
<td>Introduces an integrated systematic approach for business enterprise redesign that combines five BPR methodologies, and is thus a rich source of BPR process patterns.</td>
</tr>
<tr>
<td>Method 12</td>
<td>Stermerberger and Jaklic [34]</td>
<td>2007</td>
<td>Introduces a methodology for the public sector through customizing the S-A framework [23] for BPC projects defined in this context.</td>
</tr>
<tr>
<td>Method 13</td>
<td>Harmon [35]</td>
<td>2007</td>
<td>Introduces the “BPTrends Process Redesign Methodology”, mainly aimed at structuring the training of BPC practitioners; it prescribes the activities required to redesign/improve business processes.</td>
</tr>
<tr>
<td>Method 14</td>
<td>Grau et al. [36]</td>
<td>2008</td>
<td>Introduces the PRM methodology, which incorporates a BPR process which utilizes the i* framework [37] for modeling functional and non-functional requirements.</td>
</tr>
<tr>
<td>Method 15</td>
<td>Du et al. [38]</td>
<td>2010</td>
<td>Introduces a business process re-engineering framework based on IT solutions.</td>
</tr>
<tr>
<td>Method 16 (BPI)</td>
<td>Lee and Chuah [2]</td>
<td>2001</td>
<td>Introduces the SUPER methodology for BPI. SUPER provides complete and detailed coverage of process improvement activities, many of which can also be used in BPR.</td>
</tr>
<tr>
<td>Method 17 (BPI)</td>
<td>Adesola and Baines [39]</td>
<td>2005</td>
<td>Introduces a BPI methodology which provides complete and detailed coverage of process improvement activities, many of which can also be used in BPR.</td>
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</tbody>
</table>
2 Proposed method for situational engineering of BPR methodologies

The procedure that we have used for developing our proposed method has been derived from the PattCaR method [22]. By following the three steps prescribed by this procedure (shown in Fig. 1), we have first reviewed and selected a set of existing BPR frameworks and methodologies to serve as pattern sources; we have then elicited the target process patterns from these frameworks and methodologies, and have organised the patterns into a high-level framework (BPDP); as the final step, we have developed a process for applying this framework for constructing custom BPR methodologies.

The following sections contain detailed accounts of the activities performed in each of the above steps. The final product is our proposed SME method, which consists of two parts: (i) The proposed framework of BPR process patterns (BPDP); and (ii) a process for applying BPDP to engineer BPR methodologies.

2.1 Identifying and reviewing the sources of process patterns

Previous BPR research has been explored to identify a set of BPR methodologies and frameworks to be used as pattern sources. Only those frameworks and methodologies have been selected that: (i) are widely known and adopted; (ii) offer new and novel features; and (iii) provide adequate coverage of BPR activities. The selected BPR frameworks and methodologies are shown in Table 1 (Methods 1–15). In addition to BPR methodologies and frameworks, we have also included two BPI methodologies (Methods 16 and 17 in Table 1); BPI is an approach for continuous enhancement of operational processes through the use of streamlining techniques. The two selected BPI methodologies include activities that can also be used for BPR purposes.

2.2 Delivering patterns

This step is concerned with extracting the target process patterns and organising them into a generic process framework for BPR. We will first introduce our proposed BPR framework (BPDP), and will then provide detailed descriptions for its constituent process patterns.

BPDP consists of six high-level phase process patterns (Fig. 2): Envision, initiate, diagnose, redesign, implement redesigned processes, and roll out the redesigned processes. The new processes are implemented in the roll out the redesigned processes phase. Umbrella activities are also considered in BPDP (depicted on the arrow at the bottom of Fig. 2).

Throughout the rest of this section, details will be provided for the process patterns that constitute the proposed BPDP. Some patterns are designated as optional, as they are not supported by most BPR methods; these patterns will only be mentioned without further elaboration.

2.2.1 Phase 1 – envision: The aim of this phase is to identify the BPR needs of the organisation and to establish readiness in the organisation for the BPR project. The organisation investigates existing business process strategies and reviews the business processes for obtaining goal improvement and IT opportunities.

Activities performed in this phase are explained below.

Stage 1 – Justify reengineering: Evaluations are made to justify the execution of a BPR project in the organisation. The tasks are as follows:

- Task 1: Strategic assessment. Business requirements are identified and the reengineering needs of the organisation are evaluated by identifying the relevant factors (such as critical success factors [CSF]).
- Task 2: Technological assessment. Technical requirements and IT levers are identified, based on which the BPR needs of the organisation are reevaluated.

Stage 2 – Establish organisational readiness: The aim of this stage is to establish readiness in the organisation for implementing a BPR project. The tasks include the following:

- Task 1: Establish management commitment.
- Task 2: Communicate and introduce BPR. The goals of the BPR project are explained to the people involved, and employees are educated as to the realities of BPR, thus mitigating the risks involved [27, 32].
- Task 3: Launch the steering committee. A committee of senior managers and departmental representatives is formed to define the reengineering strategy of the organisation. This committee determines the priorities, conducts resource allocation, and helps reengineering teams in analysing the problems [24, 25, 35].

