MASTER

An approach to select redesign best practices

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An approach to select redesign best practices

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Abstract

In today's dynamic business environment, the ability to improve business performance is a critical requirement for any organization. Though many firms have been pursuing Business Process Redesign (BPR) to obtain better performance, **BPR in practice is still more art than science** [1] [2] [3] [4]**.** Practitioners tend to fall back on best practices as performing business process redesign. Although there are various papers addressing the Business Process Redesign (BPR) and BPR best practices (see e.g. [5] [6] [7] [8] [9] [10]), little is known about the general guidelines as for the application of best practices. Valiris and Glykas [11] identified "*there is a lack of a systematic approach that can lead a process re-designer through a series of steps for the achievement of process redesign* ".

At this moment in time, there exists different forms of guidance for applying BPR best practices but they are still limited in their application domain and/ or not adopted broadly in industry [12] . In the scope of this master thesis, an approach is proposed to help practitioners selecting applicable best practices for the redesign effort i.e. the application of the BPR best practices for the *as-is* model based on their expected impacts on the process performance.

Key words: Business Process Redesign, Best Practices, Process Performance, Business Process Improvement, Alignment.

Preface

This thesis is the result of my graduation project which completes my Master's degree in Business Information Systems at Eindhoven University of Technology (TU/e). The project was performed at the Information Systems (IS) research group of the Industrial Engineering and Innovation Sciences (IE&IS) Department of TU/e; and was carried out at Philips Enterprise Information Management (Philips - EIM). Throughout this project I met and collaborated with many professionals from the University and the Company, whom I would like to express my sincere appreciation to.

First of all, I would like to thank my first supervisor, Anna Wilbik for her guidance, all the detailed comments on my thesis and feedback sessions during this period. She has been abundantly helpful and I am very grateful to her supervision. My special thanks go to Irene Vanderfeesten who provided me the right support so I could realize my ideas and also inspired me on how to make the project more challenging. Her critical view on my work and valuable feedback contributed significantly to this result. Without her help, this project would not have been completed in the way it did. I also want to extend my thank to Dirk Fahland for his feedback and for being part of the assessment committee.

Next, I would like to thank Rauto Siba, my supervisor from Philips EIM, who gave me the opportunity to conduct such a research project, especially in a large, well-established organization. My thanks also go to Frits Wiegel for his review during the first phase of my thesis.

Furthermore, I am grateful to Michael Westergaard and Boudewijn van Dongen, who even though were not officially involved in this thesis project, for being always available to answer my questions.

Last but not least, I would like to thank my parents and brothers for their unconditional love and support. My sincere recognition goes out to my husband, for his love, encouragement and big support during all my period of studying. The very most special thank is for my little girl My, who made my Master study unforgettable journey. I feel very happy having you all in my life. This result would not be possible if you were not by my side all this time.

Thank you!

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Contents

List of Abbreviations

BPR: Business Process Redesign

BPM: Business Process Management

DAMA: The Data Management Association

APQC: American Productivity and Quality Center

BPMN: Business Process Modeling Notation

WfMS: Workflow Management System

BP: Business Process

MCDA: Multiple Criteria Decision Analysis

AHP: Analytic Hierarchy Process

GRIP: Generalized Regression with Intensities of Preference

List of Figures

List of Tables

1 Introduction

In the world of process oriented organizations, the improvement of business processes is a vital need for the survival and advancement of any organization. There are varieties of theories, methodologies associated with process improvement. Among of them, process redesign is considered to be fast and effective way. BPR has been defined as "*the analysis and design of workflows and processes within and between organization [enabled by] the capabilities offered by computers, software applications and telecommunications*" [4]. Nowadays, in industry, BPR projects have been and still are popular [13].

In our research, we are interested in BPR implementation by mean of applying best practices. Though best practices were created by different researchers for different domains, Reijers and Limam identified 29 best practices for the redesign effort [14]. Despite the wide range of application of best practices in BPR, there is still lack of general guidelines as for the application of BPR best practices. In our research, the goal is to help the practitioners in choosing the suitable best practices when dealing with the implementation of BPR.

In this context, the first task is to adopt an existing framework for BPR, which identifies all views that the practitioners should consider when dealing with the BPR implementation. Because one of the objectives of the project is translated into process performance measures, the second task is introduce the set of performance measures defined by Netjes [8], specifically for business process, which are the most common and straightforward relating to time, cost, quality and flexibility dimensions, in Devil's quadrangle [15]. These performance measures is proposed to guide the practitioners to explore the goal(s) of redesign project. Our third task is to describe 29 best practices [14] that are widely applied by the practitioners in BPR. In addition, starting from Reijers and Limam 's work [14] on defining the potential effects and possible drawback of best practices, though many of them lack an adequate (qualitative) support, as observed by Van der Aalst [16], we aim to indicate these effects in more details i.e. along the set of performance measures by Netjes [8]. We believe that in presenting the qualitative assessments of best practices in such that manner, we provide more support for the application of each of these. And most important is to guide the practitioners towards the selection of applicable best practices in BPR implementation.

1.1 Problem statement and motivation

The literature review [14] revealed a substantial gap in the topic of Business Process Redesign. In short, though there are extensive papers on Business Process Redesign (BPR) and best practices available, there is still lack of concrete guidance to the application of these best practices. Most important, practitioners in the field of BPR lack a support to choose appropriate best practices to enhance their business processes.

Therefore, the following research question is addressed in this thesis:

> ***How to support the selection of applicable redesign best practices based on their expected impacts on the performance of the process?***

By answering this research question, this thesis extends the current field of research in the following ways. Using the Regulative Cycle [17], designed for business problem solving in general, our proposed approach is developed to support practitioners choosing the applicable best practices for the redesign effort. Because one of our objectives is presenting the effects and drawbacks of best practices along the set of performance measures, this research extends the list of impacts of best practices on business process (BP), as indicated by Reijers and Limam [14]. By presenting the assessments of best practices in a detailed manner, we can improve their application in BPR and especially the alignment of effects of best practices on the performance measures and the redesign goals.

1.2 Research objective

The research objective of the study is to develop an approach to select applicable redesign best practices based on their expected impact on the performance of the process. The approach is provided together with case study example to illustrate how it can be applied in industry.

To understand the problem, to analyze its cause and to identify a feasible solution, the following questions will be investigated in more details.

1.2.1 Research question 1

To propose a new approach for the application of best practices, our first concern is to figure out different forms of guidance/ support for using best practices in BPR that already exist. The research question 1 is, therefore, can be formed as:

RQ1. What forms of guidance for using best practices in BPR already exist?

1.2.2 Research question 2

Since there exists forms of guidance for using best practices in BPR implementation, why do we need to propose another one? What can it do and not do for us in comparison with all the existing ones? In order to answer these questions, it requires a lot of understanding about those approaches and especially their “sideways”. This solid knowledge will help us conducting a new idea. As a result, we frame here the second research question as:

RQ2. Which are the gaps in the existing guidance/ support for using best practices in BPR?

1.2.3 Research question 3

Business process redesign is one of the most powerful way to boost business performance and to improve customer satisfaction [14]. A possible approach to business process redesign is using best practices. 29 best practices and their effects on time, cost, quality and flexibility dimensions are identified by Reijers and Limam in [14]. However, little is known about the impacts of these on the performance of a business process i.e. setup time, service time, labor cost, resource cost, external quality, internal quality, mix flexibility, labor flexibility, etc. Since these extended impacts are the necessary material as developing our approach, it is therefore of vital importance to answer the research question three phrased as:

RQ3. What is the impacts of BPR best practices along the process performance measures?

1.2.4 Research question 4

Knowing the various forms of guidance for applying best practices in BPR implementation and their gaps, now we have to consider which gap(s) will be the focus of our work and most important develop our approach in such a way that it can fill the identified gap(s) and should be compared to the existing forms/ approaches. In that sense, we form the research question four as:

RQ4. How to develop a concrete approach for selecting applicable BPR best practices?

1.2.5 Research question 5

Having a new approach to select applicable BPR best practices defined does not meant that the research is done here. Testing its feasibility is as important as developing it. There comes the time when we have to evaluate our approach against the defined requirements which results in our last research question as:

RQ5. Is the defined approach feasible and applicable to the enterprise processes?

Answer to these individual research questions, when combined together will give a solution to the problem statement as defined.

1.3 Research Methodology and Thesis outline

The Regulative Cycle, developed by P.J. van Strien [17] is the research method used in this thesis. The method consists of 5 main steps which are depicted in Figure 1.

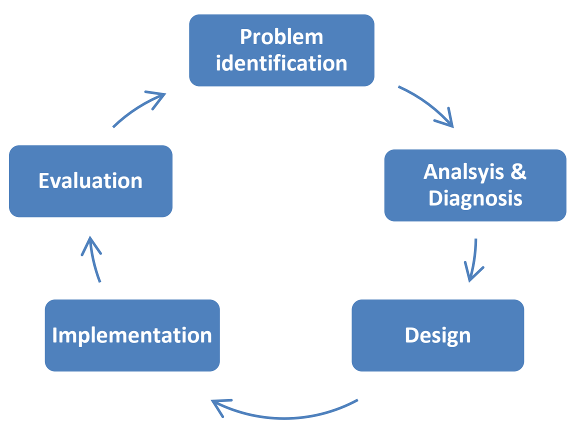


Figure 1: The Regulative Cycle[17]

- **Problem identification**

In almost every problem solving methodology, the first step is defining or identifying the problem. It is the most important step involving well considering the situation and inducing the real problem. In this context, we introduce and define the problem (Ch.1).

- **Analysis & Diagnosis**

This phase aims to study the literature on different forms of guidance for using best practices that already exist, and identify the gaps in the area of choosing the applicable best practices for the redesign effort. During the analysis phase, we study and analyze problems in details (RQ1, RQ2).

This part also includes the background to describe the existing framework for BPR implementation, the process performance measures and 29 best practices with their impacts on the performance dimensions, defined by Reijers and Limam.

These contents are presented in Ch.2 of the thesis.

- **Design**

In the design phase, an approach to select redesign best practices based on their expected impacts on the process performance are presented (RQ3, RQ4). The design is introduced in Ch.3.

- **Implementation & Evaluation:**

These two phases give the answer to the defined RQ5 and are presented in Ch.4 of the thesis. We implement the proposed approach and discuss its feasibility. For this, we use a redesign project that is defined in Philips. The project describes a real life business process that is performed at Philips Enterprise Information Management (Philips - EIM)

Eventually, the thesis concluded with discussion of the limitations and ideas for future work (Ch.5).

The thesis outline follows the research process conducted during the project execution. Figure 2 shows the activities carried out during the research with corresponding research questions and report chapters.

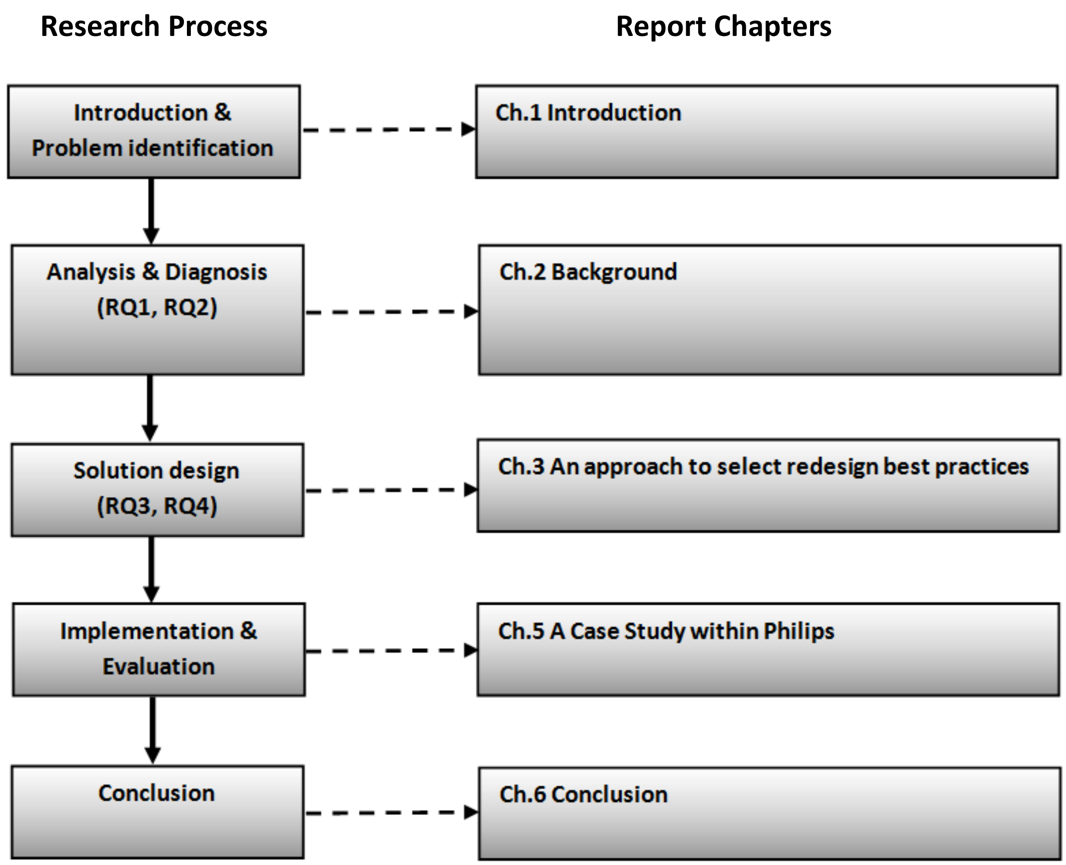


Figure 2: Thesis outline

2 Background

This chapter introduces preliminary concepts used throughout this thesis. Section 2.1 starts with a brief discussion on Business Process Redesign Framework which guides the practitioners in which topics should be taken into account when dealing with the implementation of BPR. Section 2.2 introduces 29 best practices identified by Reijers and Limam [14], to support the implementation of an improved process design. In section 2.3 an evaluation framework is presented. This framework helps assessing the effects of best practices on the redesigned business process. An introduction about the *multiple criteria decision analysis (MCDA)* concerned with structuring and solving decision using multiple criteria is given in Section 2.4. Finally, this chapter is concluded with Section 2.5 in which different forms of guidance for applying BPR best practices are briefly discussed.

2.1 Business Process Redesign Framework

Business process design or redesign of a business process varies on the primary aspect if this is the first time the process needs to be designed, developed and implemented or if there already exists a process that need to be modified. Literature shows that business process (re)design and engineering/reengineering are topics of research from the early 1980's. First available literature is from IBM [18] and CIMOSA [19].

Business Process Redesign (BPR) is dealt almost as an organizational initiatives and is handled through an organization. Frameworks in Business Process Redesign have been developed to handle the different influencing factors including soft aspects such as people, management, etc. Hence, the frameworks come with recommendation on the different aspects and views that need to be considered when redesigning a business process.

In the last 20 years, best practices have been collected and applied in various areas, such as business planning, healthcare, manufacturing, and software development [20]. In BPR field, the use of BPR best practices is a way to support the creation of one or more *to-be* processes from the *as-is* processes. A BPR best practice is a solution that has been applied previously and seems worthwhile to replicate in another situation or setting [14]. In order to help the users in choosing the correct best practices when dealing with the implementation of BPR, it is important to define a framework for it. As the nature of BPR, it is clear that the business process framework used for this perspective is on the design specification level.

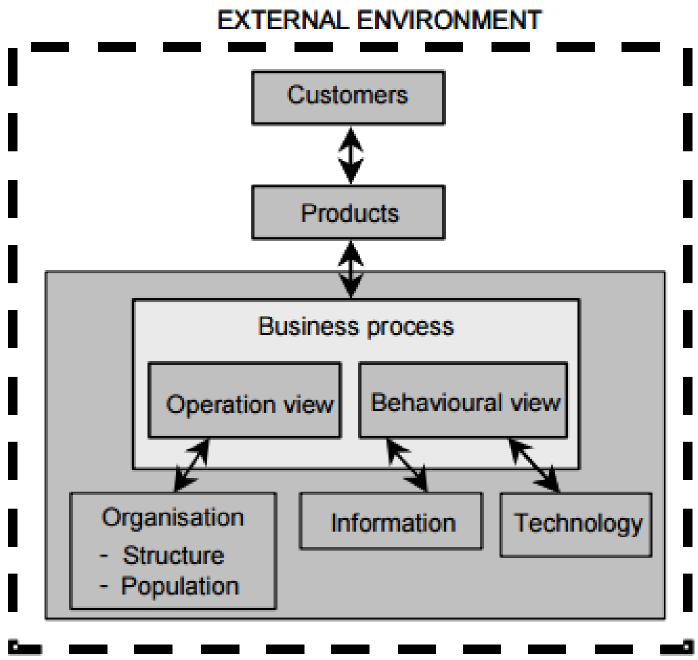


Figure 3: Final framework for BPR [14]

For this purpose, Reijers and Limam [14] presented a BPR framework in their paper. However, their framework did not emerge at once but evolved from different frameworks that have been developed throughout the time i.e. *Computer Integrated Manufacturing Open System Architecture (CIMOSA)* [19], *Work-centered Analysis Framework (WCA)* [21], and the *MOBILE model* [22]. Reijers and Limam offered the final framework of BPR by synthesizing the frameworks mentioned above to guide the practitioners in which topics should be taken into account when implementing BPR. This framework is presented in Figure 3.

The framework has six elements which are linked to each other [14]. These are:

- **The Customer**: this element considers the internal or external customers of a business process.
- **The Product**: this element covers all the products or services generated by a business process.
- **The Business Process**: this is the core element of the framework, considered with two views
    - **The operation view**: how is a workflow operation implemented? (number of task in a job, relative size of tasks, nature of tasks, degree of customization), and
    - **The behavior view**: when is a workflow executed? (sequencing of tasks, task consolidation, scheduling of job, etc.)
- **The Organization**: this element covers the organizational aspects of a workflow, including:
    - **The organization structure** (elements: roles, users, groups, departments, etc.) and
    - **The organization population** (individuals: agents which can have tasks assigned for execution and relationships between them)

- **The information**: it covers all inputs and outputs the business process uses or creates.

- **The technology**: this element covers all the technology the business process uses.

- **The external environment**: all issues outside the scope of the first six elements are under this element.

2.2 The Evaluation Framework (Devil's Quadrangle)

2.2.1 Performance dimensions

Reijers and Limam [14] presented a framework to access the effects of BPR best practices. This framework was proposed by Brand and Van der Kolk [15] where they introduced four main dimensions used to evaluate the effects of best practices. They are: *time*, *cost*, *quality* and *flexibility*. The evaluation framework can be seen below

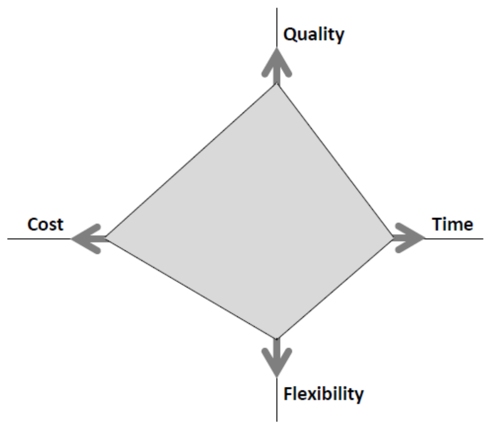


Figure 4: The Devil's Quadrangle

- **Quality dimension**: the way the new business process is generally perceived by its users (internal/ external customers).

- **Cost dimension**: a reduction in the operational costs of the redesigned process.

- **Time dimension**: a reduction in the throughput time (or similar time measures) of the new process.

- **Flexibility dimension**: the extent to which the new process offers more alternatives (in terms of resources and solutions) in delivering the product/ service.

This evaluation framework helps the practitioners to think about the possible outcomes of a best practice before implementing it. This is very important because we seems to think about the positive effects of a BPR best practice and miss its negative sides. With this framework, the tradeoffs are properly taken into account. And actually, the framework is called as the "Devil's Quadrangle" to reflect this tradeoff.

For instance, the *Task Elimination* best practice proposes to reduce the cost of handling an order but the drawback may be that the service deteriorates. Or, the *Parallelism* best practice can considerably reduces the throughput time of a business process. However, a drawback of introducing parallelism may be that the cost of process execution may increase. Also, the management of business process with concurrent behavior can become complex, which may introduce errors (quality reduced).

In conclusion, Reijers and Limam stated in their paper [14]:

"Ideally, a redesign of a business process decreases the time required to handle an order, it decreases the required cost of executing the business process, it improves the quality of the service delivered and it improves the ability of the business process to react to variation. The attractive property of their model is that, in general, improving upon one dimension may have a weakening effect on another."

2.2.2 Performance Measures

In the previous section, we discussed about the Devils' Quadrangle with four dimensions of performance: time, cost, quality and flexibility, which are depicted in Figure 4. Here, we would like to present the performance dimensions with related performance measures.

Performance measures are the indicators which quantify how well the organization/ process achieves a specific goal [23]. However, it would be impractical to mention all the possible performance measures of a business process. The target is, therefore, measuring only what is important i.e. thing has impact the customer satisfaction, etc.

Based on the information on the four dimensions of performance [15] [24] [25] [26] [27] [28] [29] [30], Netjes has derived a set of performance measures, specifically for business processes, which are the most common and straightforward relating to time, cost, quality and flexibility dimensions in Devil's Quadrangle [15]. Those measures are presented in Table 1.

Though lead time and throughput time are two important measures in process improvement, they are often used interchangeably in some cases, which naturally lead to the confusion in the goals of redesign effort. This should be noted that, specifically for the process workflows, there is a clear distinction between lead time and throughput time.

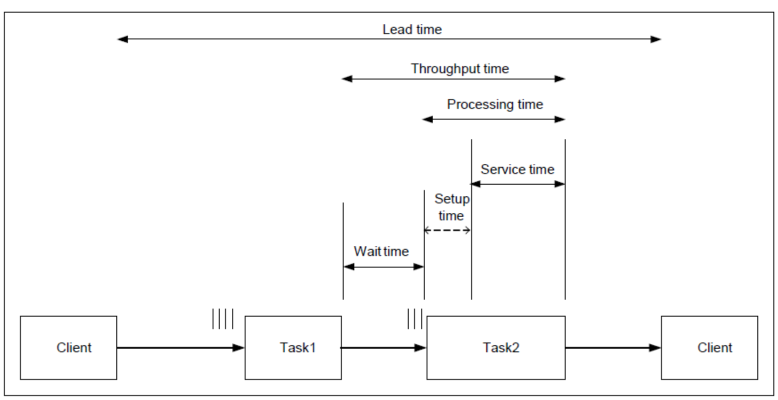


Figure 5: Performance measures - Time dimension [8]

As shown in Figure 5, lead time is the time span between a process starts and when it is completed, in other words, *the time it takes to handle an entire case* [8]. Lead time is important in business process as companies often want to reduce the time it takes to deliver the final products/ services to customers to keep it source of sustained competitive advantage. Components of lead time include wait time, setup time, and service time which are the three elements of throughput time. Like lead time, a short throughput time is also a competitive advantage.

