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Towards a method engineering approach for business process reengineering

Saeedeh Ghanadbashi, Raman Ramsin ✉

Department of Computer Engineering, Sharif University of Technology, Azadi Avenue, Tehran, Iran
✉ *E-mail: ramsin@sharif.edu*

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

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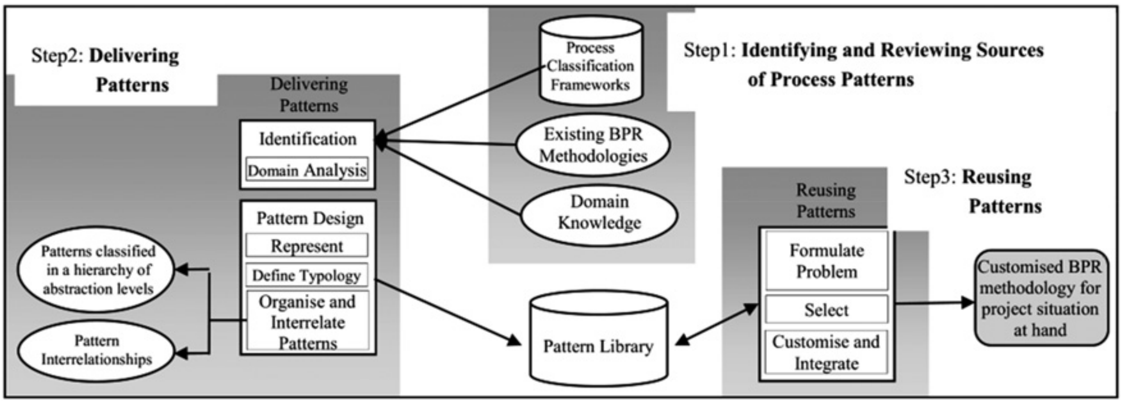

Fig. 1 *Procedure for developing our proposed method – based on PattCaR [22]*

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

Index	Author(s)	Year	Description
Method 1	Kettinger et al. [23]	1997	Introduces a Stage-Activity (S-A) framework for tools and methods of Business Process Change (BPC), covering 25 BPC methodologies.
Method 2	Sharon et al. [24]	1997	Introduces the Workflow Reengineering Methodology (WRM), which utilizes workflow management automation for enabling BPR. WRM is obtained through combining BPR and process improvement methodologies.
Method 3	Mayer and Dewitte [25]	1999	Introduces a phased BPR approach that uses an integrated collection of methods which are applied incrementally; the risk of failure is hence reduced.
Method 4	Castano et al. [26]	1999	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 analysed from two aspects: Organizational Structure and Operational Structure.
Method 5	Valiris and Glykas [27]	1999	Introduces the Agent Relationship Morphism Analysis (ARMA) approach which provides a holistic organization-wide aspect to BPR efforts.
Method 6	Wastell et al. [28]	2000	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.
Method 7	Tatsiopoulos et al. [29]	2002	Introduces a methodology for implementing an E-Commerce enabler BPR, thus focusing on a rather different aspect of the field.
Method 8	Changchien and Shen [30]	2002	Introduces an object-oriented simulation framework that reduces BPR risk by evaluating and analysing the proposals for reengineering.
Method 9	Simon Kai [31]	2003	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.
Method 10	Cameron and Braiden [32]	2004	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).
Method 11	Muthu et al. [33]	2006	Introduces an integrated systematic approach for business enterprise redesign that combines five BPR methodologies, and is thus a rich source of BPR process patterns.
Method 12	Stemberger and Jaklic [34]	2007	Introduces a methodology for the public sector through customizing the S-A framework [23] for BPC projects defined in this context.
Method 13	Harmon [35]	2007	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.
Method 14	Grau et al. [36]	2008	Introduces the PRiM methodology, which incorporates a BPR process which utilizes the i* framework [37] for modeling functional and non-functional requirements.
Method 15	Du et al. [38]	2010	Introduces a business process re-engineering framework based on IT solutions.
Method 16 (BPI)	Lee and Chuah [2]	2001	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.
Method 17 (BPI)	Adesola and Baines [39]	2005	Introduces a BPI methodology which provides complete and detailed coverage of process improvement activities, many of which can also be used in BPR.

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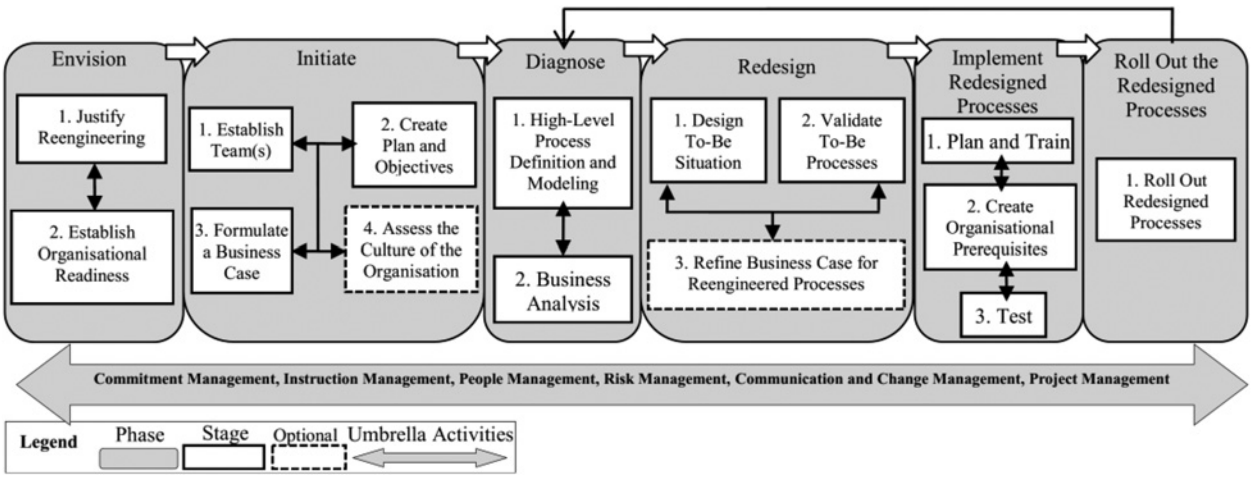

Fig. 2 *Proposed BPRP*

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 (BPRP); 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 (BPRP); and (ii) a process for applying BPRP 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 (BPRP), and will then provide detailed descriptions for its constituent process patterns.

BPRP consists of six high-level phase process patterns (Fig. 2): Envision, initiate, diagnose, redesign, implement redesigned processes, and roll out the redesigned processes. In the *Envision* phase, the need for executing a reengineering project is investigated. In the *Initiate* phase, the necessary preconditions are fulfilled so that the project can be started. In the *Diagnose* phase, analysis is performed on organisational processes, and suggestions are formed for redesign. Models of the suggestions are produced and validated in the *Redesign* phase. The main goal of the *implement redesigned processes* phase is to create plans and organisational prerequisites for implementing the redesigned processes. The new processes are implemented in the *roll out the redesigned processes* phase. Umbrella activities are also considered in BPRP (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 BPRP. 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. The 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, 28, 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

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Table 2 Details of the process patterns proposed in BPRP