2.2.2 Phase 2 – initiate: In this phase, the differences between the current organisational situation and the desirable one are identified and translated into top-level goals that shape the strategic plan of improvement. Moreover, a business case is
produced based on the goals and estimated costs. The stages are explained below.

**Stage 1 – Establish team(s):** The tasks include the following:

- **Task 1:** Organise reengineering team(s). The BPR team can involve business analysts, designers, customer representatives, domain experts, human resources (HR) experts, IT/IS technical experts, facilitators, sponsors, process managers, employees, and testers [24, 28, 29, 35, 39].
- **Task 2:** Prepare and authorise team(s). Team members are trained on BPR methods, tools, and techniques.
- **Task 3:** Select consultant (optional task).

**Stage 2 – Create plan and objectives:** The tasks include the following:

- **Task 1:** Define methodology, methods and tools to be used in the project. The BPR methodology and techniques, business process analysis and redesign tools, and communication tools are specified [28].
- **Task 2:** Conduct project planning. Planning is performed based on the hardware and software requirements [26].
- **Task 3:** Stakeholder analysis. External process requirements [23, 26] are determined, and interviews, questionnaires and

<table>
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<th>Required Artifacts (Input)</th>
<th>Produced Artifacts (Output)</th>
<th>Index</th>
<th>Tasks (of stage)</th>
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<tr>
<td>Phase 1: Identify</td>
<td>Previous Project Experience &amp; Constraints</td>
<td>Project Description</td>
<td>JRL</td>
<td>Strategic Assessment</td>
</tr>
<tr>
<td>Establish Organizational Readiness</td>
<td>Project Description</td>
<td>Steering Committee</td>
<td>JRL</td>
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</tr>
<tr>
<td>Establish Team(s)</td>
<td>Previous Project Experience &amp; Project Description</td>
<td>Team Members Information</td>
<td>EOR</td>
<td>Establish Management Commitment</td>
</tr>
<tr>
<td>Create Plan and Objectives</td>
<td>Detaile Project Plan</td>
<td>Requirements Document</td>
<td>EOR</td>
<td>Communicate and Formulate BPR</td>
</tr>
<tr>
<td>Formulate a Business Case</td>
<td>Previous Project Experience &amp; Project Description</td>
<td>Team Members Information</td>
<td>EOR</td>
<td>Organize Reengineering Teams</td>
</tr>
<tr>
<td>Assess the Culture of the Organization (Optional)</td>
<td>Previous Project Experience</td>
<td>Detailed Project Plan</td>
<td>ET</td>
<td>Prepare and Anchor Team(s)</td>
</tr>
<tr>
<td>High-Level Process Definition and Modeling</td>
<td>Previous Project Experience</td>
<td>Business Case for Project</td>
<td>ET</td>
<td>Select Consultant (Optional)</td>
</tr>
<tr>
<td>Business Analysis</td>
<td>Process Maps</td>
<td>Process Description</td>
<td>C-Pm</td>
<td>Conduct Project Planning</td>
</tr>
<tr>
<td>Design To-Be Situation</td>
<td>Process Models</td>
<td>Process Models</td>
<td>C-Pm</td>
<td>Stakeholder Analysis</td>
</tr>
<tr>
<td>Validate To-Be Processes</td>
<td>New Process Models</td>
<td>New Process Documents</td>
<td>FIC</td>
<td>Identify Core Business Processes to be Redesigned</td>
</tr>
<tr>
<td>Refined Business Case for Reengineered Processes (Optional)</td>
<td>New Process Models</td>
<td>Redesigned BS</td>
<td>FIC</td>
<td>Prioritize Core Business Processes Based on Business Priority and Redesign Urgency (Optional)</td>
</tr>
<tr>
<td>Plan and Train</td>
<td>Finalized Models</td>
<td>Transition Plans</td>
<td>FIC</td>
<td>Establish Project Business Case</td>
</tr>
<tr>
<td>Create Organizational Prerequisites</td>
<td>Redesigned BS</td>
<td>New HR Infrastructure</td>
<td>RBCRP</td>
<td>Plan the Cost/Performance Associated with Implementing and Operating the New Design</td>
</tr>
<tr>
<td>Test</td>
<td>Finalized Models</td>
<td>Transition Plans</td>
<td>RBCRP</td>
<td>RBCRP: Realign Business Case</td>
</tr>
<tr>
<td>Implement (Full Out Reengineering Process)</td>
<td>Finalized Models (Upgraded Transition Plans)</td>
<td>Implemented New Process</td>
<td>BORP</td>
<td>Full Implementation</td>
</tr>
<tr>
<td>Evaluate</td>
<td>Finalized Models (Upgraded Transition Plans)</td>
<td>New IT Processes</td>
<td>BORP</td>
<td>Execute Transition Plan(s)</td>
</tr>
<tr>
<td>Improve</td>
<td>Finalized Models (Upgraded Transition Plans)</td>
<td>New IT Systems and Procedures for Continuous Improvement</td>
<td>BORP</td>
<td>Improve Process Continuously</td>
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<tr>
<td>Implement (Half Out Reengineering Process)</td>
<td>Finalized Models (Upgraded Transition Plans)</td>
<td>Implemented New Process</td>
<td>BORP</td>
<td>Full Implementation</td>
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<tr>
<td>Evaluate</td>
<td>Finalized Models (Upgraded Transition Plans)</td>
<td>New IT Systems and Procedures for Continuous Improvement</td>
<td>BORP</td>
<td>Improve Process Continuously</td>
</tr>
<tr>
<td>Improve</td>
<td>Finalized Models (Upgraded Transition Plans)</td>
<td>New IT Systems and Procedures for Continuous Improvement</td>
<td>BORP</td>
<td>Improve Process Continuously</td>
</tr>
</tbody>
</table>