Dimension	***Performance measures***	***Description***
Time	*Lead time*	*The time it takes to handle an entire case*
	Throughput time *(*) Throughput time is composed of: wait time, setup time, service time.*	*The time between the moment a task is completed for a specific case and the moment the next task for the same case is completed*
	Wait time	*The time a case spends on waiting (for instance in a queue)*
	Setup time	*The time it takes to setup a task for a case*
	Service time	*The time that resources spend on actually handling the case*
	Processing time	*The service time plus the setup time*
Cost	*Running costs* *(*) Running costs is composed of: labor costs, resources costs and training costs*	*Costs for executing the process*
	Labor costs	*Costs of the workforce*
	Resource costs	*An investment in, for instance, machinery to obtain (semi-)automation*
	Training costs	*Costs for training employees*
Quality	*External quality* *(*) External quality is composed of (1) and (2)* *(1) Quality of product* o *Product performance* o *Product conformance* o *Serviceability* *(2) Quality of process* o *Information availability* o *Quality of information*	*Client satisfaction with product/ process*
	Internal quality *(*) Internal quality is composed of (3), (4), (5), (6) and (7)* *(3) A whole and identified piece of work is completed* *(4) Variety of skills need to be used* *(5) The work has a substantial impact on the lives/ works of others* *(6) Substantial autonomy is provided* *(7) Direct and clear feedback about the performance effectiveness is available*	*Quality of a process from workers' perspective*

Flexibility	*Mix flexibility*	*The ability to process different types of cases (per resource, task or process)*
	Labor flexibility	*The ability to perform different tasks (per resource or per process)*
	Routing flexibility	*The ability to process a case using multiple routes*
	Volume flexibility	*The ability to handle changing volumes of input*
	Process modification flexibility	*The ability to modify the process*

Table 1: Performance measures [8]

2.3 BPR Best Practices

Business process redesign is one of the most powerful ways to boost the business performance and to improve the customer satisfaction [14]. A possible approach to BPR is using redesign best practices which help the practitioners to tackle *the technical challenge of BPR*.

Though the best practices were created by different researchers for different domains, Reijers and Limam identified and brought them together in their paper [14]. These best practices are classified under 6 elements of the final framework for BPR (Figure 3), and the Devil's Quadrangle (Figure 4) can be used to express the tradeoffs of possible outcomes of implementing a best practice . It is important to point out that these best practices should be seen as being on a lower, more operational level. Table 2 presents a set of 29 best practices including their effects on time, cost, quality and flexibility dimensions.

In addition, there are four perspectives on the process that need to be considered as applying BPR best practices [31]

- the **control flow perspective** describes the tasks in the process and their execution order,
- the **data perspective** focuses on the processing of data, imposing pre- and post-conditions on the task execution,
- the **resource perspective** involves the organizational structure i.e. the resources performing the task execution, and
- the **performance perspective** describes the performance of the process, i.e., how the process performs with respect to time, cost, etc.

Besides, best practices are discussed per class. As presented in [25], there are 6 classes of best practices:

- **Task rules**, focusing on the optimization of individual tasks in the process,
- **Routing rules**, attempting to improve upon the routing structure of the process,
- **Allocation rules**, improving allocation of the resources working on the process,
- **Resource rules,** focusing on the type and number of resources involved in the process,
- **Rules for external parties**, improving the collaboration and communication with the client and third parties, and
- **Integral workflow rules,** applicable to the process as a whole.

There is an affinity between the perspectives on the process and separate classes of best practices. For example the *task rules* and *routing rules* focus on the *control flow perspective*. Or, the allocation and resource rules mainly affect the resource perspective [8].

A list of best practices by Reijers and Limam [14] with name, a correlative class and the aspect of BPR framework is given in Appendix A.

Best practice	Description	Time	Cost	Quality	Flexibility
Control relocation	Move controls towards the customer	0	-	+	0
Contact reduction	Reduce the number of contacts with customers and third parties	+	-	+	0
Integration	Consider the integration with a business process of the customer or the supplier	+	+	0	-
Order types	Determine whether tasks are related to the same type of order and, if necessary, distinguish new business process	+	+	-	-
Task elimination	Eliminate unnecessary tasks from a business process	+	+	0	-
Order-based work	Consider removing batch-processing and periodic activities from a business process	+	-	0	0
Triage	Consider the division of a general task into two or more alternative tasks or consider the integration of two or more alternative tasks into one general task	+	+	+	-
Task composition	Combine small tasks into composite tasks and divide large tasks into workable smaller tasks	+	+	+	-
Resequencing	Move tasks to more appropriate places	+	+	0	0
Parallelism	Consider whether tasks may be executed in parallel	+	0/-	-	-
Knock-out	Order knock-outs in an increasing order of effort and in a decreasing order of termination probability	-	+	0	0
Exception	Design business processes for typical order and isolate exceptional order from normal flow	+	0	+	-
Order assignment	Let workers perform as many steps as possible for single orders	+	0	+	-
Flexible assignment	Assign resources in such a way that maximal flexibility is preserved for the near future	+	0	+	-
Centralization	Treat geographically dispersed resources as if they are centralized	+	-	0	+
Split responsibilities	Avoid assignment of task responsibility to people from different functional units	-	0	+	-
Customer teams	Consider assigning teams out of different departmental workers that will take care of the complete handling of specific sorts of orders	+	+	-	-
Numerical involvement	Minimize the number of departments, groups and persons involved in a business process	-	+	-	0

Case manager	Appoint one person as responsible for the handing of each type of order, the case manager	0	-	+	0
Extra resources	If capacity is not sufficient, consider increasing the number of resources	+	-	0	+
Specialist – Generalist	Consider to make resources more specialized or more generalist	+ (speci-alist)	0	0	+ (generalist)
Empower	Give workers most of the decision-making authority and reduce middle management	+	+	-	0
Control addition	Check the completeness and correctness of incoming materials and check the output before it is sent to the customer	-	+	+	0
Buffering	Instead of requesting information from an external source, buffer it by subscribing to updates	+	-	0	0
Task automation	Considering automating tasks	+	0	+	-
Integral business process technology	Try to elevate physical constraints in a business process by applying new technology	+	+	+	0
Trusted party	Instead of determining information oneself, use results of a trusted party	+	+	0	0
Outsourcing	Consider outsourcing a business process in whole or parts of it	0	+	-	0
Interfacing	Consider a standardized interface with customers and partners	+	+	+	0

Table 2: BPR best practices with their impacts [14]

2.4 Multiple Criteria Decision Analysis (MCDA)

There is currently a variety of approaches and methods that help prioritizing criteria and score alternatives, which are in general the *multiple criteria decision analysis (MCDA)* concerned with structuring and solving decision using multiple criteria. In this field, it is worth mentioning two decision making techniques: AHP and GRIP.

The *Analytic Hierarchy Process* (AHP) is a method developed by Saaty [32] for complex multi-criteria problems for which qualitative and qualitative aspects could be taken into account. AHP is widely used to classify alternatives based on a range of criteria. The core mechanism of AHP is pairwise comparison using discrete scale containing the value from 1 to 9. Pairwise comparisons produce weighting scores that measure how much importance items and criteria have with each other. Table 3 shows the scale measurement in-line with AHP algorithm.

Definition	Numerical Value
Extremely importance	9
Very strong to extremely	8
Very strong importance	7
Strongly to very strong	6
Strong Importance	5
Moderately to Strong	4
Moderate Importance	3
Equally to Moderately	2
Equal Importance	1

Table 3: Scale measurement for AHP [32]

The paired comparison of two items (item *i* and item *j*) is as follow:

(Item i) 9-8-7-6-5-4-3-2-1-2-3-4-5-6-7-8-9 (Item j)

For examples, item i is 5 times (*strong importance*) more important than item j or item i is 1 (*equal importance*) with item j, for a given criteria.

With the help of AHP software [1], criteria are prioritized and alternatives are then scored.

Another noticeable method called *Generalized Regression with Intensities of Preference* (GRIP) for ranking a finite set of actions evaluated on multiple criteria [33]. GRIP can be compared to AHP, which can also express the intensity of preference. However, in AHP, this intensity can be transferred into quantitative terms (scale from 1 to 9), meanwhile in GRIP there is no such transformation. For this reason, it makes AHP easier to use and more intuitive for users than GRIP. Besides, AHP was used for variety of decision making problems to achieve better outcomes [34]. It is, therefore, well-proven. Last but not least, with a set of comparison, it is often difficult to be consistent; or it even takes long time to identify and fix all the inconsistencies. Fortunately, AHP software can help us to validate those judgments and even check its consistency.

2.5 Analysis of existing guidelines

Although there are various papers addressing BPR and BPR best practices [5] [6] [7] [8] [9] [10], little is known about the general guidelines as for the application of BPR best practices. Valiris and Glykas [11] identified "*there is a lack of systematic approach that can lead a process redesigner through a series of steps for the achievement of process design*". At this moment in time, though there exists different forms of guidance for applying BPR best practices, they are still limited in their application domain and not adopted broadly in industry [12]. In this section, we would like to mention some of them to identify the potential gaps and improvements.

1. The paper by Buzacott [9] is one of the few papers trying to assess the validity of reengineering rules proposed by Hammer and Champy [35]. These rules are presented in Figure 6. While his work indicated that "the

[1] http://bpmsg.com/academic/ahp_calc.php

reengineering principles are not always valid in all situations", they have great value in structuring the business processes. Unfortunately there does not seem to be an approach for the design team in deciding which reengineering rules are applicable for the current business process.

1. Several task are combined into one
2. Workers make decisions
3. The steps in the process are performed in a natural order
4. Processes have multiple versions
5. Work is performed where it makes the most sense
6. Checks and controls are reduced
7. Reconciliation is minimized
8. A case manager provides a single point of contact
9. Hybrid centralized/decentralized operations are prevalent

Figure 6: Reengineering rules based on Hammer and Champy [35]

2. In his study [36], Wil van der Aalst proposed an approach to re-engineer knock-out processes with three easy-to-apply steps, based on his Propositions and Heuristics: (1) Determine the ordering of tasks, (2) Combine tasks and (3) Determine whether it makes sense to handle tasks in parallel. This approach is proven to help the practitioners obtain an "optimal" process regarding the utilization of resources and flow time. It should be noted that both the result of this study and the mentioned approach only hold for knock-out processes, which implies that his work still has not solved the problem of lacking the general guidelines for redesigning business process using best practices.

3. Jansen-Vullers, Kleingeld, Loosschilder, Netjes and Reijers [37] came up with an approach to quantify the impact of redesign best practices i.e. the parallel, the knockout and triage best practices along the dimensions of time, cost and flexibility. With the lack of information regarding the impact of remaining best practices, this approach still could not support the identification of the correct choice when selecting a redesign best practice to improve a specific performance dimension. Hence, the guideline about what best practices should be applied in what situation, process remains unsolved.

4. Netjes [8] presented the approach for Process Improvement by Creating and Evaluating process alternatives (in short: the PrICE approach), which "*describes and supports the steps to derive from an existing process a better performing one*". The PrICE approach consists of four steps: (1) Find the applicable redesign operation, (2) Select suitable process parts, (3) Create alternative models and (4) Evaluate performance of alternatives, as depicted in Figure 7.

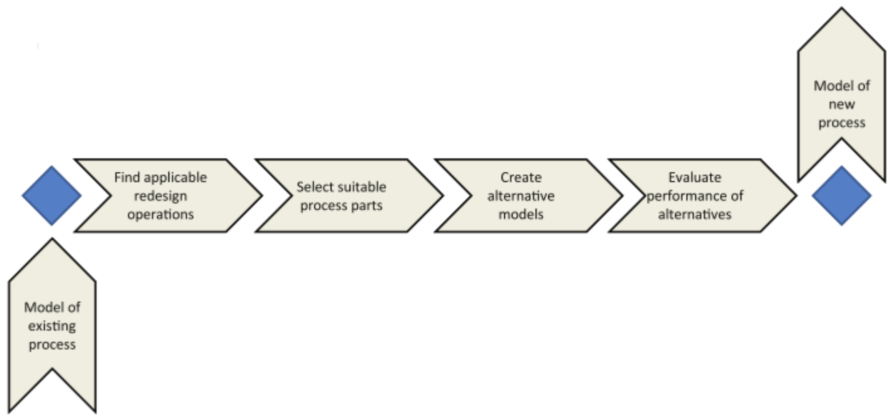


Figure 7: The PrICE approach [8]

Here, we would like to study in detail the first step "Find applicable redesign operations" since it is well-aligned with the goal of our research.

As indicated, the first step of the PrICE approach is to find the applicable redesign operations, thus BPR best practices ("*a redesign operation performs the concrete process change that is described by the related BPR best practice*" [8]). According to Netjes, the calculation of the process measures for the existing process model is a way to find applicable best practices. Besides the measures included from Nissen [38], Netjes developed eight new measures. Definition of these process measures can be seen in Table 4 (measures that originate from Nissen's set are marked with a *).

The next step is the evaluation of the condition statements for each BPR best practices. Each condition statement is connected to one best practice, and the application of a certain best practice is suggested when the condition statement is fulfilled. In her work, Netjes has created condition statements for 17 out of 29 best practices proposed by Reijers and Limam [14], as shown in Table 5.

Process measures with range [0, ..., 1]		
Parallelism*	$= \frac{\lvert T_{par} \rvert}{\lvert T \rvert}$, perc. of parallel tasks[1]	
Process contacts	$= \frac{\lvert \{t \in T \mid communication \in C(t)\} \rvert}{\lvert T \rvert}$, perc. of communication tasks	
Batch	$= \frac{\lvert \{t \in T \mid batch \in C(t)\} \rvert}{\lvert T \rvert}$, perc. of batch tasks	
Periodic	$= \frac{\lvert \{t \in T \mid periodic \in B(t)\} \rvert}{\lvert T \rvert}$, perc. of periodic tasks	
Level of control	$= \frac{\lvert \{t \in T \mid check \in C(t)\} \rvert}{\lvert T \rvert}$, perc. of control tasks	
Level of authorization	$= \frac{\lvert \{t \in T \mid authorize \in C(t)\} \rvert}{\lvert T \rvert}$, perc. of authorization tasks	
IT automation*	$= \frac{\alpha \cdot \lvert \{t \in T \mid ET(t) \neq \emptyset \wedge t \notin dom(A)\} \rvert + \beta \cdot \lvert \{t \in T \mid ET(t) \neq \emptyset \wedge t \in dom(A)\} \rvert}{(\alpha + \beta) \cdot \lvert T \rvert}$, perc. of (semi-)automated tasks	
IT comm.*	$= \begin{cases} \frac{\lvert \{t \in T \mid digital \in B(t) \wedge communication \in C(t)\} \rvert}{\lvert \{t \in T \mid communication \in C(t)\} \rvert}, & for\ \{t \in T \mid communication \in C(t)\} \neq \emptyset \\ 1, & for\ \{t \in T \mid communication \in C(t)\} = \emptyset \end{cases}$	
Department involvement*	$= \frac{\lvert D \rvert}{\lvert T \rvert}$, perc. of departments	
Department share	$= \frac{\lvert \{t \in T \mid \lvert DT(t) \rvert \geq 2\} \rvert}{\lvert T \rvert}$, perc. of tasks shared by departments	
Process hand offs*	$= \frac{\lvert \{t_1, t_2 \in T \mid t_1 \bullet \cap \bullet t_2 \neq \emptyset \wedge AH(t_1) \cap AH(t_2) = \emptyset\} \rvert}{\lvert \{t_1, t_2 \in T \mid t_1 \bullet \cap \bullet t_2 \neq \emptyset\} \rvert}$, perc. of work that is handed over to another role	
Specialization*	$= \frac{\lvert \{A(t) \mid t \in dom(A)\} \rvert}{\lvert T \rvert}$, specialization of roles (with a higher perc. meaning more specialists)	
Role usage*	$= \frac{\lvert \{A(t) \mid t \in dom(A)\} \rvert}{\lvert R \rvert}$, perc. of actively involved roles	
Managerial layers*	$= \frac{\lvert lrp \rvert}{\lvert R \rvert}$, perc. of hierarchical layers[2]	
Knock outs	$= \frac{\lvert \{p \in P \mid \lvert \bullet p \rvert > 1 \wedge (\forall_{t \in \bullet p}\ check \in C(t) \wedge S(t) = XOR \wedge \lvert t \bullet \rvert > 1) \wedge (\exists ep \in EP_{PN} \mid \bullet p \subseteq \lvert\lvert ep \rvert\rvert)\} \rvert}{\lvert P \rvert}$, perc. of k.outs[3]	
		Range
Process size*	$= \lvert T \rvert$, the number of transitions	[1, 2, ..., number of transitions]
Versions	$= \lvert G \rvert$, the number of products and services	[1, 2, ..., number of products and services]
User involvement*	$= \frac{\lvert U \rvert}{\lvert T \rvert}$, the average number of users per task	[0, ..., 1, ..., number of users]

Table 4: Process measures

Best practice	**Condition statement**
Task Elimination	*Level of control* > 0.2
Task Automation	*IT automation* < 0.5 OR (*IT communication* < 0.5 AND *Level of control* > 0.2)
Knock-Out	*Knock outs* > 0
Parallelism	*Parallelism* < 0.2
Split Responsibilities	*Department share* > 0
Numerical Involvement	*Department involvement* > 0.25 OR *User involvement* > 1 OR *Role usage* < 0.5
Specialist - Generalist	*Specialization* < 0.3 [more generalists working on current process] OR *Specialization* > 0.7 [more specialized roles in current process]
Contact Reduction	*Process contacts* > 0.1
Case Types	*Process versions* > 1
Technology	*IT automation* < 0.5 OR (*Parallelism* < 0.25 AND *Process hand offs* > 0.5)
Case-Based Work	*Batch* > 0 OR *Periodic work* > 0
Task Addition	*Level of control* < 0.05
Task Composition	*Parallelism* < 0.25 AND *Process hand offs* < 0.3 AND *Process versions* < 2
Control Relocation	*Level of control* > 0.2 AND *IT communication* > 0.5
Triage	*Process versions* > 1 AND User involvement > Process versions
Case Manager	*IT automation* > 0.75 AND *Process contacts* > 0.2
Empower	*Managerial layers* > 0.2 AND *Level of authorization > 0.1*

Table 5: Condition statements

To illustrate the calculation of process measure and the evaluation of the condition statements, Netjes applied them to the process of handling insurance claim.

The process handles the insurance claims of both individual and business clients. The process starts when a claim is received. After receipt, the claim is classified as "individual" or "business". Then the claim is checked for validity. Three checks, Check policy, Check amount (only for business clients, requires the receipt of a damage report) and Check legal are performed. A check either results in OK (proceed with next check) or not OK (reject claim). Claims that pass all checks are accepted and paid. Payments are authorized at the end of each day by the finance manager. For all claims (both rejected and accepted) a letter is written and the claim is archived. The Protos model is depicted in Figure 8.

Using the set of measures defined in Table 4, process measures are computed, which are presented in Table 6.

Parallelism = 0	*Department share = 0.1*
Process contacts = 0.2	*Process hand offs = 0.4*
Batch = 0	*Specialization = 0.7*
Periodic = 0.1	*Role usage = 0.7*
Level of control = 0.3	*Managerial layers = 0.3*
Level of authorization = 0.1	*Knock outs = 0.1*
IT automation = 0.2	*Process size = 10*
IT communication = 0	*Process versions = 2*
Department involvement = 0.3	*User involvement = 2*

Table 6: Values for process measures

Using Table 5 and Table 6, it is shown that the first 11 of the 17 condition statements evaluate to true for the current insurance claim process. The related best practices e.g. Task Elimination, Task Automation, Knock-Out, Parallelism, Split Responsibilities, Numerical Involvement, Specialist – Generalist, Contact Reduction, Case Types, Technology, Case-Based Work are therefore most likely to be applicable for the redesign of this process.

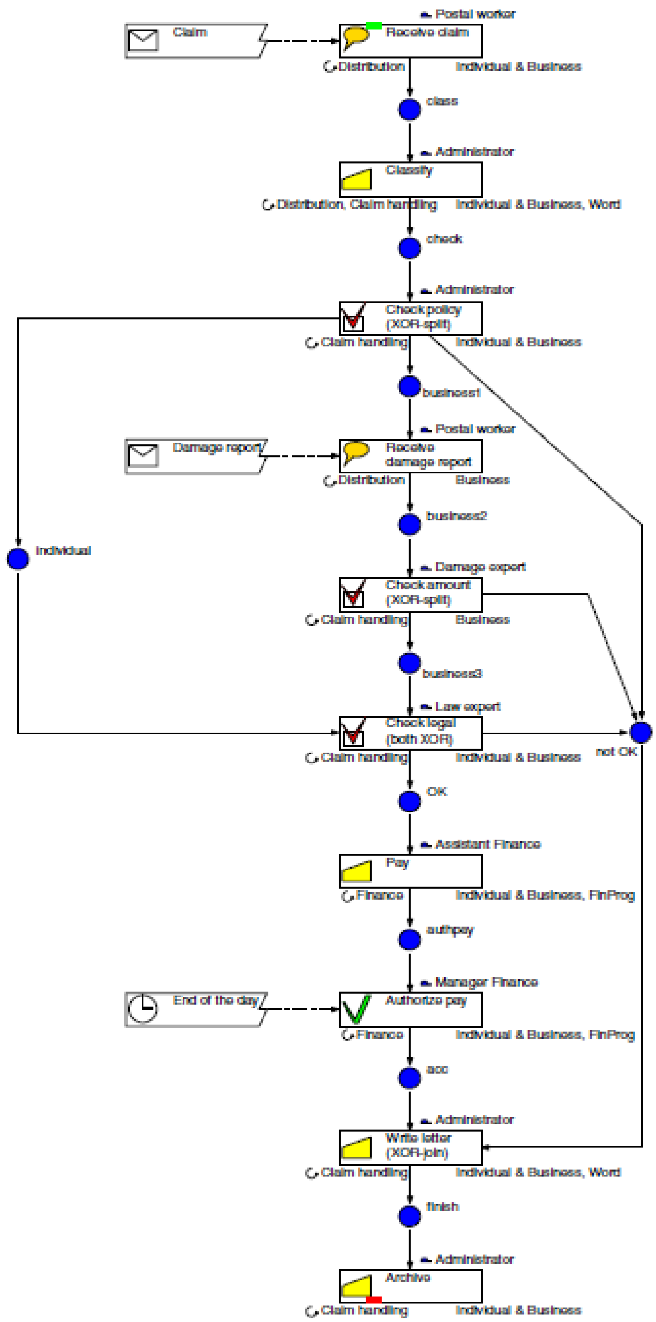


Figure 8: The insurance claim process modeled in Protos

Though the approach by Netjes has contribution in "the proposal of the applicable best practices" [12], as we have seen, it holds some limitations:

1. The improvement of the existing process is driven by the structural characteristics of the process model i.e. the number of activities, the percentage of parallel activities, etc. Given that, Netjes proposed formal notations to define the process measures (Table 4), which can be seen as a systematic way to understand about the weakness of a process. However, a proper computation requires extensive knowledge of Workflow net (WF-net) and annotated WF-net. It is even time-consuming and error-prone if it is done by hand. Besides, the condition statements used to find applicable BPR best practices (Table 5) are "*an initial proposal and not thoroughly validated*" [8].

2. Netjes' approach is not covering the whole set of 29 best practices indicated by Reijers and Limam [14]. It targets instead only 17 best practices. Hence, the step "Find applicable redesign operations" of the approach could not reveal the complete applicable best practices.