Phase	Phase (Stage)	Required Artefacts (Input)	Produced Artefacts (Output)	Index	Tasks (of Stage)
Phase 1: Envision	Justify Reengineering	Previous Project Experience ♦ Constraints ♦	♦ Project Description	JR_1	Strategic Assessment
				JR_2	Technological Assessment
	Establish Organizational Readiness	Project Description ♦	♦ Steering Committee	EOR_1	Establish Management Commitment
				EOR_2	Communicate and Introduce BPR
				EOR_3	Launch the Steering Committee
Phase 2: Initiate	Establish Team(s)	Previous Project Experience ♦ Project Description ♦	♦ Team Members Information ♦ Training Document	ET_1	Organize Reengineering Team(s)
				ET_2	Prepare and Authorize Team(s)
				ET_3	Select Consultant (Optional)
	Create Plan and Objectives	Previous Project Experience ♦ Project Description ♦	♦ Detailed Project Plan ♦ Requirements Document ♦ Scope of BPR ♦ Mode of BPR ♦ Performance Indicators ♦ Organizational Critical Success Factors (CSF)	$CPaO_1$	Define Methodology, Methods and Tools to be Used in the Project
				$CPaO_2$	Conduct Project Planning
				$CPaO_3$	Stakeholder Analysis
				$CPaO_4$	Establish Objectives, Scope and Mode of BPR
	Formulate a Business Case	Previous Project Experience ♦ Requirements Document ♦ Scope of BPR ♦ Mode of BPR ♦ Performance Indicators ♦ Organization CSF ♦	♦ Core Business Processes ♦ Business Case for Project	FBC_1	Identify Core Business Processes to be Redesigned
				FBC_2	Prioritize Core Business Processes Based on Business Priority and Redesign Urgency (Optional)
				FBC_3	Establish Project Business Case
	Assess the Culture of the Organization (Optional)	Business Case for Project ♦ Previous Project Experience ♦	♦ Schedule Sessions ♦ Contract Forms	$ACoO_1$	Analyse Culture
				$ACoO_2$	Assess and Reduce Resistance to Change
				$ACoO_3$	Gain a Consensus of Support for Process Improvement
Phase 3: Diagnose	High-Level Process Definition and Modeling	Business Case for Project ♦ Stakeholder Information ♦	♦ Process Maps ♦ Process Description ♦ Process Models	$HLPDaM_1$	Map Process
				$HLPDaM_2$	Prepare Documentation and Descriptions on Existing Process, Sub-processes and Activities (Optional)
				$HLPDaM_3$	Create Models
				$HLPDaM_4$	Verify Models
				$HLPDaM_5$	Confirm Models (Optional)
	Business Analysis	Process Maps ♦ Process Description ♦ Process Models ♦	♦ Evaluation Report ♦ Process Improvement Proposals ♦ IT Improvement Proposals ♦ Presentations and Discussions with Employees	BA_1	Measure Existing Processes
				BA_2	Discover Factors that Result in Higher Costs and Lower Quality
				BA_3	Assess Processes
				BA_4	Assess Technology
Phase 4: Redesign	Design To-Be Situation	Process Models ♦ Proposals for Redesign ♦ Presentations and Discussions with Employees ♦	♦ New Process Models ♦ New Process Documents ♦ Redesigned IS ♦ Redefined HR Structure	$DTBS_1$	Develop Process Design Alternatives
				$DTBS_2$	Review New Design and Change Proposals
				$DTBS_3$	Document and Detailed-Design New Processes
				$DTBS_4$	Analyse and Design IS
				$DTBS_5$	Redefine HR Structure
	Validate To-Be Processes	New Process Models ♦ New Process Documents ♦ Redesigned IS ♦ Redefined HR Structure ♦	♦ Best Possible To-Be Scenarios ♦ Evaluation Report ♦ Process Owners	$VTBP_1$	Validate/ Evaluate New Processes
				$VTBP_2$	Obtain Approval for Change from Organizational Decision-Makers (Optional)
				$VTBP_3$	Select New Processes for Implementation
				$VTBP_4$	Designate Process Owners
	Refine Business Case for Reengineered Processes (Optional	Business Case for Project ♦ Best Possible To-Be Scenarios ♦ Evaluation Report ♦	♦ Refined Business Case	$RBCfRP_1$	Project the Costs/Performance Associated with Implementing and Operating the New Design
				$RBCfRP_2$	Refine Business Case
Phase 5: Implement Redesigned Processes	Plan and Train	Finalized Models ♦	♦ Transition Plans ♦ Trained Employees	PaT_1	Evolve Transition Plan
				PaT_2	Train Users
				PaT_3	Review and Approve Transition Plan
	Create Organizational Prerequisites	Redesigned IS ♦ Redefined HR Structure ♦ Transition Plans ♦	♦ New HR Infrastructure ♦ Upgraded Technology ♦ Process Management and Measurement Systems	COP_1	Create HR Infrastructure
				COP_2	Upgrade Technology
				COP_3	Run a Culture Change Program (Optional)
				COP_4	Implement Process Management and Measurement Systems
	Test	Transition Plans ♦ Finalized Models ♦	♦ Test Report ♦ [Upgraded] Transition Plans	T_1	Prototype and Simulate Transition Plan
				T_2	Execute Larger-Scale Pilots (Optional)
				T_3	Monitor New Process Tests
				T_4	Obtain Implementation Approval from Organizational Decision Makers (Optional)
Phase 6: Roll Out Redesigned Processes — Roll Out Redesigned Processes	Implement	Finalized Models ♦ [Upgraded] Transition Plans ♦	♦ Implemented New Process	$RORP_1$	Full Implementation
	Evaluate	Implemented New Process ♦ New HR System ♦ Upgraded Technology ♦	♦ Fine-Tuned New Process ♦ Refined Methodology ♦ New Threats ♦ New Opportunities ♦ Routine Improvements ♦ Monitoring Results ♦ Lessons Learned Document	$RORP\text{-}E_1$	Review New Processes and Methodology
				$RORP\text{-}E_2$	Monitor New HR Systems (Optional)
				$RORP\text{-}E_3$	Monitor Upgraded Technology (Optional)
				$RORP\text{-}E_4$	Monitor Environment (Optional)
				$RORP\text{-}E_5$	Document Lessons Learned (Optional)
	Improve	Refined Methodology ♦ New Threats ♦ New Opportunities ♦ Routine Improvements ♦ Monitoring Results ♦ Lessons-Learned Document ♦	♦ IT Systems and Procedures for Continuous Improvement	$RORP_2$	Improve Process Continuously
Umbrella Activities				UA_1	Commitment Management
				UA_2	Instruction Management
				UA_3	People Management
				UA_4	Risk Management
				UA_5	Communication and Change Management
				UA_6	Project Management

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

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market investigation techniques are used for analysis of customer demands [26].
• Task 4: Establish objectives, scope and mode of BPR. Measureable 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].

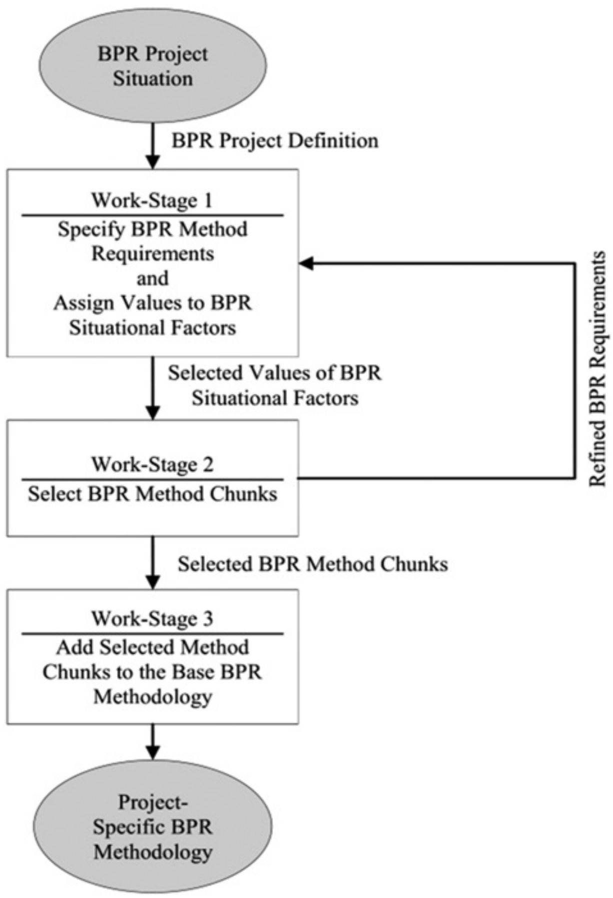

Fig. 3 *Proposed process for applying BPRP for situational engineering of BPR methodologies*