Table 2: Details of the process patterns proposed in BPRP

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market investigation techniques are used for analysis of customer demands [26].

- Task 4: Establish objectives, scope and mode of BPR. Measurable business goals are defined, and metrics and means are defined for assessing their satisfaction [25]. The scope of the BPR effort and the mode (incremental or radical) are also determined (e.g. by using benchmarking [34]).

**Stage 3 – Formulate business case:** The tasks include the following:

- Task 1: Identify core business processes to be redesigned. A subset of the processes, which is most valuable to the stakeholders, is chosen for the BPR effort [30, 31].
- Task 2: Prioritise core business processes based on business priority and redesign urgency (optional task).
- Task 3: Establish project business case. A business case is developed for the BPR project based on the five main factors of cycle time, cost, quality, asset utilisation, and generated revenue [25].

**Stage 4 – Assess the culture of the organisation (optional stage):** The tasks of this optional stage are as follows:

- Task 1: Analyse organisational culture
- Task 2: Assess and reduce resistance to change
- Task 3: Gain consensus on support for process improvement

**2.2.3 Phase 3 – diagnose:** Modelling and analysing the core processes of the organisation is the objective of this phase. Process models are used as a basis for exploring process strengths/weaknesses and delineating the requirements. The stages are explained below.

**Stage 1 – High-level process definition and modelling:** The top-level view of the core processes is defined and modelled, and structured interviews are performed with process agents. Detailed specifications of the processes are produced [25]. The tasks include the following:

- Task 1: Map Process. Process mapping is performed as a method for obtaining a graphical view of the process situation [25]. The RESCUE method can be used for capturing information on current business processes [36].
- Task 2: Prepare documentation and descriptions on existing process (optional task).
- Task 3: Create models. The main goal is to model the different aspects (technological, human, and macro-organisational) of the relevant as-is processes [26]. Activity models, process models [33], conceptual and formal models [27], workflow models [26], and *i* models [37] can be used for this purpose.
- Task 4: Verify models. The validity and accuracy of the models is verified through reviews conducted by the stakeholders, or by applying consistency checking methods (such as those used in PRIM [36]).
- Task 5: Confirm models (optional task).

**Stage 2 – Business analysis:** The business models that were produced in the previous stage are scanned for problems that might necessitate process reengineering [25]. Techniques such as simulation, activity-based costing (ABC), and critical path analysis (CPA) are used for analysing the as-is processes [25, 33]. Group discussions are then conducted, resulting in suggestions for process improvement [40]. KAOS patterns [36] can be used for analysing and verifying the as-is models. The tasks include the following:

- Task 1: Measure existing processes. Process efficiency is measured according to criteria such as cost, quality, time, and customer feedback.
- Task 2: Discover factors that result in higher costs and lower quality. Non-value-adding, disconnected and inconsistent activities are identified [25].

**Task 3: Assess processes.** Processes are analysed through the identification of their strengths and weaknesses, and targeted investigation is performed by benchmarking the processes of industrial leaders [32, 33], interviewing employees and managers, and identifying internal/external opportunities and threats [28].

- Task 4: Assess technology. Processes are scrutinised for determining IT requirements. The IT infrastructure required for achieving the intended improvement is then selected, and its efficiency is evaluated.

**2.2.4 Phase 4 – redesign:** In this phase, target processes are designed and evaluated. The stages are explained below.

**Stage 1: Design to-be situation:** The tasks include the following:

- Task 1: Develop process design alternatives. The team may decide to develop new processes or modify existing ones [25]. Based on process design principles [33], alternatives are typically identified and modelled through brainstorming and creativity-boosting techniques [23, 36].
- Task 2: Review new design and change proposals. A review is performed to make sure that the new design can achieve the strategic goals and is compatible with the HR and IT architectures [23]; checking the consistency of the alternatives is also performed in this task [36].
- Task 3: Document and detailed-design new processes. Based on the top-level model produced, detailed design of the new processes is performed, resulting in models of the new activities ("to-be" models).
- Task 4: Analyse and design information system (IS). The IS and enabling technology architecture are designed [41].
- Task 5: Redefine HR structure. Roles and responsibilities are reviewed and revised [41].