5. Vanwersch's work [39] presented an application procedure supporting practitioners in generating improvement ideas for care processes using a set of RePro principles. This set is a combination of two groups of principles: BPR best practices [14] which support redesigning processes and TRIZ innovation principles [40] which provide support for innovating products. All these principles address one of the aspects of a care process: customer, external environment, tasks, task order and timing, human resources, facilities, equipment and material, information, information and communication technology or physical lay-out. The developed procedure is contended "to have the potential to advance support for rethinking care processes". However, it is still limited in its application domain i.e. redesigning care processes and hence not widely adopted in industry. Besides that, the procedure presented by Vanwersch does not introduce the guidance for selecting applicable best practices. Vanwersch made use of multi-level design approach "*assuming that service systems can be designed on different levels of abstraction. This approach separates concerns and starts with redesigning the to-be at a relatively high level of abstraction, i.e. the to-be serivce concept. Subsequently, two lower levels of abstraction related to the to-be process are successively considered*" [39].

In summary, the main shortcoming of the above-mentioned literatures is that none of them provides guidelines for redesigning business processes using BPR best practices, based on their expected impact on the performance of the process, which is ultimately our goal in this research.

3 An approach to select redesign best practices

Although it is suggested that BPR should be pertinent to organizational goals and strategy, this pertinence does not occur in reality [41]. Thus, it is a challenge to apply these BPR best practices, which align well with the goal(s)/ objectives(s).

Studying and evaluating best practices in the literature by Reijers and Limam [14], our research comes up with an *approach for identifying applicable best practices based on their expected impact on the performance of the process*, taking into account that the business process is redesigned to obtain better performance i.e. low cost, high quality, high flexibility, etc.

Netjes' work [8] has inspired us to develop an approach to find the applicable best practices that nonetheless has some different backbones:

1. Our approach is developed from a different starting point. Instead of computing the process measures to spot the inefficiencies in the process, we begin with the initial redesign goals e.g. improvement on throughput time or reduce operational cost, etc. The redesign goals can be grouped under one or more measures of performance i.e. time, cost, quality and flexibility resulted from the Devil's Quadrangle performance dimensions [15], which would allow the practitioners in selecting the applicable best practices, with reference to the list of impacts on business process of best practices by Reijers and Limam (Table 7). For example, if the goal of redesign is improvement on throughput time, then all of the applicable BPR best practices should have an impact on time, specifically reducing the time.

2. On account of the limitation about the completeness in Netjes' work, in our approach, we would like to address the whole set of 29 best practices. Our proposal for the applicable best practices is therefore more practical.

Framework elements	Best practice	Impact on BP
Customer	Control relocation	Quality ↑, Cost ↑
	Contact reduction	Time ↓, Quality ↑, Cost ↑
	Integration	Time ↓, Flexibility ↓, Cost ↓
Operation view	Order types	Time ↓, Flexibility ↓, Cost ↓, Quality ↓
	Task elimination	Time ↓, Flexibility ↓, Cost ↓
	Order-based work	Time ↓, Cost ↑
	Triage	Time ↓, Flexibility ↓, Cost ↓, Quality ↑
	Task composition	Time ↓, Flexibility ↓, Cost ↓, Quality ↑
Behavioral view	Resequencing	Time ↓, Cost ↓
	Parallelism	Time ↓, Flexibility ↓, Cost ↑, Quality ↓
	Knock-out	Time ↑, Cost ↓
	Exception	Time ↓, Flexibility ↓, Quality ↑
Organizational structure	Order assignment	Time ↓, Flexibility ↓, Quality ↑
	Flexible assignment	Time ↓, Flexibility ↓, Quality ↑
	Centralization	Time ↓, Flexibility ↑, Cost ↑
	Split responsibility	Time ↑, Flexibility ↓, Quality ↑
	Customer team	Time ↓, Flexibility ↓, Cost ↓, Quality ↓
	Numerical involvement	Time ↑, Quality ↓, Cost ↓
	Case manager	Quality ↑, Cost ↑
Organization: population	Extra resources	Time ↓, Flexibility ↑, Cost ↑
	Specialist-Generalist	Time ↓, Flexibility ↑
	Empower	Time ↓, Quality ↓, Cost ↓
	Control addition	Time ↑, Quality ↑, Cost ↓
Information	Buffering	Time ↓, Cost ↑
Technology	Task automation	Time ↓, Flexibility ↓, Quality ↑
	Integral BP Technology	Time ↓, Quality ↑, Cost ↓
External environment		Time ↓, Cost ↓
	Trusted party	Quality ↓, Cost ↓
	Outsourcing	Time ↓, Quality ↑, Cost ↓
	Interfacing	

Table 7: Impact of best practices on business process indicated by Reijers and Limam [14]

In addition, our approach will be developed based on the prior knowledge:

- The Devil's Quadrangle [15], a framework for performance measures that can be used to evaluate the effect of a redesign with the dimensions of time, cost, quality and flexibility.

- An extended framework, proposed by Reijers and Limam [14] which helps the practitioners in identifying different topics and choosing the correct best practices when dealing with the implementation of BPR.

- 29 best practices that can be used for business process redesign [14].

- Impacts of best practices along the dimensions of time, cost, quality and flexibility [14]. Table 7 presents the potential effects and possible drawback of each best practice.

In general, our approach consists of 4 main steps, as depicted in Figure 9 .

Figure 9: Approach for identifying applicable BPR best practices

3.1 Find the performance measurements

Any redesign implementation targets a need for a business process improvement to some specific areas e.g. improve customer service, reduce costs, reduce service time, etc. Performance measures are the indicators which quantify how well the organization/ business process achieves a specific goals [23]. Having a list of qualitative/ quantitative performance measures of a process helps the practitioner in deciding whether the process is in line which what is expected. Also, it provides a solid basic for defining the goal of the redesign effort.

A list of performance measures identified by Netjes [8] (Table 1) is used for our approach.

Throughout this approach, we will use a running example to illustrate our ideas. The redesign team is concerned with the selection of best practices that can improve the flexibility, both internal and external quality of a current business process.

3.2 Define & Prioritize BPR goals

3.2.1 Defining BPR goals

"While the performance dimensions of Devil's Quadrangle are helpful to think of the desired effects of business process redesign in general and for a particular business process in particular, they are also useful to think about common approach to improve business process" [42]

Different goals may lead to different redesign options. Explicitly defining the goal is, therefore, of a vital need before the start of any redesign project.

Based on the performance measures resulted from step 1, the practitioner identifies the goal(s) of redesign effort. These goals are grouped under the dimensions of time, cost, quality and flexibility (Devil's Quadrangle [15]). In particular, these goals are defined in terms of time/cost reduction, quality/flexibility improvement. For example, the goal of redesign effort is often reducing the lead time [43]. Also, it is very common to reduce the labor cost [43]. In practice, goals are usually fall into the following categories: *Goals of BPR relating to time*, *goals of BPR relating to cost*, *goals of BPR relating to quality* and *goals of BPR relating to flexibility*. Detailed information is presented in Table 8.

Goals of BPR relating to time	***Goals of BPR relating to cost***
• Reducing lead time • Reducing throughput time • Reducing wait time • Reducing setup time • Reducing service time • Reducing processing time	• Reducing labor costs • Reducing resource costs • Reducing training costs • Reducing running costs
Goals of BPR relating to quality	***Goals of BPR relating to flexibility***
• Improving product performance • Improving product conformance • Improving serviceability • Improving the availability of information • Improving the quality of information • Improving the degree to which a whole and identifiable piece of work is completed • Improving the variety of skills • Improving the impact of work on the lives/ works of others • Improving the substantial autonomy • Improving the availability of feedback about the performance effectiveness	• Improving the mix flexibility • Improving the labor flexibility • Improving the routing flexibility • Improving the volume flexibility • Improving the process modification flexibility

Table 8: Goals of BPR

In many cases, organizations have their own goals/ objectives for the BPR effort. As long as these goals are relating to the performance dimensions in Devil's Quadrangle [15]; our approach is still hold.

In redesigning a business process, there is usually a host of main goals that need to be addressed when choosing among alternatives e.g. reducing time, reducing cost, improving quality and improving flexibility. Given that, goal can be formulated as **single goal** i.e. goal relating to one dimension, such as:

- Reducing time, reducing wait time, reducing lead time, etc.
- Reducing cost, reducing labor costs, reducing the training costs, etc.
- Improving quality, improving external quality improving internal quality, etc.
- Improving flexibility, improving labor flexibility, improving volume flexibility, etc.

Or, one can also formulate **complex goal** i.e. goal relating to more than one dimension depending on the specific context. For example, the complex goal can be reducing the waiting time and training costs (relating to 2 dimensions); or, reducing cost and also improve the external quality and flexibility (relating to 3 dimensions), etc.

As in our running example, the complex goal includes improving flexibility, improving both internal and external quality of a business process.

3.2.2 Prioritizing BPR goals

Ideally, the process redesign should result in the improvements of these four dimensions. However, there is always a tradeoff between them. In general, improving upon one dimension may have a weakening effect on another [14]. For example, it appears that some measures of quality are in conflict with cost. Or, improving the quality aspect may have a drawback on the timeliness. Hence, before stepping into the redesign phase i.e. finding the suitable best practices, we need to work out how important those goals/ criteria are. AHP is used as a multi-criteria method to help us weight and prioritize BPR goals.

Having the BPR goals identified in the previous step, we do the pairwise comparison of goals of BPR. With the help of AHP priority calculator[2], we can obtain their resulting weights/ priorities.

For our running example, the BPR goal includes improving flexibility, improving both internal and external quality. The redesign team has done the pairwise comparisons with respect to the AHP scales, as follow:

- Improving External Quality is 2 times (**equally to moderately**) more important than improving Flexibility
- Improving External Quality is 3 times (**moderate importance**) more important than improving Internal Quality
- Improving Flexibility is 2 times (**equally to moderately**) more important than improving Internal Quality

In the AHP priority calculator, we can fill in these comparisons as shown in Figure 10.

[2] http://bpmsg.com/academic/ahp_calc.php

	A - Importance - or B?			Equal	How much more?
1	(●) Improving External Quality	or	( ) Improving Flexibility	( ) 1	(●) 2 ( ) 3 ( ) 4 ( ) 5 ( ) 6 ( ) 7 ( ) 8 ( ) 9
2	(●) Improving External Quality	or	( ) Improving Internal Quality	( ) 1	( ) 2 (●) 3 ( ) 4 ( ) 5 ( ) 6 ( ) 7 ( ) 8 ( ) 9
3	(●) Improving Flexibility	or	( ) Improving Internal Quality	( ) 1	(●) 2 ( ) 3 ( ) 4 ( ) 5 ( ) 6 ( ) 7 ( ) 8 ( ) 9

Figure 10: Pairwise comparison example

Based on these comparisons, the resulting weights for the BPR goals can be obtained, as presented in Figure 11

	Category	Priority	Rank
1	Improving External Quality	54.0%	1
2	Improving Flexibility	29.7%	2
3	Improving Internal Quality	16.3%	3

Figure 11: Resulting weights example

By this point, we have prioritized goals according to their relative importance. The ability to systematically use these goals i.e. the indicators of time, cost, quality and flexibility; together with their weights/ priorities to select applicable redesign best practices is discussed in details in the next step.

3.3 Identify best practices aligned with BPR goal

"Sometimes, the effect of a redesign measure may be that the result from some point of view is worse than the existing business process. Also, the application of several best practices may result in the (partly) neutralization of the desired effects of each of the single measures" [14].

Provided the references to Reijers and Limam's work [14] which presents the potential effects and possible drawbacks for each best practice along the dimensions of time, cost, quality and flexibility (Devil's Quadrangle [15]), we aim to indicate these effects in more details i.e. along the set of performance measures, originating from Netjes' work [8] (Table 1). We believe that in presenting the qualitative assessments of best practices in such that manner, we provide more support for the application of BPR best practices. Moreover, these effects are proposed to guide the practitioners to explore the goal(s) of redesign project.

For example, it was stated in Reijers and Limam [14] that *Split Responsibility* best practice can lead to a better quality of task execution, a positive effect on the quality dimension. However, reducing the overlap in responsibility also means higher responsiveness. Customers are, therefore, served quicker, hence positive effect on external quality in particular. Or, *Task Elimination* best practice is stated by Reijers and Limam to have positive effects on cost dimension. By our own reasoning, we realize that it might reduce the labor costs in particular as eliminating task, in many cases, also means reducing the concerned workforce and therefore costs of the workforce.

In that sense, we extend the table of impacts of BPR best practices through 3 main steps:

1. We adopt a list of BPR best practice impacts along the time, cost, quality and flexibility dimensions defined by Reijers and Limam [14] as our starting point.

2. By literature study/review, we extend these impacts along the set of performance measures from Netjes' work [8].

3. By our own qualitative analysis, we put additions to these impacts.

As a result, the impact of best practices by Reijers and Limam [14] is extended along the set of performance measures from Netjes' work [8], as introduced in Table 9 with the detailed explanation (in Appendix B). Our main contribution is stated in blue.

The alignment between best practices and the goal(s) of BPR is assessed in Table 9, in which the alignment is stated as "*+*" (positive effect), non-alignment as "*-*" (negative effect) and "*0*" stands for "no effect expected", according to Reijers and Limam's work [14]. It should be noted that *these impacts of best practices lack a quantitative support.*

	Time						Costs				Quality		Flexibility				
	LT	TT	WT	SUT	ST	PT	RNC	LC	RC	TC	EQ	IQ	MF	LF	RF	VF	PF
Customer																	
Control relocation	0						-	-	0	0	+	0	0				
Contact reduction	+	+	+	0	0	0	-	-	0	0	+	0	0				
Integration	+	+	0	0	0	0	+	+	+	0	0		-	-	-	-	-
Operation view																	
Order types	+	+	0	+	0	+	+	+	+	0	-	-	0	0	0	0	-
Task elimination	+	0	0	0	0	0	0	+	0	0	0	0	-				
Order-based work	+	+	+	0	0	0	0	0	-	0	0		0				
Triage	+	+	+	0	0	0	+	+	+	0	+	0	0	-	0	0	0
Task composition	+	+	0	+	0	0	+	+	0	0	+	0	0	-	0	-	0
Behavioral view																	
Resequencing	+	+	0	+	0	0	+	+	0	0	0		0				
Parallelism	+	+	0	0	0	0	-	-	0	0	-	-	0	-	0	-	0
Knock-out	-	-	0	0	0	0	+	+	0	0	0		0				
Exception	+	+	0	+	+	+	0				+	+	0	-	0	0	0
Organization																	
Order assignment	+	+	0	+	0	+	0				+	0	0	-	0	0	0
Flexible assignment	+	+	+	+	+	+	0				+	0	0	-	0	0	0
Centralization	+	+	0	0	0	0	-	0	-	0	0		0	+	0	0	0
Split responsibility	-	-	-	0	0	0	0				+	+	0	-	0	0	0
Customer team	+	+	0	+	+	+	+	+	0	0	+	+	0	-	0	0	0
Numerical involvement	-	-	0	-	-	-	+	+	0	0	-	0	0				
Case manager	0						-	-	0	0	+	+	0				
Population																	
Extra resources	+	+	+	0	0	0	-	-	0	0	0		0	+	0	0	0
Specialist (S)-Generalist (G)	+	+	0	+ (S)	+ (S)	+ (S)	0				+ (S)	0	0	+ (G)	0	0	0
Empower	+	+	0	0	0	0	+	+	0	0	-	0	0				
Information																	
Control addition	-	0	0	0	0	0	+	+	0	0	+	0	0				
Buffering	+	+	0	0	0	0	-	0	-	0	0		0				
Technology																	
Task automation	+	+	0	+	+	+	0				+	0	-	+	0	0	0
Integral BP technology	+	+	0	+	+	+	+	+	0	0	+	-	0				
External environment																	
Trusted party	+	+	0	0	0	0	+	+	0	0	0		0				
Outsourcing	0						+	+	+	0	-	-	0				
Interfacing	+	+	0	0	+	+	+	+	0	0	+	0	0				

Table 9: Extended impacts of best practices on time, cost, quality and flexibility dimensions

LT: lead time, TT: throughput time, WT: wait time, SUT: setup time, ST: service time, PT: processing time, RNC: running costs, LC: labor costs, RC: resource costs, TC: training costs, EQ: external quality, IQ: internal quality, MF: mix flexibility, LF: labor flexibility, RF: routing flexibility, VF: volume flexibility, PF: process modification flexibility

From step 2 of the approach, the weights of BPR goals can be obtained; for examples:

- Rank 1 – Reducing time: m%
- Rank 2 – Reducing cost: n%
- Rank 3 – Improving quality: o%
- Rank 4 – Improving flexibility: p%

The goals are then scored as follow:

	Positive effect (+)	Negative effect (-)	No effect expected (0)
First (important) goal (rank 1)	+m	-m	0
Second (important) goal (rank 2)	+n	-n	0
Third (important) goal (rank 3)	+o	-o	0
Fourth (important) goal (rank 4)	+p	-p	0

Table 10: Goal scores

As in our running example, the resulting weights for BPR goals are:

- Improving External Quality: 54.0%
- Improving Flexibility: 29.7%
- Improving Internal Quality: 16.3%

Goals are then scored as below:

	Positive effect (+)	Negative effect (-)	No effect expected (0)
Improving External Quality	+54.0	-54.0	0
Improving Flexibility	+29.7	-29.7	0
Improving Internal Quality	+16.3	-16.3	0

Table 11: Goal scores for running example

We walk through the list of best practices in Table 9 and do the scoring for each of the best practice. Next, adding up the scores of each best practice and ranking these results from high to low. Its purpose is generating a prioritized list of best practices that are worthwhile to consider.

The ones ranked highest are the most likely to be applicable for the redesign of a business process.

To illustrate the selection of applicable best practices, we applied them to our running example, using the goal scores identified in Table 11.

	Time						Costs				Quality		Flexibility					Result
	LT	TT	WT	SUT	ST	PT	RNC	LC	RC	TC	EQ	IQ	MF	LF	RF	VF	PF	
Customer																		
Control relocation	0						-	-	0	0	+54	0	0					54
Contact reduction	+	+	+	0	0	0	-	-	0	0	+54	0	0					54
Integration	+	+	0	0	0	0	+	+	+	0	0		-	-29.7	-	-	-	-29.7
Operation view																		
Order types	+	+	0	+	0	+	+	+	+	0	-54	-16.3	0	0	0	0	-29.7	-100
Task elimination	+	0	0	0	0	0	0	+	0	0	0	0	-29.7					-29.7
Order-based work	+	+	+	0	0	0	0	0	-	0	0		0					0
Triage	+	+	+	0	0	0	+	+	+	0	+54	0	0	-29.7	0	0	0	24.3
Task composition	+	+	0	+	0	0	+	+	0	0	+54	0	0	-29.7	0	-	0	24.3
Behavioral view																		
Resequencing	+	+	0	+	0	0	+	+	0	0	0		0					0
Parallelism	+	+	0	0	0	0	-	-	0	0	-54	-16.3	0	-29.7	0	-	0	-100
Knock-out	-	-	0	0	0	0	+	+	0	0	0		0					0
Exception	+	+	0	+	+	+	0				+54	+16.3	0	-29.7	0	0	0	40.6
Organization																		
Order assignment	+	+	0	+	0	+	0				+54	0	0	-29.7	0	0	0	24.3
Flexible assignment	+	+	+	+	+	+	0				+54	0	0	-29.7	0	0	0	24.3
Centralization	+	+	0	0	0	0	-	0	-	0	0		0	+29.7	0	0	0	29.7
Split responsibility	-	-	-	0	0	0	0				+54	+16.3	0	-29.7	0	0	0	40.6
Customer team	+	+	0	+	+	+	+	+	0	0	+54	+16.3	0	-29.7	0	0	0	40.6
Numerical involvement	-	-	0	-	-	-	+	+	0	0	-54	0	0					-54
Case manager	0						-	-	0	0	+54	+16.3	0					70.3
Population																		
Extra resources	+	+	+	0	0	0	-	-	0	0	0		0	+29.7	0	0	0	29.7
Specialist (S)-Generalist (G)	+	+	0	+ (S)	+ (S)	+ (S)	0				+54 (S)	0	0	+29.7 (G)	0	0	0	83.7
Empower	+	+	0	0	0	0	+	+	0	0	-54	0	0					-54
Information																		
Control addition	-	0	0	0	0	0	+	+	0	0	+54	0	0					54
Buffering	+	+	0	0	0	0	-	0	-	0	0		0					0
Technology																		
Task automation	+	+	0	+	+	+	0				+54	0	-	-29.7	0	0	0	24.3
Integral BP technology	+	+	0	+	+	+	+	+	0	0	+54	-16.3	0					37.7
External environment																		

Trusted party	+	+	0	0	0	0	+	+	0	0	0		0	0
Outsourcing	0						+	+	+	0	-54	-16.3	0	-70.3
Interfacing	+	+	0	0	+	+	+	+	0	0	+54	0	0	54

Table 12: Best practices' scores for the running example

LT: lead time, TT: throughput time, WT: wait time, SUT: setup time, ST: service time, PT: processing time, RNC: running costs, LC: labor costs, RC: resource costs, TC: training costs, EQ: external quality, IQ: internal quality, MF: mix flexibility, LF: labor flexibility, RF: routing flexibility, VF: volume flexibility, PF: process modification flexibility

One of the redesign goals in the running example is *improving flexibility* which indeed relates to the performance dimension, and does not concern about the performance measures e.g. mix flexibility, labor flexibility, or process modification flexibility, etc. Hence, when we do the scoring for all best practices, as in Table 12, the way is as long as we see any positive effect in any of the performance measures of flexibility dimensions, we add its weight i.e. 29.7 *only one time* for the flexibility dimension. The same thing happens with negative effect, if there are negative effects in any of the performance measures, we add -29.7 *only one time* for the flexibility dimension.

After the scoring and ranking have been done, it appears that there are 2 best practices having the highest scores: Specialist-Generalist (83.7), Case Manager (70.3). They are therefore more likely to be applicable for the redesign of the process in our running example.

3.4 Select a process part for redesign

Best practices are applied on a process part. It is, therefore, important to select specific parts of the process that can be redesigned. This selection is *partly* done with the help of PrICE Tool Kit developed by Netjes [8]. The tool kit is implemented in the Redesign Analysis ProM plug-in with some specific constraints:

- The Redesign Analysis plug-in supports the selection of the process part for redesign on the basis of the *control flow best practices* [8].

- The *compose operation* is not completely implemented in line with its definition, and *unfold operation* is not implemented [8]. Table 13 displays the control flow best practices and the redesign operations that specify their applications. Definitions of redesign operations are presented in Table 14.

- It is important to stress here that the Redesign Analysis plug-in is not thoroughly validated by the practitioners. The plug-in is, therefore, referred as a prototype and it may not work in some cases.