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

	Situational Factor	Value Range	Bases for Evaluation (Value Assignment)	Proposed Process Patterns
Cultural Factors	Motivation of staff to carry out the project	<u>Low</u>*/ High	❖ Level of job satisfaction ⇩ ❖ Level of work complexity ⇧ ❖ Need for different kinds of maintenance ⇧ ❖ Level of effectiveness of staff work ⇩	ACoO$_2$, UA$_3$
	Effective communication between internal and external stakeholders	<u>Inadequate</u>/ Adequate	❖ Level of stakeholder satisfaction ⇩ ❖ Stakeholders' tendency to communicate with each other ⇩ ❖ Study of communication effects on promoting mutual goals ⇩ ❖ Holding repetitive meetings on the same subject (As these repetitions can be reduced to less frequent but more effective meetings) ⇧	EOR$_2$, UA$_3$, UA$_5$
	Level of staff empowerment	<u>Inadequate</u>/ Adequate	❖ High degree of task relegation ⇧ ❖ Redundant dependencies among staff ⇧	ACoO$_2$, UA$_3$
	Collaboration level between staff in the re-engineering project	<u>Low</u>/ High	❖ Considering active participation of staff in offering proposals for change, and the quality of these proposals ⇩	EOR$_2$, UA$_2$, UA$_3$
	Staff information level in regard to re-engineering projects	<u>Inadequate</u>/ Adequate	❖ Lack of knowledge on basic BPR concepts ⇩ ❖ Consideration of the experience on previous BPR projects ☒ ❖ Consideration of the experience on similar change projects ☒	EOR$_2$, EOR$_3$, ET$_3$, UA$_3$
	Effective culture to accept change in organization	<u>No</u>/ Yes	❖ Effective support for BPR in the current culture ⇩ ❖ Individuals' fear and resistance towards change ⇧	ACoO$_1$, ACoO$_2$, UA$_3$, UA$_5$
	Sharing values and beliefs	<u>Inadequate</u>/ Adequate		
Management Competence Factors	Commitment and authority of management	<u>Inadequate</u>/ Adequate	❖ Management's attitude towards holding educational courses ⇩ ❖ Management enthusiasm for pursuing change and improvement ⇩ ❖ Management consideration for systematic elicitation of change proposals ⇩ ❖ Management consideration for motivational methods ⇩	ACoO$_3$, HLPDaM$_5$, VTBP$_2$, PaT$_3$, T$_4$, UA$_1$
	Pioneering and financial support	<u>Inadequate</u>/ Adequate	❖ Proper justification of the project for sponsors ☐ ❖ Importance of the project for the organization ⇩	JR$_1$, EOR$_2$, EOR$_3$, CPaO$_2$
	Risk management	<u>Inadequate</u>/ 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$_2$, ACoO$_1$, ACoO$_2$, ACoO$_3$, COP$_3$, UA$_4$
Organizational Structure Factors	Organizational structure	<u>Function-oriented</u>/ Process-oriented	❖ Determination based on main characteristics of function-oriented and process-oriented organizational structures F	DTBS$_5$, COP$_1$
	Possibility of emerging new jobs and responsibilities	Low/ <u>High</u>	❖ Analysing suitability of existing roles by considering current activities and their counterparts in the reengineered solution ⇩	DTBS$_5$, COP$_1$, COP$_3$
	Efficiency of re-engineering team(s)	<u>Low</u>/ Average/ High	❖ Difficulty of finding qualified team members ⇧ ❖ Communication and teamwork among team members ⇩ ❖ Level of involvement of each team member in the project ⇩ ❖ Level of the team's BPR skill ⇩ ❖ Authority given to re-engineering team(s) ⇩	ET$_2$, CPaO$_1$
BPR Project Management Factors	Project risk concerning time constraints	Low/ Moderate/ <u>High</u>	❖ Negotiation with managers and decision makers to clearly settle time constraints ☒ ❖ Consideration given to the lack or weakness of time management tasks related to this situational factor ☒	CPaO$_2$, RBCfRP$_1$, RBCfRP$_2$, T2, T3, UA$_3$, UA$_4$, UA$_6$
	Risk of acquiring adequate resources (e.g. budget, staff)	Low/ Moderate/ <u>High</u>	❖ Considering the size of the organization and the scope of the BPR project ⇧	EOR$_3$, DTBS$_3$, VTBP$_2$, RBCfRP$_1$, RBCfRP$_2$, T$_4$, UA$_4$
	Documentation level	<u>Inadequate</u>/ Adequate	❖ Existence of adequate documentation on organizational processes and previously-proposed improvement opportunities ☒	ET$_3$, CPaO$_3$, HLPDaM$_4$, BA$_1$, BA$_2$, BA$_3$, RORP-E$_5$
	Focus on stakeholder requirements	Low/ Moderate/ <u>High</u>	❖ Focus of process on stakeholder requirements ⇧ ❖ Traceability of requirements throughout the process life cycle ⇧	EOR$_3$, CPaO$_3$, DTBS$_2$, UA$_6$
	Project radicalness	Low/ <u>High</u>	❖ Assessment of project radicalness level by using a set of 11 contingency factors concerning BPR project planning [23] ⇧	EOR$_2$, CPaO$_2$, CPaO$_3$, FBC$_1$, DTBS$_2$, DTBS$_3$, DTBS$_5$, VTBP$_1$, RBCfRP$_1$, RBCfRP$_2$, COP$_1$, UA$_4$
	Complexity level of organizational processes	Low/ Moderate/ <u>High</u>	❖ Considering the size of the organization, span of its services, or volume and diversity of its products ⇧ ❖ Extent of the interactions among different sections required to achieve a unified goal ⇧	HLPDaM$_1$, HLPDaM$_2$, HLPDaM$_3$, HLPDaM$_4$, HLPDaM$_5$, BA$_1$, BA$_2$, VTBP$_4$, T$_1$
	Focus on core processes	Low/ Moderate/ <u>High</u>	❖ Evaluating the added values intended for the processes at hand ☑ ❖ Considering the size of the project ⇧ ❖ Investigation of the time and resources required for the project ⇧	FBC$_1$, FBC$_2$
	Focus on continuous improvement	Low/ Moderate/ <u>High</u>	❖ Inclination of management and financial support towards making continuous changes ⇧ ❖ Assessment of the amount of efficient changes required at regular intervals ⇧	RORP$_2$
IT Factors	To-Be process requirements for new programs and software tools	No/<u>Yes</u>	❖ Satisfaction with current tools ⇩ ❖ Use of state-of-the-art tools ⇩	COP$_2$, RORP-E$_3$
	The need for innovation in using IT	Low/<u>High</u>	❖ Evaluating the level of usage of IT facilities ⇩ ❖ Possibility of automating current processes ⇧ ❖ Level of bureaucracy in the organization ⇧ ❖ Degree to which staff are overwhelmed with the tasks assigned ⇧	JR$_2$, ET$_2$, CPaO$_2$, BA$_4$, DTBS$_3$, RORP$_2$, RORP-E$_1$, PaT$_2$, COP$_2$, UA$_2$, UA$_3$
	The need to analyse and design new ISs	Low/<u>High</u>	❖ The need to integrate ISs ☑ ❖ The need to re-engineer legacy ISs ☑	JR$_2$, CPaO$_2$, DTBS$_4$, COP$_2$, UA$_1$, UA$_5$

* If in 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 (⇩)), then the value of the situational factor 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.
⇩ : Low. ⇧ : High. ⇳ : Intermediate.
☒ : Does not exist. ☑ : Exists.
☐ : Inadequate. ⍁ : Adequate.
F : Function-oriented. P : Process-oriented.

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.

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Antecedent	Consequent
$\sum_{i=1}^{n} I_i(x) \geq \frac{n}{2}$ $I_1(x) + I_2(x) + I_3(x) + I_4(x) = 1 + 0 + 1 + 1 = 3 \geq \frac{4}{2}$	"Communicate and Introduce BPR" (EOR2) "People Management" (UA3) "Communication and Change Management" (UA5)

I_1 = Level of stakeholder satisfaction
I_2 = Stakeholders' tendency to communicate with each other
I_3 = Study of communication effects on promoting mutual goals
I_4 = Holding repetitive meetings on the same subject (as these repetitions can be reduced to less frequent but more effective meetings)

$$I_1(x) = \begin{cases} 1 & \text{IF } x = \text{low} \\ 0 & \text{Else} \end{cases} \quad I_2(x) = \begin{cases} 1 & \text{IF } x = \text{low} \\ 0 & \text{Else} \end{cases} \quad I_3(x) = \begin{cases} 1 & \text{IF } x = \text{low} \\ 0 & \text{Else} \end{cases} \quad I_4(x) = \begin{cases} 1 & \text{IF } x = \text{low} \\ 0 & \text{Else} \end{cases}$$

Fig. 4 *Example of an indicator function and rule for mapping situational factors to method parts*

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).

2.2.6 Phase 6 – roll out the redesigned processes: Implementation of the new processes is the goal of this phase. Change management techniques (e.g. change management matrix [28]) are used for transferring the tasks to new responsibilities and roles. The single stage of this phase is explained below.

Stage 1 – 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).