Fig. 3 Proposed process for applying BPRP for situational engineering of BPR methodologies
Stage 2: Validate to-be processes: The tasks include the following:

- **Task 1:** Validate/evaluate new processes. The completeness and efficiency of the to-be processes is verified through goal and efficiency validation [25], and a feasibility study is performed [32]. Simulation, CPA, ABC, and cycle time analysis techniques are typically used for analysing the efficiency of the to-be design.
- **Task 2:** Obtain approval-for-change from organisational decision-makers (optional task).
- **Task 3:** Select new processes for implementation. The best scenarios of the to-be situation are chosen through structural analysis [36], trade-off analysis, and also through analysing the results obtained from task 1 [33].
- **Task 4:** Designate process owners. Owners are specified for the processes that will be reengineered.

### Table 3 Proposed situational factors for BPR methodologies, and the related process patterns

<table>
<thead>
<tr>
<th>Situational Factor</th>
<th>Value Range</th>
<th>Bases for Evaluation (Value Assignment)</th>
<th>Proposed Process Patterns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural Factors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motivation of staff to carry out the project</td>
<td>Low* / High</td>
<td>Level of job satisfaction</td>
<td>ACoO, Ua; ACoO, Ua; HLPdMs, VTBP, PaT</td>
</tr>
<tr>
<td>Effective communication between internal and external stakeholders</td>
<td>Inadequate/ Adequate</td>
<td>Level of satisfaction</td>
<td>EOR, Ua; Ua; AcO</td>
</tr>
<tr>
<td>Level of staff empowerment</td>
<td>Adequate</td>
<td>Level of task-relatedness</td>
<td>StK, Ua; AcO</td>
</tr>
<tr>
<td>Collaboration level between staff in the re-engineering project</td>
<td>Low/ High</td>
<td>Considering active participation of staff in offering proposals for change, and the quality of those proposals</td>
<td>EOR, Ua; Ua; AcO</td>
</tr>
<tr>
<td>Staff information level in regard to re-engineering projects</td>
<td>Inadequate/ Adequate</td>
<td>Lack of knowledge on basic BPR concepts</td>
<td>EOR, EOR, ET, Ua</td>
</tr>
<tr>
<td>Effective culture to accept change in organization</td>
<td>No/ Yes</td>
<td>Effective support for BPR in the current culture</td>
<td>ACoO, ACoO, ACoO, Ua; A</td>
</tr>
<tr>
<td>Sharing values and beliefs</td>
<td>Inadequate/ Adequate</td>
<td>Individuals' fear and resistance towards change</td>
<td>ACoO, HLPdMs, VTBP, PaT, T2, T1, Ua</td>
</tr>
</tbody>
</table>

### Management Competence Factors

- **Commitment and authority of management**
  - Inadequate/ Adequate | Management's attitude towards holding educational courses | ACoO, HLPdMs, VTBP, PaT, PaT, T1, Ua |
- **Pioneering and financial support**
  - Inadequate/ Adequate | Proper justification of the project for sponsors | JR, EOR, EOR, CPAO |
- **Risk management**
  - Inadequate/ Adequate | Considering the lack or weakness of risk management tasks (such as those proposed for this situational factor) considering the criticality of the project | EOR, ACoO, ACoO, ACoO, COP, Ua |

### Organisational Structure Factors

- **Possibility of emerging new jobs and responsibilities**
  - Low/ High | Analysing unavailability of existing roles by considering current activities and their counterparts in the reengineered solution | DTBS, COP, COP |
- **Efficiency of re-engineering team(s)**
  - Low/ Average/ High | Difficulty of finding qualified team members | ET, CPA |

### BPR Project Management Factors

- **Risk of acquiring adequate resources (e.g. budget, staff)**
  - Low/ Moderate/ High | Considering the size of the organization and the scope of the BPR project | EOR, DTBS, VTBP, BCR, BCR, BCR, T2, T1, T2 |
- **Document level**
  - Inadequate/ Adequate | Existence of adequate documentation on organizational processes and previously-proposed improvement opportunities | EOR, DTBS, VTBP, BCR, BCR, BCR, T2, T1, T2 |
- **Focus on stakeholder requirements**
  - Low/ Moderate/ High | Level of involvement of each team member in the project | CPA, DTBS, Ua |
- **Project readiness**
  - Low/ Moderate/ High | Level of the team’s BPR skill | EOR, CPA, DTBS, Ua |
  - Low/ Moderate/ High | Level of the team’s BPR skill | CPA, DTBS, Ua |
  - Low/ Moderate/ High | Level of the team’s BPR skill | CPA, DTBS, Ua |
  - Low/ Moderate/ High | Level of the team’s BPR skill | CPA, DTBS, Ua |