Control flow best practice	Redesign operation
Task Elimination	Remove Task
Task Addition	Add Task
Task Composition	Compose Unfold Group
Task Automation	-
Resequencing	Sequentialize Add Task Remove Task
Control Relocation	Remove Task
Knock-out	Sequentialize Add Task Remove Task
Parallelism	Parallelize
Triage	Compose Unfold

Table 13: Control flow best practices and the redesign operations [8]

Redesign operation	Description
Group	Place tasks with the same role together
Compose	replace tasks with the same role with one composite task
Unfold	Replace a composite task with the tasks it is composed from
Parallelize	Put tasks in parallel
Sequentialize	Put task in a sequential
Add Task	Add a task
Remove Task	Remove a task

Table 14: Redesign operations and their descriptions

In what follows, we will shortly discuss how the Redesign Analysis plug-in can help the users in selecting the process part for redesign. First an applicable redesign operation is selected. Then, the user selects a process part for redesign by clicking on tasks in the process model. After this selection, the colors are updated to display the process parts that can be formed. There is user guidance with colors to help the user in this selection process. The color and their meaning are given in Table 15.

If a suitable process part is selected, the redesign operation is automatically performed and an alternative model is created. Detailed information about this process can be found in [8].

Color of a task	Meaning
Red	it is not possible to include the task in a process
Yellow	it is possible to include the task in a process
Light green	the task is selected by the user
Dark green	the task is selected by the user and forms (together with other dark green tasks) a process part that can be redesigned with the selected redesign operation

Table 15: Task colors and their meaning [8]

For best practices in the categories: **allocation rules** and **resource rules**, which mainly focus on the resource perspective of a process, it is however subjective to the process owners. They have their own discipline for the adaptation of the allocation of roles to tasks and the number of resources, enhancing their individual and collective contribution while considering employees with interests and dynamics. In a broad sense, the process owner can decide upon how and even when or where to apply those best practices in a business process. For examples, the process owner decides to what degree that the number of departments, groups and persons involved in a process can be minimized (**Numerical involvement** best practice). Or, it is determined by the process owner how much needed to increase the capacity of a certain resource class of a business process, etc.

Best practices from the class **rules for external parties** and **integral workflow rules** mostly deal with the collaboration and communication with the third parties, which is the business process experts' area of expertise. The business process expert not only can prescribe solutions for key business process issues, but also can guide the correct use of technology to solve these issues. It is therefore their final decision on the application of these best practices on a process. For examples, they can determine whether it is best to outsource some parts of the process or the whole process (**Outsourcing** best practice). Or they can consider/ introduce a standardized interface with clients and partners (**Interfacing** best practice). Last but not least, with the knowledge of both business and IT fields, business process expert can try to elevate the physical constraints in a process by applying new technology (**Technology** best practice).

4 Case study within Philips

In this chapter, the aim is to realize the goals of this project by applying the developed approach to the Philips process. Within this case study, the original process of Philips is assessed, the selection of redesign best practices that could be applied to the existing processes is presented, and the applicability of the approach is discussed.

4.1 Methodology

Since the goal is to determine whether the proposed approach to select applicable redesign best practices (based on their expected impact on the performance of the process), could be applied to real world cases, our approach is validated within Philips.

In this section, first we will describe the original process (*the as-is situation*). Then, we step-by-step apply our approach which is described in details in the previous chapter in order to select the applicable redesign best practices. And finally, we present our conclusion for the proposed approach.

The methodology can be depicted in Figure 12

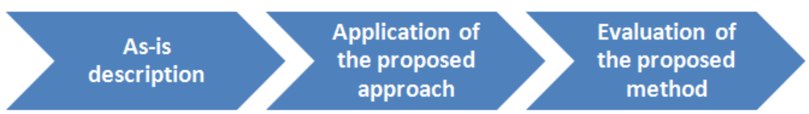


Figure 12: Case study methodology

As-is description

To understand the process and its core tasks, we have held several meetings with Data Quality Manager, Data Standards & Process Improvement Officer and Project Manager. In addition, we have asked each of the interviewees for a reference to relevant sources to have a better understanding of the selected process.

Data collection techniques can be divided into three levels: *direct method*, *indirect method* and *independent analysis* [44]. *Direct method* means the direct contact with the stakeholders and collect data in real time. *Indirect method* is realized through the collection raw data without actual interaction with the subject e.g. the usage of tool. Finally, independent analysis means individual work to analyze the artifacts where available and complied data is used.

For the Philips process, we collect data through ***direct method*** and ***independent analysis.*** The information from stakeholders is obtained from individual interviews and discussions. The main objective of the interviews is to understand the process perspectives i.e. the control flow perspective, the data perspective, the resource perspective, the performance perspective and most important. The topics discussed during these interviews can be formulated as follows, with reference to [45] [8].

Q1. How does the process currently work?

Q2. Who work in the process and what are their roles?

Q3: Who work in the same task?

Q4. What is the average service time for each task?

Q5. What information flows from one person to another?

Q6. How many cases arrive at the process per month/ week/ day?

Q7. How many resources available per role for this process?

Besides, information about existing processes and the methodology to perform business process modeling are collected independently based on the existing documentation available at Philips Enterprise Information Management department (Philips EIM).

Finally, the Philips process perspectives are documented and refined in a textual format after each interaction with the stakeholders and have been iteratively checked for accuracy and clearness.

Application of the proposed approach

In this section, our main goal is to demonstrate the proposed approach, to test whether it is feasible to select the applicable redesign best practices based on their expected impacts on the process performances. In that sense, first we describe the original process then apply the approach to select best practices for the redesign effort. Next, we discuss the suitable process part to apply chosen best practices.

Evaluation of the proposed method

Here, we present our conclusions for the feasibility of the proposed approach.

4.2 As-is Description

The *as-is* process for the feasibility test is ***Manage Data Quality Issues (Manage DQ Issues)*** process (L4), which is one of the three activities in the Run Data Quality process. *Run Data Quality (L3)* is a sub process of *Run Enterprise Information* process group (L2), which belongs to the *Information Technology* process category (L1). Table 16 describes the process level of *Manage DQ Issues* Process.

Detailed information about the Enterprise Architecture and Philips Business Process is given in Appendix C.

Process Level Classification	Example of ***Manage DQ Issues*** process
L1: Process Category	20 Information Technology
L2: Process Group	20.7 Run Enterprise Information
L3: Process	20.7.3 Run Data Quality
L4: Activity	20.7.3.1 Continuously Measure and Monitor Data Quality **20.7.3.2 Manage Data Quality Issues** 20.7.3.3 Clean and Correct Data Quality Defects

Table 16: Process level classification

The ***Manage DQ Issues*** process (***L4***) describes the steps which need to be taken when a Data Quality Issue is found within an organization. It starts with an Issue Form, from which the problem is assessed and the correct track for resolving is chosen. ***Manage DQ Issues*** consists of these following tasks:

- **Select appropriate tool**: Select the appropriate tool to register the request: the DQ Register.
- **Select DQ Reporting Issue Form**: Based on the type of request, select the appropriate request form: the DQ Reporting Issue Form
- **Fill DQ Reporting Issue Form:** Fill the DQ Reporting Issue Form with the master data details (mandatory fields at minimum). Fields for business impact and complexity are the foundation for calculating the proposed priority of request handling. User can also save the filled in form to submit it later.
- **Submit request:** Submit the created request in the selected tool.
- **Adjust entries in form:** Adjust any missing or incomplete information when the form does not fulfill the requirements.
- **Assign request to data domain:** This issue is assigned to a data domain.
- **Assign analyst**: Assign analyst to the registered data quality issue.
- **Perform sanity check:** Validate if content in the request form is sufficient for further analysis. If insufficient, contact requestor to obtain required additional information.
- **Check compliance prerequisites:** Check compliance requirements applicable for the request.
- **Define requirements and scope (for execution)**: Contact responsible data manager to collect requirements (business rules, including compliance) and scope (including data sources) of the data quality issue, to be able to assess it.
- **Perform initial assessment of DQ Issue**: Based on the information provided in the DQ Issue Form, perform a first assessment to determine if it concerns a DQ Issue. A DQ Issue Report is created. It will at this stage contain the information of the form:
  - Date
  - Name of the Requestor
  - Observed Issue
  - Conditions under which the issue occurs
  - Impact on processes.

  When the issue is judged not to be a DQ Issue, this report will contain the fact and arguments to support this judgment.

  When it is judged to be a data quality issue, an assessment will be made later in the process to determine the root cause of the issue.

- **Set priority for in-depth assessment:** Determine the priority for performing in depth assessment.
- **Determine work effort of in-depth assessment:** Determine the work effort to perform in-depth assessment of identified DQ Issue.
- **Schedule in-depth assessment:** Schedule by when the in-depth assessment of the DQ Issue will be performed.
- **Request to reassign request:** Request to reassign request to other analyst.
- **Perform in-depth assessment of DQ Issue:** Perform in-depth assessment of the DQ Issue to identify the root-cause of it.

In Figure 13, we start with the process view diagram containing these tasks. The control flow and resource information is available in the model.

The data is added to the model based on the provided process description and also information retrieval from meetings with Project Manager, Process Expert and Data Quality Manager at Philips-EIM. The model including data perspective is given in Figure 14.

In Table 17, the processing time distributions and roles executing the tasks in the process are given by Data Quality Manager and Process Analyst at Philips. We use for most tasks a uniform distribution and estimate the variation in processing time for each task.

Task	Role	Processing time (in minutes)		
		Distribution	Minimum	Maximum
1. Select appropriate tool	BPE	Uniform	5	10
2. Select DQ Reporting Issue Form	BPE	Uniform	5	10
3. Fill DQ Reporting Issue Form	BPE	Uniform	10	15
4. Submit request	BPE	Constant	1	-
5. Adjust entries in form	BPE	Uniform	5	10
6. Assign request to data domain	BPE	Uniform	10	15
7. Assign analyst	OCM	Constant	10	-
8. Perform sanity check	SME	Uniform	10	30
9. Check compliance prerequisite	SME	Uniform	10	30
10. Define requirements, scope	SME	Uniform	30	90
11. Perform initial assessment	SME	Uniform	30	90
12. Set priority for in-depth assessment	SME	Uniform	10	20
13. Determine work effort of in-depth assessment	SME	Uniform	10	15
14. Schedule in-depth assessment	SME	Uniform	10	15
15. Request to reassign request	SME	Constant	10	-
16. Perform in-depth assessment of DQ Issue	SME	Uniform	60	120

Table 17 : Processing time and roles for the tasks in Manage DQ Issues process

The number of available resources per role is listed in Table 18.

Role	Number
Business Process Expert (**BPE**)	4
Subject Master Expert (**SME**)	4
Operations & Competence Manager (**OCM**)	7

Table 18: Number of resources available per role for the Manage DQ Issues process

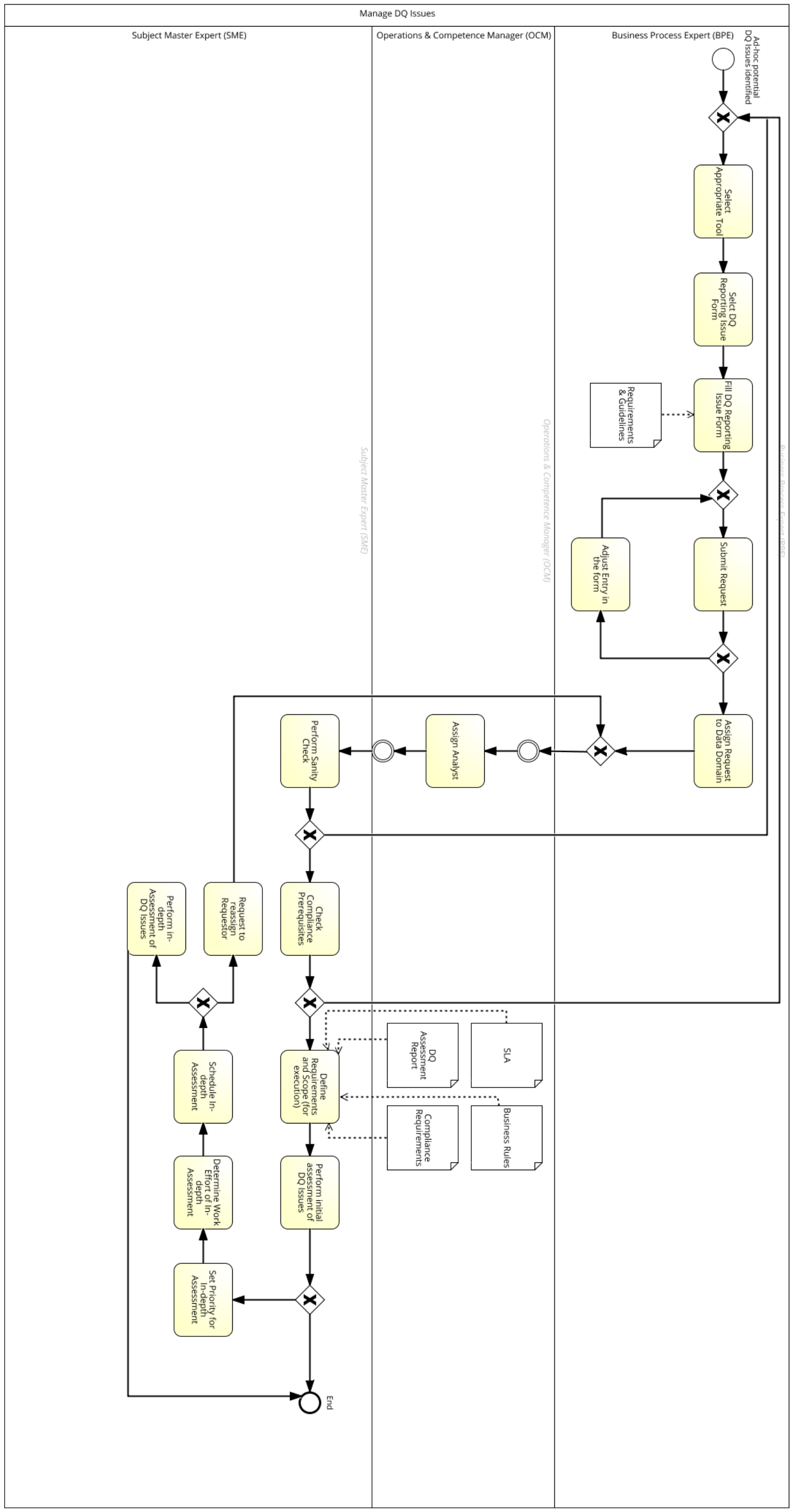


Figure 13: Manage DQ Issues process (Regulated)

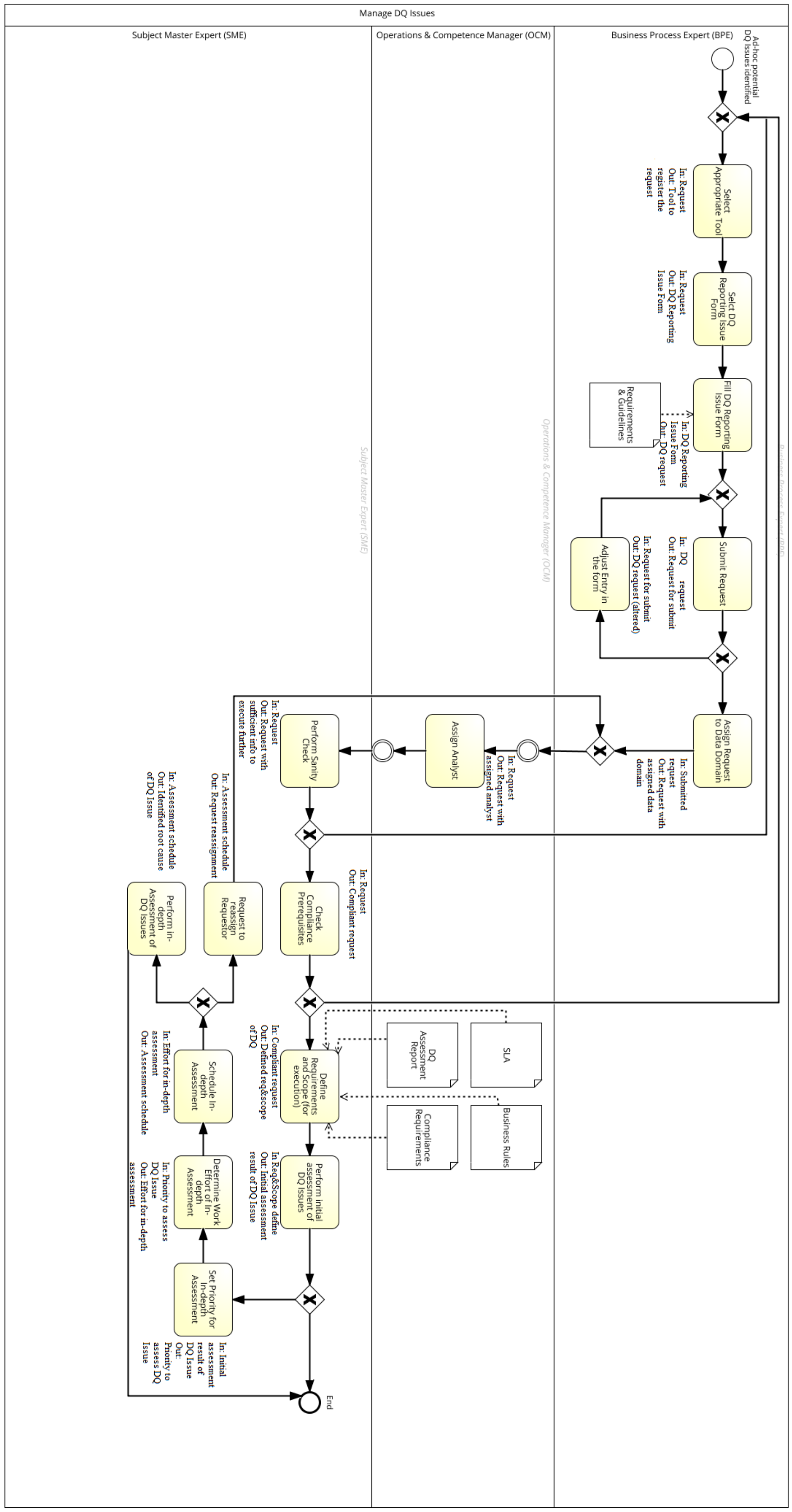


Figure 14: Manage DQ Issues process including the data perspective (Regulated)

4.3 Application of the proposed approach

In this section, we will apply the developed approach to select the applicable BPR best practices based on their expected impacts on the process performance for the redesign effort. For this test, we use the ***Manage DQ Issues*** process at Philips as the original process.

4.3.1 Step 1: Find the performance measures

It appears that the data to calculate the process performance measures is not available within Philips EIM, except the processing time of the task. Therefore, the four performance dimensions i.e. time, cost, quality and flexibility cannot be refined quantitatively and thoroughly into a number of process performance measures.

To overcome this challenge, we have held several meetings with the Data Quality Manager, who has an extensive pool of knowledge of the ***Manage DQ Issues*** process in order to gain insights into a process. It appears that the *Manage DQ Issues* process is poorly executed within Philips. Currently, each role does its own tasks. Once the task is done, the results are handed over to the next role/ person. There is not much communication/ connection between people to the corporate efforts, which eventually causes the process to become inefficient. In addition, when the problem occurs, more time is spent on searching for responsible person, instead of solution generating activities. This increases costs for executing the process in general and more important, the process of choosing the correct track for resolving once a Data Quality Issue is found within an organization is delayed.

Although the results obtained from qualitative analysis are not detailed enough for the process performance measures, it provides a solid basic for decision making, in particular for defining the redesign goals in the next step.

4.3.2 Step 2: Define the goals of redesign

4.3.2.1 Define redesign goals

Due to the lack of the process performance measures at Philips, there is no concrete evaluation of the process performance measures to find the goal of redesign, as depicted in the approached. We have conducted stakeholder interviews for the goals of the ***Manage DQ Issues*** process redesign, the so-called goal-seeking sessions in which the purpose is reaching agreement among many stakeholders about the current situation and future needs of the process. Most important is trying to answer the question: *What would you like the process to be?*

The redesign goals are then realized according to the concerns of the stakeholders. After all, they agree on the following goals:

- Improve external quality
- Reduce lead time
- Reduce labor cost
- Improve internal quality

These goals will be prioritized in the next step of the approach.

4.3.2.2 *Prioritize the goals*

The business process redesign is used to reach a higher performance. Knowing the weaknesses of the process gives room to prevent or practically alternate the weaknesses. Though we can have multiple BPR goals, prioritize them will help focus the redesign effort on achieving the desired outcomes.

We have done the exercises with the Data Quality Manager and consider the response as the most critical information since he has the most general knowledge about the process among the stakeholders, and most important he has been involved in the ***Manage DQ Issues*** process for years. According to the Data Quality Manager, goals of the redesign are prioritized as depicted in Table 19.

Redesign goal	Priority
Improve external quality	1
Reduce lead time	2
Reduce labor cost	3
Improve internal quality	4

Table 19: Priority setting for the redesign goals

Also, their pair wise comparisons are presented in Table 20 with the related meanings:

- Improving External quality is 2 times (**equally to moderately**) more important than Internal quality
- Improving External quality is 2 times (**equally to moderately**) more important than reducing Lead time
- Improving External quality is 2 times (**equally to moderately**) more than reducing Labor cost
- Reducing Lead time is 2 times (**equally to moderately**) more important than reducing Labor cost
- Reducing Lead time is 4 times (**moderately to strong**) more important than improving Internal quality
- Reducing Labor cost is 5 (**strong importance**) more important than improving Internal quality

	A - Importance - or B?			Equal	How much more?
1	(●) Improve External Quality	or	( ) Reduce lead time	( ) 1	(●) 2 ( ) 3 ( ) 4 ( ) 5 ( ) 6 ( ) 7 ( ) 8 ( ) 9
2	(●) Improve External Quality	or	( ) Reduce labor cost	( ) 1	(●) 2 ( ) 3 ( ) 4 ( ) 5 ( ) 6 ( ) 7 ( ) 8 ( ) 9
3	(●) Improve External Quality	or	( ) Improve Internal Quality	( ) 1	( ) 2 ( ) 3 (●) 4 ( ) 5 ( ) 6 ( ) 7 ( ) 8 ( ) 9
4	(●) Reduce lead time	or	( ) Reduce labor cost	( ) 1	(●) 2 ( ) 3 ( ) 4 ( ) 5 ( ) 6 ( ) 7 ( ) 8 ( ) 9
5	(●) Reduce lead time	or	( ) Improve Internal Quality	( ) 1	( ) 2 ( ) 3 ( ) 4 (●) 5 ( ) 6 ( ) 7 ( ) 8 ( ) 9
6	(●) Reduce labor cost	or	( ) Improve Internal Quality	( ) 1	( ) 2 (●) 3 ( ) 4 ( ) 5 ( ) 6 ( ) 7 ( ) 8 ( ) 9

Table 20: Philips BPR goals - Pairwise comparison

With the help of AHP priority calculator[3], we obtain the resulting weights/ priorities for the goals based on the pair wise comparisons , as given in Table 21.

	Category	Priority	Rank
1	Improve External Quality	42.2%	1
2	Reduce lead time	31.2%	2
3	Reduce labor cost	19.1%	3
4	Improve Internal Quality	7.5%	4

Table 21: Prioritized BPR goals

4.3.3 Step 3: Identify best practices aligned with the BPR goals

Based on the prioritized goals in step 2, goals are scored as depicted in Table 22.

	Positive effect (+)	Negative effect (-)	No effect expected (0)
Improve external quality	42.2	- 42.2	0
Reduce lead time	31.2	- 31.2	0
Reduce labor cost	19.1	- 19.1	0
Improve internal quality	7.5	- 7.5	0

Table 22: Goals score for Manage DQ Issues process

Having the qualitative impacts of each best practice along the set of performance measures (Table 9), we do the scoring and the results are shown in Table 23.