2.2.7 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):

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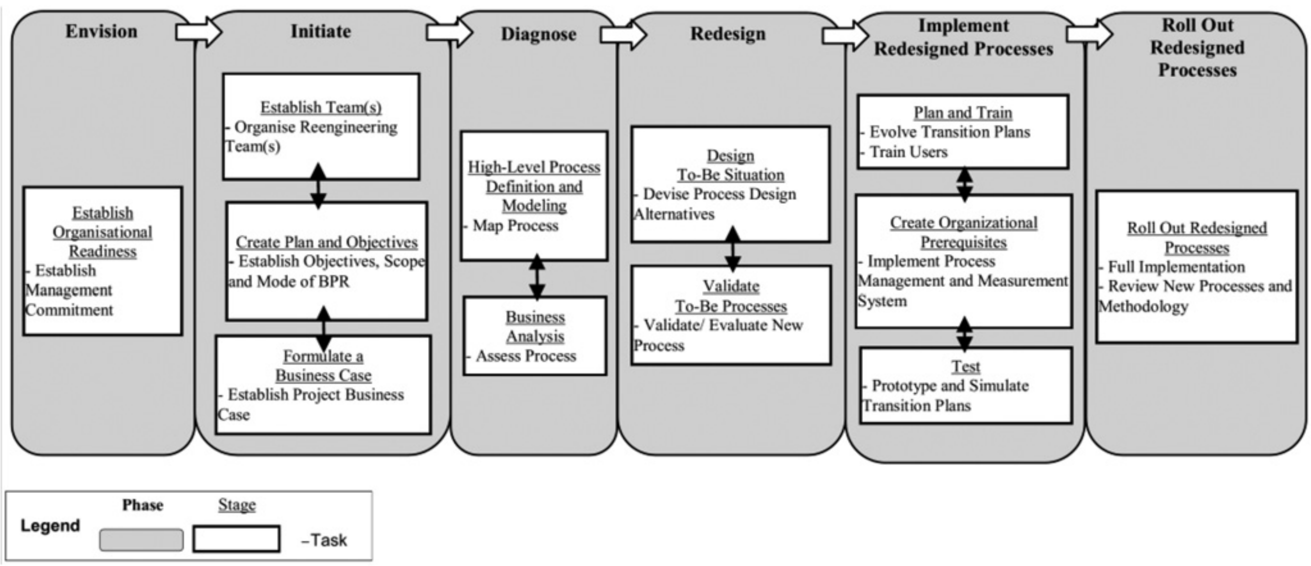

Fig. 5 *Base Methodology for developing bespoke BPR methodologies*

(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:

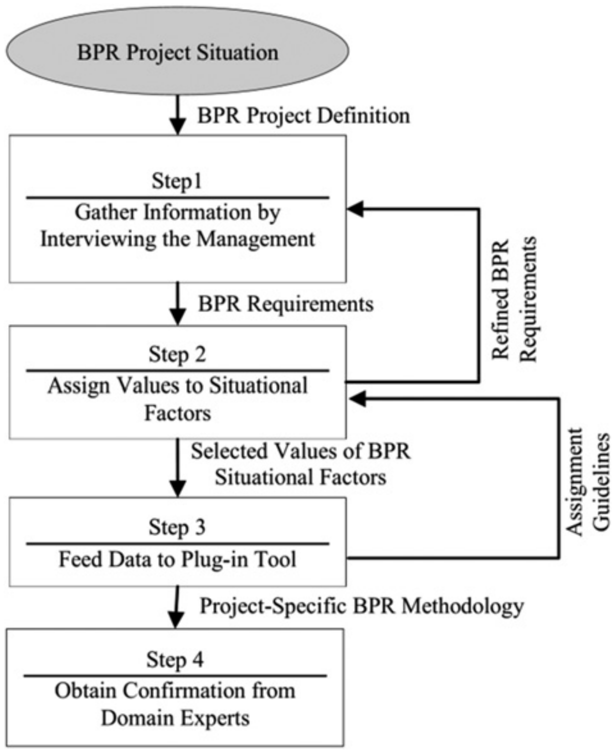

Fig. 6 *Steps of the case study*

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Table 4 Values of situational factors for the case study, and the relevant task process patterns

	Situational Factor	Value	Bases for Evaluation (Value Assignment)	Proposed Task Patterns
Cultural Factors	Motivation of staff to carry out the project	High	❖ Level of job satisfaction ⋃ ❖ Level of work complexity ⋂ ❖ Need for different kinds of maintenance ⋂ ❖ Level of effectiveness of staff work ⋃	---
	Effective communication between internal and external stakeholders	Adequate	❖ Level of stakeholder satisfaction ⋂ ❖ Stakeholders' tendency to communicate with each other ⋂ ❖ Study of communication effects in promoting mutual goals ⋂ ❖ Holding repetitive meetings on the same subject (As these repetitions can be reduced to less frequent but more effective meetings) ⋃	---
	The level of staff empowerment	Adequate	❖ High degree of task relegation ⋃ ❖ Redundant dependencies among staff ⇳	---
	Collaboration level between staff in the re-engineering project	Low	❖ Considering active participation of staff in offering proposals for change, and the quality of these proposals ⋃	EOR_2, UA_2, UA_3
	Staff information level in regard to re-engineering projects	Inadequate	❖ Lack of knowledge on basic BPR concepts ⋃ ❖ Consideration of the experience on previous BPR projects ☒ ❖ Consideration of the experience on similar change projects ☑	EOR_2, EOR_3, ET_3, UA_3
	Effective culture to accept change in organization	No	❖ Effective support for BPR in the current culture ⋃ ❖ Individuals' fear and resistance towards change ⋂	$ACoO_1$, $ACoO_2$, UA_3, UA_5
	Sharing values and beliefs	Inadequate		
Management Competence Factors	Commitment and authority of management	Adequate	❖ Management's attitude towards holding educational courses ⋂ ❖ Management enthusiasm for pursuing change and improvement ⇳ ❖ Management consideration for systematic elicitation of change proposals ⇳ ❖ Management consideration for motivational methods ⋂	---
	Pioneering and financial support	Adequate	❖ Proper justification of the project for sponsors ⍓ ❖ Importance of the project for the organization ⋂	---
	Risk management	Adequate	❖ Considering the lack or weakness of risk management tasks (such as those proposed for this situational factor) considering the criticality of the project ⍓	---
Organizational Structure Factors	Organization structure	Function-oriented	❖ Determination based on main characteristics of function/process-oriented organizational structures F	$DTBS_5$, COP_1
	Possibility of emerging new jobs and responsibilities	High	❖ Analysing suitability of existing roles by considering current activities and their counterparts in the reengineered solution ⋃	$DTBS_5$, COP_1, COP_3
	Efficiency of re-engineering team(s)	Low	❖ Difficulty of finding qualified team members ⋂ ❖ Communication and teamwork among team members ⇳ ❖ Level of involvement of each team member in the project ⇳ ❖ Level of the team's BPR skill ⋃ ❖ Authority given to re-engineering team(s) ⋂	ET_2, $CPaO_1$
BPR Project Management Factors	Project risk concerning time constraints	Moderate	❖ Negotiation with managers and decision makers to clearly settle time constraints ☑ ❖ Consideration given to the lack or weakness of time management tasks related to this situational factor ☑	---
	Risk of acquiring adequate resources (e.g. budget, staff)	Moderate	❖ Considering the size of the organization and the scope of the BPR project ⇳	---
	Documentation level	Adequate	❖ Existence of adequate documentation on organizational processes and previously-proposed improvement opportunities ☑	---
	Focus on stakeholder requirements	Moderate	❖ Focus of process on stakeholder requirements ⋂ ❖ Traceability of requirements throughout the process life cycle ⇳	---
	Project radicalness	Low	❖ Assessment of project radicalness level by using a set of 11 contingency factors concerning BPR project planning [23] ⋃	---
	Complexity level of organizational processes	Low	❖ Considering the size of the organization, span of its services, or volume and diversity of its products ⋃ ❖ Extent of the interactions among different sections required to achieve a goal ⇳	---
	Focus on core processes	High	❖ Evaluating the added values intended for the processes at hand ☑ ❖ Considering the size of the project ⇳ ❖ Investigation of the time and resources required for the project ⋂	FBC_1, FBC_2
	Focus on continuous improvement	Low	❖ Inclination of management and financial support towards making continuous changes ⋃ ❖ Assessment of the amount of efficient changes required at regular intervals ⋃	---
IT Factors	To-Be process requirements for new programs and software tools	Yes	❖ Satisfaction with current tools ⋃ ❖ Use of state-of-the-art tools ⋃	COP_2, $RORP\text{-}E_3$
	The need for innovation in using IT	Low	❖ Evaluating the level of usage of IT facilities ⋂ ❖ Possibility of automating current processes ⋃ ❖ Level of bureaucracy in the organization ⇳ ❖ Degree to which staff are overwhelmed with the tasks assigned ⇳	---
	The need to analyse and design new ISs	High	❖ The need to integrate ISs ☑ ❖ The need to re-engineer legacy ISs ☑	JR_2, $CPaO_2$, $DTBS_4$, COP_2, UA_1, UA_5

• 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 invariably start with objective-setting, thereby specifying the scope and method of operation.
• Establish project business case: 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

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Table 5 Realisation of proposed process patterns in twelve prominent methodologies