### IT Factors

- **To-Be process requirements for new programs and software tools**
  - No/Yes | Satisfaction with current tools | CPA, RORP, RORP-Ed |
  - Low/ High | Use of state-of-the-art tools | CPA, RORP, RORP-Ed |
  - Low/ High | Evaluating the level of usage of IT facilities | CPA, RORP, RORP-Ed |
  - Low/ High | Level of business efficiency in the organization | CPA, RORP, RORP-Ed |
  - Low/ High | Degree to which staff are overachieving with the tasks assigned | CPA, RORP, RORP-Ed |

- **The need to analyse and design new ISs**
  - Low/ High | The need to integrate ISs | JR, CPA, DTBS, Ua; Ua; Ua |
  - Low/ High | The need to re-engineer legacy ISs | JR, CPA, DTBS, Ua; Ua |

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* If the current project, the values of the guidelines are consistent with the values specified in the “Bases for Evaluation” column (e.g., if the job satisfaction level is low (1)), then the value of the situational factors is equal to the value underlined in the “Value Range” column. To address a situational factor, certain method chunks should be added to the base methodology, as indicated in the “Proposed Process Patterns” column.

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Stage 3: Refine business case for reengineered processes (optional stage): The tasks of this optional stage are as follows:

- Task 1: Project the costs/benefits associated with implementing and operating the new design.
- Task 2: Refine the business case.

2.2.5 Phase 5 – Implement redesigned processes: In this phase, the details of the execution plan are produced and tested through pilot studies, utilisation of measurement systems, and process management. HR structures are revised, and software, hardware and IS infrastructures are created. The stages are explained below.

Stage 1 – Plan and train: The tasks include the following:

- Task 1: Evolve transition plan. The transition plan often consists of a systems integration strategy, a technology strategy, and an IS strategy [25].
- Task 2: Train users. The people who will work on the reengineered processes are trained [35].
- Task 3: Review and approve transition plan.

Stage 2 – Create organisational prerequisites: The tasks include the following:

- Task 1: Create HR infrastructure. The HR structure and the new roles are created in the organisation.
- Task 2: Upgrade technology. The IS and software applications of the new processes are implemented [25, 35].
- Task 3: Run a culture change program (optional task).
- Task 4: Implement process management and measurement systems.

Stage 3 – Test: The tasks include the following:

- Task 1: Prototype and simulate transition plan. The plan is validated through prototyping and simulation.
- Task 2: Execute larger-scale pilots (optional task).
- Task 3: Monitor new process tests. The results of testing the new processes are reviewed, and the transition plan and design documents are updated [31].
- Task 4: Obtain implementation approval from organisational decision-makers (optional task).

Stage 4 – Roll out redesigned processes: This stage consists of two tasks and one sub-stage:

- Task 1: Full implementation. The plan is executed and new processes are implemented [31].
- Task 2: Improve process continuously. Since organisations operate in continuously changing environments, BPR endeavours are ongoing activities [25].
- Sub-stage 1 – Evaluate. This sub-stage consists of five tasks: (i) Review new processes and methodology (required task); (ii) Monitor new HR systems (optional); (iii) Monitor upgraded technology (optional); (iv) Monitor environment (optional); and (v) Document the lessons learned (optional).

Tabulated list of BPRP process patterns: Table 2 lists the patterns which constitute the BPRP framework. Each pattern has been assigned a designator which will be used as an index for referring to it in later sections.

2.3 Reusing patterns

In assembly-based SME, the focus is on building the target methodology (or improving an existing methodology) by reusing method parts [14]. To this aim, a repository of method parts is used; suitable method parts are selected from this repository and assembled based on the requirements (situational factors) of the project. The BPR process patterns proposed in this research can be used as method parts for constructing bespoke BPR methodologies. In this section, a process will be presented for selecting and assembling these process patterns to address the situational factors. The process, shown in Fig. 3, relies on a base methodology as the core process: The selected method parts will be added to this core to yield the target methodology.

2.3.1 Work-stage 1 – Specify BPR method requirements and assign values to BPR situational factors: BPR situational factors are the characteristics by which BPR projects are defined [42, 43]; examples include: Project radicalness, and motivation of staff. There are certain rules for situational factors that should be observed [44], including:

(i) The number of factors should be small, so that determining their values does not become overly complex.
(ii) The dependencies among factors should be clearly defined.
(iii) The people involved in the project should agree on the weights and values given to these factors.

The following categories can be identified for BPR situational factors (as shown in Table 3):
(i) Cultural factors: Factors related to human-related and social changes, and also cultural adjustments that facilitate the ultimate introduction of newly designed processes and structures into the workplace.
(ii) Management competence factors: Management factors which guarantee that BPR efforts will be implemented in the most effective way.
(iii) Organisational structure factors: Factors related to the organisational structure affecting BPR efforts.
(iv) BPR project management factors: Factors related to the project management processes required for successful implementation of BPR projects.
(v) IT factors: Factors related to IT issues, as outlined in [42].

2.3.2 Work-stage 2 – select BPR method parts: After identifying and determining the values of situational factors for the project at hand, the next step is the selection of appropriate method parts (process patterns). For this purpose, the multi-criteria technique [45] is used: Based on the values obtained for the situational factors, and according to the mapping of situational factors to process patterns (shown in Table 3), suitable process patterns are identified and added to the base methodology. In Table 3, if the value of a factor is equal to the underlined value, then the proposed tasks will be added to the base methodology to address the situational factor.