[3] http://bpmsg.com/academic/ahp_calc.php

	Time						Costs				Quality		Flexibility					Result
	LT	TT	WT	SUT	ST	PT	RNC	LC	RC	TC	EQ	IQ	MF	LF	RF	VF	PF	
Customer																		
Control relocation	0						-	-19.1	0	0	+42.2	0	0					23.1
Contact reduction	+31.2	+	+	0	0	0	-	-19.1	0	0	+42.2	0	0					54.3
Integration	+31.2	+	0	0	0	0	+	+19.1	+	0	0		-	-	-	-	-	50.3
Operation view																		
Order types	+31.2	+	0	+	0	+	+	+19.1	+	0	-42.2	-7.5	0	0	0	0	-	0.6
Task elimination	+31.2	0	0	0	0	0	0	+19.1	0	0	0	0	-					50.3
Order-based work	+31.2	+	+	0	0	0	0	0	-	0	0		0					31.2
Triage	+31.2	+	+	0	0	0	+	+19.1	+	0	+42.2	0	0	-	0	0	0	92.5
Task composition	+31.2	+	0	+	0	0	+	+19.1	0	0	+42.2	0	0	-	0	-	0	92.5
Behavioral view																		
Resequencing	+31.2	+	0	+	0	0	+	+19.1	0	0	0		0					50.3
Parallelism	+31.2	+	0	0	0	0	-	-19.1	0	0	-42.2	-7.5	0	-	0	-	0	-37.6
Knock-out	-31.2	-	0	0	0	0	+	+19.1	0	0	0		0					-12.1
Exception	+31.2	+	0	+	+	+	0				+42.2	+7.5	0	-	0	0	0	80.9
Organization																		
Order assignment	+31.2	+	0	+	0	+	0				+42.2	0	0	-	0	0	0	73.4
Flexible assignment	+31.2	+	+	+	+	+	0				+42.2	0	0	-	0	0	0	73.4
Centralization	+31.2	+	0	0	0	0	-	0	-	0	0		0	+	0	0	0	31.2
Split responsibility	-31.2	-	-	0	0	0	0				+42.2	+7.5	0	-	0	0	0	18.5
Customer team	+31.2	+	0	+	+	+	+	+19.1	0	0	+42.2	+7.5	0	-	0	0	0	100
Numerical involvement	-31.2	-	0	-	-	-	+	+19.1	0	0	-42.2	0	0					-54.3
Case manager	0						-	-19.1	0	0	+42.2	+7.5	0					30.6
Population																		
Extra resources	+31.2	+	+	0	0	0	-	-19.1	0	0	0		0	+	0	0	0	12.1
Specialist (S)-Generalist (G)	+31.2	+	0	+ (S)	+ (S)	+ (S)	0				+42.2 (S)	0	0	+ (G)	0	0	0	73.4
Empower	+31.2	+	0	0	0	0	+	+19.1	0	0	-42.2	0	0					8.1
Information																		
Control addition	-31.2	0	0	0	0	0	+	+19.1	0	0	+42.2	0	0					30.1
Buffering	+31.2	+	0	0	0	0	-	0	-	0	0		0					31.2
Technology																		
Task automation	+31.2	+	0	+	+	+	0				+42.2	0	-	-	0	0	0	73.4
Integral BP technology	+31.2	+	0	+	+	+	+	+19.1	0	0	+42.2	-7.5	0					85
External environment																		
Trusted party	+31.2	+	0	0	0	0	+	+19.1	0	0	0		0					50.3

Outsourcing	0						+	+19.1	+	0	-42.2	-7.5	0	-30.6
Interfacing	+31.2	+	0	0	+	+	+	+19.1	0	0	+42.2	0	0	92.5

Table 23: Best practices' scores for Manage DQ Issues process

LT: lead time, TT: throughput time, WT: wait time, SUT: setup time, ST: service time, PT: processing time, RNC: running costs, LC: labor costs, RC: resource costs, TC: training costs, EQ: external quality, IQ: internal quality, MF: mix flexibility, LF: labor flexibility, RF: routing flexibility, VF: volume flexibility, PF: process modification flexibility

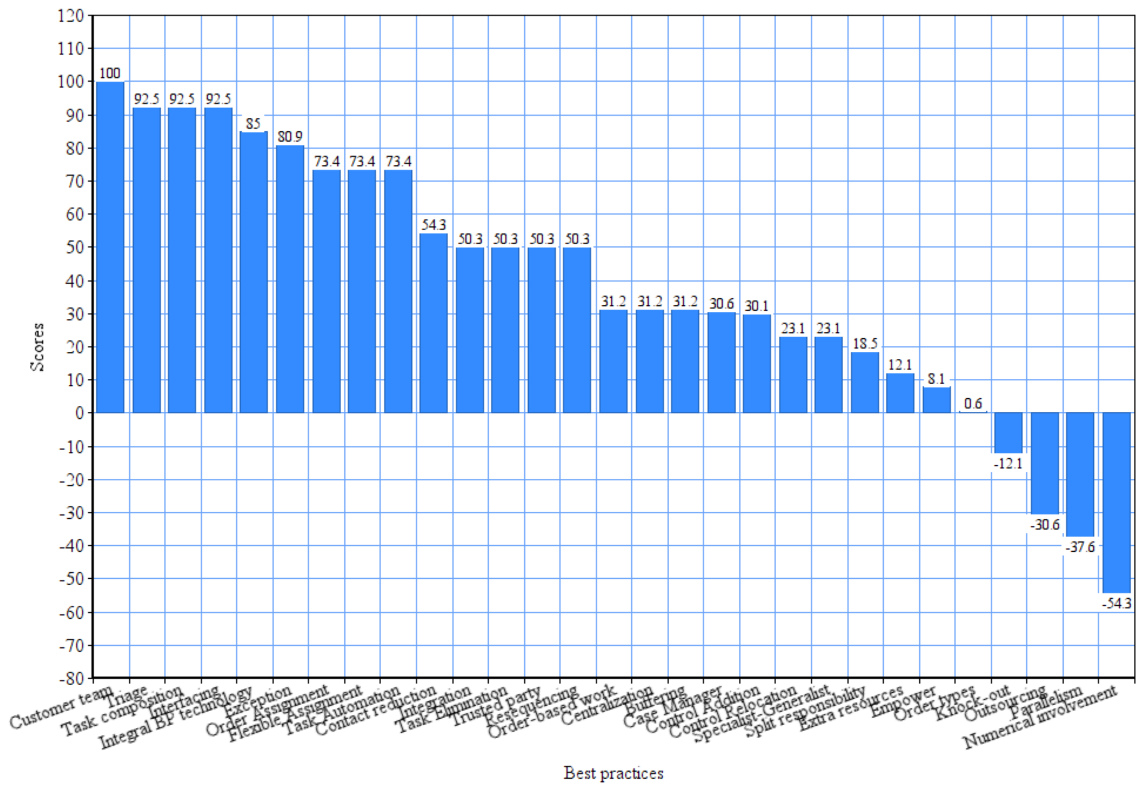


Figure 15: Best practices' scores for Manage DQ Issues process

A bar chart in Figure 15 graphically summarizes and displays the best practices' scores for the *Manage DQ Issues* process. It appears that there are four best practices having the highest scores: ***Customer team (100)*** *(in the class: allocation rules)*, ***Triage (92.5)*** *(control flow best practice)*, ***Task Composition (92.5)*** *(control flow best practice)*, and ***Interfacing (92.5)*** *(in the class: rules for external parties)****.*** They are therefore more likely to be applicable for the redesign of the *Manage DQ Issues* process in Philips.

4.3.4 Step 4: Select a process part for redesign

As a result of step 3, there are 4 best practices likely to be applicable for the redesign effort. They are *Customer team*, *Triage*, *Task Composition* and *Interfacing*. In this step, the team select suitable process parts on which a certain redesign best practice can be applied.

Customer team best practice is in the class *allocation rules* which focus on improving allocation of resources working on the process. This best practice recommends assigning team out of different departmental workers that will take care of the complete handling of orders. In fact, the Business Process Expert (BPE), Subject Master Expert (SME) and Operations & Competence Manager (OCM) resources currently performing activities in the *Manage DQ Issues* process are in one department/unit in an organization and most important they are capable of handling the whole process. Thus, *Customer team* is not applicable for our Philips case.

Interfacing best practice is in the class *rules for external parties* mainly improving the collaboration and communication with the customer and third parties to eliminate the probability of mistakes thus induce less rework and enhance the processing time. For the *Manage DQ Issues* process, it shows that there are no customers and third parties involved. Hence, applying *Interfacing* becomes not possible in this case.

For the control flow best practices, ***Triage*** and ***Task composition***, PrICE approach [8] is used to select process parts for redesign. Due to this approach, the redesign operations that specify best practice's application are derived. *A redesign operation performs the concrete process change that is described by the related BPR best practice* [8].For that, the redesign operations that operationalize the Task Composition best practice are the *group* and the *compose* operations as we "combine smaller tasks into composite task"; and *unfold* operation as we "divide large tasks into workable smaller tasks". And, the main interpretation of Triage best practice is the division of a general task into two or more alternative tasks (specified with the *unfold operation*) and its opposite formulation is consider the integration of two or more alternative tasks into one general task (specified with the *compose operation*), which is less popular.

Triage is in some sense similar to the Task Composition best practice since both are concerned with the division and combination of tasks in a process. The difference is that the Triage best practice considers *alternative tasks*, which is not applicable for the *Manage DQ Issue* process at Philips. In fact, as perceived by the stakeholders, there are no alternatives smaller tasks for the current tasks in the process.

That is an explanation to the fact that for redesigning *Manage DQ Issues* process at Philips, we only consider the ***Task Composition*** best practice, or *Group*, *Unfold*, *Compose* operations in detailed.

For the application of Task Composition (control flow best practice), PrICE approach i.e. the Redesign Analysis plug-in by Netjes [8] will help us to select the process part for redesign. In fact, the plug-in only supports the *Group* operation as depicted in Figure 16. Hence, for the other two operations i.e. unfold and compose, we will based on their descriptions and requirements to select process part (s) and perform the creation of the process alternatives manually.

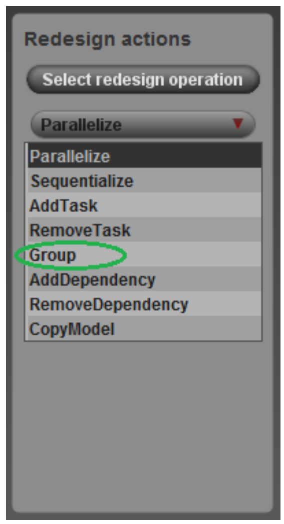


Figure 16: Supported redesign operations by Redesign Analysis Plug-in

- **Group operation**

For the Group operation, all possible combinations of tasks with the same role can be placed together with a correct data distribution.

In the original model (Figure 13), it appears that tasks with the same role assignment are already placed together. By using the Redesign Analysis plug-in [8], after our trials on selecting tasks in the process, it eventually shows that there is no possible selection of a process part for the *Manage DQ Issues*.

An example is depicted in Figure 17. After selecting the *Assign Analyst* task (colored with light green), all the other tasks in the process become red, which implies that it is not possible to include these tasks with the selected *Assign Analyst* task to form a process part for redesign. An explanation is, in the whole process, only the *Assign Analyst* task is performed by role *Operations & Competence Manager (**OCM**)*.

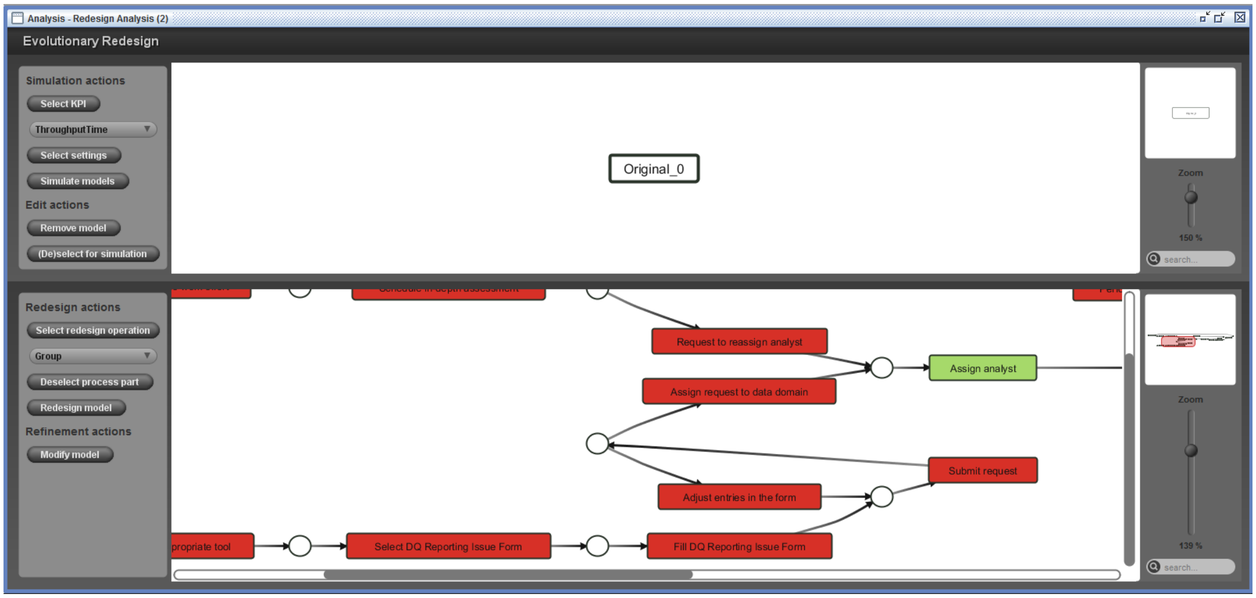


Figure 17: Selection of a process part for the group operation (1)

In addition, as we obtain no information concerning setup time and waiting time for tasks in *Manage DQ Issues* process, the intended effect of *Group* operation that a resource can execute multiple tasks to reduce setup time and waiting time is not included in the model.

The *Group operation* could not be applied in the original process, therefore, we do not gain the reduced lead time and labor costs as expected. Since, the control flow of the process stay the same and hence there is no improvement on the external and internal quality aspects.

- **Unfold operation**

The unfolding of task is done with the unfold operation. If the task is too large, it is logical to divide it into smaller pieces of work, which may result in higher job satisfaction from the employees and most important, high quality of the delivered work. With the application of the *unfold*, the composite transition is removed from the original process and replaced by the tasks in the associated sub-process.

As perceived by the stakeholders, all the tasks in *Manage DQ Issues* process currently can be done as one chunk The process is, therefore, originally the unfolded process. Applying *unfold* becomes not possible in this case.

- **Compose operation**

Due to the formal foundation for the development of tool support for the creation of process alternative defined by Netjes [14], for the redesign operations, all possible process parts needs to be calculated. These checking and calculating are time consuming for a real business process. Figure 16 shows that the Redesign analysis plug-in does not support the *compose operation*. Hence, for a selection of process part where the BPR best practice can be applied, we based on the description of the redesign operation to select process part (s) and perform the creation of the process alternatives manually.

The *compose operation* is performed on part of the *as-is* process model, thus, creating the alternative process model(s). According to the descriptions of redesign operations are given in Table 14, tasks with the same role assignment can be replaced with the composite task. In many cases, reasonable composite tasks can benefit from the highly concentration and continuousness from workers, resulting in the increased quality of end products/ services. Moreover, by executing large task consisting of smaller ones, *less time is spent by a resource to become familiar with an order* [14] and clearly there is a reduction in set-up time which eventually can have a positive effect on the lead time and throughput time of the business process. However, making tasks too large may lead to lower quality as tasks become unworkable. It is, therefore, wise to consider also the processing time as composing tasks in a process.

It should be stressed here that as applying *compose operation* to create the composite task, we assume all the sub tasks have to be executed and only at the end, we can make some kind of decision. In addition, the failure in one sub task leads to the new execution of the whole composite task.

In the current *Manage DQ Issues* process, the practitioner has to interact twice with a Subject Master Expert - SME (tasks ***Perform Sanity Check*** and ***Check Compliance***) to validate the content of the request. Also, the processing time of these tasks is not that long. As presented in Table 17, it is maximum half an hour for each task. It could be the case the practitioner has to interact with two different SME. It is expected that the quality of the delivered work would be improved if (s)he interact with the same SME. A solution is, therefore, both consecutive interactions between the practitioner and SME should be combined into single task. This solution is fulfilled with the application of *compose operation*. By this way, tasks relating to the validation of the request content can be handled for one practitioner at once. The process alternative resulting from the application of the compose operation, is depicted in Figure 18.

The composite task corresponding to tasks ***Perform Sanity Check*** and ***Check Compliance*** got the name **Validate content of request.** We gave a new processing time to the introduced composite task. According to [14], task composition results in a reduction of setup time and hence reduces the processing time. The composite task *Validate content of request* is given a processing time of *Uniform (10, 40).* Table 24 displays the creation of the process alternative.

Model ID	Redesign best practice	Redesign operation	Process parts
O	_	_	Original model
C	Task composition	Compose	Perform sanity check, Check Compliance

Table 24: The creation of process alternative

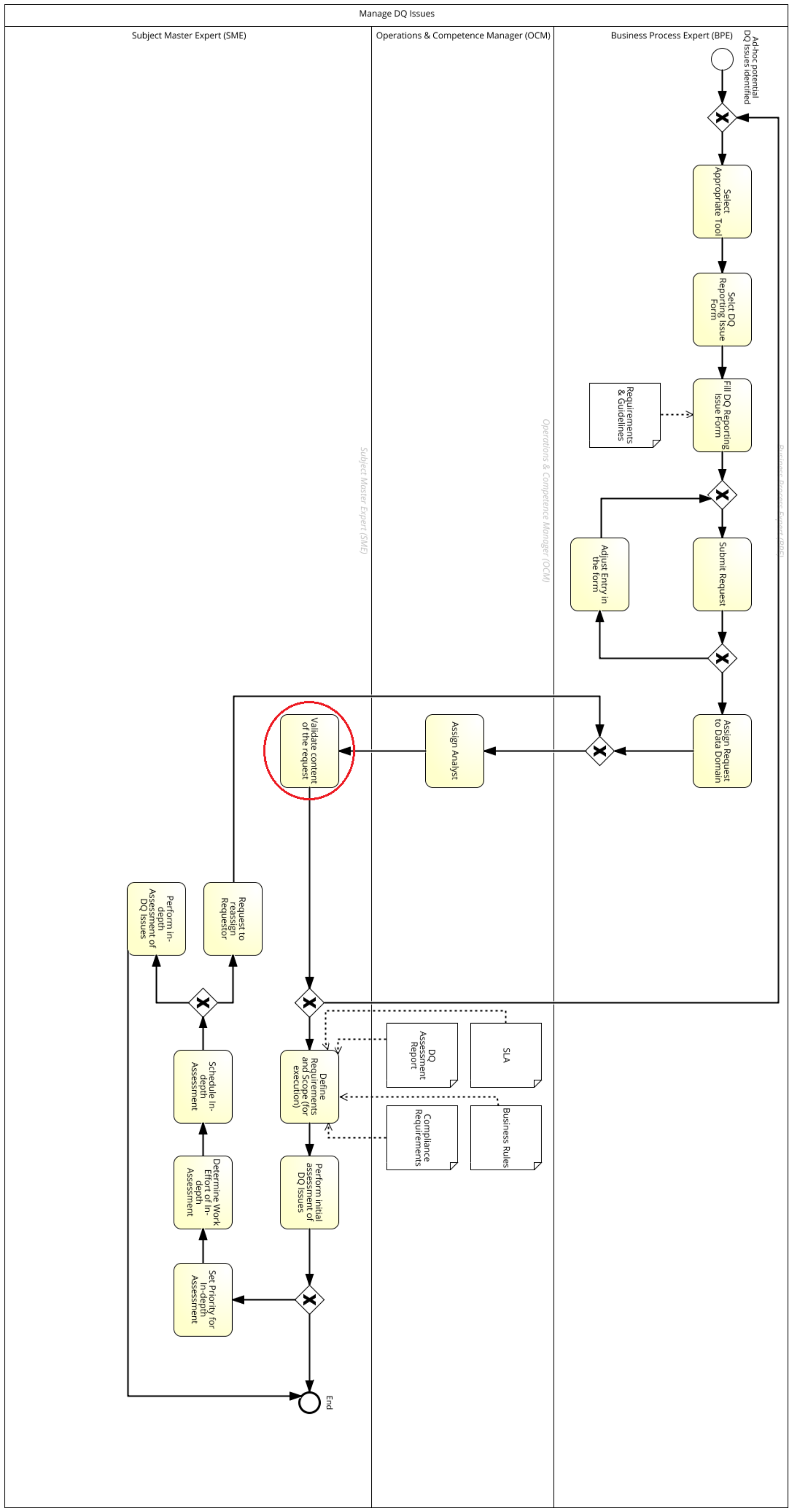


Figure 18: A model of alternative C

For the evaluation of the performance of the process alternative, Signavio Simulation[4] is used to run analysis to gain information about lead times and cost of the process. By filling the execution durations of tasks in the process, frequency of start event as well as a detailed work schedule for each role, work schedule of the resources and resources' costs per hour, Signavio Simulation helps us to calculate the selected process instance lead time and costs as well as the total sum of all run lead time and the total sum of all costs.

In case of Philips process, since there is no data stored related to the resources' costs hence we make up the costs per hour of the resources and also set up their work schedules. We assume that resources are available from Monday to Friday and from 09:00 to 17:00. Also, execution costs of a process instance consist only the resources costs. Hence, by calculating the hour of resource needed, we can generate the cost of executing the process.

A simulation study is used to evaluate the effect of the alternative model and the simulation results are compared with the results of the original model. Each model (model O and model C) has equal starting condition, starts empty i.e. without warm up period. Figure 19 shows the simulation scenario.

Frequency and probabilities

Start event	**Frequency**
Ad-hoc potential DQ Issues identified	On Mon-Fri; overall 30 times

Gateway	**Decision**	**Probability**
Gateway	Adjust Entry in the form	50.00%
	Assign Request to Data Domain	50.00%
Gateway		50.00%
	Check Compliance Prerequisites	50.00%
Gateway		50.00%
	Define Requirements and Scope (for execution)	50.00%
Gateway	End	50.00%
	Set Priority for In-depth Assessment	50.00%
Gateway	Perform in-depth Assessment of DQ Issues	50.00%
	Request to reassign Requestor	50.00%

Resources

Role	**Work schedules**	**Costs/hour**
Business Process Expert (BPE)	4 employees; 160 hours per week	€ 10.00
Operations & Competence Manager (OCM)	7 employees; 280 hours per week	€ 20.00
Subject Master Expert (SME)	4 employees; 160 hours per week	€ 15.00

Figure 19: Simulation scenario

[4] http://www.signavio.com/bpm-academic-initiative/

We run the n-case simulation to provide more stable predictions of the performance. The frequency of start event and simulation duration (the period of time the simulation should cover) on which the simulation is based are configured, as shown in Figure 20 and Figure 21.