	Methodology Phases	Corresponding Task Process Patterns in BPRP
Wastell et al. [28]	Initiating the project	EOR$_3$, ET$_1$, CPaO$_4$
	Understanding process context	EOR$_2$, CPaO$_1$, ACoO, CPaO$_3$, CPaO$_2$, FBC$_1$, HLPDaM$_2$, BA$_2$, HLPDaM$_1$, HLPDaM$_3$, BA$_3$, BA$_4$, BA$_1$
	Radical process redesign	FBC$_2$, FBC$_3$, BA$_3$, BA$_4$, DTBS$_1$, DTBS$_2$, DTBS$_3$, DTBS$_4$, DTBS$_5$, VTBP$_1$, VTBP$_3$, PaT$_1$, PaT$_3$, PaT$_2$
	Handover: change implementation	COP$_3$, COP$_1$, COP$_2$, COP$_4$, T$_4$, RORP$_1$, RORP-E, RORP$_2$, RORP-E$_5$
Harmon [35]	Understand the project	EOR$_3$, ET$_1$, CPaO$_2$, CPaO$_4$, ACoO$_3$, FBC$_3$
	Analyse business process	FBC$_1$, HLPDaM$_1$, HLPDaM$_2$, HLPDaM$_3$, HLPDaM$_4$, BA$_2$, BA$_1$, RBCfRP$_2$
	Redesign process	BA$_1$, BA$_2$, DTBS$_1$, VTBP$_3$, VTBP$_1$, VTBP$_4$, DTBS$_4$, DTBS$_5$, DTBS$_3$, VTBP$_2$, PaT$_1$, PaT$_3$
	Implement redesigned process	PaT$_2$, COP$_1$, COP$_2$, COP$_3$, RBCfRP$_1$, RBCfRP$_2$, COP$_4$, T$_3$, T$_1$, T$_2$, T$_4$
	Roll out the redesigned process	RORP$_1$, RORP-E$_1$, RORP-E$_2$, RORP-E$_3$, RORP-E$_4$, RORP$_2$
Stemberger and Jaklic [34]	Envision	CPaO$_4$, EOR$_1$
	Initiate	CPaO$_2$, ET$_1$, FBC$_1$, EOR$_2$, ACoO$_1$, ACoO$_2$, ACoO$_3$
	Business process modelling	HLPDaM$_2$, HLPDaM$_3$, HLPDaM$_4$, HLPDaM$_5$
	Analysis of key business processes (model-based)	BA$_1$, BA$_2$
	Redesign	BA$_3$, DTBS$_1$, DTBS$_2$
	Reconstruct and evaluate	PaT$_1$, COP$_2$, COP$_4$, RORP$_1$, RORP$_2$
Cameron and Braiden [32]	Re-engineering readiness	EOR$_1$, JR$_1$, CPaO$_4$
	Plan of action	FBC$_3$, EOR$_3$, CPaO$_2$
	Training of team and communication to organization	ET$_2$, EOR$_2$
	Assessing the culture of the organization	ACoO$_1$, ACoO$_2$
	Benchmarking and external support	CPaO$_1$, ET$_3$, JR$_2$, ET$_2$
	Organizational assessment	FBC$_1$, DTBS$_5$
	Mapping the route	HLPDaM$_1$,HLPDaM$_2$, BA$_3$
	Re-design processes	DTBS$_1$, DTBS$_2$, DTBS$_4$, T$_1$, T$_4$
	Redesigning organizational systems	COP$_1$
	Re-engineering implementation	PaT$_1$, PaT$_2$, T$_1$, COP$_4$, T$_3$, COP$_2$
	Measuring and monitoring: Continuous improvement	RORP-E$_1$, RORP-E$_2$, RORP$_2$
Simon Kai [31]	Diagnosis	FBC$_1$, CPaO$_4$, FBC$_3$, HLPDaM$_2$, BA$_1$, BA$_2$
	Redesign	BA$_3$, BA$_4$, DTBS$_1$, DTBS$_3$, VTBP$_1$, DTBS$_4$, DTBS$_5$, T$_1$, T$_3$
	Implementation	PaT$_1$, COP$_3$, PaT$_2$, COP$_4$, RORP$_1$, COP$_1$, COP$_2$, RORP-E$_1$, RORP$_2$
Changchien and Shen [30]	Vision and objective creation	JR$_1$, CPaO$_4$, FBC$_3$
	Core process identification	FBC$_1$
	Current processes analysis	HLPDaM$_3$, BA$_1$
	Innovative reengineering	BA$_3$, BA$_4$, DTBS$_1$
	Evaluate new processes	VTBP$_1$
	New process selection	VTBP$_3$
	Transformation and implementation	RORP$_1$, RORP-E$_1$

	Methodology Phases	Corresponding Task Process Patterns in BPRP
Tatsiopoulos et al. [29]	Envision/ Analyse	JR$_2$, FBC$_3$
	Design High Level/ Design Low Level	**HLPDaM *, BA**
	Implement/ Build	**PaT**, **T**, RORP$_1$
	Measure/ Enhance	RORP-E$_1$, RORP$_2$
Castano et al. [26]	Definition of the reengineering project	ET$_1$, CPaO$_2$, CPaO$_1$, CPaO$_4$, FBC$_1$
	Reverse engineering of the existing system	JR$_2$
	Construction of the system vision	CPaO$_4$, FBC$_1$
	Modeling and analysis of system processes	HLPDaM$_1$, HLPDaM$_3$, **BA**
	Redesign of system processes	DTBS$_1$, T$_1$, RORP$_1$, RORP-E$_1$
Muthu et al. [33]	Prepare for BPR	**JR**, EOR$_1$, ET$_1$, CPaO$_2$, CPaO$_3$, CPaO$_4$, FBC$_3$
	Map & analyse as-is process	HLPDaM$_1$, HLPDaM$_2$, HLPDaM$_3$, BA$_1$, BA$_2$
	Design to-be processes	BA$_3$, DTBS$_1$, DTBS$_3$, DTBS$_2$, VTBP$_1$
	Implement reengineered processes	COP$_3$, PaT$_1$, COP$_2$, PaT$_3$, T$_1$, T$_2$, PaT$_2$, RORP$_1$
	Improve continuously	RORP-E$_1$, RORP$_2$
Valiris and Glykas [27]	Establishing BPR vision, objectives, scope, and mode	EOR$_2$, CPaO$_4$, ACoO$_1$, FBC$_3$, ET$_1$
	Business modeling	HLPDaM$_3$, HLPDaM$_4$, HLPDaM$_5$
	Business analysis	BA$_1$, BA$_3$, DTBS$_1$
	Redesign	DTBS$_2$, DTBS$_3$, DTBS$_5$, RORP$_1$
	Continuous improvement	PaT$_2$, COP$_3$, COP$_4$, RORP-E, RORP$_2$
Mayer and Dewitte [25]	Motivating reengineering	EOR$_1$, EOR$_2$
	Justifying reengineering	CPaO$_2$, CPaO$_4$, FBC$_1$, FBC$_2$, FBC$_3$
	Planning projects	ET$_1$, CPaO$_2$
	Setting up for reengineering	CPaO$_1$, CPaO$_4$, ET$_2$, ACoO$_2$, ET$_3$
	As-is description and analysis	HLPDaM$_1$, HLPDaM$_2$, HLPDaM$_3$, BA$_2$, BA$_1$, BA$_4$
	To-be design and validation	DTBS$_1$, DTBS$_2$, DTBS$_3$, DTBS$_4$, VTBP$_1$, RBCfRP$_1$, RBCfRP$_2$, VTBP$_3$
	Implementation	PaT$_1$, COP$_2$, RORP$_1$, RORP-E$_5$, RORP$_2$
Sharon et al. [24]	Preparing for workflow innovation	**JR**, FBC$_3$, CPaO$_1$, FBC$_1$, EOR$_2$
	Automation existing workflow	HLPDaM$_2$, HLPDaM$_3$, BA$_1$
	Identifying process improvements	BA$_3$, DTBS$_1$, VTBP$_1$, VTBP$_3$

* **Stages** have been indicated by bold indices.

(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.

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Table 6 Classification of BPR success factors [42, 43]