As an example, we will look into the ‘Effective communication between internal and external stakeholders’ factor [42]. As shown in Table 3, to properly address this situational factor, it is recommended that support be provided for the ‘communicate and introduce BPR’ process pattern (EOR2 in Table 2); therefore, this process pattern should be added to the base methodology. Furthermore, certain umbrella activities should also be added, including: ‘people management’ (UA3) and ‘communication and change management’ (UA5).

To make the above technique implementable, we have developed indicator functions and rules for associating the values of the situational factors to the related method parts. The implementation of the above example has been demonstrated in Fig. 4, using the special indicator function developed for this purpose. These indicator functions have been used in our proposed tool (which will be introduced in a later section).

Other approaches can also be used for selecting the method parts, including the MAP approach [14], and the Deontic matrix approach [46]. These approaches can be used in lieu of, or as complements to, the multi-criteria technique used in our proposed approach.

2.3.3 Work-stage 3 – add selected method parts to the base BPR methodology: On the basis of the process improvement method proposed by Harbour [47], the basic BPR principles introduced in [42, 43], and the common structure of the BPR methodologies that have emerged so far, we have constructed a base methodology for BPR which consists of a minimal set of stages and tasks. We have developed the base methodology by pruning the BPRP framework (Fig. 3). The stages of the base methodology and their constituent tasks are shown in Fig. 5. The tasks of the base methodology are minimal in the sense that they are the smallest subset of tasks (from among those defined in the BPRP framework) that cover the success factors of BPR projects (these factors will be explained in Section 4.2). The stages and tasks of the base methodology, and the reasons behind their inclusion, are explained below:
Establish management commitment: Management commitment and support has a significant impact on reengineering projects, so much so that it is considered a prerequisite for commencing such projects in all BPR methodologies.

Organise reengineering team(s): Conducting the reengineering project is the responsibility of one or more specialised teams; naturally, forming the team(s) is an essential activity in all methodologies.

Establish objectives, scope and mode of BPR: BPR projects are considered unjustifiable without a business case.

Map process and assess process: The first step in any process reengineering effort is to collect and display an intuitive...
(phenomenological) graphical display of the process situation and its evaluation.

- Devise process design alternatives and validate/evaluate new processes:
  To redesign processes, these two tasks are required as a minimum.

- Evolve transition plans and train users, and implement process management and measurement system: After redesigning, it is natural to implement the redesigned process. In BPR, implementation typically begins with transition planning and user training. At the same time, the process management and measurement system should be implemented.

- Prototype and simulate transition plans: Simulation and prototyping are typically required at the following levels:
  - As-is processes: According to the model developed of the current business and the data collected, a steering committee can identify the problems afflicting the current business process. This is typically performed via simulation or analysis.
To-be processes: The impacts of the proposed and alternative processes are typically examined through prototyping and simulation. This activity is therefore considered a main requirement of the base methodology. Simulation is typically applied to measure the performance of the redesigned process and also to evaluate the feasibility of implementation prior to resource assignment [48, 49].

Full implementation: Having fulfilled all the prerequisites, implementation is the logical next step.

Review new processes and methodology: As in any development/reengineering effort, the new processes should be reviewed and validated after implementation.

- To-be processes: The impacts of the proposed and alternative processes are typically examined through prototyping and simulation. This activity is therefore considered a main requirement of the base methodology. Simulation is typically applied to measure the performance of the redesigned process and also to evaluate the feasibility of implementation prior to resource assignment [48, 49].
- Full implementation: Having fulfilled all the prerequisites, implementation is the logical next step.
- Review new processes and methodology: As in any development/reengineering effort, the new processes should be reviewed and validated after implementation.

3 BPRP framework in practice

We have demonstrated the applicability of the proposed framework by applying it to a real-world project (as a case study), in which a BPR methodology was developed from scratch for an Iranian
petroleum company. The department involved in the project provides hardware, automation, network, and software support services to other departments. The construction of the target BPR methodology helped further refine the proposed patterns and situational factors. The steps of the project are shown in Fig. 6. The values of the situational factors pertaining to the target process, and the process patterns elicited for each, are shown in Table 4. The constructed process was presented to and approved by the experts and managers of the organisation.

The method-chunk selection and addition stages of the process were performed by using a tool which we have developed for this purpose. The tool (which we have chosen to call: ‘Situational BPR Method Assembler’) is a plug-in for the Eclipse process framework composer (EPFC) [50]. The tool facilitates the semi-automatic construction of bespoke BPR methodologies based on BPRP. Values of the situational factors are entered via five input screens (one for each category of situational factors). Process patterns (method parts) are then extracted by the tool based on the

<table>
<thead>
<tr>
<th>BPRP Phase</th>
<th>Index</th>
<th>BPRP Task (of Stage)</th>
<th>Methodology Requirements Addressed by BPRP Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 4: Refined Process</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Define Business Case</td>
<td>C4 P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Design To-Be Processes</td>
<td>C4 P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Plan and Train</td>
<td>C4 P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Create Organisational Prerequisites</td>
<td>C4 P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Test</td>
<td>C4 P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Implement</td>
<td>C4 P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Evaluate (R-C-S)</td>
<td>C4 P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Improve</td>
<td>C4 P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Umbrella Activities</td>
<td>C4 P</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Roll Out</td>
<td>C4 P</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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mappings (indicator functions and rules) which associate the values to the process patterns required. The tool then constructs the target process through adding the extracted process patterns to the base methodology at the appropriate places (according to BPRP).