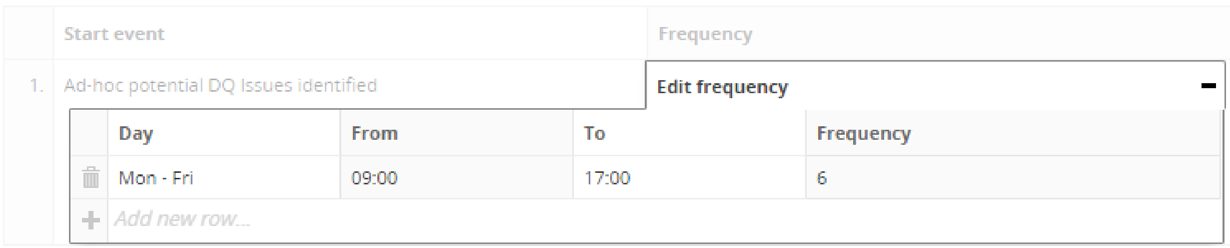


Figure 20: Frequency of start event

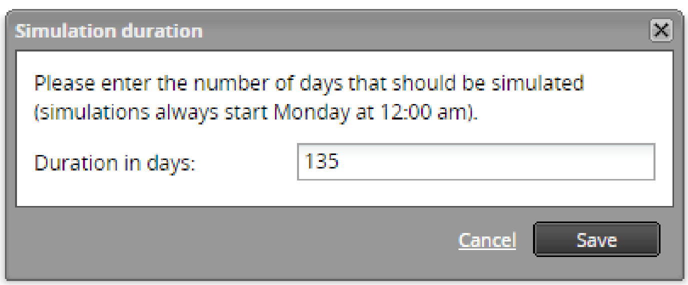


Figure 21: Simulation duration

For our simulation, the lead time of a process instance is measured between its start and completion. Execution costs of a process instance is the resources costs. The simulation will give the results of the selected process instance times and costs as well as the total lead time and total cost, in which total lead time shows the sum of all process instance lead time and total cost is sum of all costs.

Based on the reasoning in [14], task composition results in a reduction of setup time and hence reduces the processing time, the composite task *Validate content of request* was first given a processing time of *Uniform (10, 40).* In order to generate more valid prediction, we come up with not just a single processing time for the composite task, in our simulation, we tried out more values i.e. *Uniform (20, 40), Uniform (20, 50) and Uniform (20, 60).*

		Average	Minimum	Maximum	Total lead time
Model O		10d 14:54h	03:31h	59d 02:36h	5246d 17:53h
Model C	The composite task *Validate content of request* is given a processing time of ***Uniform (10, 40)***	1d 12:51h	02:10h	7d 00:48h	884d 00:18h
	The composite task *Validate content of request* is given a processing time of ***Uniform (20, 40)***	1d 17:36h	02:55h	9d 21:54h	993d 12:40h
	The composite task *Validate content of request* is given a processing time of ***Uniform (20, 50)***	3d 22:49h	03:09h	25d 20:02h	2236d 07:11h
	The composite task *Validate content of request* is given a processing time of ***Uniform (20, 60)***	4d 19:46h	03:31h	39d 20:26h	2667d 11:23h

Table 25: Lead time of the models

		Average	Minimum	Maximum	Total costs
Model O		€136.68	€36.68	€715.41	€75.316,45
Model C	The composite task *Validate content of request* is given a processing time of ***Uniform (10, 40)***	€102.50	€28.76	€407.74	€59,344,98
	The composite task *Validate content of request* is given a processing time of ***Uniform (20, 40)***	€ 103.28	€ 36.19	€ 403.48	€ 59,705.39
	The composite task *Validate content of request* is given a processing time of ***Uniform (20, 50)***	€ 109.11	€ 33.83	€ 553.09	€ 62,823.50
	The composite task *Validate content of request* is given a processing time of ***Uniform (20, 60)***	€ 109.04	€ 36.48	€ 624.45	€ 62,637.94

Table 26: Costs of the models

Due to the limitation of Signavio, it does not provides the confidence intervals for the simulation results. But, these results, as presented in Table 25 and Table 26 could be used to realize the trend in reducing the lead time and labor costs of a process by applying *Task Composition* best practice, which is well-aligned with ones of the defined redesign goals i.e. *reducing lead time, reducing labor cost.*

Though our simulation can only provide quantitative estimates for the performance on time and cost dimensions of a process model, it is a first signal to show that our approach to select applicable redesign best practices seems viable for real life processes.

4.4 Evaluation of the proposed approach

The first contribution of the approach is supporting the selection of applicable best practices based on their expected impacts on the performance of the process. As we can reproduce the approach in the context of Philips process, the study gives a first indication that our approach can be applied in real life processes although it still faces some obstacles.

First, in reality, information on the process performance measures is not always available e.g. in the context of Philips process, which makes it a real challenge for the team to define the goals of redesigning business process. And due to a lack of concrete evaluation of the process performance measures, the defined goals might be subjective and not concrete enough. Hence, companies should make an effort to document their processes, focusing on the four main perspectives i.e. the control flow perspective, the data perspective, the resource perspective and the performance perspective. On the basis of this information, a method/ approach can be developed to support the collection and/or calculation of the process measures.

Though time, cost, quality and flexibility are the basic measurements for accessing all business processes, there is not much known about what is really happening with these dimensions between the stage before and after the process is changed (process redesign), or the practitioners do not gain enough knowledge in terms of time, cost, quality and flexibility when designing a new business process, for example in the Philip case. Thus, prioritizing the redesign goals and giving them the weighting scores are also issue. Only as you have a solid understanding of the process, of what is really happening with the time, cost, quality and flexibility dimensions of the current situation and future needs of the process, you can prioritize the redesign goal in a good way and hence can apply our proposed approach. As in Philips case, stakeholders have their own ideas on defining the redesign goals and prioritizing them. Hence, using group decision making tools i.e. consensus building tools or conducting consensus workshops to bring out the creative energies of individuals and making consensus decisions might be a promising solution.

Once we are succeed in adopting the developed approach to select applicable best practices, the work has not been finished yet. Best practices are only as good as their implementation. Selecting process parts to apply best practices is therefore of vital importance. The PrICE approach, in particular the Redesign Analysis plug-in, seems to help us with this selection but it appears that the plug-in does not work for some cases. Moreover, it is often not possible to derive all the process parts manually to apply redesign best practices in case of real life business processes. As a result, there is high chance of lacking the process parts that are suitable for the application of the selected best practices/ redesign operations. Direction for solution is an extension of the PROM Redesign Analysis plug-in so that it can fully support the selection of process part for applying redesign best practices.

Simulation, as known, is a way to increase the process awareness by allowing us to visualize the process runs and to run analysis based on configurable scenarios; but it can only gain information about cost, time, resource and bottlenecks of the process but not the quality and flexibility dimensions. Hence, evaluating quality and flexibility dimension of a business process after redesigning remains a question in our developed approach. A BPM system that can provide simulation results especially concerning the quality and flexibility dimensions of a business process is the direction for improvement.

5 Conclusion

This chapter presents the conclusions that can be derived from our study. In section 5.1, we summarizes the main contributions of our research to the field. Section 5.2 lists the limitations and recommendation for future research. Section 5.3 ends the chapter by giving the recommendations for Philips.

5.1 Summary

Though there exists different forms of guidance for applying BPR best practices, they do not provide any support on how to select applicable best practices based on their expected impacts on the performance of the process. This thesis extends the current field of research in the following ways.

Using the Regulative Cycle [17], our proposed approach is developed to support practitioners in selecting the applicable best practices among 29 ones identified by Reijers and Limam [14] for the redesign effort.

Since, this selection is based on the impacts of best practices on the performance of the process, our research extends the BPR best practices' impacts on the time, cost, quality and flexibility dimensions, as qualitatively evaluated by Reijers and Limam [14]. Our extending process consists of three main steps:

1. We adopt a list of BPR best practice impacts along the time, cost, quality and flexibility dimensions defined by Reijers and Limam [14] as our starting point.

2. By literature study/review, we extend these impacts along the set of performance measures from Netjes' work [8].

3. By our own qualitative analysis, we put additions to these impacts.

We believe that in presenting the qualitative assessments of best practices in such that manner, we provide more support for the selection of best practices for the redesign effort.

Netjes' work [8] has inspired us to come up with an approach to find the applicable BPR best practices that nonetheless has some different backbones:

1. Our approach is developed from a different starting point. Instead of computing the process measures to spot the inefficiencies in the process, we begin with the initial redesign goals e.g. reduce throughput time or reduce labor cost, etc.

2. On account of the limitation about the completeness in Netjes' work i.e. it targets 17 out of 29 best practices, in our approach, we would like to address the whole set of 29 best practices. Our proposal for the applicable best practices is therefore more practical.

In addition, our approach is developed based on the prior knowledge:

- The Devil's Quadrangle [15], a framework for performance measures that can be used to evaluate the effect of a redesign with the dimensions of time, cost, quality and flexibility.
- An extended framework, proposed by Reijers and Limam [14] which helps the practitioners in identifying different topics and choosing the correct best practices when dealing with the implementation of BPR.
- 29 best practices that can be used for business process redesign [14].
- Impacts of best practices along the dimensions of time, cost, quality and flexibility [14].

Our proposed approach includes four steps:

Figure 22: The approach supports the selection of BPR best practices

- ***Find the performance measurements:*** a set of performance measures of a process provides a solid basic for defining the goal of the redesign effort.
- ***Define & Prioritize BPR goals:*** different goals may lead to different redesign options and thus BPR best practices. Explicitly defining and prioritizing the BPR goals is, therefore, of a vital need before the start of identifying best practices.
- ***Identify best practices aligned with BPR goals:*** selecting BPR best practices that are likely to support the improvement goals of a business process.
- ***Select a process parts for redesign:*** detecting the bottlenecks in the process that need improvement.

Our approach provides support on how to select applicable best practices based on their expected impacts on the performance of the process, taken into account that the business process is redesigned to obtain better performance i.e. low cost, high quality, high flexibility, etc.

5.2 Limitations and Future Works

This research, as all others, faces limitations in any form whether it is due to the imperfect data, imperfect software used, or just plain time constraint.

Our developed approach is only applied to one Philips process as discussed in Chapter 4. Although the results give first indication that our proposed approach can be used for real enterprise business processes, its real life application is still missing. Hence, future work might focus on its application in a practical setting.

Another issue related to the practical application of our developed approach is that information about the process perspectives i.e. the control flow perspective, the data perspective, the resource perspective and the performance perspective are not always explicitly available at the start of a redesign project. Hence, the collection and/or calculation of the process measures are challenging. Companies should make an effort to document their processes, focusing on the four main perspectives. On the basis of this information, a research towards a method/ approach that can support the collection and/or calculation of the requited process measures might be a good start for future research.

Another main improvement would be to investigate and implement a better way to select process part for redesign by applying best practice since the Redesign Analysis plug-in offers no full support meanwhile it is often not possible to derive all the process parts manually to apply redesign best practices in case of real life business processes.

Although simulation is typically considered as relevant and highly applicable, in our case the use of simulation is limited. An example is the assumption that resources are most of the time available (Mon-Fri from 09:00 to 17:00), resulting in the behavior of resources is modeled in a rather naive manner. Also, by using Signavio as a simulation tool, lacking the discussion about the confidence intervals, we have not drawn the concrete conclusion about the process performance, but the trend. The ideas can be tried out and analyzed using some different tools i.e. CPN Tools, Arena Simulation, etc.

Besides, our extended impacts of BPR best practices on the performance of the process are an initial proposal and not thoroughly validated. Direction for future work is, therefore, validate these impacts with more experts. Or, one can verify these impacts based on experiences/ works from others in the field. Another way of verifying can also be establishing the case study in which we can verify the correctness of BPR best practices' impacts. As such, it can help improving our approach and avoid unfeasible solution.

5.3 Recommendations for Philips

At first, through informal interviews, Philips employees confirmed that they are not using any industrial BPR best practices for business process (re)design than The Data Management Association (DAMA) and American Productivity and Quality Center (APQC) Framework. In order to gain more insights, a survey is performed with the purpose of accessing the level of best practices usage in (re)design business processes within Philips. Instead of mentioning only the name of best practices, the well-defined descriptions of best practices are put into the survey. Interestingly, most participants have showed that they are applying BPR best practices in their work. Hence, to avoid unnoticeably adopting best practices, a course introducing best practices is recommended within Philips, which can properly help the employees better map their goals with the benefit of best practices. It is important that anyone involved in applying redesign best practices is provided with the training to make it successful. However, it is not the case of adopt these practices and the result will automatically follow. Many of the most effective practices have emerged from continuous trial and error, which should be taken into account.

Once, we are succeed in convincing people to adopt BPR best practices, the work is not finished yet. Best practices are only as good as their implementation. Thus, keep pushing the usage of best practices and keep looking for the appropriate ones that can improve the business process performance.

Besides, in Philips EIM, there is not much documented about what is really happening with the process performance dimensions i.e. time, cost, quality and flexibility between the stage before and after the process is changed (process redesign), or the practitioners do not gain enough knowledge in terms of time, cost, quality and flexibility when designing a new business process. Hence, a clear objective/ goal is recommended before the start of a redesign project. Having as such, this report will support better in the step of selecting applicable redesign best practices.

Bibliography

[1] A. Sharp and P. Mcdermott, *Workflow Modeling — Tools for Process Improvement and Application Development*. 2009.

[2] M. Vakola and Y. Rezgui, “Critique of existing business process re-engineering methodologies of a new methodology,” 2000.

[3] P. Trkman, “The critical success factors of business process management,” *Int. J. Inf. Manage.*, vol. 30, pp. 125–134, 2010.

[4] J. E. S. Thomas H. Davenport, “The New Industrial Engineering: Information Technology and Business Process Redesign | MIT Sloan Management Review,” 1990. .

[5] Majed Al-Mashari and Mohamed Zairi, “BPR implementation process: An analysis of key success and failure factors,” *Bus. Process Manag. J.*, vol. 5, no. 1, pp. 87–112, 1999.

[6] V. Grover, S. Jeong, and W. Kettinger, “The implementation of business process reengineering,” *… Manag. Inf. …*, 1995.

[7] W. J. Kettinger, J. T. C. Teng, and S. Guha, “Business process change: A study of methodologies, techniques, and tools,” *MIS Q.*, vol. 21, no. 1, pp. 55–80, 1997.

[8] M. Netjes, *Process Improvement : The Creation and Evaluation of Process Alternatives*. 2010.

[9] J. a. Buzacott, “Commonalities in Reengineered Business Processes: Models and Issues,” *Manage. Sci.*, vol. 42, no. 5, pp. 768–782, 1996.

[10] M. Netjes, H. A. Reijers, and I. Vanderfeesten, “‘Intelligent’ Tools for Workflow Process Redesign,” *Bus. Process Manag. Work. BPM 2005*, vol. 3812 of Le, pp. 444–453, 2006.

[11] G. Valiris and M. Glykas, “Critical review of existing BPR methodologies,” *Bus. Process Manag. J.*, vol. 5, no. 1, pp. 65–86, 1999.

[12] M. Netjes, S. L. Mansar, H. a Reijers, and W. M. P. Van Der Aalst, “Performing Business Process Redesign with Best Practices : An Evolutionary Approach.”

[13] Gartner, “Gartner executive Programs Meeting the Challenge : The 2009 CIO Agenda,” no. January, 2009.

[14] H. a. Reijers and S. Liman Mansar, “Best practices in business process redesign: An overview and qualitative evaluation of successful redesign heuristics,” *Omega*, vol. 33, pp. 283–306, 2005.

[15] N. and H. v. d. K. Brand, “Workflow Analysis and Design,” *Deventer: Kluwer Bedrijfswetenschappen*, 1995.

[16] W. Van Der Aalst, “Workflow verification: Finding control-flow errors using petri-net-based techniques,” *Bus. Process Manag.*, 2000.

[17] P. J. van Strien, “Towards a Methodology of Psychological Practice: The Regulative Cycle,” *Theory Psychol.*, vol. 7, no. 5, pp. 683–700, 1997.

[18] J. G. Engelke, H., “Integrated manufacturing modeling system,” *IBM J. Res. Dev. 29.4*, pp. 343–355, 1985.

[19] E. C. AMICE., “CIMOSA: open system architecture for CIM,” 1993.

[20] S. L. Mansar and H. a. Reijers, “Best practices in business process redesign: use and impact,” *Bus. Process Manag. J.*, vol. 13, no. 2, pp. 193–213, 2007.

[21] S. Alter, “Information systems: a managerial perspective,” 1996.

[22] S. and C. B. Jablonski, “Workflow management: modeling concepts, architecture and implementation,” 1996.

[23] S. Kim and B. Nakhai, “The dynamics of quality costs in continuous improvement,” *Int. J. Qual. Reliab. Manag.*, vol. 25, no. 8, pp. 842–859, 2008.

[24] A. Neely, M. Gregory, and K. Platts, “Performance measurement system design: a literature review and research agenda,” *Int. J. Oper. Prod. Manag.*, vol. 15, no. 4, pp. 80–116, 1995.

[25] H. A. Reijers, *Design and Control of Workflow Processes: Business Process Management for the Service Industry*. Springer-Verlag, Berlin, 2003.

[26] A. D. T. and S. Tonchia, “Performance measurement systems: Models, characteristics and measures,” *Int. J. Oper. Prod. Man- agement*, vol. 21, no. 1, pp. 46–70, 2001.

[27] G. K. Leong, D. L. Snyder, and P. T. Ward, “Research in the process and content of manufacturing strategy,” *Omega*, vol. 18, no. 2, pp. 109–122, 1990.

[28] D. A. Garvin, “Competing on the Eight Dimensions of Quality,” *Harv. Bus. Rev.*, pp. 101–109, 1987.

[29] A. Longo and G. Motta, “Design Processes for Sustainable Performances : A Model and a Method,” *Bus. Process Manag. Work.*, vol. 3812, no. 8, pp. 399–407. Springer–Verlang, Berlin, 2005.

[30] Q. Zhang, M. a. Vonderembse, and J. S. Lim, “Manufacturing flexibility: Defining and analyzing relationships among competence, capability, and customer satisfaction,” *J. Oper. Manag.*, vol. 21, no. 2, pp. 173–191, 2003.

[31] W. M. P. VAN DER AALST, A. H. M. TER HOFSTEDE, B. KIEPUSZEWSKI, and A. P. BARROS, “Workflow Patterns,” *Distrib. Parallel Databases*, vol. 14, no. 1, pp. 5–51, 2003.

[32] T. L. Saaty, *The Analytic Hierarchy Process*. New York: Mc Graw-Hill, 1980.

[33] J. R. Figueira, S. Greco, and R. Słowiński, “Building a set of additive value functions representing a reference preorder and intensities of preference: GRIP method,” *Eur. J. Oper. Res.*, vol. 195, no. 2, pp. 460–486, 2009.

[34] T. L. Saaty, “Decision making with the analytic hierarchy process,” *Int. J. Serv. Sci.*, vol. 1, no. 1, p. 83, 2008.

[35] M. Hammer and J. Champy, *Reengineering the corporation: a manifesto for business revolution*. New York : Harper Business, 1993, 2000.

[36] W. M. P. Van Der Aalst, “Re-engineering knock-out processes,” pp. 451–468, 2001.

[37] M. Jansen-Vullers, P. a. M. Kleingeld, M. W. M. C. Loosschilder, M. Netjes, and H. a. Reijers, “Trade-Offs in the Performance of Workflows–Quantifying the Impact of Best Practices,” *Bus. Process Manag. Work.*, pp. 108–119, 2008.

[38] M. Nissen, “Knowledge-Based Organizational Process Redesign: Using Process Flow Measures to Transform Procurement,” 1996.

[39] R. J. B. Vanwersch, L. Pufahl, I. Vanderfeesten, and H. A. Reijers, “The RePro technique : a new , systematic technique for rethinking care processes,” vol. 465, no. December, 2014.

[40] K. Chai and K. Tan, "A TRIZ-Based Method for New Service Design," 2001.

[41] P. Hanafizadeh, M. Moosakhani, and J. Bakhshi, "Selecting the best strategic practices for business process redesign," *Busines*, vol. 15, no. 4, pp. 609–627, 2009.

[42] M. Dumas, J. Mendling, M. La Rosa, and H. A. Reijers, *Fundamentals of business process management*. Springer-Verlag Berlin Heidelberg, 2013.

[43] W. Van Der Aalst, M. Duman, and A. H. M. ter Hofstede, *Process-aware information systems : bridging people and software through process technology*. Hoboken : Wiley-Interscience, 2005.

[44] P. Runeson and M. Höst, "Guidelines for conducting and reporting case study research in software engineering," *Empir. Softw. Eng.*, vol. 14, no. 2, pp. 131–164, 2009.

[45] "12 Important Questions When Starting BPM Projects - BPM Leader." [Online]. Available: http://www.bpmleader.com/2012/02/14/12-important-questions-when-starting-bpm-projects/. [Accessed: 18-Nov-2015].

[46] M. Klein, "10 Principles of Reengineering," *Exec. Excell.*, vol. 12, no. 2, p. 20, 1995.

[47] C. J. Hammer M, *Reengineering the corporation:a manifesto for business revolution*. New York:Harper Business Editions, 1993.

[48] R. K. Oliver and M.D. Webber, "Supply-chain management: logistics catches up with strategy," *Logist. Strateg. Issues*, 1982.

[49] B. A and P. P, *Workflow: continuous improvement by integral process management*, Schoonhove. 1997.

[50] "The Open Group." [Online]. Available: http://pubs.opengroup.org/architecture/archimate2-doc/.