Factor Classes	Requirement group	Requirements for successful implementation of BPR	Index
C1: Factors relating to change management systems and culture		Revising reward and motivation systems	R_1C_1
		Effective communication	R_2C_1
		Empowerment	R_3C_1
		Human involvement (Staff contribution)	R_4C_1
		Training and education	R_5C_1
		Creating an effective culture for organizational change	R_6C_1
		Sharing appropriate values and beliefs	R_7C_1
		Lessons learned from other BPR efforts	R_8C_1
		Stimulating the organization's receptiveness to change	R_9C_1
		Using Change management techniques	$R_{10}C_1$
C2: Factors relating to management competence		Committed and strong leadership	R_1C_2
		Championship and sponsorship	R_2C_2
		Management of risk	R_3C_2
C3: Factors relating to organizational structure		Adequate job integration approach	R_1C_3
	Effective BPR teams (R_2C_3)	Finding suitable team members	$R_2C_3S_1$
		IS staff credibility, and involvement in re-engineering teams	$R_2C_3S_2$
		Adequate communication among members	$R_2C_3S_3$
		Training for BPR teams	$R_2C_3S_4$
		Authority given to BPR teams	$R_2C_3S_5$
		Adequate Team skills	$R_2C_3S_6$
		Appropriate job definitions and allocation of responsibilities	R_3C_3
		Organizational analysis & design	R_4C_3
C4: Factors related to BPR project management		Aligning BPR strategy with corporate strategy	R_1C_4
		Effective planning and use of project management techniques	R_2C_4
		Setting performance goals and measures	R_3C_4
		Adequate resources	R_4C_4
	Appropriate use of methodology: Coverage of major stages of BPR methodology (R_5C_4)	Envision	$R_5C_4S_1$
		Initiate	$R_5C_4S_2$
		Diagnose	$R_5C_4S_3$
		Redesign	$R_5C_4S_4$
		Reconstruct	$R_5C_4S_5$
		Evaluate	$R_5C_4S_6$
C4: Factors related to BPR project management (Continued)	External orientation and learning (R_6C_4)	Customer requirements analysis	$R_6C_4S_1$
		Effective use of consultants	R_7C_4
		Building a BPR vision	R_8C_4
		Using process measurement	R_9C_4
	Effective process redesign ($R_{10}C_4$)	Common understanding of BPR processes and their orientations	$R_{10}C_4S_1$
		Identifying process owners	$R_{10}C_4S_2$
		Adequate determination of scope of change	$R_{10}C_4S_3$
		Adequate focus on core processes	$R_{10}C_4S_4$
		Re-engineering the right processes	$R_{10}C_4S_5$
		Comprehensive definition of processes	$R_{10}C_4S_6$
		Adequate capturing and modeling of processes	$R_{10}C_4S_7$
		Using problem solving & diagnosis techniques	$R_{10}C_4S_8$
		Using process prototyping and simulation	$R_{10}C_4S_9$
	Integrating BPR with other improvement approaches ($R_{11}C_4$)	Total Quality Management (TQM)	$R_{11}C_4S_1$
	Benchmarking ($R_{11}C_4S_2$)	To identify best practice performance and processes in the future	$R_{11}C_4S_3$
		To highlight areas of change and prioritize them	$R_{11}C_4S_4$
		To make a proper decision about type of change (revolutionary or evolutionary)	$R_{11}C_4S_5$
		Adequate identification of BPR values	$R_{12}C_4$
C5: Factors related to IT infrastructure		Adequate alignment of IT infrastructure and BPR strategy	R_1C_5
		Building an effective IT infrastructure	R_2C_5
		Adequate IT investment and sourcing decisions	R_3C_5
		Adequate measurement of IT infrastructure effectiveness in BPR	R_4C_5
		Proper IS integration, (IS systems analysis and design)	R_5C_5
		Effective re-engineering of legacy IS	R_6C_5
		Increasing IT functional competency	R_7C_5
		IT expertise	R_8C_5
		Continual assessment of emerging IT capabilities	R_9C_5
		Effective use of software tools	$R_{10}C_5$

• 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.

Process patterns (method parts) are added into their respective phase, stage, or task in the base methodology; the exact extension point is determined by referring to BPRP, as it specifies the location and role of each process component in the overall process.

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

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Table 7 BPRP process patterns, and the BPR-methodology requirements addressed by the patterns

BPRP Phase | Stage		Index	BPRP Task (of Stage)	Methodology Requirements Addressed by BPRP Task
Phase 1: Envision ($R_5C_4S_1$)	Justify Reengineering	JR_1	Strategic Assessment	$R_{12}C_1, R_1C_4, R_{12}C_4$
		JR_2	Technological Assessment	$R_{12}C_1, R_{12}C_4, R_6C_5, R_9C_5, R_{11}C_{11}$
	Establish Organizational Readiness	EOR_1	Establish Management Commitment	R_1C_2
		EOR_2	Communicate and Introduce BPR	$R_2C_1, R_4C_1, R_5C_1, R_6C_1, R_7C_1, R_2C_2, R_3C_2, R_5C_4S_2, R_{12}C_4$
		EOR_3	Launch the Steering Committee	$R_2C_2, R_1C_4, R_4C_4, R_{12}C_4, R_9C_5$
Phase 2: Initiate ($R_5C_4S_2$)	Establish Team(s)	ET_1	Organize Reengineering Team(s)	$R_2C_3, R_2C_3S_1, R_2C_3S_2, R_8C_5$
		ET_2	Prepare and Authorize Team(s)	$R_5C_1, R_2C_3, R_2C_3S_4, R_2C_3S_5, R_2C_3S_6$
		ET_3	Select Consultant (Optional)	R_7C_4
	Create Plan and Objectives	$CPaO_1$	Define Methodology, Methods and Tools to be Used in the Project	$R_2C_3, R_2C_3S_3, R_5C_4, R_{11}C_4S_3$
		$CPaO_2$	Conduct Project Planning	$R_2C_2, R_2C_4, R_2C_4, R_4C_4, R_1C_5, R_3C_5$
		$CPaO_3$	Stakeholder Analysis	$R_6C_4, R_6C_4S_1$
		$CPaO_4$	Establish Objectives, Scope and Mode of BPR	$R_3C_4, R_{10}C_4S_3, R_{11}C_4S_4, R_{11}C_4S_5, R_{12}C_4$
	Formulate a Business Case ($R_{12}C_4$)	FBC_1	Identify Core Business Processes to be Redesigned	$R_5C_4S_1, R_{10}C_4S_4, R_{10}C_4S_5, R_{11}C_4S_4$
		FBC_2	Prioritize Core Business Processes Based on Business Priority and Redesign Urgency (Optional)	$R_{10}C_4S_4, R_{11}C_4S_4$
		FBC_3	Establish Project Business Case	R_8C_4
	Assess the Culture of the Organization (R_9C_1) (Optional)	$ACoO_1$	Analyse Culture	R_6C_1, R_3C_2
		$ACoO_2$	Assess and Reduce Resistance to Change	$R_1C_1, R_3C_1, R_4C_1, R_6C_1, R_3C_2$
		$ACoO_3$	Gain a Consensus of Support for Process Improvement	$R_3C_1, R_4C_1, R_1C_2, R_2C_2, R_3C_2$
Phase 3: Diagnose ($R_5C_4S_3$)	High-Level Process Definition and Modeling	$HLPDaM_1$	Map Process	$R_{10}C_4S_1, R_{10}C_4S_6$
		$HLPDaM_2$	Prepare Documentation and Descriptions on Existing Process and Sub-processes or Activities (Optional)	$R_{10}C_4S_1, R_{10}C_4S_6$
		$HLPDaM_3$	Create Models	$R_{10}C_4S_1, R_{10}C_4S_6, R_{10}C_4S_7$
		$HLPDaM_4$	Verify Models	R_7C_4
		$HLPDaM_5$	Confirm Models (Optional)	R_1C_2
	Business Analysis	BA_1	Measure Existing Processes	$R_9C_4, R_{10}C_4S_1$
		BA_2	Discover Factors that Result in Higher Costs and Lower Quality	$R_{10}C_4S_1, R_{10}C_4S_5, R_{12}C_4$
		BA_3	Assess Processes	$R_5C_4S_2, R_6C_4, R_{10}C_4S_5, R_{10}C_4S_8, R_{11}C_4S_2, R_{11}C_4S_3, R_{12}C_4$
		BA_4	Assess Technology	$R_6C_4, R_{10}C_4S_8, R_{11}C_4S_2, R_{12}C_4, R_1C_5, R_7C_5, R_9C_5, R_{11}C_{11}$
Phase 4: Redesign ($R_5C_4S_4$)	Design To-Be Situation	$DTBS_1$	Develop Process Design Alternatives	$R_{10}C_4S_7, R_{10}C_4S_9$
		$DTBS_2$	Review New Design and Change Proposals	R_1C_4, R_9C_5
		$DTBS_3$	Document and Detailed-Design New Processes	$R_4C_4, R_{10}C_4S_7, R_{10}C_4S_9$
		$DTBS_4$	Analyse and Design IS	R_1C_5, R_5C_5, R_6C_5
		$DTBS_5$	Redefine HR Structure	R_1C_3, R_3C_3, R_4C_3
	Validate To-Be Processes	$VTBP_1$	Validate/Evaluate New Processes	$R_9C_4, R_{10}C_4S_1, R_{11}C_4S_3$
		$VTBP_2$	Obtain Approval for Change from Organizational Decision-Makers (Optional)	R_1C_2
		$VTBP_3$	Select New Processes for Implementation	$R_{10}C_4S_1, R_{10}C_4S_5$
		$VTBP_4$	Designate Process Owners	$R_{10}C_4S_2$
	Refine Business Case for Reengineered Processes ($R_{12}C_4$) (Optional)	$RBCfRP_1$	Project the Costs/Performance Associated with Implementing and Operating the New Design	R_4C_4, R_8C_4
		$RBCfRP_2$	Refine Business Case	R_4C_4, R_8C_4
Phase 5: Implement Redesigned Processes	Plan and Train	PaT_1	Evolve Transition Plan	$R_{10}C_1, R_3C_2, R_4C_4$
		PaT_2	Train Users	R_5C_1, R_3C_3, R_8C_5
		PaT_3	Review and Approve Transition Plan	R_1C_2
	Create Organizational Prerequisites	COP_1	Create HR Infrastructure	R_1C_3, R_3C_3, R_4C_3
		COP_2	Upgrade Technology	$R_2C_5, R_3C_5, R_5C_5, R_6C_5$
		COP_3	Run a Culture Change Program (Optional)	R_9C_1, R_3C_2, R_3C_3
		COP_4	Implement Process Management and Measurement Systems	R_9C_4
	Test	T_1	Prototype and Simulate Transition Plan	$R_{10}C_4S_1, R_{10}C_4S_9$
		T_2	Execute Larger-Scale Pilots (Optional)	R_2C_4, R_4C_4
		T_3	Monitor New Process Tests	R_2C_4, R_4C_4
		T_4	Obtain Implementation Approval from Organizational Decision Makers (Optional)	R_1C_2
Phase 6: Roll Out Redesigned Processes	Implement	$RORP_1$	Full Implementation	$R_5C_4S_5, R_{10}C_5$
	Evaluate ($R_5C_4S_6$)	$RORP\text{-}E_1$	Review New Processes and Methodology	R_9C_4
		$RORP\text{-}E_2$	Monitor New HR Systems (Optional)	R_1C_3, R_4C_3
		$RORP\text{-}E_3$	Monitor Upgraded Technology (Optional)	$R_{10}C_5, R_7C_8$
		$RORP\text{-}E_4$	Monitor Environment (Optional)	R_4C_5
		$RORP\text{-}E_5$	Document Lessons Learned (Optional)	R_8C_1, R_6C_4
	Improve	$RORP_2$	Improve Process Continuously	$R_5C_4S_6, R_{11}C_4S_1$
Umbrella Activities		UA_1	Commitment Management	R_1C_2
		UA_2	Instruction Management	R_4C_1, R_5C_1
		UA_3	People Management	$R_1C_1, R_2C_1, R_3C_1, R_4C_1, R_6C_1, R_7C_1, R_2C_4, R_4C_4$
		UA_4	Risk Management	R_9C_1, R_3C_2, R_4C_4
		UA_5	Communication and Change Management	$R_2C_1, R_6C_1, R_7C_1, R_9C_1, R_{10}C_1$
		UA_6	Project Management	R_2C_4, R_4C_4, R_9C_5