### 4 Validation of proposed BPRP framework

In addition to using the framework in an industrial context, the proposed BPRP framework and patterns have also been validated by the following three methods, each of which will be explained in the following sections:

(i) Mapping the tasks of the BPRP framework to existing BPR methodologies.
(ii) Mapping the tasks of the BPRP framework to the typical requirements of BPR endeavours.
(iii) Criteria-based analysis of the BPRP framework.

#### Table 8 Pattern-specific analysis criteria

<table>
<thead>
<tr>
<th>Category</th>
<th>Type</th>
<th>Definition and Value Range</th>
<th>Value</th>
<th>How realized in proposed BPRP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process Pattern-Related:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Definition of problem, context and solution</td>
<td>S</td>
<td>A: No problem, context, or solution defined</td>
<td>C: Full definitions are provided for problem, context, and solution</td>
<td></td>
</tr>
<tr>
<td>Template Formality</td>
<td>S</td>
<td>A: No predetermined template</td>
<td>C: Conformance to a detailed and well-structured formal template</td>
<td></td>
</tr>
<tr>
<td>Definition of patterns related to each pattern</td>
<td>P</td>
<td>Identification of crosscutting patterns, which are related to or used in several coarser-grained process patterns.</td>
<td>Supported. Similarities have been defined for some of the patterns; e.g., ‘Diagnose’ and ‘Re-design’ phases. In addition, fine-grained patterns used in one phase are identified and reused in other phases.</td>
<td></td>
</tr>
<tr>
<td>Complexity Management</td>
<td>P</td>
<td>Provision of techniques to manage large numbers of patterns and/or to manage large patterns.</td>
<td>Supported. By categorizing the patterns into phases, stages, and tasks.</td>
<td></td>
</tr>
<tr>
<td>Consistency</td>
<td>S</td>
<td>Consistency amongst patterns, in terms of input/output work products within a pattern (local consistency) and among different patterns (global consistency).</td>
<td>C: Support for both local and global consistencies: All products are produced through patterns, and there is no overlap among the products produced.</td>
<td></td>
</tr>
<tr>
<td>Determination of Work Products</td>
<td>P</td>
<td>Determining which work products are involved in each process pattern.</td>
<td>Supported. The required and produced products are entirely determined in the stage process patterns.</td>
<td></td>
</tr>
<tr>
<td>Determination of Roles</td>
<td>S</td>
<td>Determining which roles are involved in each process pattern.</td>
<td>B: Yes. The roles involved in the process patterns are specified.</td>
<td></td>
</tr>
<tr>
<td>Cohesion</td>
<td>E</td>
<td>Levels of cohesion satisfied by different process patterns.</td>
<td>Functional, sequential, procedural, and temporal cohesions.</td>
<td></td>
</tr>
<tr>
<td>Coupling</td>
<td>E</td>
<td>Levels of coupling that exist among process patterns.</td>
<td>Data (product) coupling and control coupling.</td>
<td></td>
</tr>
<tr>
<td>Existence of Configurations of Process Patterns</td>
<td>P</td>
<td>Whether there exist any empirical or illustrative configurations of process patterns (explicitly or implicitly) regarding specific project situations, to exemplify the practicality of the application and instantiation of process patterns.</td>
<td>Supported. The approach has been applied in an industrial context (as reported in the paper).</td>
<td></td>
</tr>
</tbody>
</table>
4.1 Validation by mapping BPRP tasks to BPR methodologies

To demonstrate that BPRP provides adequate coverage of BPR activities, twelve major BPR methodologies have been used as test-beds: The phases of these methodologies were mapped to the proposed process patterns to show that none of the features and activities prescribed by existing BPR methodologies has been overlooked in BPRP. These particular methodologies were chosen because their processes cover a wider span of BPR activities.

Table 5 shows how the patterns are realised (manifest) in these twelve methodologies. It can be observed that BPRP completely covers the BPR tasks of the twelve methodologies.
4.2 Validation by mapping BPRP tasks to BPR requirements

This method aims at validating BPRP by showing that it satisfies the typical requirements of BPR endeavours. To define a set of typical BPR requirements, the factors which lead to the success or failure of BPR projects should be identified. We have used existing categories of factors for this purpose [42, 43], as shown in Table 6. Table 7 shows how these requirements are addressed by BPRP.