Appendix A: BPR best practices with correlative class & the aspects of BPR framework

Name	**Description**	**Framework aspect**
	Task Rules	
Task elimination	eliminate unnecessary tasks from a workflow	Operation view
Task addition	add tasks, e.g., control tasks, to a process	Org-population
Task composition	combine small tasks into composite tasks and divide a large task into workable smaller tasks	Operation view
Task automation	consider automating tasks	Technology
	Routing Rules	
Resequencing	move tasks to more appropriate places	Behavioral view
Knock-out	order knock-outs in an increasing order of effort and a decreasing effort of termination probability	Behavioral view
Control relocation	move controls towards the client	Customers
Parallelism	consider whether tasks may be executed in parallel	Behavioral view
Triage	consider the division of a general task into two or more alternative tasks or the opposite	Operational view
	Allocation Rules	
Case manager	appoint one person as responsible for the handling of each case	Org.-structure
Case assignment	let workers perform as many steps as possible for single cases	Org.-structure
Customer teams	consider assigning teams out of different departmental worker that take care of specific sorts of cases	Org.-structure
Flexible assignment	assign resources in such a way that maximal flexibility is preserved for the near future	Org.-structure
Resource Centralization	treat geographically dispersed resources as if they are centralized	Org.-structure
Split responsibilities	avoid assignment of task responsibilities to people from different functional units	Org.-structure
	Resource Rules	
Numerical involvement	minimize the number of departments, groups, and persons involved in a process	Org.-structure
Extra resources	increase capacity of a certain resource class	Org.-population
Specialist - Generalist	consider making resources more specialist or generic	Org.-population
Empower	give workers most of the decision-making authority and reduce middle management	Org.-population
	Rules for External Parties	
Integration	consider integration with a workflow of the client or a supplier	Customer
Outsourcing	consider outsourcing a workflow in whole or parts of it	External
Interfacing	consider a standardized interface with clients and partners	External
Contact reduction	reduce the number of contact with clients and third parties	Customers
Buffering	subscribe to updates instead of requesting information from external source	Information

Trusted party	instead of determining information oneself, use results of a trusted party	External
Integral Workflow Rules		
Case types	distinguish new workflows and product types for tasks related to the same type of case	Operation view
Technology	try to elevate physical constraints in a workflow by applying new technology	Technology
Exception	design workflows for typical cases and isolate exceptional cases from the normal flow	Behavioral view
Case-based work	consider removing batch-processing and periodic activities for a workflow	Operation view

BPR best practices with correlative class and aspect of the BPR framework [14] [25]

Appendix B: Overview of the effects of best practices

<table>
<tr><th rowspan="2"></th><th colspan="6">Time</th><th colspan="4">Costs</th><th colspan="2">Quality</th><th colspan="5">Flexibility</th></tr>
<tr><th>LT</th><th>TT</th><th>WT</th><th>SUT</th><th>ST</th><th>PT</th><th>RNC</th><th>LC</th><th>RC</th><th>TC</th><th>EQ</th><th>IQ</th><th>MF</th><th>LF</th><th>RF</th><th>VF</th><th>PF</th></tr>
<tr><td colspan="18">Customer</td></tr>
<tr><td>Control relocation</td><td colspan="6">0</td><td>-</td><td>-</td><td>0</td><td>0</td><td>+</td><td>0</td><td colspan="5">0</td></tr>
<tr><td>Contact reduction</td><td>+</td><td>+</td><td>+</td><td>0</td><td>0</td><td>0</td><td>-</td><td>-</td><td>0</td><td>0</td><td>+</td><td>0</td><td colspan="5">0</td></tr>
<tr><td>Integration</td><td>+</td><td>+</td><td>0</td><td>0</td><td>0</td><td>0</td><td>+</td><td>+</td><td>+</td><td>0</td><td colspan="2">0</td><td>-</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td colspan="18">Operation view</td></tr>
<tr><td>Order types</td><td>+</td><td>+</td><td>0</td><td>+</td><td>0</td><td>+</td><td>+</td><td>+</td><td>+</td><td>0</td><td>-</td><td>-</td><td>0</td><td>0</td><td>0</td><td>0</td><td>-</td></tr>
<tr><td>Task elimination</td><td>+</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>+</td><td>0</td><td>0</td><td>0</td><td>0</td><td colspan="5">?</td></tr>
<tr><td>Order-based work</td><td>+</td><td>+</td><td>+</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>-</td><td>0</td><td colspan="2">0</td><td colspan="5">0</td></tr>
<tr><td>Triage</td><td>+</td><td>+</td><td>+</td><td>0</td><td>0</td><td>0</td><td>+</td><td>+</td><td>+</td><td>0</td><td>+</td><td>0</td><td>0</td><td>-</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Task composition</td><td>+</td><td>+</td><td>0</td><td>+</td><td>0</td><td>0</td><td>+</td><td>+</td><td>0</td><td>0</td><td>+</td><td>0</td><td>0</td><td>-</td><td>0</td><td>-</td><td>0</td></tr>
<tr><td colspan="18">Behavioral view</td></tr>
<tr><td>Resequencing</td><td>+</td><td>+</td><td>0</td><td>+</td><td>0</td><td>0</td><td>+</td><td>+</td><td>0</td><td>0</td><td colspan="2">0</td><td colspan="5">0</td></tr>
<tr><td>Parallelism</td><td>+</td><td>+</td><td>0</td><td>0</td><td>0</td><td>0</td><td>-</td><td>-</td><td>0</td><td>0</td><td>-</td><td>-</td><td>0</td><td>-</td><td>0</td><td>-</td><td>0</td></tr>
<tr><td>Knock-out</td><td>-</td><td>-</td><td>0</td><td>0</td><td>0</td><td>0</td><td>+</td><td>+</td><td>0</td><td>0</td><td colspan="2">0</td><td colspan="5">0</td></tr>
<tr><td>Exception</td><td>+</td><td>+</td><td>0</td><td>+</td><td>+</td><td>+</td><td colspan="4">0</td><td>+</td><td>+</td><td>0</td><td>-</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td colspan="18">Organization</td></tr>
<tr><td>Order assignment</td><td>+</td><td>+</td><td>0</td><td>+</td><td>0</td><td>+</td><td colspan="4">0</td><td>+</td><td>0</td><td>0</td><td>-</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Flexible assignment</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td colspan="4">0</td><td>+</td><td>0</td><td>0</td><td>-</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Centralization</td><td>+</td><td>+</td><td>0</td><td>0</td><td>0</td><td>0</td><td>-</td><td>0</td><td>-</td><td>0</td><td colspan="2">0</td><td>0</td><td>+</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Split responsibility</td><td>-</td><td>-</td><td>-</td><td>0</td><td>0</td><td>0</td><td colspan="4">0</td><td>+</td><td>+</td><td>0</td><td>-</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Customer team</td><td>+</td><td>+</td><td>0</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>0</td><td>0</td><td>+</td><td>+</td><td>0</td><td>-</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Numerical involvement</td><td>-</td><td>-</td><td>0</td><td>-</td><td>-</td><td>-</td><td>+</td><td>+</td><td>0</td><td>0</td><td>-</td><td>0</td><td colspan="5">0</td></tr>
<tr><td>Case manager</td><td colspan="6">0</td><td>-</td><td>-</td><td>0</td><td>0</td><td>+</td><td>+</td><td colspan="5">0</td></tr>
<tr><td colspan="18">Population</td></tr>
<tr><td>Extra resources</td><td>+</td><td>+</td><td>+</td><td>0</td><td>0</td><td>0</td><td>-</td><td>-</td><td>0</td><td>0</td><td colspan="2">0</td><td>0</td><td>+</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Specialist (S)-Generalist (G)</td><td>+</td><td>+</td><td>0</td><td>+ (S)</td><td>+ (S)</td><td>+ (S)</td><td colspan="4">0</td><td>+ (S)</td><td>0</td><td>0</td><td>+ (G)</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Empower</td><td>+</td><td>+</td><td>0</td><td>0</td><td>0</td><td>0</td><td>+</td><td>+</td><td>0</td><td>0</td><td>-</td><td>0</td><td colspan="5">0</td></tr>
<tr><td colspan="18">Information</td></tr>
<tr><td>Control addition</td><td>-</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>+</td><td>+</td><td>0</td><td>0</td><td>+</td><td>0</td><td colspan="5">0</td></tr>
<tr><td>Buffering</td><td>+</td><td>+</td><td>0</td><td>0</td><td>0</td><td>0</td><td>-</td><td>0</td><td>-</td><td>0</td><td colspan="2">0</td><td colspan="5">0</td></tr>
<tr><td colspan="18">Technology</td></tr>
<tr><td>Task automation</td><td>+</td><td>+</td><td>0</td><td>+</td><td>+</td><td>+</td><td colspan="4">0</td><td>+</td><td>0</td><td>-</td><td>+</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>Integral BP technology</td><td>+</td><td>+</td><td>0</td><td>+</td><td>+</td><td>+</td><td>+</td><td>+</td><td>0</td><td>0</td><td>+</td><td>-</td><td colspan="5">0</td></tr>
<tr><td colspan="18">External environment</td></tr>
<tr><td>Trusted party</td><td>+</td><td>+</td><td>0</td><td>0</td><td>0</td><td>0</td><td>+</td><td>+</td><td>0</td><td>0</td><td colspan="2">0</td><td colspan="5">0</td></tr>
<tr><td>Outsourcing</td><td colspan="5">0</td><td></td><td>+</td><td>+</td><td>+</td><td>0</td><td>-</td><td>-</td><td colspan="5">0</td></tr>
<tr><td>Interfacing</td><td>+</td><td>+</td><td>0</td><td>0</td><td>+</td><td>+</td><td>+</td><td>+</td><td>0</td><td>0</td><td>+</td><td>0</td><td colspan="5">0</td></tr>
</table>

Extended impacts of best practices on time, cost, quality and flexibility dimensions

LT: lead time, TT: throughput time, WT: wait time, SUT: setup time, ST: service time, PT: processing time, RNC: running costs, LC: labor costs, RC: resource costs, TC: training costs, EQ: external quality, IQ: internal quality, MF: mix flexibility, LF: labor flexibility, RF: routing flexibility, VF: volume flexibility, PF: process modification flexibility

Customer best practices

Control relocation: "move controls towards the customer" (Quality ↑, Cost ↑)

"*Different checks and reconciliation operations that are part of a business process may be moved towards the customer. Klein* [46] *gives the example of Pacific Bell that moved its billing controls towards its customers eliminating in this way the bulk of its billing errors. It also improved customer's satisfaction. A disadvantage of moving a control towards a customer is higher probability of fraud, resulting in less yield"*

By rethinking and moving the checks towards the customer, according to Reijers and Limam [14], this best practice can improve customer satisfaction and hence **the external quality**. **No effect is realized on the internal quality,** by our own reasoning. However, its side effect lies on the cost dimension. Different checks are put on the customer side can lead to "*higher probability of fraud, less yield*" [14], resulting the negative effect on the costs for executing the process (running costs), and **the labor cost in particular since the employees have to redo the work due to the customer error checking**. There appears no effect on the resource and training costs.

Contact reduction: "reduce the number of contacts with customers and third parties" (Throughput Time ↓, Quality ↑, Cost ↑)

"*The exchange of information with a customer or third parties is always time-consuming. Especially when information exchanges take place by regular mail, substantial wait times may be involved. Also each contact introduces the possibility of intruding an error. Hammer and Champy* [47] *describe a case where the multiple of bills, invoices and receipts creates a heavy reconciliation burden. Reducing the number of contact may therefore decrease throughput time and boost quality. Note that it is not always necessary to skip certain information exchanges, but that is possible to combine them with limited extra cost. Combining contacts may result in the delivery or receipt of too much data, which involves costs*"

Reijers and Limam [14] stated that, by applying this best practice, there is no effect expected on the flexibility dimension. However, it can reduce the throughput time. Moreover, reducing the number of contacts also means that the exchange of information is eliminated and hence we think that **the waiting time can be reduced**. **No effect is noted on the processing time (set up time and service time)**. As a result, this best practice can **reduce the lead time** eventually. Moreover, contact reduction best practice can "*boost quality*"[14] of the whole process. Note that skipping unnecessary information exchange can eliminate the loss of information and erroneous information, resulting the **improved external quality** for the process. There is **no effect realized on the internal quality**. If communication with customers and third parties is reduced, the likelihood to have more errors in the process is increased. Therefore, there is extra time spent on going over the errors and fixing them, this is increased labor cost and hence the **increased running cost** as a consequence. By applying this best practices, we see that there is **no effect on the resource cost and training cost**.

Integration: "consider the integration with a business process of the customer or supplier" (Time ↓, Cost ↓, Flexibility ↓)

"This best practice can be seen as exploiting the supply-chain concept known in production [48]*". The actual application of this best practice may take on different forms. For example, when two parties have to agree upon a*

product they jointly produce, it may be more efficient to perform several intermediate reviews than performing one large review after both parties have completed their part. In general, integrated business processes should render a more efficient execution, from both a time and a cost perspective. The drawback of integration is that mutual dependence grows, and therefore, flexibility may decrease".

Following Reijers and Limam's discussion [14], integrated business processes "*render a more efficient execution, both from time and cost perspective*". **Throughput time is therefore reduced.** By our own reasoning, integrating processes **does not alter the service time and set up time** of an activity, hence **the processing time is not affected**. Besides, this best practice has **no effect on the wait time**. As a result, reduced throughput time will lead **to reduced lead time** of a process. On the cost dimension, as a better coordination between different subunits in a process is established, error is found in the earliest stage. Therefore, less/ no extra cost is spent on fixing the error in the last moment, redoing all the activities in a worse situation. In other words, applying this best practice will **reduce the labor and resource costs** which results in the **reduced running cost** of a process.

As stated by Reijers and Limam, flexibility may decrease by applying integration best practice. We realize that it counts for all types of flexibility since the more mutual dependence it has, the less ability to process different types of cases, or to handle changing volumes of input or even to modify the process itself, etc.

Business process operation best practices

Order types: "*determine whether tasks are related to the same type of order and, if necessary, distinguish new business process*" (Time ↓, Cost ↓, Flexibility ↓, Quality ↓)

"Especially Berg and Pottjewijd [49] *convincingly warn for parts of business processes that are not specific for the business process they are part of. Ignoring this phenomenon may result in a less effective management of this "sub-flow" and a lower efficiency. Applying this best practices may yield faster processing time and less cost. Also, distinguishing common sub-flows of many different flows may yield efficiency gains. Yet, it may also result in more coordination problems between the business process (quality) and less possibilities for rearranging the business process as a whole (flexibility)"*

Applying this best practices may **reduce the setup time** since process handles only the same type of order, which leads to **reduced processing time** as components of processing time include setup time. With the same reasoning, yet, it may also result in **reduced throughput time** and **lead time** of a process.

Besides, distinguishing and putting tasks of the same type of order in one business process could also gain the labor efficiency. As a result, there is **a positive effect on labor costs and the resource costs** either since all the materials, equipment, facilities even workers are fully utilized. Since labor costs and resource costs are components of running costs, we obtain also the **reduced running costs** for a process. Also, this best practice may introduce "*more coordination problems between the business process*" [14], which may **negatively affect both the external and internal quality**. In addition, Order Type p**rovides "*less possibility for rearranging the business process"*** [14]***,*** **which is indeed the process modification flexibility**. There seems **no effect on the other type of flexibility.**

Task elimination: "*eliminate unnecessary tasks from a business process*" (Time ↓, Cost ↓, Flexibility ↓)

"*A common way of regarding a task as unnecessary is when it adds no value from a customer's point of view. Typically, control tasks in a business process do not do this; they are incorporated in the model to fix the problems created (or not elevated) in earlier steps. Control tasks are often identified by iterations. Tasks redundancy can also be considered as a specific case of task elimination. The aims of this best practice are to increase the speed of processing and to reduce the cost of handling an order."*

Task elimination best practice is stated by Reijers and Limam Mansar to have positive effects cost dimension. By our own reasoning, we realize that it reduces the **labor costs** in particular as eliminating tasks, in many cases, also means reducing the concerned workforce and hence costs of the workforce. And as labor costs is a component of the running cost of a process, **reduced labor cost may lead to reduced running cost** as well. This best practice also increases "*the speed of processing*" [14], resulting in **reduced lead time** of a process in general. A disadvantage of eliminating number of tasks in a process is the reduce of flexibility in general according to Reijers and Limam Mansar's work [14].

Order-based work: "*consider removing batch-processing and periodic activities from a business process*" (Time ↓, Cost ↑)

"*Some notable examples of disturbances in handling a single order are: (a) its piling up in a batch and (b) periodic activities, e.g. because processing depends on a computer system that is only available at a specific times. Getting rid of these constraints may significantly speed up the handling of individual orders. On the other hand, efficiencies of scale can be reached by batch processing. Also, the cost of making information systems permanently available may be costly. This best practice results from our own reengineering experience. "*

Getting rid of processing depending on a computer system that is only available at a specific times, this best practice **reduces the wait time hence the throughput and lead time** of a business process since wait time is a component of through put time and lead time. To our opinion, there seems **no effect on the setup time and service time**. But, avoid periodic processing also means that the information systems have to be permanently available, which is indeed a **negative effect on the resource costs**.

Triage: "*consider the division of a general task into two or more alternative tasks*" or *"consider the integration of two or more alternative tasks into one general task"* (Time ↓, Cost ↓, Flexibility ↓, Quality ↑)

"When applying this best practice in it first and most popular form, it is possible to design tasks that are better aligned with the capabilities of resources and the characteristics of the orders being processed. Both interpretations improve upon the quality of business process. Distinguishing alternative tasks also facilitates a better utilization of resources, with obvious cost and time advantages. On the other hand, too much specialization can make processes become less flexible, less efficient, and cause monotonous work with repercussions for quality. An alternative form of triage best practice is to divide a task into similar instead of alternative tasks for different subcategories of orders being processed. For examples, a special cash desk may be set up for customers with an expected low processing time"

Distinguishing alternatives tasks facilitates "*a better utilization of the resource*" [14]. Having the personal as well as equipment available at the right time for the tasks and avoiding idle resource resulting in **less time spent on waiting** plus the **advantage on the labor costs and resource costs**. The reduced wait time may lead to **reduced throughput time and lead time** as wait time is a component of throughput time and lead time. With the same reasoning there seems **a positive effect on the running costs** of the whole process.

According to Reijers and Limam Mansar's work [14], applying this best practice can improve upon the quality of a process because when tasks are better aligned with capability of resources and the characteristics of the orders being processed, it will lead to **higher productivity which is indeed the external quality.**

On the other hand, too much specialization may lead to **less ability to perform different tasks (per resource) which is labor flexibility**. We realize no effect on the other types of flexibility.

Task composition: "*combine smaller tasks into composite task and divide large tasks into workable smaller tasks*" (Time ↓, Cost ↓, Flexibility ↓, Quality ↑)

"Combining tasks should result in the reduction of setup times i.e., the time that is spent by a resource to become familiar with the specifics of a order. By executing a large task which used to consist of several smaller ones, some positive effect may also be expected on the quality of the delivered work. On the other hand, making tasks too large may result in (a) smaller run-time flexibility and (b) lower quality as tasks become unworkable. Both effects are exactly countered by dividing tasks into smaller ones. Obviously, smaller tasks may also result in longer setup times"

By executing large task consisting of smaller ones, "*less time is spent by a resource to become familiar with an order*"[14]. **There is therefore a reduction in the costs for the workforce, named labor cost** and as a result, a **positive effect on the running costs** of the process as labor costs is a component of running costs. In general, workable small tasks get direct attention and are easy to coordinate; hence there will be little room for errors. Also, in some cases, reasonable composite tasks can benefit from the highly concentration and continuousness from workers, resulting in the increased efficiency. Both interpretations of this best practice may **improve the external quality of a process**. Besides, an application of the task composition best practices results in a reduction of setup times when multiple smaller tasks are combined into one task. This reduction in setup time may also reduce the lead time and throughput time of a process.

On the other hand, making tasks too large should lead to smaller run time flexibility, which can be the **less ability to handle changing volume of input (volume flexibility), to perform different task (labor flexibility)** . By our own reasoning, **there is no clear effect on the other types of flexibility.**

Business process behavior best practices

Resequencing: "*move tasks to more appropriate places*" (Time ↓, Cost ↓)

"*In existing business process, actual tasks orderings do not reveal the necessary dependencies between tasks. Sometimes, it is better to postpone a task if it is not required for immediately following tasks, so that perhaps its* *execution may prove to become superfluous. This saves costs. Also, a task may be moved into the proximity of a similar task, in this way diminishing setup times*"

If the task is not required for immediately following tasks, this best practice suggests postponing it. Reijers and Limam argued that its execution may prove to become superfluous. If that is the case, it may **save the costs for the workforce and hence the running costs of the process finally**. We realized **no effect on the resource costs and training costs.**

If a task is moved to the proximity of a similar task, **a setup time may be reduced**, which will lead to **the reduced throughput time and lead time** since setup time is a component of throughput time and lead time.

Knock-out: "order knock-outs in an increasing order of effort and in a decreasing order of termination probability" (Time ↑, Cost ↓)

"A typical part of a business process is the checking of various conditions that must be satisfied to deliver a positive end result. Any condition that is not met may lead to a termination of that part of a business process: the knock-out. If there is freedom in choosing the order in which the various conditions are checked, the condition that has the most favorable ratio of expected knock-out probability versus the expected effort to check the condition should be pursued. Next, the second best condition, etc. This way of ordering checks yields on average the least costly business process execution. There is no obvious drawback on this best practice, although it may not always be possible to freely order these kinds of checks. Also, implementing this best practice may result in a (part of a) business process that takes a longer throughput time than a fully parallel checking of all conditions"

By ordering checks in a decreasing order of termination, cost for executing the process, in particular **labor costs can be saved since workforce is optimal used which results in the reduced running cost of the process**. However, as argued by Reijers and Limam, implementing this best practice may lead to **longer throughput time** and hence **longer lead time** at the end. By our own reasoning, there is no **drawback on the wait time, setup time, and service time of the task**.

Parallelism: "consider whether tasks may be executed in parallel" " (Time ↓, Cost ↑, Flexibility ↓, Quality ↓)

"The obvious effect of putting tasks in parallel is that the throughput time may be considerably reduced. The application of this best practice in business process redesign is large. In practical experience, we have had with analyzing existing business process, tasks were mostly ordered sequentially without the existence of hard logical restrictions prescribing such an order. A drawback of introducing more parallelism in a business process that incorporates possibilities of knock-outs is that the cost of business process execution may increase. Also, the management of business process with concurrent behavior can become more complex, which may introduces errors (quality) or restrict run-time adaptations (flexibility)"

As stated, implementing this best practice results in the reduced **throughput time and hence the lead time of the process**. However, its application of this best practice may be costly because of the simultaneous arrangement of labor work and hence **increased labor costs** and finally the **increased running costs** of the process.

Besides, the concurrent behavior is natural more complex than sequential and hence errors can occur, resulting in **decreased external** and **internal quality** of a process. This best practice restricts run-time adaptations. There seems less ability to perform different tasks or to handle changing volumes of input which are accordingly **the labor and volume flexibility**. There is no obvious drawback on the other types of flexibility.

Exception: "design business processes for typical orders and isolate exceptional orders from normal flow" (Time ↓, Quality ↑, Flexibility ↓)

"Exceptions may seriously disturb normal operations. An exception, will require workers to get acquainted with the specifics of the exception, although they may not be able to handle it . Setup times are then wasted. Isolating exceptions, for example by a triage, will make the handling of normal orders more efficient. Isolating exceptions may possibly increase the overall performance as specific expertise can be built up by workers working on the exceptions. The price paid is that the business process will become more complex, possibly decreasing its flexibility. Also, if no special knowledge is developed to handle the exceptions (which is costly), no major improvements are likely to occur"

Isolating exceptions from normal flow can help the workers concentrate on their work without any unnecessary interruption (an exception will require workers to get acquainted with the specifics of the exception although they may not be able to handle it), which leads to a whole or piece of work being completed in a timely manner. **Setup time and service time are likely reduced**, which possibly **decrease the throughput time and lead time** of the process. Also, when workers can focus fully on what they are doing without caring much on the exception handling, the quality of the process is high from workers' perspective and more important they are likely deliver good products/ services in the end, which are signs of positive effects on the **internal** and **external quality** of a business process.

By our own reasoning, **the drawback is realized on the labor flexibility** of a process there is less possibility to process different tasks (per resource, task or process). No obvious drawbacks are noted on other types of flexibility.

Organization best practices

Order assignment: "*let workers perform as many steps as possible for single orders*" (Time ↓, Quality ↑, Flexibility ↓)

"By using order assignment in the most extreme form, for each task execution, the resource is selected from the ones capable of performing it that has worked on the order before – if any. The obvious advantage of this best practice is that this person will get acquainted with the case and will need less setup time. An additional benefit may be that the quality of service is increased. On the negative side, the flexibility of resource allocation is seriously reduced. The execution of an order may experience substantial queue time when the person to whom it is assigned is not available."