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

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Table 8 Pattern-specific analysis criteria

Category	Criterion	Type	Definition and Value Range	Value | How realized in proposed BPRP
General Pattern-Related	Definition of problem, context and solution	S	A: No problem, context, or solution defined B: Partial definition C: Full definition for problem, context, and solution	**C.** Full definitions are provided for problem, context, and solution.
General Pattern-Related	Template Formality	S	A: No predetermined template B: Conformance to a concise semi-formal/informal template C: Conformance to a detailed and well-structured formal template	**C.** Conformance to a detailed and well-structured formal template that describes the name of the pattern, as well as its purpose, required products, tasks, and produced products (Table 2).
General Pattern-Related	Definition of patterns related to each pattern	P	Identification of crosscutting patterns, which are related to or used in several coarser-grained process patterns.	**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.
Process Pattern-Related	Complexity Management	P	Provision of techniques to manage large numbers of patterns and/or to manage large patterns.	**Supported**. By categorizing the patterns into phases, stages, and tasks.
Process Pattern-Related	Consistency	S	Consistency amongst patterns, in terms of input/output work products within a pattern (local consistency) and among different patterns (global consistency). A: No consistency B: Support for either local or global consistency C: Support for both local and global consistency	**C.** Support for both local and global consistencies: All products are produced through patterns, and there is no overlap among the products produced.
Process Pattern-Related	Determination of Work Products	P	Determining which work products are involved in each process pattern.	**Supported**. The required and produced products are entirely determined in the stage process patterns.
Process Pattern-Related	Determination of Roles	S	Determining which roles are involved in each process pattern. A: The involved roles in each process pattern are fully defined. B: The roles involved in each process pattern are mentioned, but not fully defined. C: No mention of roles.	**B.** Yes. The roles involved in the process patterns are specified.
Process Pattern-Related	Classification of Work Products/Roles	P	Proposal of a classification scheme for work products/roles.	Not Supported.
Process Pattern-Related	Cohesion	E	Levels of cohesion satisfied by different process patterns.	Functional, sequential, procedural, and temporal cohesions.
Process Pattern-Related	Coupling	E	Levels of coupling that exist among process patterns.	Data (product) coupling and control coupling.
Process Pattern-Related	Instantiation Guidance	P	Offering techniques/guidelines for instantiation/composition of process patterns.	**Supported**.
Process Pattern-Related	Existence of Configurations of Process Patterns	P	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.	**Supported**. The approach has been applied in an industrial context (as reported in the paper).

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.

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Table 9 General methodology analysis criteria

Hierarchy		Criterion	Type	Definition and Value Range	Value — How realized in proposed BPRP
Life Cycle	Work Unit	Coverage of Generic Lifecycle	E	The phases of the generic BPR lifecycle that are covered by the process.	Diagnose Processes, Analyse As-Is Processes, Design To-Be Processes, Test, Implementation and Roll-out.
		Smooth and Seamless Transition between Phases	S	<u>A</u>: Transition between phases is neither smooth nor seamless. <u>B</u>: Transition between phases is either smooth or seamless. <u>C</u>: Transition between phases is smooth and seamless.	**B.** Transition between phases is either smooth or seamless. To produce products (the most important of which are process models), the same method and notation is applied from the beginning of the methodology until the end. Thus, it can be regarded as seamless. However, new models are developed during the methodology which are not refined versions of previous models; therefore, smooth transition from phase to phase is not always maintained.
		Type of Lifecycle	D	The type of lifecycle model that is applied in the BPR process (iterative, incremental, cascade, etc.)	Lifecycle is iterative-incremental. The 'Improve Process Continuously' task and the recursive loop to the third phase point to the iterative nature of the lifecycle.
	Product	Adequacy	P	Whether the BPR process produces the products that are related to the phases.	**Supported**. Required products are produced by stage process patterns.
		Consistency	P	Whether the products complement each other with minimum overlapping.	**Supported**. Since all required and complementary products are produced via patterns, and there are no overlaps among the produced products, consistency is maintained.
		Supported Views	P	Structural view	**Supported**. Via applying the IDEF1 modeling technique (Integrated Definition for Information Modeling). It should be noted that in this research, the techniques corresponding to each and every task have been fully determined; however, due to space limitations, they have been excluded from this paper.
				Behavioural view	**Supported**. This view is supported by the application of IDEF3 modeling technique (standard workflow graphical representation format).
				Functional view	**Supported**. This view is supported by the application of the IDEF0 modeling technique (Integrated Definition for Function Modeling).
		Abstraction Levels	P	The granularity/abstraction levels at which the products are presented (system, package, component, object, etc. – at analysis, design, or implementation levels).	**Supported**. As BPRP uses multi-level modeling for defining and modeling the stages of the high-level process, it produces As-Is models after having passed multiple levels; namely, 'Map Process', 'Documentation', and 'Model Creation'. Furthermore, in the 'Design To-Be Situation' stage, To-Be models are produced after going through multiple levels; namely, 'Devise Process Design Alternatives', 'Review New Designs', and 'Documentation and Detailed Design'.
		Tangibility/ Testability/ Visibility	P	Whether products are tangible, testable, and understandable.	**Supported**. The decision as to which products and models are required depends on the project situation. Therefore, only a select subset of the products and models is produced, thus avoiding unnecessary complexity and clutter. Moreover, pattern templates have been used to enhance understandability.
		Appropriate Documentation	P	Provision of proper documentation spanning the entire development lifecycle.	**Supported**. Detailed documentation has been provided (as outlined in this paper). Furthermore, references/sources have been specified in detail for all of the elicited patterns.
	Role	User Involvement	P	Whether users are actively involved in the process through specially defined roles.	**Supported**. Many tasks recognize and explicitly state the need for active customer involvement.
		Roles Specification	S	<u>A</u>: The roles involved in each process pattern are identified in detail. <u>B</u>: The roles involved in each process pattern are only mentioned, but not elaborated upon. <u>C</u>: No mention of the roles involved.	**B.** The roles involved in the process patterns are only mentioned. For example, in every work area, the roles and tasks assigned to the members of BPR teams have been determined.
Support for Umbrella Activities		Commitment Management	S	<u>A</u>: No support for umbrella activities. <u>B</u>: Supported, yet leaving the concrete definition of the activities to the developer/method-engineer. <u>C</u>: Supported by providing specific methods for umbrella activities.	**C.** Commitment management is supported through these tasks: $ACoO_3$, $HLPDaM_5$, $VTBP_2$, PaT_3, and T_4.
		Instruction Management			**C.** Instruction management is supported through these tasks: EOR_2, EOR_3, ET_3, $CPaO_3$, $HLPDaM_4$, BA_1, BA_2, BA_3, and $RORP\text{-}E_5$.
		People Management			**C.** People management is supported through these tasks: EOR_2, EOR_3, $ACoO_1$, and $ACoO_2$.
		Risk Management			C. Risk management is supported through these tasks: EOR_2, EOR_3, $CPaO_2$, $ACoO_1$, $ACoO_2$, $ACoO_3$, $DTBS_3$, $VTBP_2$, $RBCfRP_1$, $RBCfRP_2$, COP_3, T_2, T_3, and T_4.
		Communication and Change Management			**C.** Communication and change management is supported through these tasks: EOR_2, EOR_3, ET_3, $ACoO_1$, and $ACoO_2$.
		Project Management			**C.** Project management is supported through these tasks: EOR_2, EOR_3, ET_3, $CPaO_2$, $ACoO_1$, $ACoO_2$, $ACoO_3$, $CPaO_3$, $HLPDaM_4$, BA_1, BA_2, BA_3, $DTBS_2$, $DTBS_3$, $VTBP_2$, $RBCfRP_1$, $RBCfRP_2$, COP_3, T_2, T_3, T_4, and $RORP\text{-}E_5$.
Development Context	Understandability and Ease of Use	Understandability	D	Understandability of the BPR process.	The complexity and heftiness of the process reduces the understandability of the framework.
		Usage	D	Usability of the BPR process in its intended context.	Proposal of a process for methodology engineering, along with the process framework, has significantly simplified its use for users. In addition, we have developed a special plug-in for the EPFC tool [50] which automates the methodology construction process, and hence, considerably facilitates the use of this framework (Due to space constraints, this tool will not be elaborated upon in this paper).
	Efficiency	Time	D	Balance between the BPR throughput and the time that the BPR process consumes.	The proposed process for methodology engineering is a straightforward procedure, and this saves time. An additional performance-enhancing benefit is the fact that the target methodology is developed by taking into consideration the recurring success and failure factors of BPR projects, and many of these factors address performance issues.
		Resources	D	Amount of resources, including human and financial, that are used by the process.	In order to apply the proposed process framework to construct a custom methodology, a 'Methodology Engineer' role should be added to the BPR team. Hence, the use of the proposed process framework does indeed demand additional human resources.