4.3 Criteria-based analysis of the BPRP framework

The evaluation criteria were developed through an iterative refinement process, starting from an initial collection of basic criteria which were obtained through studying the relevant literature. This collection was then refined according to validation meta-criteria (i.e. criteria for evaluation of other criteria). Once the evaluation criteria were stabilised, they were applied to BPRP.

Generality, preciseness, comprehensiveness, and balance are the main validation meta-criteria used in the refinement process [51]; however, to present a comprehensive and balanced collection of criteria, a number of complementary meta-criteria have also been defined. The final set of meta-criteria, as listed below, ensures that evaluation criteria possess the traits essential for evaluating processes effectively:

(i) Preciseness: To effectively differentiate the similarities and differences of processes.
(ii) Clarity (simplicity): To enhance understandability and applicability of the criteria.
(iii) Minimum overlap: To minimise interdependencies among the criteria.
(iv) Generality: So that the criteria are applicable regardless of the type of the process being evaluated.
(v) Balance: To cover all of the three dimensions of processes (technical, managerial, and usage).
(vi) Comprehensiveness: So that the criteria address all of the important aspects of processes.
(vii) Inclusion of pattern-specific criteria: To evaluate 'pattern' characteristics of the processes being evaluated.
(viii) Inclusion of general process evaluation criteria: To evaluate general traits of processes.
(ix) Inclusion of BPR-specific criteria: To evaluate BPR-specific characteristics of processes.
(x) Inclusion of method engineering-related characteristics of processes.

To define a range of values for each criterion, a method similar to the Feature Analysis technique has been used [52]; in this method, criteria are divided into four distinct types according to their evaluation values:

- **Scaled**: Discrete levels of satisfaction are defined for these criteria, each with its own specification.
- **Enumerated**: A list of possible values is defined for these criteria.
- **Simple**: Two values are defined for these criteria, denoting satisfaction or non-satisfaction.
- **Descriptive**: Evaluation results are in narrative form, describing the level of satisfaction in a non-formal manner.

The compiled set of criteria has been divided into four groups: Pattern-specific, General, BPR-specific, and SME-related. These groups will be explained in the following sub-sections.

4.3.1 Pattern-specific analysis criteria: To analyse the pattern features of BPRP (as prescribed by meta-criterion 7), we have collected a set of pattern-specific criteria by reusing the generic criteria of [12]. In addition, past experience in the field of process patterns has been applied in forming and refining these criteria [11–13, 53–55]. These criteria are listed in Table 8; this table also contains the results of applying the criteria to BPRP.

4.3.2 General methodology analysis criteria: To analyse general methodology features (as prescribed by meta-criterion 8), the criteria proposed by Hesari et al. [55] have been refined and used. These criteria are listed in Table 9; the table also contains the results of evaluating BPRP based on these criteria.
4.3.3 BPR-specific methodology analysis criteria: To evaluate BPR features (as prescribed by meta-criterion 9), BPR principles [1] and success/failure factors of BPR projects [42] have been studied for identifying the BPR-specific criteria listed in Table 10; this table also contains the results of evaluating BPRP based on these criteria.

4.3.4 SME-related analysis criteria: The majority of the SME-related criteria introduced in [58] can be used to evaluate BPRP (as prescribed by meta-criterion 10). These criteria are listed in Table 11; the table also contains the results of evaluating BPRP based on these criteria.

5 Discussion

Various BPR methodologies have been proposed in the literature. However, there is no comprehensive framework that covers the whole BPR lifecycle and that prescribes all the relevant work-units at different levels of granularity (phases, stages, and tasks). The main contribution of this paper is presenting such a framework, and providing a systematic method for applying it for situational engineering in the context of BPR methodologies. The significant advantages of this framework include the following:

(i) Attention to success and failure factors [42, 59].
(ii) Special attention to IT issues and infrastructure.
(iii) Consideration given to continuous improvement in the organisation.
(iv) Adequate coverage of the general lifecycle of BPR methodologies.

Two limitations of this research should also be noted:

(i) As BPRP has been developed based on a limited number of existing BPR methodologies, its richness and applicability depends on the status quo of the BPR domain; it should therefore be updated on a regular basis.
(ii) The proposed approach has been tried and tested in practice; however, it needs to be applied to different BPR projects in a variety of domains so as to be further refined and improved.

6 Conclusions and future work

We propose a collection of process patterns which constitute a BPR process framework, along with a process for applying these patterns for situation-specific engineering of BPR methodologies. A plug-in has been added to the EPFC environment to automate, enhance, and
facilitate the use of the proposed framework (BPRP). Evaluation of BPRP shows that it adequately addresses the features expected from such a framework. This research can be further extended by refining the fine-grained task process patterns. Consequently, the application of the proposed process framework and patterns in industrial-scale SME projects will be facilitated. Future research can focus on the extension of the proposed method base with new method parts according to the feedback received from methodology engineers, and the completion of the specification of method parts via specifying the roles engaged and the products produced in each. Furthermore, guidelines and situational factors can be extended based on the BPRP orientation (improvement or reengineering) and the project type [60].

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