This best practice means tasks are coordinated and assigned to the highest specialized workers, hence the obvious advantage is the **high external quality** of the process in the end. Since implementing this best practice will require **less setup time**, as argued by Reijers and Limam and hence the **less throughput time and lead time** of the process. However, the price paid is that there may be less possibility to perform different tasks per resource and so the **reduced labor flexibility**.

Flexibility assignment: "*assign resources in such a way that maximal flexibility is preserved for the near future*" (Time ↓, Quality ↑, Flexibility ↓)

"For example, if a task can be executed by either of two available resources, assign it to the most specialized resource. In this way, the possibilities to have the free, more general resource execute another task are maximal"

By using this best practice, the task is assigned to the most specialized resources. The obvious advantage is that the quality of product/ process is improved, so the **high external quality** of a business process. The additional benefit may be that the workers already got acquainted with the case hence **less setup time needed** and also because of their experience less time spent on actually handling the case which is indeed **the service time**. Besides, implementing this best practice, there is high possibility to have free, more general resource to execute tasks; and hence the **less time is spent on waiting for available resources.** As a result, there is possible **decrease in processing time, through put and lead time of a process**.

However, **the labor flexibility is reduced** since there is a reduction in the possibilities to perform different tasks. There seems no obvious drawback on the other types of flexibility.

Centralization: "treat geographically dispersed resources as if they are centralized" (Time ↓, Cost ↑, Flexibility ↑)

"This best practice is explicitly aimed at exploiting the benefits of a Workflow Management System or WfMS for short. After all, when a WfMS takes care of assigning work to resources, it has become less relevant where these resources are located geographically. In this sense, this best practice is a special form of the integral technology best practice. The specific advantage of this measure is that resources can be committed more flexibly, which gives a better utilization and possibly a better throughput time"

As defined, this best practice can help resources commit more flexible and perform different tasks no Master where they are located geographically, leading to the **positive effect on labor flexibility**. There seems no effect on the other types of flexibility. Reijers and Limam stated that applying this best practice may result in a **better throughput time and hence the reduced lead time of a business process.**

However, **the costs for executing the process can be high** since there is extra investment on the facilities, equipment and especially the communication technology (**resource costs**), which will lead **to high running cost** of a process.

Split responsibility: "avoid assignment of task responsibilities to people from different functional units" (Time ↑, Quality ↑, Flexibility ↓)

"The idea behind this best practice is that tasks for which different departments share responsibility are more likely to be a source of neglect and conflict. Reducing the overlap in responsibilities should lead to a better quality of task execution. Also, a higher responsiveness to available work may be developed so that customers are served quicker. On the other hand, reducing the effective number of resources that is available for a work item may have a negative effect on its throughput time, as more queuing may occur"

Applying this best practice can lead to a better quality of task execution; a positive effect on the quality dimension. However, reducing the overlap in responsibility also means higher responsiveness. Customers are therefore served quicker, hence positive effect on **external quality** in particular. On the other hand, assigning tasks for people in the same department can also reduce conflict as they work in the same "working culture", feedback about the process performance is direct and clear, and most importantly it is retrieved in a timely manner. These are referred as the **internal quality.** The price paid is that there is a **negative effect on the labor flexibility** because of the decreased ability for workers to perform different tasks.

Customer teams: "consider assigning teams out of different departmental workers that will take care of the complete handling of specific sorts of orders" (Time ↓, Quality ↑, Flexibility ↓, Cost ↓)

"This best practice is a variation of the order assignment best practice. Depending on its exact desired form, the customer team best practice may be implemented by the order assignment best practice. Also, a customer team may involve more workers with the same qualifications, in this way relaxing the strict requirements of the order assignment best practice. Advantages and disadvantages are similar to those of the order assignment best practice. In addition, work as a team may improve the attractiveness of the work and a better understanding, which are both quality aspects."

This best practice may **reduce the ability to perform different tasks per resource** (**labor flexibility**). However, team work creates **higher quality outcomes (external quality)**. In that sense, less cost is spent on rework/ fixing errors. The social aspect of teamwork can motivate team members and help them come up with high performance (**internal quality**). Also, teams are built up by many contributors; there is **less setup time and service time** needed, which lead to the **reduced throughput time and lead time** for a business process

Numerical involvement: "minimize the number of departments, groups, and person involved in a business process" (Time ↑, Quality ↓, Cost ↓)

"Applying this best practice should lead to less coordination problems. Less time spent of coordination makes more time available for the processing of orders. Reducing the number of departments may lead to less split responsibilities, with similar pros and cons as the split responsibilities best practice. In addition, smaller numbers of specialized units may prohibit the build of expertise (a quality issue) and routine (a cost issue)"

This best practice may minimize the number of specialized workers/ units involved in a business process which may lead to the **decreased quality of final products/ processes (external quality**). Lacking of expertise, workers often have to spend more time to fulfill the tasks, showing **the negative effect on the processing time** and hence **possibly increase the throughput time and lead time** of a process. However, as argued by Reijers and Limam, smaller numbers of expertise can **save the cost, in particular the labor costs and hence leading to the reduced running cost** of the process.

Case manager: “appoint one person as responsible for the handling of each type of order, the case manager” (Quality ↑, Cost ↑)

“*The case manager is responsible for a specific order or customer, but he or she is not necessarily the (only) resource that will work on it. The difference with the order assignment practice is that the emphasis is on management of the process and not on its execution. The most important aim of the best practice is to improve upon the external quality of a business process. The business process will become more transparent from the viewpoint of a customer as the case manager provides a single point of contact. This positively affects the customer satisfaction . It may have the positive effect on the internal quality of the business process, as someone is accountable for correcting mistakes. Obviously, the assignment of a case manager has financial consequences as capacity must be devoted to this job*”

As reasoned in in Reijers and Limam’s work [14], this best practice has positive effects on **the internal and external quality of a process**. The obvious drawback is the **increased labor cost** since we have to pay for this additional role which may possibly **increase the running cost**.

Population best practices

Extra resources: “if capacity is not sufficient, consider increasing the number of resources” (Time ↓, Flexibility ↑, Cost ↑)

“This straightforward best practice speaks for itself. The obvious effect of extra resources is that there is more capacity for handling orders, in this way reducing the queue time. It may also help to implement a more flexible assignment policy. Of course, hiring or buying extra resources has its costs.”

Implementing this best practice **reduces the queue time**, as stated by Reijers and Limam hence possibly reduces **throughput and lead time** of a business process. It also has the **positive effect on the labor flexibility** since more resources involved may improve the flexibility of assignment policy. On the negative side, **the labor cost** is increased of hiring or buying extra resources which will lead to the **increased running cost** at the end.

Specialist – Generalist: “consider to make resources more specialized or more generalist” (Time ↓ in case of “Specialist”, Flexibility ↑ in case of “Generalist”)

“Resources may be turned from specialists into generalists or the other way around. A specialist resource can be trained for other qualifications; a generalist may be assigned to the same type of work for a longer period of time, so that his other qualifications become obsolete. When a redesign of a new business process is considered, application of this best practice comes down to considering the specialist-generalist ratio of new hires. A specialist builds up routine more quickly and may have a more profound knowledge than a specialist. As a result, he or she works quicker and delivers higher quality. On the other hand, the availability of generalists adds more flexibility to the business process and can lead to a better utilization of resources. Depending on the degree of specialization or generalization, either type of resource may be more costly. ”

In the form of making resources more specialized, this best practice should lead to **less time spent on setting up (setup time) and actually handling the case (service time)**; so possibly **reduce the throughput time and lead time**

of a business process. Also, its important aim is to improve the external quality of a process by specialized workers' contribution. As making the resource more generalist, this best practice can **improve the labor flexibility** since the workers are able to perform different tasks. To our opinion, there is **no obvious drawbacks on the other type of flexibility.**

Empower: "give workers most of the decision making authority and reduce middle management" (Time ↓, Quality ↓, Cost ↓)

"In traditional business processes, substantial time may be spent on authorizing work that has been done by others. When workers are empowered to take decisions independently, it may result in smoother operations with lower throughput times. The reduction of middle management from the business process also reduces the labor cost spent on the processing orders. A drawback may be that the quality of the decisions is lower and that obvious errors are no longer found. If bad decisions re errors result in rework, the cost of handling a order may actually increase compared to the original situation."

As discussed by Reijers and Limam [14], implementing this best practice may result in positive effect on throughput time and hence **the total lead time of a process**. There is **no obvious drawback on the other type of time realized**. Also, it can reduce the labor cost and so **the cost for executing the process (running cost)**. A drawback may be the low quality of decision which can lead to the introduction of errors and may require rework at the latter stage, hence **decreased external quality**.

Information best practices

Control addition: "check the completeness and correctness of incoming materials and check the output before it is sent to the customers" (Time ↑, Quality ↑, Cost ↓)

"This best practice promotes the addition of controls to a business process. It may lead to a higher quality of the business process execution and, as a result, to less required rework. Obviously, an additional control will require time and will absorb resources."

Applying this best practice may reduce the errors and hence less required rework, less is spent on the labor costs, and as a result less costs for executing the process (running cost). More important, **high quality of output will be delivered to customer (external quality)**. However, it takes longer to handle an entire case, hence **a negative effect on the lead time**.

Buffering: "instead of requesting information from an external source, buffer it by subscribing to updates" (Time ↓, Cost ↑)

"Obtaining information from other parties is a major time-consuming part in many business process. By having information directly available when it is required, throughput times may be substantially reduced. This best practice can be compared to the caching principle microprocessors apply. Of course, the subscription fee for information updates maybe rather costly. This is especially so when we consider information sources that contain far more information than is ever used. Substantial cost may also be involved with storing all the information. "

The positive effect is recognized on the throughput time as discussed by Reijers and Limam [14] which may lead to the reduced lead time of a business process. There is an **extra spent on resource costs** i.e. facilities, equipment for storing all the information and so **the increased running cost**.

Technology best practices

Task automation: "consider automating tasks" (Time ↓, Quality ↑, Flexibility ↓)

"A particular positive result of automating tasks maybe that tasks can be executed faster, with less cost, and with a better result. An obvious disadvantage is that the development of a system that perform a task maybe very costly. Generally speaking, a system performing a task is also less flexible in handling variations than a human resource. Instead of fully automating a task, an automated support of resource executing the task may also be considered."

The specific advantage is that it can speed up the **processing time (setup time + service time)** and results in **better throughput and service time of a process**. Moreover, by automation, the outcomes of a process will be stable and have better quality, resulting in **high external quality**. Disadvantage lies on the flexibility dimension because of the decreased **possibility to process different type of cases (mix flexibility) or perform different task per resource (labor flexibility)**.

Integral BP technology: "try to elevate physical constraints in a business process by applying new technology" (Time ↓, Quality ↑, Cost ↓)

"In general, new technology can offer all kinds of positive effects. For example, the application of a WfMS may results in less time that is spend on logistical tasks. A Document Management System will open up the information available on orders to all participants, which may result in a better quality of service. New technology can also change the traditional way of doing business by giving participants completely new possibilities. The purchase, develop, implementation, training and maintenance efforts related to technology are obviously costly. In addition, new technology may arouse fear with workers or may result in other subjective effects; this may decrease the quality of the business process"

With the help of new technology, a particular positive result of this best practice maybe that tasks can be executed faster hence a **better processing time (set up time + service time)** which can possibly **reduce the throughput and lead time of a business process.** Integral BP technology may lead to a higher quality of the business process execution and, as a result, **high external quality.** However, as stated by Reijers and Limam, new technology may arouse fear with worker, this may **decrease the internal quality**. Moreover, high quality of a business process execution may result in less required rework and hence **less is spent on the labor costs**, and as a result **costs for executing the process (running cost) can be reduced**.

External environment best practices

Trusted party: "instead of determining information oneself, use results of trusted party" (Cost ↓, Time ↓)

"Some decisions or assessments that are made within business process are not specific for the business process they are part of. Other parties may have determined the same information in another context, which – of it were known- could replace the decision or assessment. An example is the creditworthiness of a customer that bank A wants to establish. If a customer can present a recent creditworthiness certificate of bank B, then bank A will accept it. Obviously, the trusted party best practice reduces cost and may even cut back throughput time. On the other hand, the quality of the business process becomes dependent upon the quality of some other party's work. Some coordination effort with trusted parties is also likely to be required, which diminishes the flexibility."

Besides **reducing the throughput time** as stated by Reijers and Limam [14], obviously **the labor cost can be reduced** as well by using the existing results of the trusted parties. **Less throughput time can lead to less lead time** of a business process. Moreover, **the reduced labor costs possibly results in the reduced the total running cost.** There is **no obvious drawback on the other types of cost and time**, to your opinion.

Outsourcing: "consider outsourcing a business process in a whole or part of it" (Cost ↓, Quality ↓)

"Another party may be more efficient in performing the same work, so it might as well perform it for one's own business process. The obvious aim of outsourcing work is that it will generate less cost. A drawback may be that quality decreases"

Most of the time the organization cannot manage all the steps of a business process internally, hence outsourcing a whole process or part of it to the specialized external service can lead to less **labor and resource costs** spent, which possibly reduces the running cost of a business process. However, it appears some difficulties in coordinating the quality when outsourcing or even if it is not outsourced to the right service, the quality of the work can be notably reduced (**external quality**).

Interfacing: "consider a standardized interface with customers and partners" (Cost ↓, Time ↓, Quality ↑)

"The idea behind this best practice is that a standardized interface will diminish the probability of mistakes, incomplete applications, unintelligible communications. A standardized interface may result in less errors (quality), faster processing (time) and less rework (cost)"

A standardized interface may result in less error and hence **improve external quality** of a process. Even though this best practice might increase the investment costs, in the long run, the lower error rate saves labor time and therefore **induces lower labor cost and hence lower running cost** of a business process. Moreover, as stated, a standardized interface might reduce the processing time which possibly **decreases the throughput and service time** as well.

Appendix C: Enterprise Architecture and Philips Business Process

The enterprise architecture defined at Philips currently contains four layers, *Motivation*, *Business*, *Application* and *Technology* layers. The model has a top-down structure showing the realization levels of business goals starting from the *Motivation* layer, followed by supporting business processes and corresponding application/ technologies.

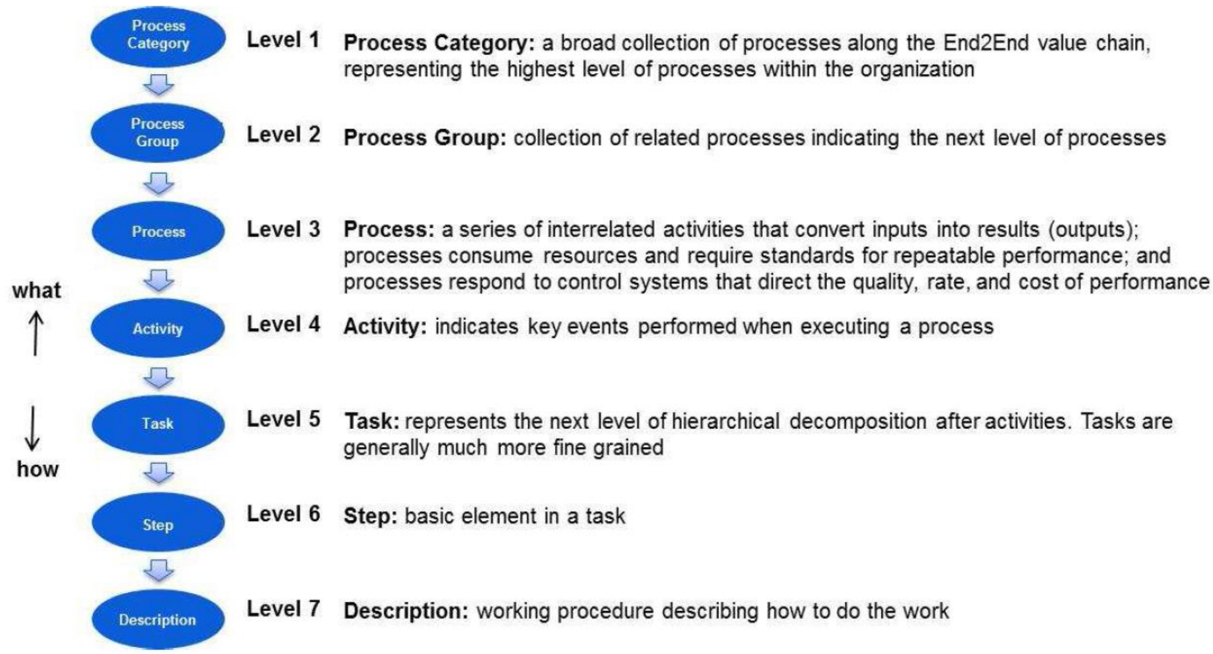
Motivation layer describes the highest level of organization goals. It uses ArchiMate objects [50], such as *goal*, *driver*, and *requirement, etc.* to show the underlying motivation for design or change of enterprise architecture components.

- Goal: A goal is defined as an end state that a stakeholder intends to achieve.
- Driver: A driver is defined as something that creates, motivates, and fuels the change in an organization
- Assessment: An assessment is defined as the outcome of some analysis of some driver.
- Requirement: A requirement is defined as a statement of need that must be realized by a system.

Business layer describes the process framework of a company.

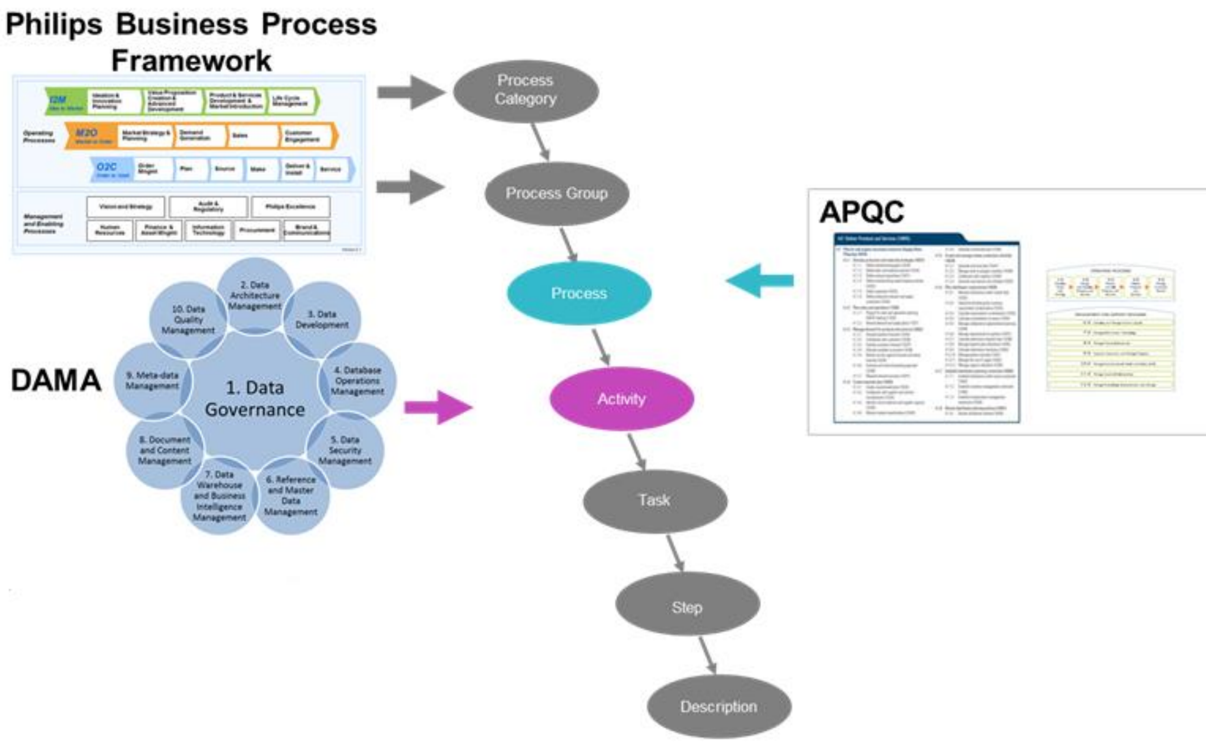
In the past, variations across Philips business processes and systems have resulted in a high degree of diversity in the business models, processes and underlying IT Landscape and data. The diversity introduced complexity and it is hard to rapidly replicate best practices. This duplication can be seen from sector to sector, region to region and even from country to country.

It is very important to operate in a common and leveraged way across the business. This requires a Philips-wide set of business processes, called the Philips Excellence Process Framework (PEPF) to be used by the business. This framework is defined in 7 levels, which is depicted in *Process Level Definition* Figure, and is based on the industry standard American Productivity and Quality Center (APQC) Framework, which gives the common, public domain process language. It is used as a structure for process change and best practices.



Process Level Definition

Philips specific definitions are used for level 1 and 2 to define the scope and ownership of process areas e.g. Level 1: Information Technology, Level 2: Run Enterprise Information. At level 3, Philips uses APQC cross industry version 6.1.1.1 as best practice process classification framework. This framework defines which processes a company should have. APQC provides common terms and definitions, by which the businesses understand each other better. APQC has organized its processes on the basic of Mutual Exclusive and Collectively Exhausting. Hence, it includes all processes a business uses to satisfy customer needs, and there is no overlap in the definition. The Data Management Association (DAMA) is established as a framework for level 4 process design, to provide standards definitions for commonly used data management functions, deliverables, roles and other terminologies. Levels 5 – 7 are in the IT domain. Level 5 describes activities done by a single person at a time. Level 6 is even more granular breakdown of tasks and Level 7 provides guidelines to accomplish a particular process activity. Inputs to process levels are illustrated in figure below.



Inputs to Process Levels

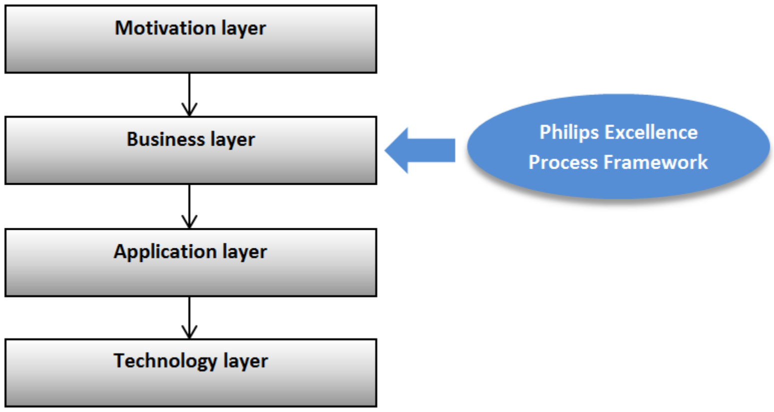
In general, a process is executed by people or by software system, which is illustrated using a *Business Role* element. Other related terms in business architecture are described below:

- Business role: A business role is defined as the responsibility for performing specific behavior, to which ac actor can be assigned.
- Business process: A business process is defined as a behavior element based on an ordering of activities. It is intended to produce a defined set of products or services.
- Business event: A business event is defined as something that happens internally or externally and influences behavior.
- Business objects (Input/ Output): A business object is defined as a passive element that has relevance from a business perspective.

Application layer provides supports for business processes.

Technology layer is used to define and map application components to supporting software systems.

All Philips Business Processes are positioned and executed in the Business layer, as illustrated in *Philips Realization Layer* Figure.



Philips Realization Layer