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.

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Table 9 Continued

Hierarchy		Criterion	Type	Definition and Value Range	Value | How realized in proposed BPRP
Development Context	Precision	Traceability	D	Whether the artefacts can be traced to the requirements or to real-world concepts.	To produce different versions of a product, the same method and notation is applied from the beginning to the end, and requirements are adequately captured during the BPR process. Traceability tasks have been incorporated in the process; in addition, our proposed plug-in for the EPFC tool supports traceability.
		Formalism	P	Support for formalism at the process level.	**Supported**. A detailed and polished template has been used for defining the process patterns which constitute the generic process framework.
		Well-Definedness	P	**Expressiveness:** The ability to define the process without ambiguity.	**Supported**. The elements of the process framework and their relationships have been clearly delineated.
			P	**Rationality:** Logical appeal of the process and its constituents.	**Supported**. There is a logical reason behind the inclusion of each process pattern, even at the task level (Table 7). Furthermore, no redundant products are produced.
			P	**Completeness:** A complete definition must include rigorous explanations for all aspects of the methodology, including work units, products, and people.	**Supported**. Complete documents are available regarding all the details of the proposed process framework.
			P	**Tool Support:** Whether the process is supported by specific tools.	**Supported**. A plug-in has been developed for the EPFC tool which supports the development of bespoke methodologies according to the process framework.
	Maintainability	Modularity	P	Ability to preserve the parts (corresponding to components) from side effects. This criterion addresses the interoperability of the process patterns and their products [9].	**Supported**. Modularity has been observed in the process patterns and the models produced by applying IDEF (Integrated DEFinition) modeling techniques.
		Reusability	P	Ability to reuse the process in various applications.	**Supported**. One of the main objectives of the proposed process framework is to promote reusability through the provision of a method base.
		Testability	D	Possibility and practicality of verification of each phase against the outcomes of previous phases, and product validation against user requirements.	The proposed process framework incorporates verification and validation stages (such as 'Validate To-Be Processes' and 'Test'), so the models are checked for traceability to the requirements. In addition, simulation is applied whenever needed.
	Complexity Management	Evolvability	D	Ability to increasingly improve the system's functional and non-functional features.	**Supported**. The ability to improve functional and non-functional aspects of the organization has been supported through the inclusion of the 'Improve Process Continuously' task.
		Configurability/ Extensibility/ Flexibility/ Scalability	D	Means by which these criteria are satisfied in order for the process to fit different project situations.	This criterion is naturally satisfied by the concept of process patterns [56]. It is also supported by the method chunks and method base as well as the tool support currently available. In particular, the 'Review new process and methodology' task plays an important role in promoting flexibility.

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 criteria: To evaluate 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.

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Table 10 BPR-specific methodology analysis criteria

Criterion		Type	Value Range	Value | How realized in proposed BPRP
Support for radical change		D	---	The proposed process framework provides support for radical organizational change through the following features: Inclusion of a 'Redesign' stage, consideration given to tasks related to changing the HR infrastructure, and application of IT and IS solutions. Moreover, various techniques have been provided by the process framework to induce creativity in reengineering teams; examples include: Out-of-the-Box Thinking, Visioning, and Brainstorming.
Focus on important processes		D	---	Two stages (namely 'Formulate a Business Case' and 'Identify Core Business Processes to be Redesigned') address this criterion explicitly.
Support for application of IT as an enabler		D	---	All the main tasks regarding the application of IT (as an enabler) have been included in the process framework. These tasks include: 'Technological Assessment', 'Analyse and Design IS', 'Upgrade Technology', and 'Monitor Upgraded Technology'.
Quality Assurance	Provision of a training program	P	---	**Supported**. Via the inclusion of the following tasks and activities: 'Prepare Team(s)', 'Train Users', and 'Instruction Management'.
	Inclusion of collaborative managerial and technical reviews	S	A: Strong support B: Weak support C: Lack of support	**A.** Q/A Tasks have been included in the process framework, which focus on the quality of the redesigned processes and the outcome of the project. Examples include: 'Verify Models', 'Review New Design and Change Proposals', 'Obtain Approval for Change', 'Review and Approve Transition Plan', and 'Obtain Implementation Approval'.
Mechanisms for maintaining management commitment		D	---	Through the tasks which support the 'Commitment Management' umbrella activity (as listed in Table 9), commitment and management requirements are addressed throughout the life cycle of BPR processes.
Inclusion of cultural measures		S	A: Strong support B: Weak support C: Lack of support	**A.** To support cultural measures, various tasks have been incorporated into the process framework; examples include: EOR_2, $ACoO_1$, $ACoO_2$, and $ACoO_3$ (as defined in Table 2).
Application	Organization size	D	---	By using the proposed process framework, BPR methodologies can be constructed and aligned regardless of the size of the organization. The following situational factors consider organization size in their guidelines for constructing custom methodologies: 'Risk of acquiring adequate resources', 'Complexity level of organizational processes' and 'Focus on core processes' (Table 3).
	Applicability to various contexts	D	---	The proposed process framework has been constructed based on the results of scrutinizing BPR methodologies that are used in different contexts; examples include: Workflow reengineering [24], Supply chain reengineering [57], Business process change in the public sector [34], and Assessment of e-commerce technologies [29]. Therefore, the framework can be customized for application in various contexts.

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

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Table 11 SME-Related Analysis Criteria

Criterion	Type	Value Range	Value | How realized in proposed BPRP
Support for meta-modeling	S	A: Full support B: Partial support C: No support	**A: Full support.** The proposed framework supports tasks, stages, phases and products. Support is such that the framework could play the role of a meta-model for methodology engineering.
Flexibility	S	A: Full support B: Partial support C: No support	**A: High level of flexibility.** Due to the assembly-based SME approach, the framework has a high level of flexibility.
Reusability of method chunks	P	---	**Supported.** Because of the formation of a method base for the method chunks, this criterion has been satisfied.
Modularity	S	A: Full support B: Partial support C: No support	**A: Full support.** Because of the formation of a method base and existence of an integrated set of situational factors, this criterion has been satisfied.
Organization of method knowledge in a method base	P	---	**Supported.** Because of the formation of a method base, this criterion has been satisfied.
Selection approach	D	---	The selection and assembly (creation) approaches have both been described in detail.
Creation approach	D	---	

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 BPR orientation (improvement or reengineering) and the project type [60].

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